DETERMINATION OF WATER RESOURCE CLASSES, RESERVE AND RQOS IN THE LIMPOPO (A5-A9) CATCHMENTS & OLIFANTS (B9) CATCHMENT

PROJECT STEERING COMMITTEE MEETING #4

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WATER IS LIFE - SANITATION IS DIGNITY

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

2030 NDP

30 YEARS OF FREEDOM
South Africa 1994 - 2024

OUTLINE

1. Overview of the Resource Quality Objectives (RQO) Process (A Singh)
2. Recommended RQOs for Rivers (A Singh, K Reinecke, C Todd, M Ross, J MacKenzie, N Rossouw)
3. Recommended RQOs for Dams (T Tlou, N Rossouw, M Ross)
4. Recommended RQOs for Wetlands (J MacKenzie)
5. Recommended RQOs for Groundwater (M Holland)

OVERVIEW OF THE RESOURCE QUALITY OBJECTIVE (RQO) PROCESS

RESOURCE QUALITY OBJECTIVES

- Resource Quality Objectives (RQOs) are specific targets set to maintain or improve the quality of water resources within a defined area.
- They are essential components of water resource management, providing clear goals for the ecological health, water quality, and overall sustainability of water systems.
- RQOs aim to protect and enhance the ecological integrity of water resources.
- They provide benchmarks for monitoring and managing water quality and ecological health.
- RQOs guide regulatory and management actions to ensure sustainable use of water resources.

RESOURCE QUALITY OBJECTIVES

They include both narrative and numerical goals and are developed through a comprehensive process involving assessment, stakeholder consultation, and scientific analysis

Narrative RQOs: Descriptive statements that outline the desired conditions or goals for water resources. These may include general objectives such as maintaining biodiversity, ensuring safe recreational use, or protecting habitat integrity.

Numerical RQOs: Specific, quantifiable targets for various water quality parameters (e.g., concentrations of pollutants, flow rates, temperature, pH levels). These provide measurable benchmarks for assessing compliance and progress.

RESOURCE QUALITY OBJECTIVES

Examples of RQOs:

Flow RQOs: Targets for maintaining adequate flow regimes to support aquatic ecosystems.

Water Quality RQOs: Limits on concentrations of pollutants, nutrients, and other water quality parameters.

Habitat RQOs: Objectives for preserving or restoring habitat integrity and connectivity.

Biota RQOs: Goals for maintaining or enhancing populations of key species and overall biodiversity.

PROCESS OF DETERMINING RQOS

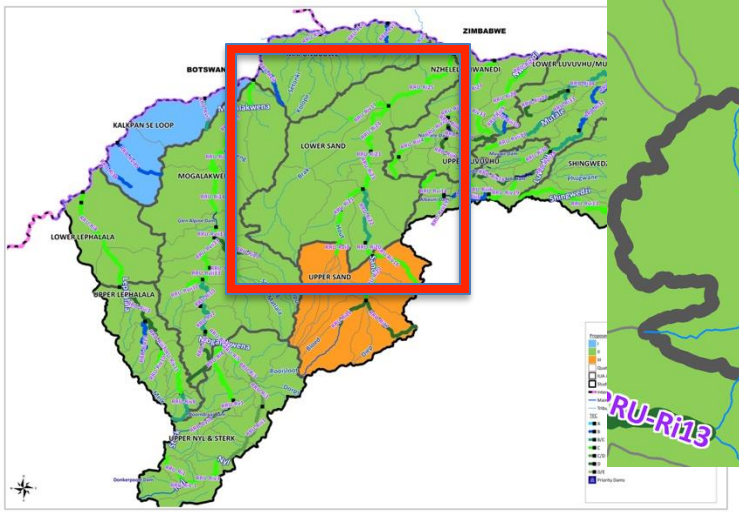
Classification process

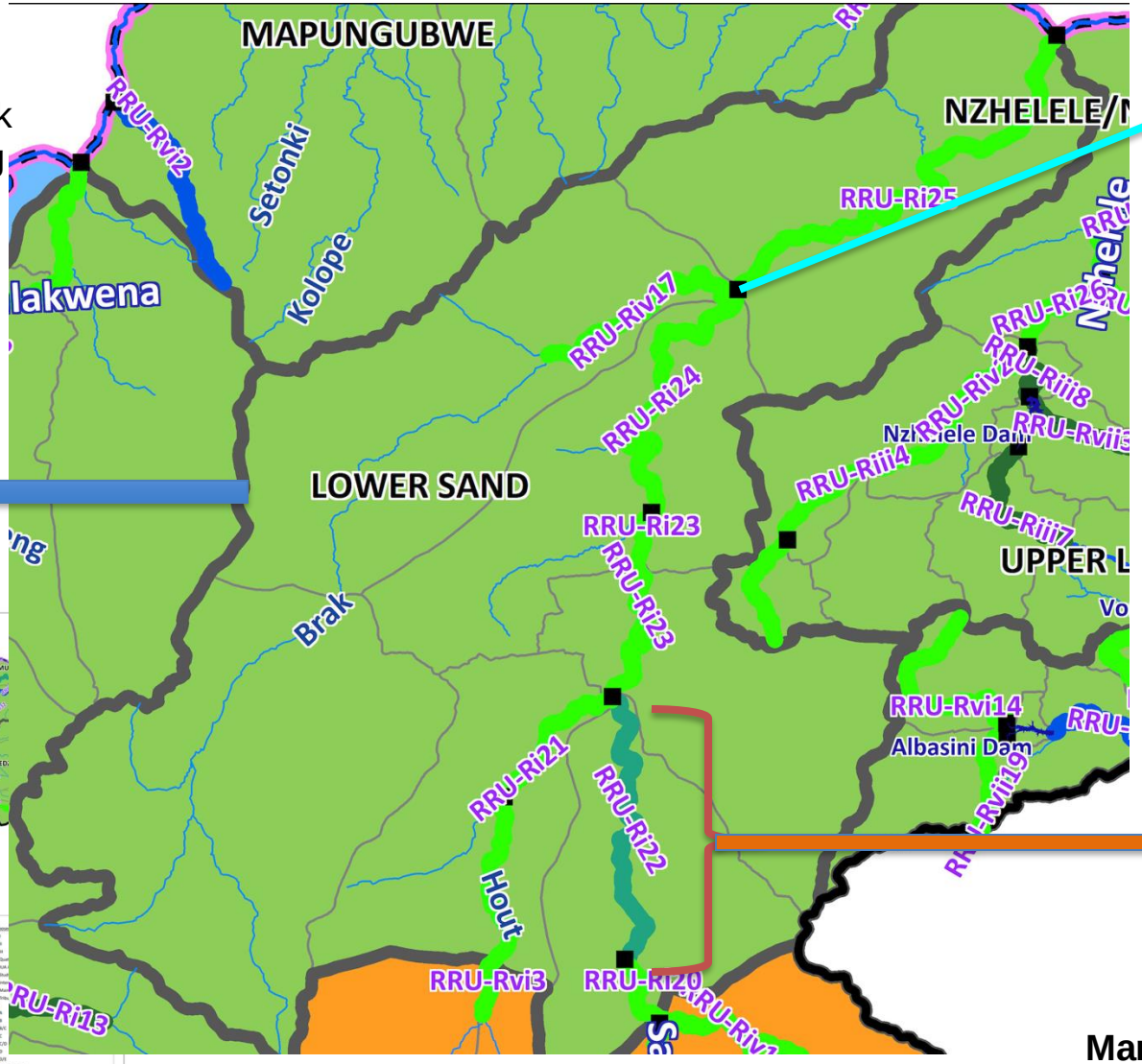
STAKEHOLDER ENGAGEMENT

IUA, RU AND NODES

IUA

- Provides the **broader** framework for understanding and managing water resources
- Delineated based on the similarity of ecological state, system operation, land use, and socio-economic factors





Nodes

- Represent key biophysical points within a RU
- Used to establish a network configuration for modelling purposes, allowing for the simulation of water movement and quality throughout the system
- Important for evaluating scenarios and setting Ecological Water Requirements (EWRs)

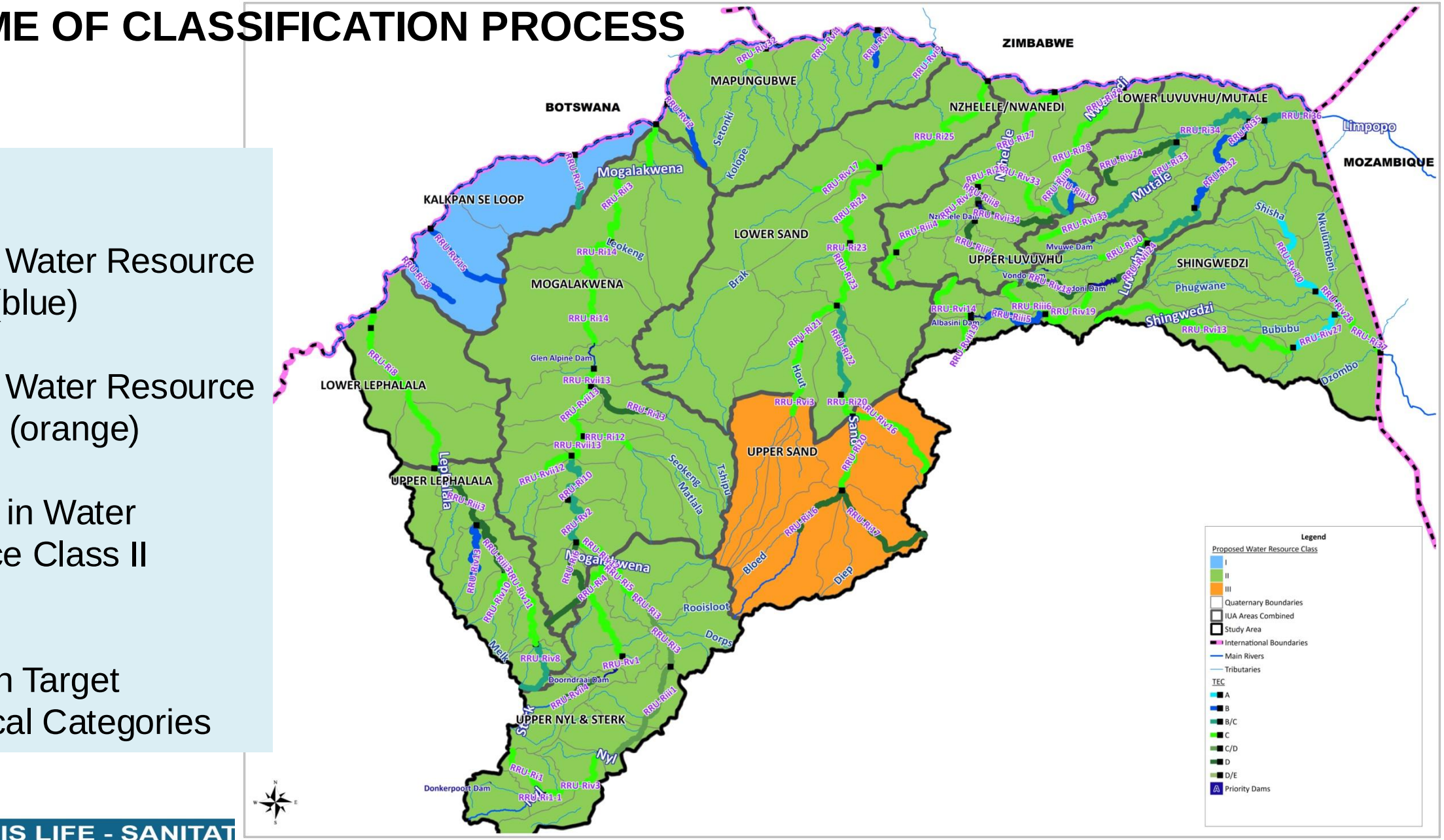
RU

- Defined segment or area within an IUA that is used for **detailed** ecological and hydrological assessments and management actions
- Delineated based on ecological and hydrological characteristics
- Segments of rivers, wetlands, or groundwater systems.

Management actions and strategies are developed at the IUA level but are implemented and monitored at the RU level.

OUTCOME OF CLASSIFICATION PROCESS

- 12 IUAs
- 1 IUA in Water Resource Class I (blue)
- 1 IUA in Water Resource Class III (orange)
- 10 IUAs in Water Resource Class II (green)
- RUs with Target Ecological Categories



STEP 3: PRIORITISE AND SELECT RESOURCE UNITS

- A rationalisation process to prioritise and select the most useful RUs for RQO determination.
- A decision support tool, the Resource Unit Prioritisation Tool (RUPT) has been developed to guide this selection process (DWA, 2011).
  - It considers a range of criteria, that would indicate the importance of monitoring the RU, such as: the position of the RU within an IUA, the importance of the RU to current and future users, threat posed to users, the ecological importance of the RU and the threat faced by the ecological component of the RU, management and practical considerations

STEP 3: PRIORITISING RESOURCE UNITS

Outcomes of the prioritisation process

- High Priority RUs: Areas identified as critical for detailed assessments and intensive management due to their ecological or water use importance or vulnerability.
- Moderate and Low Priority RUs: Areas that require broader, less intensive assessments and management actions.
- They help in focusing efforts on areas that need the most attention and ensuring that management actions are effective and efficient.

STEP 4. PROPOSE SUB-COMPONENTS, INDICATORS AND PROPOSE DIRECTION OF CHANGE

- Identify and prioritise the sub-components of the water resource that may be important to either users or the environment These may include key variables that influence flow, water quality (nutrients, pollutants), habitat integrity, and biota (fish, invertebrates, vegetation).

- Choose specific indicators that will be used to measure the quality and health of the water resource. Indicators should be representative of the critical aspects of the ecosystem and should be measurable.

→ Resource Unit Evaluation Tool

STEP 5. DRAFT RQOS AND NUMERICAL LIMITS

- The outputs of the RQO determination procedure includes both descriptive statements and linked numerical values

- The descriptive statements are easy to understand and are meaningful to both stakeholders and responsible managers and give direction for the action needed to achieve the vision of the resource.

- Numerical limits are generally quantitative descriptors of the different components of the resource. They give a quantitative measure of the RQOs that can be used for monitoring

STEP 6. AGREE RU, RQOS AND NUMERICAL LIMITS WITH STAKEHOLDERS

- Stakeholder engagements:
  - TTG meetings to workshop the RUs, RQOs and Numerical Limits
  - Updated RQOs and Numerical Limits
  - Presentation to Project Steering Committee and at Public meetings
- Update further if needed

Step 7: Finalise and Gazette

RESOURCE QUALITY OBJECTIVES (RQOS) FOR RIVERS

PRESENT ECOLOGICAL STATE (PES)

- The Present Ecological State (PES) refers to the current condition of an aquatic ecosystem. It is an assessment of the health and functioning of the ecosystem based on various ecological indicators, such as:

  - **Water Quality**: Levels of pollutants, nutrients, and other chemical parameters.
  - **Habitat Integrity**: Condition of physical habitats, such as riverbanks, streambeds, and vegetation.
  - **Biodiversity**: Presence and abundance of different species, including fish, invertebrates, and plants.
  - **Ecological Processes**: Natural processes like sediment transport, nutrient cycling, and flow regimes.

RECOMMENDED ECOLOGICAL CATEGORY (REC) AND TARGET ECOLOGICAL CATEGORY (TEC)

Recommended Ecological Category (REC):

- The REC is derived based on the Present Ecological State (PES) and a set of rules provided by the Department of Water and Sanitation (DWS).
- It represents the desired condition of the ecosystem, taking into account factors such as ecological importance, sensitivity, and current pressures.
- The REC includes identifying actions required to achieve the desired ecological objectives.

Target Ecological Category (TEC):

- The TEC is the final goal or target state that is set for the water resource after considering the REC.
- It is determined through a more detailed assessment and stakeholder consultation process.
- The TEC is used to guide management actions and set Resource Quality Objectives (RQOs) to achieve the desired ecological state.

RECOMMENDED ECOLOGICAL CATEGORY (REC) AND TARGET ECOLOGICAL CATEGORY (TEC)

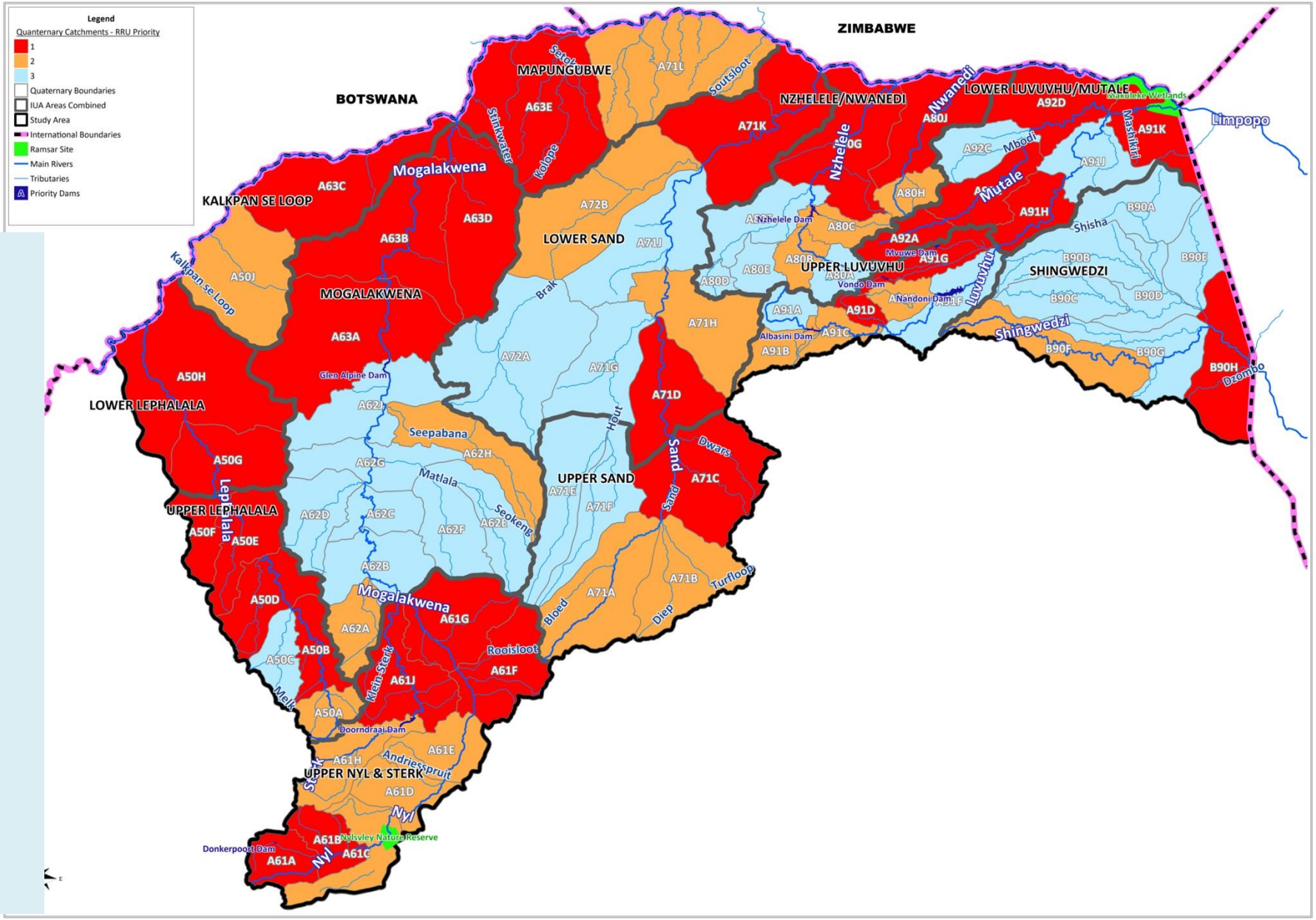
Relationship between REC and TEC:

- The REC serves as an initial recommendation based on the current state and desired improvements.
- The TEC is the confirmed target state that is agreed upon after further analysis and consultation.
- The TEC may be the same as the REC or adjusted based on additional factors such as feasibility, stakeholder input, and resource availability.
- Once the TEC is determined, the associated Ecological Water Requirements (EWRs) and other management actions are implemented to achieve the TEC.
- **In summary, the REC is a preliminary recommendation, while the TEC is the final target state for the water resource, guiding the implementation of management actions and monitoring efforts.**

RU PRIORITISATION

- 75 river RUs
- 30 High priority RU (red)
- 24 medium priority (orange)
- 21 low priority (blue)

- High-priority RUs were taken forward to develop RQOs and Numerical Limits, where possible.



LOWER LUVUVHU/MUTALE IUA

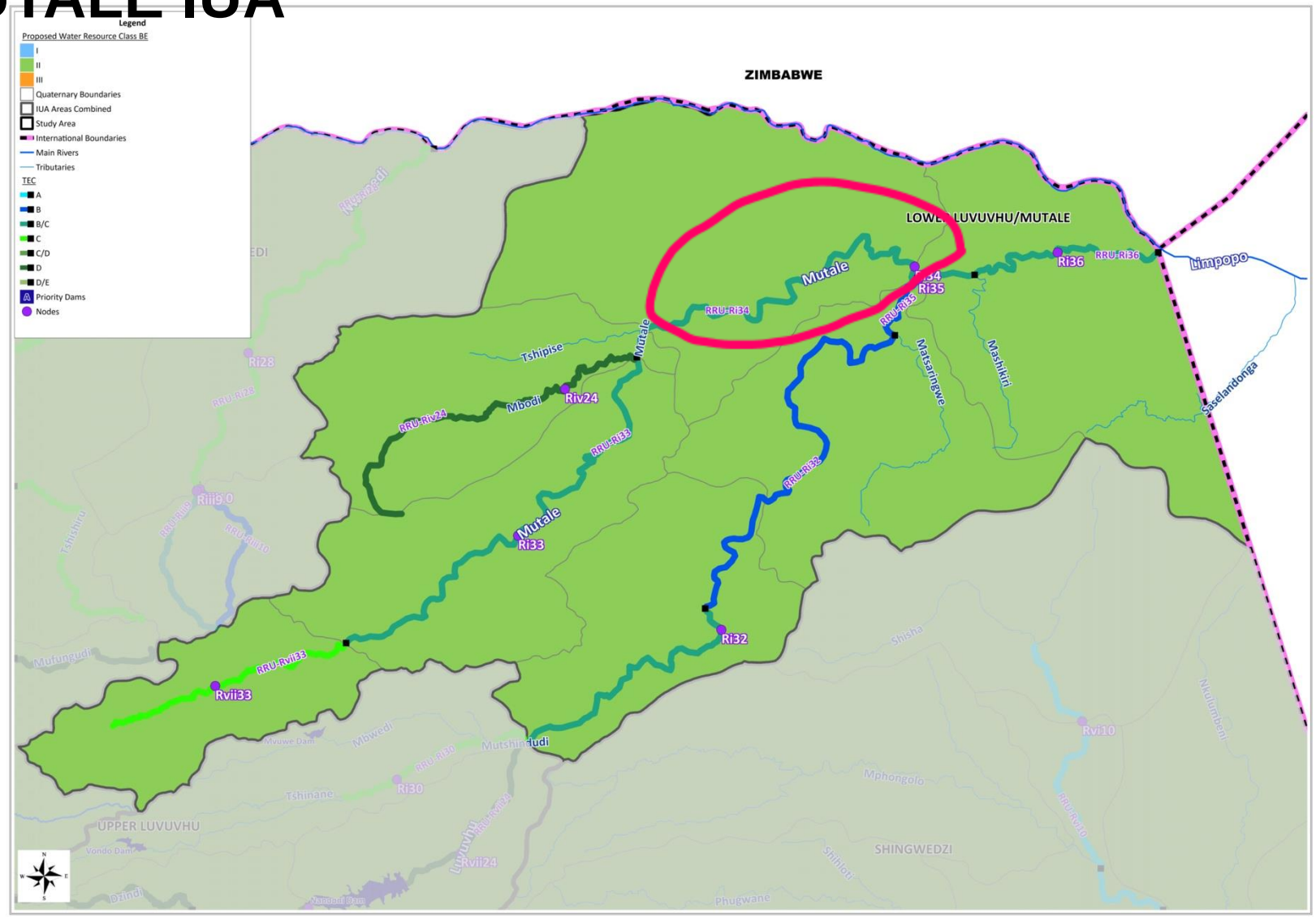
7 RUs delineated

5 high-priority RUs

Water Resource Class II

RQOS for RRU_Ri34 Lower Mutale River

PES = C
REC = C
TEC = B/C



RQOs FOR RRU_Ri34 - LOWER MUTALE RIVER, IN LOWER LUVUVHU/MUTALE IUA

- This site is in a conservation area just upstream of the confluence with the Luvuvhu,
- It represents the lowermost flows and consequences of upstream activities on the Mutale River.
- It is in good ecological condition despite there being some exotic plants on the left bank. The in-channel habitats and therefore conditions for invertebrates and fish are good.

Mutale River (looking upstream)

Mutale River (looking downstream)

Ecological Water Requirements (EWR) - site

nMAR	121.822 MCM	
S.Dev.	7.536	
CV	0.062	
Q75	0.315	
Ecological Category	C	
	MCM	% MAR
Total EWR	87.596	71.905
Maint. Lowflows	56.109	46.058
Drought Lowflows	26.295	21.585
Maint. Highflows	31.487	25.847

Excludes floods with return period ≥1:2 years.

Monthly Distributions (MCM)

	Natural	Modified Flows (EWR)			
		Lowflows		Highflows	Total EWR
Month	Mean	Maint.	Drought	Maint.	Maint.
Oct	2.908	1.828	1.059	0.415	2.243
Nov	5.668	3.207	1.695	1.472	4.679
Dec	12.037	5.888	2.877	4.181	10.069
Jan	22.649	9.399	4.294	5.897	15.296
Feb	31.766	10.421	4.464	7.925	18.346
Mar	23.447	10.140	4.505	7.593	17.733
Apr	10.662	6.325	2.745	3.299	9.624
May	4.208	3.143	1.440	0.360	3.503
Jun	2.376	1.720	0.872	0.061	1.781
Jul	2.323	1.608	0.856	0.104	1.712
Aug	1.911	1.258	0.752	0.043	1.301
Sep	1.868	1.173	0.735	0.137	1.310
Total	121.82	56.11	26.30	31.49	87.60

Ecological Water Requirements (EWR) - basin

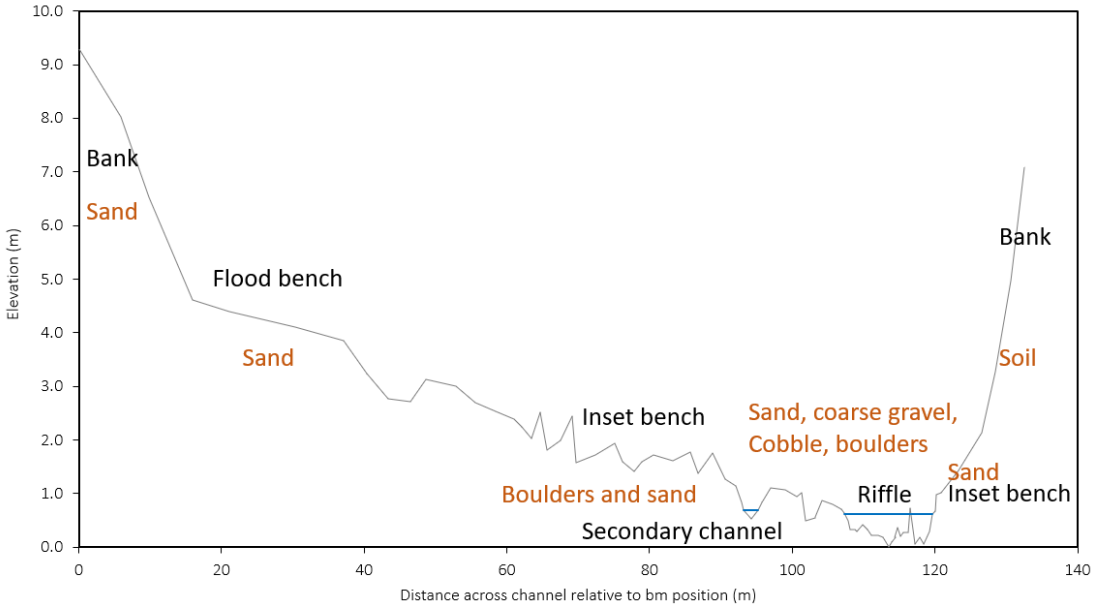
Flows shall be sufficient to maintain the Luvuvhu River in a condition equal to or better than a C category. Flows must be met at the confluence with the Limpopo River, i.e. must flow into the Limpopo.

Quat	Node	River	PES	REC	TEC	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Lower Luvuvhu/Mutale IUA																		
A91H	Ri32	Luvuvhu	C	B/C	C	1.98	4.575	11.723	34.637	71.668	59.208	24.057	9.565	5.336	3.703	2.832	2.18	231.468
A92A	Rvii33	Mutale	C		C	1.408	2.828	5.683	11.565	15.937	13.589	7.055	2.337	1.105	0.975	0.718	0.753	63.947
A92B	Ri33	Mutale	C	C	C	2.106	4.651	10.302	21.034	29.762	22.573	10.601	3.529	1.77	1.559	1.174	1.2	110.263
A92C	Riv24	Mbodi	D		D	0	0.108	0.538	0.951	1.81	0.812	0.1	0	0	0	0	0	4.31
A92D	Ri34	Mutale	C	C	C	2.324	5.714	13.407	27.108	39.584	27.51	11.757	4.024	2.075	1.811	1.387	1.387	138.092
A91J	Ri35	Luvuvhu	B		B	1.614	4.031	14.106	38.074	76.494	61.135	24.447	7.522	4.261	3.008	2.3	1.771	238.764
A91K	Ri36	Luvuvhu	C	C	C	3.927	9.735	29.276	69.196	122.877	93.28	37.941	11.417	6.322	4.81	3.679	3.151	395.616

RQO, Geomorphological Indicators and Rationale

- **GAI score** - maintain or improve GAI score – integrates catchment drivers, reach impacts and site impacts
- **Bed erosion** – maintain the elevation of the river bed – allow some vertical variation, but monitor for ongoing directional change – incision or sedimentation
- **Bank erosion** – erosion is a natural process, but needs some balance with stable/aggrading banks for habitat
- **Riffle sediment size** – does it show armouring or widespread sedimentation?
- **Embeddedness** – are the larger particles smothered by fine sediment providing low interstitial space?
- **Pool depth** – are the deep portions of pools being lost?
- **Flood benches** – links to bank erosion – are there some depositional features in the macro channel that serves as habitat and is inundated during freshets and floods?

RQOs FOR RRU_Ri34 - LOWER MUTALE RIVER - GEOMORPHOLOGY



RQOs for RRU_Ri34 - lower Mutale River: Geomorphology

SUB-COMPONENT	INDICATOR	RQO NARRATIVE	RQO NUMERICAL	TPC
Geomorphology	GAI score	Maintain or improve catchment drivers and site impacts. Maintain pool-riffle/rapid channel morphology	Maintain a GAI PES score of at least a 'C' or > 63%.	GAI PES score < 63%. Change from pool-riffle/rapid channel morphology
	Bed erosion	Maintain bed elevation in relation to banks and benches	Maintain lowest point along riffle cross-section at < 0.5 m difference in elevation	Riffle bed aggradation or degradation of more than 0.5 m from reference/longer-term average
	Bank erosion	Maintain low to moderate proportion of banks actively eroding	Maintain bank erosion below 30%	Bank erosion of more than 30%
	Bed sediment size	Maintain dominant riffle sediment size to include gravel and cobble	Maintain riffle with mobile sediment in the range of a D50 of 24 mm, D16 of 15 mm and D84 of 50 mm	Riffle dominated by sand or only cobble
	Embeddedness	Maintain low embeddedness of riffle sediment	Maintain embeddedness of < 25% for riffle	Embeddedness levels of > 25% for 25% of riffle area/sampling points
	Pool depth	Maintain downstream pool with deep open water	Maintain downstream pool with water > 0.5 m deep for 60% of pool area	Downstream pool is > 60% filled with sediment
	Flood bench	Maintain flood benches along at least one of the banks	Maintain flood bench of > 5 m wide along at least one bank	Channel erosion to the extent where there are no benches wider than ~ 5 m

Water quality indicators and rationale

Indicator	Variables	Motivation
Nutrients	Total inorganic nitrogen Orthophosphate	Eutrophication potential and impacts of nutrient enrichment
Salts	EC / TDS	Osmoregulation of aquatic organisms, taste of drinking water, salinisation of irrigated soils
System variables	Dissolved oxygen	Required by all aquatic organisms
	pH	Acidity or alkalinity, solubility of metals
	Water temperature	Temperature tolerance of aquatic organisms
Toxins/Biocides	Unionized ammonia, pesticides, metals	Risk of agrochemicals to aquatic organisms and human users
Pathogens	E coli / Faecal coliforms	Risk to human water users (waterborne diseases)

RQOs for RRU_Ri34 - lower Mutale River: Water quality

SUB-COMPONENT	INDICATOR	RQO NARRATIVE	RQO NUMERICAL	TPC
Salts	Electrical conductivity (EC)	Salt concentrations need to be maintained at levels that is do not adversely affect aquatic ecosystems (B/C category).	95 percentile EC ≤ 42.5 mS/m	95 percentile Electrical conductivity between 34 – 42.5 mS/m
Nutrients	Total Inorganic nitrogen (TIN)	River nutrient concentrations should be maintained in a mesotrophic state or better (Ideal/Acceptable or B/C category).	Median TIN ≤ 1.23 mg/l	Median TIN between 0.98 - 1.23 mg/l
	Orthophosphate (PO_4-P)		Median PO4-P ≤ 0.050 mg/l	Median PO4-P between 0.040 - 0.050 mg/l
System variables	Dissolved oxygen	Dissolved oxygen concentrations should be such that some oxygen sensitive species are present in the river.	5% percentile Dissolved oxygen concentration ≥ 6 mg/l	Dissolved oxygen concentrations between 6.0 - 7.2 mg/l
	pH	pH values should be maintained at in a B/C category to protect aquatic ecosystems.	6.5 ≤ pH ≤ 8.5	pH between 6.0 - 6.5 or pH between 8.5 - 9.0
	Water temperature	Water temperatures (°C) should fall within the reference thermograph (graph of the 95% band of seasonal pattern of minimum and maximum temperatures river).	Water temperature within the reference thermograph (95% band) plus or minus 1 standard deviation	Water temperatures outside of the reference thermograph (95% band) plus or minus 1 standard deviation

RQOs for RRU_Ri34 - lower Mutale River: Water quality

SUB-COMPONENT	INDICATOR	RQO NARRATIVE	RQO NUMERICAL	TPC
Toxins	Ammonia (NH3-N)	Toxicity levels should not pose a threat to river aquatic ecosystems.	Ammonia (NH3-N) ≤ 44 µg/l (95% percentile)	95th percentile Ammonia (NH3-N) between 35 - 44 µg/l
	Atrazine		Atrazine ≤ 49 µg/l (95% percentile)	95th percentile Atrazine between 39-49 µg/l
	Endosulfan		Endosulfan ≤ 0.075 µg/l (95% percentile)	95th percentile Endosulfan ≤ 0.06 - 0.075 µg/l
Pathogens	Escherichia coli (E coli)	Concentrations of waterborne pathogens should be maintained in an Acceptable category for contact recreation	E coli / Faecal coliforms ≤ 25 cfu/100ml (95th percentile)	95th percentile E coli / Faecal coliforms between 20-25 cfu/100ml
	Faecal coliforms			

RQOs for RRU_Ri34 - lower Mutale River: Riparian Vegetation

SUB-COMPONENT	INDICATOR	RQO NARRATIVE	RQO NUMERICAL	TPC
Marginal zone	Dominant vegetation	Non-woody vegetation should dominate the marginal zone	Non-woody cover >= 60% (aerial cover).	Non-woody cover less than 60%
	Key species	*Phragmites mauritianus* and *Br eonadia salicina* must be present.	2 listed key species present.	Absence of 1 or more listed key species
	Alien plant species	The riparian vegetation structure and composition in the marginal zone should maintain desired dominance and non-dominance.	No perennial alien plant species.	Presence of perennial alien plants
	Terrestrial woody cover		No terrestrial woody plants.	Presence of terrestrial woody species
	Indigenous woody cover		Woody cover <= 5% (aerial cover).	Woody cover more than 5%
	Non-woody cover		Non-woody cover >= 60% (aerial cover).	Non-woody cover less than 60%

RQOs for RRU_Ri34 - lower Mutale River: Riparian Vegetation

SUB-COMPONENT	INDICATOR	RQO NARRATIVE	RQO NUMERICAL	TPC
Non-marginal (lower - flood benches)	Dominant vegetation	Woody and non-woody vegetation should co-dominate the flood features	Dominance by either woody or non-woody plants.	Non-woody or woody cover less than 10%
	Key species	*Faidherbia albida, Phragmites mauritianus and Plu chea bojeri* must be present.	3 listed key species present.	Absence of 1 or more listed key species
	Alien plant species	The riparian vegetation structure and composition on the flood features should maintain desired dominance and non-dominance.	Perennial alien plant species <= 5% (aerial cover).	Cover by perennial alien plants more than 5%
	Terrestrial woody cover		Terrestrial woody cover <= 5% (aerial cover).	Cover by terrestrial woody species more than 5%
	Indigenous woody cover		Woody cover <= 20% (aerial cover).	Woody cover more than 20%
	Non-woody cover		20% >= Non-woody cover <= 60%	Non-woody cover less than 20% or more than 60%

RQOs for RRU_Ri34 - lower Mutale River: Riparian Vegetation

SUB-COMPONENT	INDICATOR	RQO NARRATIVE	RQO NUMERICAL	TPC
Non-marginal (upper - banks)	Dominant vegetation	Woody vegetation should dominate the macro-channel banks	Woody cover >= 60% (aerial cover).	Woody cover less than 60%
	Alien plant species	Alien invasive plant species should be kept low or absent on macro-channel banks	No perennial alien plant species.	Presence of perennial alien plants
Riparian zone	PES	The PES category should be a B at least	VEGRAI score >= 82%	VEGRAI score < 82%
	Species richness	Indigenous plant species richness in the riparian zone should be maintained.	>= 35 indigenous species.	Less than 35 indigenous plant species present
	Threatened riparian species	3 nationally protected tree species: Apple Leaf (*Philenoptera violacea*) Leadwood (*Combretum imberbe*) and Matumi (*Breonadia salicina*) must be present.	3 listed protected species present.	Absence of 1 or more listed protected species

Fish Indicators and Rationale

- What affects the distribution of fish within a catchment unit, within a river reach and within a river segment?
  - Instream barriers is the greatest influencer of fish distributions within catchments (dams and weirs);
  - Water abstraction leading to increased seasonality of watercourses, physically inhibiting fish movement/survivability within systems;
  - Habitat specificity (rheophilic vs non-rheophilic).
- What variables impact on fish presence/absence?
  - Flow drivers > geomorphological drivers > habitat availability > water quality > resource availability.
- Why are fish species communities assessed?
  - Because the presence of fish is dependent on so many variables, their presence reflects the level of the functionality of the aquatic ecosystem as a whole;
  - Sensitivity to changes and habitat requirements are different per species (minimum flow requirements, habitat specificity associated with flow drivers, etc);
  - Habitat specialists vs generalists and the response to habitat transformation (displacement/destruction of fish populations).

Fish Indicators and Rationale

- How are fish assessed for a particular river reach/site?
  - Survey sites are chosen for the habitat diversity that they present, accessibility, conditions suited to the collection methods employed.
  - Sites should be representative of the river reach or unit that is being assessed.
  - Variety of methods (electrofishing, gill nets, cast nets, traps) depending on the site conditions.
  - A desktop reference list of species expected from the river reach is derived. This is refined according to habitat features.
  - The fish that are collected during a field survey are identified, and the abundance is recorded according to relative abundance.
  - Those are the two main data needed for the application of the FRAI (Fish Response Assessment Index) (Kleynhans, 2009)
  - Habitat drivers pertaining to how they would influence the fish presence/absence at the site allow for further refinement of the ratings.
  - The FRAI provides a PES score for the site/river reach.

Fish Indicators and Rationale

- Setting/Deriving the RQOs:
  - Identification of the **fish species** that would be most impacted by flow-derived transformations within a river reach and consider them as "**key species**". (Easily identified and representative of a guild).
  - May be **different for specific river reaches**, but there is a large overlap for sites that share the same catchment.
  - Some sites include **specific habitat types that support unique species**.
  - Assess the ecological consequence of **habitat transformations** (Habitat drivers) including **habitat connectivity**;
  - Assess **fish species diversity and abundance** (Biological responders);
  - Overall **fish health** (Water quality and habitat drivers).

RQOs for RRU_Ri34 - lower Mutale River: Fish

SUB-COMP	INDICATOR	RQO NARRATIVE	RQO NUMERICAL	TPC
Fish	FRAI score	The Ecological Category should be maintained within a C Category, using reference data used for the EWR studies	FRAI to be maintained within the range of a C category (>62%)	A FRAI score that calculates to a PES category less than C for two or more consecutive surveys
	Overall fish health	Fish generally healthy (no ulcerative bacterial infections, and limited parasite burden)	Bacterial infections and/or parasitic burdens must impact <1% of the fish population	Bacterial infections and/or parasitic burdens impacting >1% of the fish population during any survey
	Species diversity	To maintain suitable habitat conditions that would support the key species.	Maintain the diversity of species as per EWR studies	Loss of species diversity that results in a drop in PES category
	Key species	To maintain suitable flow conditions to support the key species identified at the site	Presence/absence records. Relative abundance of species: *Labeobarbus marequensis (2), Labeo cylindricus (2) (2), Chiloglanis pretoriae, Anoplopterus "southern stargazer sp" (formerly Amphilius uranoscopus) (1), Glossogobius callidus (1), Micralestes acutidens (2)* and *Anguilla marmorata (1)*	The absence of any of the target species for two or more consecutive surveys

Macroinvertebrate Indicators and Rationale

- MIRAI Category and Score – to ensure that the desired Ecological Category is maintained or improved on;
- SASS Total Score and ASPT – to ensure that the SASS scores attained, support the specified Ecological Category;
- Key taxa and abundance – criteria for taxon selection:
  - Taxa must have a reasonably strong preference for a certain habitat type or velocity type, i.e. normally a 4 or 5 preference value (as indicated in the MIRAI), sometimes even a 3 value is used when no other appropriate taxa are present;
  - Taxa must occur frequently enough i.e. a FROC value of 4 or 5, or minimally at least 50% of the time;
  - Taxa must be at least moderately sensitive to changes in water quality.
- Taxon dominance - to ensure that no taxon/group consistently dominates the fauna, defined as C abundance (>100) over a specified number of surveys, usually two.

RQOs for RRU_Ri34 - lower Mutale River: Macroinvertebrates

SUB-COMPONENT	INDICATOR	RQO NARRATIVE	RQO NUMERICAL	TPC
Macroinvertebrates	MIRAI Category and Score	The Ecological Category should remain within a B/C Category.	To ensure that the MIRAI score remains within the range of a B/C category (>78 - ≤82%), using the same reference data used in the EWR study.	A MIRAI score of 80% or less.
	SASS5 Total Score and ASPT	To ensure that the SASS scores attained, support the specified Ecological Category.	To ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score: >160; ASPT value: >6.0.	SASS5 scores less than 165 and ASPT less than 6.1.

RQOs for RRU_Ri34 - lower Mutale River: Macroinvertebrates

SUB-COMPONENT	INDICATOR	RQO NARRATIVE	RQO NUMERIC	TPC
	Key taxa and abundance	To maintain suitable flow velocity (>0.6m/s) and to maintain clean, unembedded surface area (cobbles) to support the following flow-dependent taxa: Perlidae Heptageniidae	Minimum abundance of an A attained for Perlidae and Heptageniidae.	If Perlidae or Heptageniidae is missing in two consecutive surveys or has a single individual present in two consecutive surveys.
		To maintain sufficient quantity and quality of inundated vegetation to support the following vegetation-dwelling taxon: Coenagrionidae	Minimum of an A abundance attained.	Coenagrionidae missing in two consecutive surveys or has a single individual present in two consecutive surveys.
	Taxon dominance	To ensure that no taxon consistently dominates the fauna, over more than two consecutive surveys.	No taxon occurs in a C abundance (>100 individuals).	

MOGALAKWENA IUA

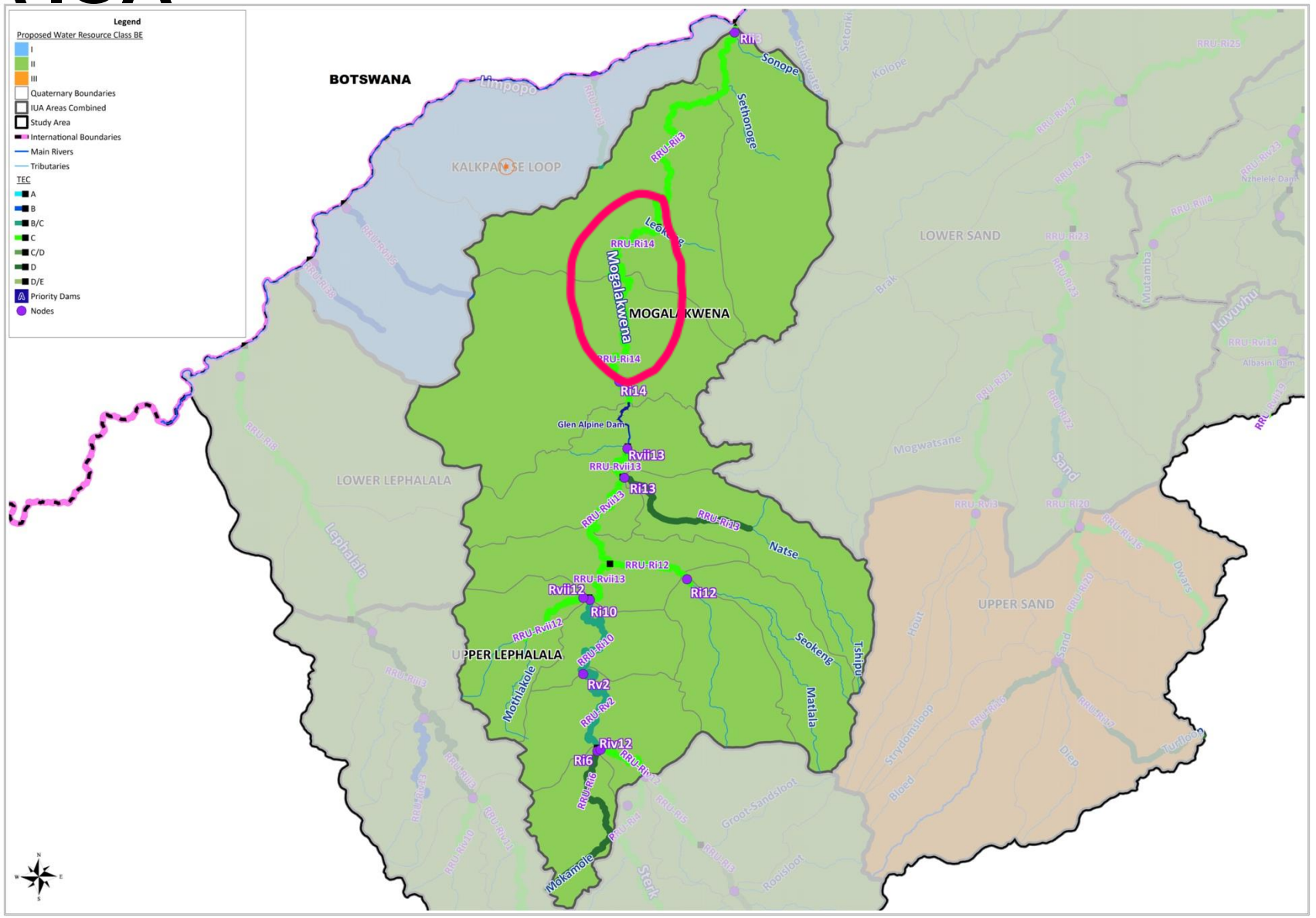
10 RUs delineated

2 high-priority RUs

Water Resource Class II

RQOS for RRU_RI14 on the Mogalakwena River

PES = C
REC = C
TEC = C



RQOS FOR MIDDLE MOGALAKWENA RIVER, IN MOGALAKWENA IUA

- This site is a REMP site.
- It is downstream of Glen Alpine Dam.
- The site is good ecologically because the riparian vegetation is in relatively good condition, despite there being some exotic plants, and the channel has a nice range of aquatic habitat for invertebrates and fish.

Mogalakwena River (aerial view)

Mogalakwena River (downstream view)

Ecological Water Requirements (EWR) - site

nMAR	188.946 MCM	
S.Dev.	15.804	
CV	0.084	
Q75	0.2848	
Ecological Category	C	
	MCM	% nMAR
Total EWR	43.439	22.990
Maint. Lowflows	39.096	20.692
Drought Lowflows	26.707	14.135
Maint. Highflows	4.343	2.299

Excludes floods with return period ≥1:2 years.

Monthly Distributions (MCM)

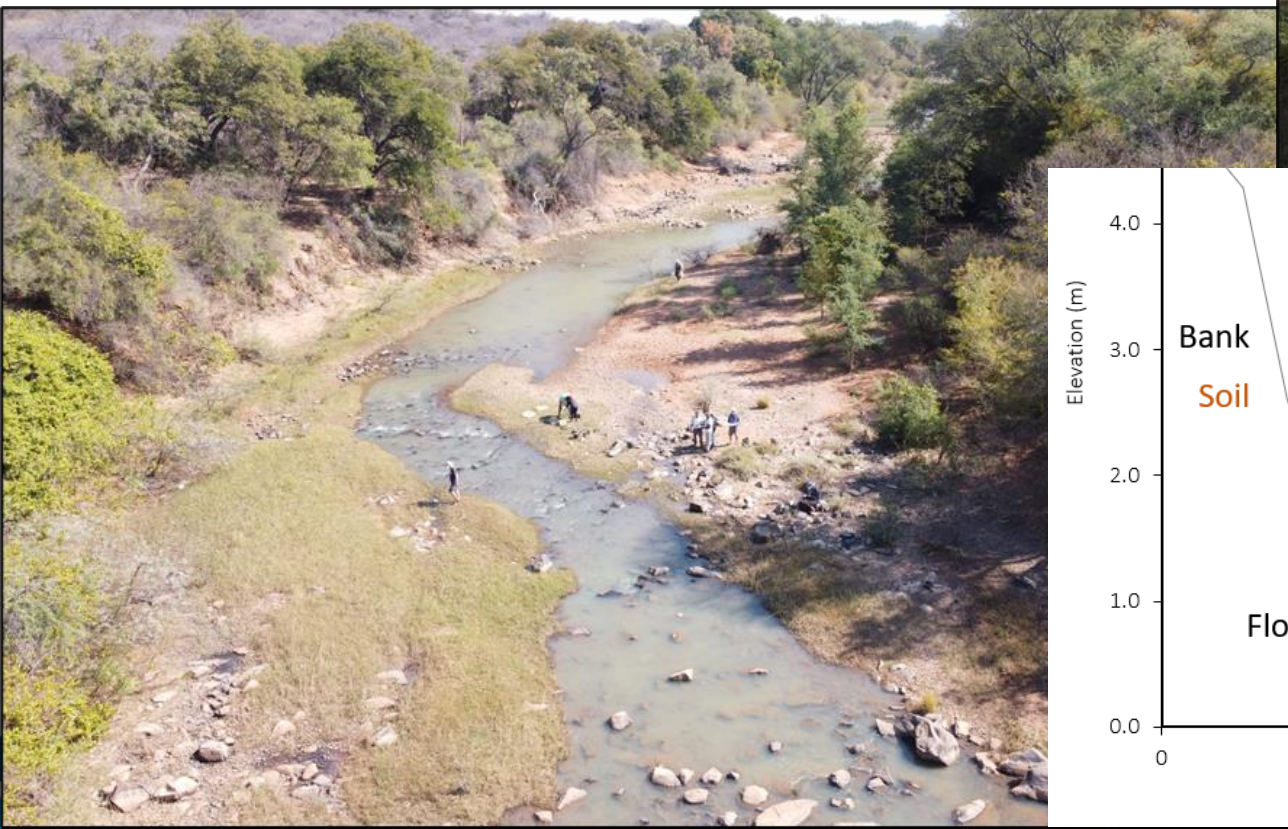
	Natural	Modified Flows (EWR)			
		Lowflows		Highflows	Total EWR
Month	Mean	Maint.	Drought	Maint.	Maint.
Oct	3.417	0.487	0.741	0.107	0.594
Nov	13.305	2.120	1.020	0.135	2.255
Dec	18.652	2.557	1.951	0.313	2.870
Jan	31.569	3.906	3.485	0.758	4.663
Feb	52.951	10.470	4.785	0.495	10.965
Mar	26.374	9.273	4.619	0.606	9.879
Apr	15.229	4.486	2.522	0.658	5.143
May	8.955	2.496	2.082	0.629	3.125
Jun	5.898	1.351	1.632	0.367	1.717
Jul	4.964	1.104	1.552	0.183	1.287
Aug	4.168	0.546	1.266	0.057	0.603
Sep	3.464	0.300	1.054	0.038	0.338
Total	188.95	39.10	26.71	4.34	43.44

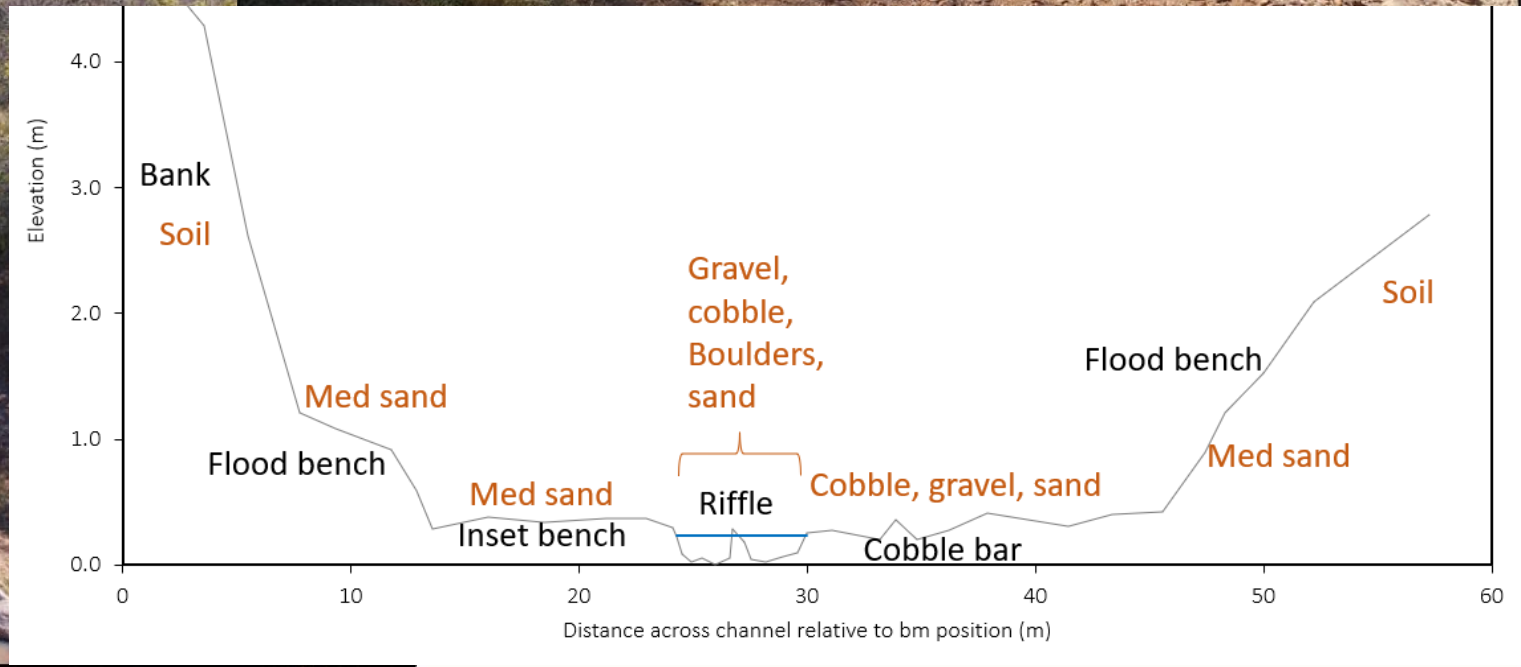
Ecological Water Requirements (EWR) - basin

Flows shall be sufficient to maintain the Mogalakwena River in a condition equal to or better than a C category. Flows must be met at the confluence with the Limpopo River, i.e. must flow into the Limpopo.

Quat	Node	River	PES	REC	TEC	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Mogalakwena IUA																		
A62B	Riv12	Mogalakwena	C		C	1.008	4.091	7.978	16.858	28.355	11.702	5.288	2.752	1.928	1.751	1.454	1.237	84.403
A62A	Ri6	Mokamole	D		D	0.001	0.495	0.524	1.892	4.039	2.51	1.658	0.969	0.337	0.086	0.024	0.002	12.532
A62B	Rv2	Mogalakwena	C		B/C	0.876	4.889	8.734	19.904	35.336	15.734	7.794	4.357	2.657	2.047	1.56	1.232	105.118
A62D	Rvii12	Klein Mogolakwena	C		C	0.028	0.309	0.144	0.478	1.649	0.627	0.177	0.149	0.125	0.105	0.079	0.056	3.929
A62C	Ri10	Mogalakwena	C		B/C	0.825	4.993	8.779	20.196	36.403	16.257	8.126	4.599	2.796	2.103	1.571	1.224	107.869
A62F	Ri12	Matlalane	C		C	0.019	0.791	0.396	1.096	2.319	1.55	1.195	0.421	0.131	0.106	0.073	0.043	8.137
A62H	Ri13	Seepabana	D		D	0.017	0.314	0.204	0.476	1.139	0.747	0.662	0.266	0.095	0.082	0.056	0.025	4.087
A62J	Rvii13	Mogalakwena	C		C	0.912	6.821	9.779	22.867	42.957	20.124	10.979	5.76	3.264	2.495	1.844	1.379	129.177
A63A	Ri14	Mogalakwena	C	C	C	0.7	6.07	8.305	20.613	42.112	19.069	10.021	4.627	2.262	1.704	0.911	0.547	116.939
A63D	Rii3	Mogalakwena	C	C	C	0.273	5.688	8.258	21.999	45.638	21.122	10.301	4.331	1.954	1.404	0.668	0.294	121.927

RQOS FOR MIDDLE MOGALAKWENA RIVER, IN MOGALAKWENA IUA





RQOs for RRU_Ri14 - Middle Mogalakwena: Geomorphology (Habitat)

SUB-COMPONENT	INDICATOR	RQO NARRATIVE	RQO NUMERICAL	TPC
Geomorphology	GAI score	Maintain or improve catchment drivers and site impacts. Maintain pool-riffle channel morphology	Maintain a GAI PES score of at least a 'C' or > 63%	GAI PES score < 63%. Change from pool-riffle channel morphology
	Bed erosion	Maintain bed elevation in relation to banks and benches	Maintain lowest point along riffle cross-section at <0.5 m difference in elevation	Riffle bed aggradation or degradation of more than 0.5 m from reference/longer-term average
	Bank erosion	Maintain low to moderate proportion of banks actively eroding	Maintain bank erosion below 30%	Bank erosion of more than 30%
	Bed sediment size	Maintain dominant riffle sediment size to include gravel and cobble	Maintain riffle with mobile sediment in the range of a D50 of 35 mm, D16 of 17 mm and D84 of 55 mm	Riffle dominated by sand or only cobble
	Embeddedness	Maintain low to moderate embeddedness of riffle sediment	Maintain embeddedness of < 25% for riffle	Embeddedness levels of > 25% for 25% of riffle area/sampling points
	Pool depth	Maintain downstream pool with deep open water	Maintain downstream pool with water >0.5 m deep for 60% of pool area	Downstream pool is > 60% filled with sediment
	Flood bench	Maintain flood benches along at least one of the banks	Maintain flood bench of >5 m wide along at least one bank	Channel erosion to the extent where there are no benches wider than ~ 5 m

RQOs for the RRU_Ri14 – middle Mogalakwena River: Water quality

SUB-COMPONENT	INDICATOR	RQO NARRATIVE	RQO NUMERICAL	TPC
Salts	Electrical conductivity (EC)	Salt concentrations need to be maintained at levels that is do not adversely affect aquatic ecosystems (C category).	95 percentile EC ≤ 85 mS/m	95 percentile Electrical conductivity between 68 - 85 mS/m
Nutrients	Total Inorganic nitrogen (TIN)	River nutrient concentrations should be maintained in a mesotrophic state or better (Acceptable category).	Median TIN ≤ 2.24 mg/l	Median TIN between 1.79 - 2.24 mg/l
	Orthophosphate (PO_4-P)		Median PO4-P ≤ 0.090 mg/l	Median PO4-P between 0.072 - 0.090 mg/l
System variables	Dissolved oxygen	Dissolved oxygen concentrations should be such that some oxygen sensitive species are present in the river.	5% percentile Dissolved oxygen concentration ≥ 6 mg/l	Dissolved oxygen concentrations between 6.0 - 7.2 mg/l
	pH	pH values should be maintained at in a B/C category to protect aquatic ecosystems.	5.6 ≤ pH ≤ 9.2	pH between 5.6 - 5.9 or pH between 8.8 - 9.2
	Water temperature	Water temperatures should fall within the reference thermograph (graph of the 95% band of seasonal pattern of minimum and maximum temperatures river).	Water temperature within the reference thermograph (95% band) plus or minus 1 standard deviation	Water temperatures outside of the reference thermograph (95% band) plus or minus 1 standard deviation

RQOs for the RRU_Ri14 – middle Mogalakwena River: Water quality

SUB-COMPONENT	INDICATOR	RQO NARRATIVE	RQO NUMERICAL	TPC
Toxins	Ammonia (NH3-N)	Toxicity levels should not pose a threat to river aquatic ecosystems.	Ammonia (NH3-N) ≤ 44 µg/l (95% percentile)	95th percentile Ammonia (NH3-N) between 35 - 44 µg/l
	Atrazine		Atrazine ≤ 49 µg/l (95% percentile)	95th percentile Atrazine between 39-49 µg/l
	Endosulfan		Endosulfan ≤ 0.075 µg/l (95% percentile)	95th percentile Endosulfan ≤ 0.06 - 0.075 µg/l
Pathogens	Escherichia coli (E coli)	Concentrations of waterborne pathogens should be maintained in an Acceptable category for contact recreation	E coli / Faecal coliforms ≤ 25 cfu/100ml (95th percentile)	95th percentile E coli / Faecal coliforms between 20-25 cfu/100ml
	Faecal coliforms			

RQOs for the RRU_Ri14 - middle Mogalakwena River Riparian Vegetation

SUB-COMPONENT	INDICATOR	RQO NARRATIVE	RQO NUMERICAL	TPC
Marginal zone	Dominant vegetation	Non-woody vegetation should dominate the marginal zone	Non-woody cover >= 70% (aerial cover).	Non-woody cover less than 70%
	Key species	*Juncus lomatophyllus, Cyperus digitatus, Ischaemum fasciculatum* and *Salix mucronata* must be present.	4 listed key species present.	Absence of 1 or more listed species
	Alien plant species	The riparian vegetation structure and composition in the marginal zone should maintain desired dominance and non-dominance.	No perennial alien plant species.	Presence of perennial alien plants
	Terrestrial woody cover		No terrestrial woody plants.	Presence of terrestrial woody species
	Indigenous woody cover		Woody cover <= 10% (aerial cover).	Woody cover more than 10%
	Non-woody cover		Non-woody cover >= 70% (aerial cover).	Non-woody cover less than 70%
	Reed cover		Reed cover <= 20% (aerial cover).	Reed cover more than 20%

RQOs for the RRU_Ri14 - middle Mogalakwena River Riparian Vegetation

SUB-COMPONENT	INDICATOR	RQO NARRATIVE	RQO NUMERICAL	TPC
Non-marginal (lower - flood benches)	Dominant vegetation	Non-woody vegetation should dominate the flood features	Non-woody cover >= 80% (aerial cover).	Non-woody cover less than 80%
	Key species	*Cyperus digitatus* and *Gomphocarpus fruticosus* must be present.	2 listed key species present.	Absence of 1 or more listed species
	Alien plant species	The riparian vegetation structure and composition on the flood features should maintain desired dominance and non-dominance.	Perennial alien plant species <= 20% (aerial cover).	Perennial alien plant cover more than 20%
	Terrestrial woody cover		Terrestrial woody cover <= 30% (aerial cover).	Terrestrial woody species cover more than 30%
	Indigenous woody cover		Woody cover <= 30% (aerial cover).	Woody cover more than 30%
	Non-woody cover		Non-woody cover >= 50% (aerial cover).	Non-woody cover less than 50%

RQOs for the RRU_Ri14 - middle Mogalakwena: River Riparian Vegetation

SUB-COMPONENT	INDICATOR	RQO NARRATIVE	RQO NUMERICAL	TPC
Non-marginal (upper - banks)	Dominant vegetation	Woody vegetation should dominate the macro-channel banks	Woody cover >= 50% (aerial cover).	Woody cover less than 50%
	Alien plant species	Alien invasive plant species should be kept low or absent on macro-channel banks	No perennial alien plant species.	Presence of perennial alien plants
Riparian zone	PES	The PES category should be a C at least	VEGRAI score >= 62%	VEGRAI score < 62%
	Species richness	Indigenous plant species richness in the riparian zone should be maintained.	>= 20 indigenous species.	Less than 20 indigenous plants species present
	Endemic riparian species	*Schotia brachypetala* (southern African endemic) must be present.	1 listed endemic species present.	Absence of 1 or more listed species
	Threatened riparian species	3 nationally protected tree species: Apple Leaf (*Philenoptera violacea*), Leadwood (*Combretum imberbe*) and Camel Thorn (*Vachellia erioloba*) must be present.	3 listed protected species present.	Absence of 1 or more listed species

RQOs for the RRU_Ri14 - middle Mogalakwena: Fish

INDICATOR	RQO NARRATIVE	RQO NUMERICAL	TPC
FRAI score	The Ecological Category should be maintained within a A/B Category, using reference data used for the EWR studies	FRAI to be maintained within the range of a A/B category (>87%)	A FRAI score that calculates to a PES category less than A/B for two or more consecutive surveys
Overall fish health	Fish generally healthy (no ulcerative bacterial infections, and limited parasite burden)	Bacterial infections and/or parasitic burdens must impact <1% of the fish population	Bacterial infections and/or parasitic burdens impacting >1% of the fish population during any survey
Species diversity	To maintain suitable habitat conditions that would support the key species.	Maintain the diversity of species as per EWR studies	Loss of species diversity that results in a drop in PES category
Key species	To maintain suitable flow conditions to support the key species identified at the site.	Presence/absence records. Relative abundance of species: *Labeobarbus marequensis (2), Labeo cylindricus (2), Chiloglanis pretoriae (2) Micralestes acutidens (1), Enteromius trimaculatus (1), Engrulicypris brevianalis (1)*	The absence of any of the target species for two or more consecutive surveys

RQOs for the RRU_Ri14 - middle Mogalakwena: Macroinvertebrates

INDICATOR	RQO NARRATIVE	RQO NUMERICAL	TPC
MIRAI Category and Score	The Ecological Category should remain within a C Category.	To ensure that the MIRAI score remains within the range of a C category (>62 - ≤78 %), using the same reference data used in the EWR study.	A MIRAI score of 64% or less.
SASS5 Total Score and ASPT	To ensure that the SASS scores attained, support the specified Ecological Category.	To ensure that the SASS5 scores and ASPT values occur in the following range: SASS5 score: >110; ASPT value: >5.2.	SASS5 scores less than 115 and ASPT less than 5.3.

RQOs for the RRU_Ri14 - middle Mogalakwena: Macroinvertebrates

INDICATOR	RQO NARRATIVE	RQO NUMERICAL	TPC
Key taxa and abundance	To maintain suitable flow velocity (>0.6m/s) and to maintain clean, unembedded surface area (cobbles) to support the following flow-dependent taxa: Simuliidae	Minimum abundance of an A attained.	If Simuliidae is missing in two consecutive surveys or has a single individual present in two consecutive surveys.
	To maintain sufficient quality and quantity of inundated vegetation to support vegetation-dwelling Coenagrionidae.	Minimum abundance of an A attained.	Coenagrionidae missing in two consecutive surveys or has a single individual present in two consecutive surveys.
Taxon dominance	To ensure that no taxon consistently dominates the fauna,over more than two consecutive surveys.	No taxon occurs at a C abundance (>100 individuals).	

DETERMINATION OF WATER RESOURCE CLASSES, RESERVE AND RQOS IN THE LIMPOPO (A5-A9) CATCHMENTS & OLIFANTS (B9) CATCHMENT – RQOs for DAMS

PSC MEETING # 4

Presented by, Toriso Tlou, Nico Rossouw and Mathew Ross

Date: 1 April 2025

WATER IS LIFE - SANITATION IS DIGNITY

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

2030 NDP

30 YEARS OF FREEDOM
South Africa 1994 - 2024

RQOS FOR DAMS

PRIORITISATION OF DAMS

- Major dams in the study area were identified based on size and importance of dams for water supply.
- Further screening was conducted to identify the Dams RUs that should be prioritised.
- Selection criteria
  - Water use sectors dependent on the dam
  - Impact of upstream use on inflows
  - Importance to downstream water users
  - Importance to in-dam activities (fishing, recreational activities, etc)
  - Water quality impact on the downstream use

Criteria for Dam Resource Prioritisation

- The cumulative level of impact of current & future use –
  - This is the anticipated level of impact of current and future use/ activities in the upstream catchments on the inflows to the dam.
  - Impact rating scores can range between very high: -1; High: -0.75; Moderate: -0.5; Low: -0.25 and None; 0.
  - Where current & future use activities have a positive impact on the dam the ratings would be positive. This is particularly the case for upstream dams where compensation releases are made.
- Protection of the Resources –
  - This is evaluated based on the importance of releases for EWRs downstream of the dam.
  - Where the recommended EC is higher than current this was reflected as high.
  - Impact Rating scores ranged from Very High: 1; High:0.75; Moderate: 0.5, Low: 0.25; Not Important: 0.

Criteria for Dam Resource Prioritisation

- Water Resource Dependent Activities –
  - This is evaluated based on importance of the dam for in-dam activities and releases of water for downstream use (irrigation, domestic, mining and industries, etc.)
  - Impact rating scores given range from Very High 1; High:0.75; Moderate: 0.5, Low: 0.25; Not Important: 0.
  - The magnitude of the releases for and the categories of downstream use was considered in the rating.
- Water quality impact to dependent activities –
  - This criterion intends to determine the dams which have a negative impact on the quality of the dependent activities both in dam as well as the releases for the downstream users
  - Impact rating scores can range between very high: -1; High: -0.75; Moderate: -0.5; Low: -0.25 and None; 0

PRIORITISATION OF DAMS

- Not all the criteria have equal weights. These were weighted differently below.
- Components with weighted importance scores of 0.5 and higher for the 'importance for protection' or 'importance for other water use' are then selected to be included as an EcoSpec and/or UserSpec and will form part of the final set of RQOs for that specific dam

Criteria	Weight
Cumulative level if Impact of current and future use in upstream activities	0.20
Protection of the Resources - Releases for EWRs downstream of the dam	0.25
Water Resource Dependent Activities - Downstream Uses	0.25
Water Resource Dependent Activities – In dam activities	0.15
Water Quality Impact on downstream use	0.15
Total Score	1.00

Ranking of Dams in the Mogalakwena

Dams	River or Watercourse	Quartenary	MAR (million m3/a)	FSC (million m3/a)	FSC:MAR Ratio	Purpose	Criteria	Rating	Weight	Score	Ranking
Donkerpoort	Little Nyl	A61A	5.3	2.4	0.45	Municipal Use & Industries	Cumulative level if Impact of current and future use in upstream activities	-	0.20	-	2
							Protection of the Resources	1.00	0.25	0.25	
							Water Resource Dependent Activities - Downstream Uses	1.00	0.25	0.25	
							Water Resource Dependent Activities – In dam activities	0.25	0.15	0.04	
							Water Quality Impact on downstream use	0.25	0.15	0.04	
							Total Score		**1.00**	**0.58**	
Doorndraai	Sterk	A61H	38.1	46.5	1.22	Municipal Use & Industrial Use	Cumulative level if Impact of current and future use in upstream activities	- 0.25	0.20	- 0.05	1
							Protection of the Resources	1.00	0.25	0.25	
							Water Resource Dependent Activities - Downstream Uses	1.00	0.25	0.25	
							Water Resource Dependent Activities – In dam activities	0.50	0.15	0.08	
							Water Quality Impact on downstream use	0.50	0.15	0.08	
							Total Score		1.00	0.60	
Glen Alpine	Mogalakwena	A62J	204	18.9	0.09	Irigation	Cumulative level if Impact of current and future use in upstream activities	- 0.25	0.20	- 0.05	3
							Protection of the Resources	1.00	0.25	0.25	
							Water Resource Dependent Activities - Downstream Uses	1.00	0.25	0.25	
							Water Resource Dependent Activities – In dam activities	0.25	0.15	0.04	
							Water Quality Impact on downstream use	0.25	0.15	0.04	
							Total Score		**1.00**	**0.53**	

Ranking of Dams in the Luvhuvhu/Mutale System

Dams	River or Watercourse	Quartenary	MAR (million m3/a)	FSC (million m3/a)	FSC:MAR Ratio	Purpose	Criteria	Rating	Weight	Score	Ranking
Albasini	Luvhuvhu	A91B	14.56	25.2	1.73	Irrigation , Domestic & Industrial Use	Cumulative level if Impact of current and future use in upstream activities	- 0.25	0.20	- 0.05	2
							Protection of the Resources	1.00	0.25	0.25	
							Water Resource Dependent Activities - Downstream Uses	1.00	0.25	0.25	
							Water Resource Dependent Activities – In dam activities	0.75	0.15	0.11	
							Water Quality Impact on downstream use	- 0.25	0.15	- 0.04	
							Total Score		**1.00**	**0.53**	
Mambedi Lower Dam	Mambedi Spruit	A91C	57.72	7.2	0.12	Irrigation	Cumulative level if Impact of current and future use in upstream activities	-	0.20	-	6
							Protection of the Resources	0.75	0.25	0.19	
							Water Resource Dependent Activities - Downstream Uses	1.00	0.25	0.25	
							Water Resource Dependent Activities – In dam activities	0.50	0.15	0.08	
							Water Quality Impact on downstream use	- 0.25	0.15	- 0.04	
							Total Score		**1.00**	**0.48**	
Vondo	Mutshindundi	A91G	132.75	30.45	0.23	Irrigation	Cumulative level if Impact of current and future use in upstream activities	-	0.20	-	4
							Protection of the Resources	1.00	0.25	0.25	
							Water Resource Dependent Activities - Downstream Uses	1.00	0.25	0.25	
							Water Resource Dependent Activities – In dam activities	0.50	0.15	0.08	
							Water Quality Impact on downstream use	- 0.25	0.15	- 0.04	
							Total Score		1.00	0.54	
Nandoni	Luvhuvhu	A91F	30.8	164	5.32	Irrigation, Domestic, Industrial & Recreational Use	Cumulative level of Impact of current and future use in upstream activities	-	0.20	-	1
							Protection of the Resources	1.00	0.25	0.25	
							Water Resource Dependent Activities - Downstream Uses	0.75	0.25	0.19	
							Water Resource Dependent Activities – In dam activities	1.00	0.15	0.15	
							Water Quality Impact on downstream use	- 0.25	0.15	- 0.04	
							Total Score		**1.00**	**0.55**	
Damani	Mbwedi	A91G	132.75	11	0.08	Irrigation, Domestic & Industrial Use	Cumulative level if Impact of current and future use in upstream activities	-	0.20	-	3
							Protection of the Resources	1.00	0.25	0.25	
							Water Resource Dependent Activities - Downstream Uses	1.00	0.25	0.25	
							Water Resource Dependent Activities – In dam activities	0.25	0.15	0.04	
							Water Quality Impact on downstream use	- 0.25	0.15	- 0.04	
							Total Score		**1.00**	**0.50**	

Ranking of Dams in the Luvhuvhu/Mutale System

Dams	River or Watercourse	Quartenary	MAR (million m3/a)	FSC (million m3/a)	FSC:MAR Ratio	Purpose	Criteria	Rating	Weight	Score	Ranking
Tshakhuma	Latonyanda	A91D	48.12	3.85	0.08	Domestic & Industrial Use	Cumulative level if Impact of current and future use in upstream activities	-	0.20	-	5
							Protection of the Resources	0.75	0.25	0.19	
							Water Resource Dependent Activities - Downstream Uses	0.50	0.25	0.13	
							Water Resource Dependent Activities – In dam activities	0.50	0.15	0.08	
							Water Quality Impact on downstream use	- 0.25	0.15	- 0.04	
							Total Score		**1.00**	**0.35**	
Phiphindi	Mutshindundi	A91G	132.75	0.19	0.00	Domestic & Industrial Use	Cumulative level if Impact of current and future use in upstream activities	-	0.20	-	7
							Protection of the Resources	0.50	0.25	0.13	
							Water Resource Dependent Activities - Downstream Uses	0.50	0.25	0.13	
							Water Resource Dependent Activities – In dam activities	-	0.15	-	
							Water Quality Impact on downstream use	0.25	0.15	0.04	
							Total Score		**1.00**	**0.29**	
Mukumbani (Lake Fundudzi)	Mutale	A92A	114.19	21.5	0.19	Cultural Use	Cumulative level if Impact of current and future use in upstream activities	-	0.20	-	1
							Protection of the Resources	0.75	0.25	0.19	
							Water Resource Dependent Activities - Downstream Uses	0.50	0.25	0.13	
							Water Resource Dependent Activities – In dam activities	1.00	0.15	0.15	
							Water Quality Impact on downstream use	- 0.25	0.15	-0.04	
							Total Score		**1.00**	**0.43**	
Thate Vondo Dam	Tshirovho	A92A	114.19	3.9	0.03	Domestic & Industrial Use	Cumulative level if Impact of current and future use in upstream activities	- 0.25	0.20	- 0.05	2
							Protection of the Resources	0.75	0.25	0.19	
							Water Resource Dependent Activities - Downstream Uses	1.00	0.25	0.25	
							Water Resource Dependent Activities – In dam activities	0.25	0.15	0.04	
							Water Quality Impact on downstream use	- 0.25	0.15	- 0.04	
							Total Score		**1.00**	**0.39**	

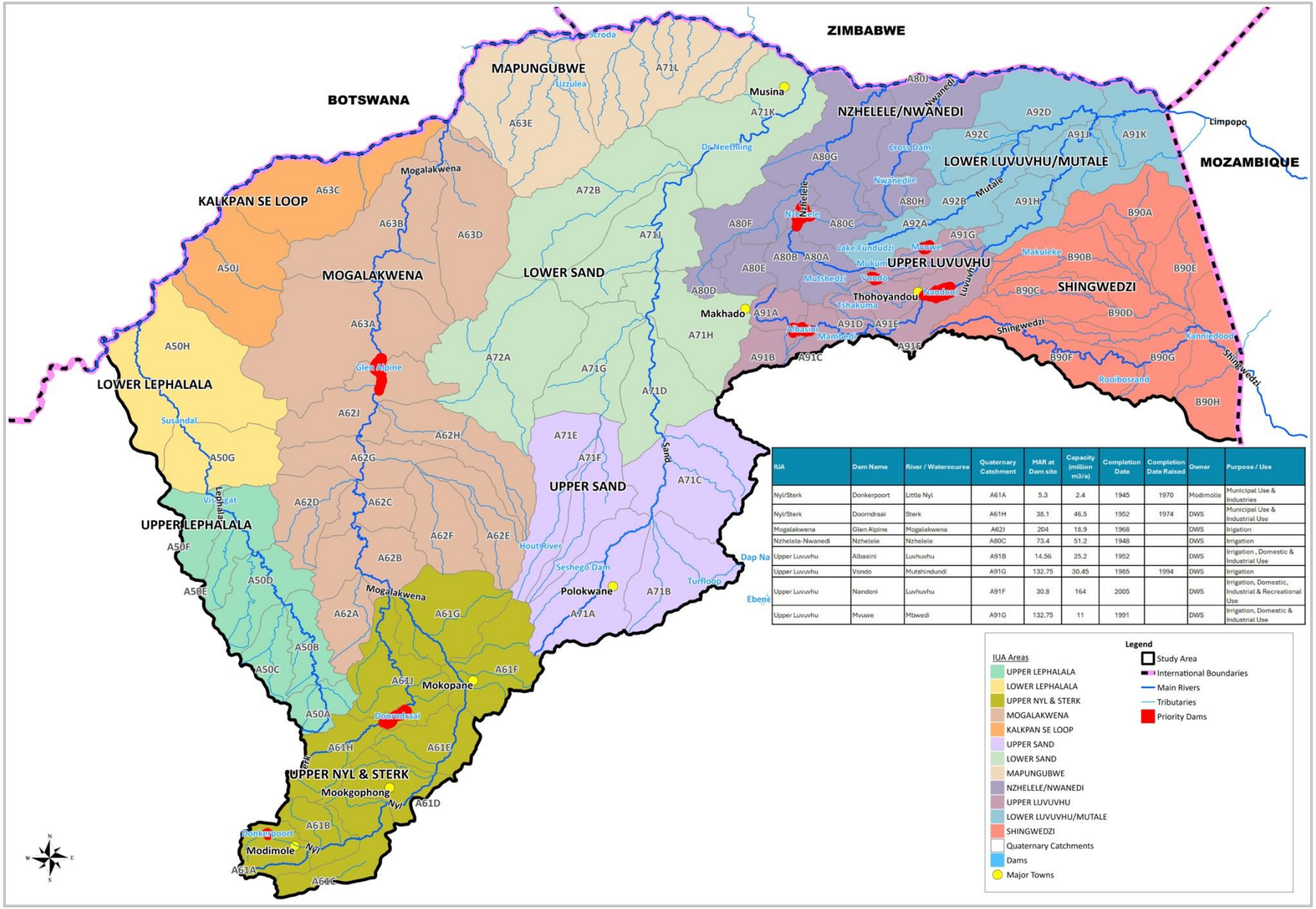
PRIORITISATION OF DAMS

- 8 dams prioritized
  - 3 dams in the Mogalakwena System
  - Main dam in the Nzhelele/Nwanedi System
  - 4 Dams in the Luvhuvhu System
- No major dams in the Sand River system
  - Seshego Dam has very limited storage capacity

IUA	Dam Name	River / Watercourse	Quaternary Catchment	MAR at Dam site	Capacity (million m3)	Completion Date	Completion Date Raised	Owner	Purpose / Use
Nyl/Sterk	Donkerpoort	Little Nyl	A61A	5.3	2.4	1945	1970	Modimolle	Municipal Use & Industries
Nyl/Sterk	Doorndraai	Sterk	A61H	38.1	46.5	1952	1974	DWS	Municipal Use & Industrial Use
Mogalakwena	Glen Alpine	Mogalakwena	A62J	204	18.9	1968		DWS	Irrigation
Nzhelele-Nwanedi	Nzhelele	Nzhelele	A80C	73.4	51.2	1948		DWS	Irrigation
Upper Luvuvhu	Albasini	Luvuvhu	A91B	14.56	25.2	1952		DWS	Irrigation , Domestic & Industrial Use
Upper Luvuvhu	Vondo	Mutshindudi	A91G	132.75	30.45	1985	1994	DWS	Irrigation
Upper Luvuvhu	Nandoni	Luvuvhu	A91F	30.8	164	2005		DWS	Irrigation, Domestic, Industrial & Recreational Use
Upper Luvuvhu	Mvuwe	Mbwedi	A91G	132.75	11	1991		DWS	Irrigation, Domestic & Industrial Use

PRIORITISATION OF DAMS

- Dams are operating as a system – 3 main systems
  - Mogalakwena
  - Nzhelele/Nwanedi
  - Luvhuvhu system



IUA	Dam Name	River / Watercourse	Quaternary Catchment	MAR at Dam site	Capacity (million m3/a)	Completion Date	Completion Date Raised	Owner	Purpose / Use
Nyl/Sterk	Donkerpoort	Little Nyl	A61A	5.3	2.4	1945	1970	Modimolle	Municipal Use & Industries
Nyl/Sterk	Doorndraai	Sterk	A61H	38.1	46.5	1952	1974	DWS	Municipal Use & Industrial Use
Mogalakwena	Glen Alpine	Mogalakwena	A62J	204	18.9	1968		DWS	Irrigation
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Upper Luvuvhu	Mvuwe	Mbwedi	A91G	132.75	11	1991		DWS	Irrigation, Domestic & Industrial Use

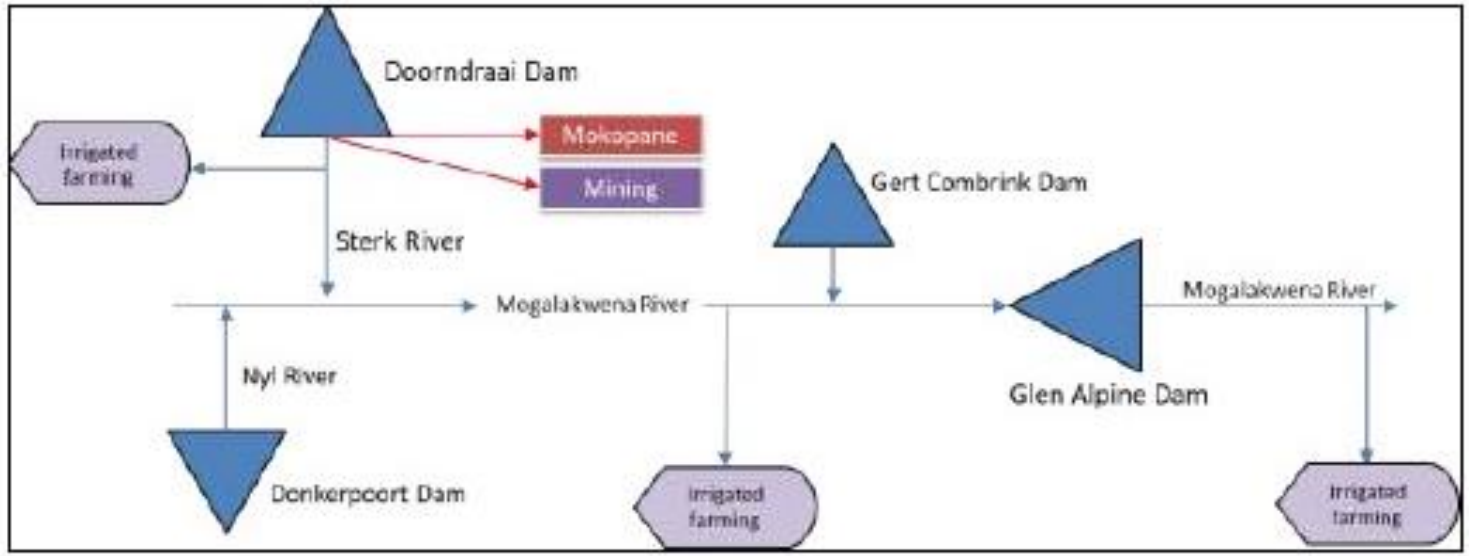
RQOS FOR DAMS – WATER QUANTITY

- Water Quantity / availability and requirements
  - Determined by undertaking an Annual Operating Analysis of the system provided by the dam
  - AOA determines the amount of water that can be
    - released for the EWR to meet the base flows
    - supplied sustainably & equitably to the water use sector dependent over the coming hydrological year being considered
  - Water Restrictions
    - Where the water available to carry over to the next hydrological cycle
    - Restrictions will be implemented based on priority classification approved at the system operating forum
- Directorate: System Analysis
  - Responsible for determining the releases required in each hydrological year depending on the starting storage level of each dam
  - Monthly monitoring of projected releases for the EWR

RQOS FOR MOGALAKWENA SYSTEM– WATER QUANTITY

Objective	Task ID	Task	Description of Task	Unit of Measure	Data Source
Maintain theDam storage capacity to meet the releases to meet Base Flows	1	**Starting Storages at beginning of hydrological year (1 April)**	Establish the starting storage of the dam level	% of storage capacity	Use of SAWS data and SARCOF for weather outlook prediction & application
	2	**Short term Characteristic Curve of Dam**	Determine the short-term characteristic curves (STCCs) -	Volume of water available at different assurance levels for a given starting period	Water Resource Yield Model
	3	**User priority classification of the dam incl. EWR releases**	Review and Update the User categories for each system to include the EWR & International Obligations	Priority classification table	Annual Operating Analysis
	4	**Curtailment Curve**	Apply the STCCs to the starting storage to determine the water allocations that can be supplied to each user sector with EWR a priority user	Graphical plot of starting storage level vs factor of water allocation to be supplied for the hydrological year	Hydrological Drought Analysis Model (HDAM)
	5	**Stakeholder Participations**	Engage with the System Operating Forum (SOF) on the proposed releases for the hydrological year (including releases for the EWR)	Avoid dam storage level going down below the percentage to carryover to the next hydrological cycle. Review at 1 Nov- projected runoff	N/A

RQOS FOR MOGALAKWENA SYSTEM– Location



Dam	User	User Classification	2021 (million m³/a)	2022 (million m³/a)	2023 (million m³/a)	2024 (million m³/a)	2025 (million m³/a)
Doorndraai	Legends Golf Course	Irrigation	0.14	0.14	0.14	0.14	0.14
	TVET College	Irrigation	0.12	0.12	0.12	0.12	0.12
	Mokopane	Urban (Domestic)	4.38	4.63	4.88	5.12	5.37
	Akanani Platinum Mine	Mining	2.16	2.16	2.16	2.16	2.16
Glen Alpine	Farming Downstream	Irrigation	7.30	7.30	7.30	7.30	7.30
	Potential supply to augment groundwater	Urban (Domestic)	4.44	4.44	4.44	4.44	4.44
Total			**18.54**	**18.79**	**19.04**	**19.28**	**19.53**

RQOS FOR MOGALAKWENA SYSTEM– Recommended EWRs

	10	20	30	40	50	60	70	80	90	99
Oct	1.023	0.932	0.787	0.694	0.612	0.491	0.414	0.338	0.285	0.278
Nov	5.365	1.494	0.804	0.686	0.602	0.497	0.402	0.333	0.332	0.332
Dec	6.616	3.084	1.849	0.759	0.631	0.514	0.416	0.347	0.3	0.265
Jan	9.232	4.167	2.216	1.92	0.729	0.531	0.426	0.351	0.304	0.275
Feb	7.72	3.405	2.1	1.108	0.603	0.461	0.374	0.319	0.283	0.261
Mar	3.745	2.479	1.29	0.855	0.669	0.52	0.427	0.354	0.339	0.338
Apr	1.957	1.255	0.936	0.753	0.624	0.498	0.411	0.341	0.328	0.328
May	1.378	1.074	0.839	0.717	0.626	0.514	0.416	0.352	0.302	0.271
Jun	1.071	0.939	0.78	0.686	0.603	0.497	0.402	0.339	0.292	0.256
Jul	1.051	0.946	0.803	0.705	0.623	0.514	0.416	0.351	0.302	0.26
Aug	1.025	0.936	0.794	0.701	0.621	0.513	0.416	0.346	0.295	0.253
Sep	0.986	0.904	0.758	0.67	0.598	0.495	0.4	0.327	0.265	0.22
Total	**41.169**	**21.615**	**13.956**	**10.254**	**7.541**	**6.045**	**4.92**	**4.098**	**3.627**	**3.337**

EWR Monthly Rule curve – Doorndraai

EWR Monthly Rule curve – Glen Alpine

nMAR	188.946	MCM			
S.Dev.	15.804				
CV	0.084				
Q75	0.2848				
Ecological Category	**C**				
	MCM	% nMAR	Excludes floods with return period ≥1:2 years.		
Total EWR	43.439	22.99			
Maint. Lowflows	39.096	20.692			
Drought Lowflows	26.707	14.135			
Maint. Highflows	4.343	2.299			

Monthly Distributions (MCM)

	Natural	Modified Flows (EWR)			
		Low flows		High flows	Total EWR
Month	Mean	Maint.	Drought	Maint.	Maint.
Oct	3.417	0.487	0.741	0.107	0.594
Nov	13.305	2.12	1.02	0.135	2.255
Dec	18.652	2.557	1.951	0.313	2.87
Jan	31.569	3.906	3.485	0.758	4.663
Feb	52.951	10.47	4.785	0.495	10.965
Mar	26.374	9.273	4.619	0.606	9.879
Apr	15.229	4.486	2.522	0.658	5.143
May	8.955	2.496	2.082	0.629	3.125
Jun	5.898	1.351	1.632	0.367	1.717
Jul	4.964	1.104	1.552	0.183	1.287
Aug	4.168	0.546	1.266	0.057	0.603
Sep	3.464	0.3	1.054	0.038	0.338
Total	**188.95**	**39.1**	**26.71**	**4.34**	**43.44**

RQOS FOR MOGALAKWENA SYSTEM– Priority Classification

User Category	Portion of water supply within indicated priority class and associated recurrence interval of failure (years) and annual assurance of supply				
	High 1:100 (99%)	Medium High 1:50 (98%)	Medium Low 1:20 (95%)	Low 1:10 (90%)	Total
Domestic	60%	0%	30%	10%	100%
Irrigation	0%	30%	30%	10%	100%
Industry	80%	0%	10%	10%	100%
Curtailment Level	4	3	2	1	-

Current priority classification

Category /Water User	Priority Classification				
	Low	Medium Low	Medium	High	
	90% Assurance	95% Assurance	98% Assurance	99% Assurance	To
	(1 in 10 years)	(1 in 20 years)	(1 in 50 years)	(1 in 100 years)	
Domestic & Urban	10%	30%	0%	60%	
Irrigation	10%	30%	30%	30%	
Mining, Industries & Power Generation	10%	10%	0%	80%	
EWR	20%	0%	0%	80%	
Return Flows					
Curtailment Level	**0**	**1**	**2**	**3**	**4**

- Preliminary EWR determined in the LNRS
  - Not included in the priority classifications of the dams in Mogalakwena
  - Currently not being implemented
- For the gazetted EWR maintenance flows
  - Need to determine RI
  - Include into the priority classification
- System operating forum should include the EWR in the operation of the two dams

RQOS FOR LUVUVHU SYSTEM– RQOs for Quantity

	10	20	30	40	50	60	70	80	90	99
Oct	2.434	2.074	1.749	1.484	1.253	1.158	1.076	1.012	0.958	0.937
Nov	2.302	1.973	1.647	1.391	1.228	1.114	1.032	0.971	0.927	0.898
Dec	2.409	2.124	1.824	1.541	1.3	1.169	1.071	0.969	0.968	0.966
Jan	3.934	2.61	2.147	1.641	1.367	1.204	1.109	1.026	0.97	0.938
Feb	6.281	2.762	2.021	1.594	1.288	1.108	1.008	0.938	0.893	0.859
Mar	5.508	3.76	2.473	1.835	1.463	1.241	1.119	1.042	0.991	0.96
Apr	4.569	3.312	2.595	1.857	1.512	1.303	1.135	1.028	1.018	0.972
May	4.663	3.418	2.738	2.015	1.629	1.376	1.236	1.071	1.012	0.991
Jun	4.16	3.215	2.592	1.981	1.542	1.221	1.201	1.032	0.99	0.947
Jul	3.785	3.09	2.565	1.923	1.506	1.253	1.168	1.043	1.036	0.98
Aug	3.323	2.842	2.388	1.797	1.429	1.231	1.117	1.039	0.992	0.977
Sep	2.711	2.316	1.924	1.569	1.293	1.155	1.064	0.996	0.951	0.921
Total	**46.079**	**33.496**	**26.663**	**20.628**	**16.81**	**14.533**	**13.336**	**12.167**	**11.706**	**11.346**

EWR Monthly Rule curve – Albasini Dam

EWR Monthly Rule curve EWR site Ri27 – Vondo Dam

nMAR	56.42	MCM			
S.Dev.	3.444				
CV	0.061				
Q75	0.135				
Ecological Category	C				
	MCM	% MAR	Excludes floods with return period ≥1:2 years.		
Total EWR	40.811	72.335			
Maint. Lowflows	24.108	42.73			
Drought Lowflows	11.736	20.802			
Maint. Highflows	16.703	29.605			

Monthly Distributions (MCM)

	Natural	Modified Flows (EWR)			
		Low flows		High Flows	Total EWR
Month	Mean	Maint.	Drought	Maint.	Maint.
Oct	1.154	0.664	0.421	0.078	0.742
Nov	2.528	0.967	0.688	0.436	1.403
Dec	6.135	2.094	1.267	1.827	3.921
Jan	9.959	3.638	1.847	3.433	7.07
Feb	13.104	4.14	1.803	4.931	9.071
Mar	10.55	4.494	1.897	3.825	8.32
Apr	5.171	2.662	1.178	1.711	4.373
May	2.593	1.633	0.776	0.324	1.958
Jun	1.707	1.213	0.569	0.082	1.295
Jul	1.374	1.035	0.491	0.015	1.05
Aug	1.125	0.853	0.413	0.016	0.87
Sep	1.02	0.714	0.387	0.025	0.739
Total	56.42	24.11	11.74	16.7	40.81

RQOS FOR LUVUVHU SYSTEM– RQOs Quantity

	Natural	Modified Flows (EWR)				
		Lowflows		Highflows		Total EWR
Month	Mean	Maint.	Drought	Maint.		Maint.
Oct	9.253	1.441	3.625	0.169		1.61
Nov	14.455	2.622	4.419	1.095		3.718
Dec	30.646	7.833	7.423	4.808		12.641
Jan	60.397	15.474	10.84	7.867		23.34
Feb	92.187	25.241	13.731	9.055		34.296
Mar	74.955	28.602	15.832	8.316		36.917
Apr	37.623	16.085	10.752	5.574		21.658
May	20.738	6.64	7.113	0.732		7.372
Jun	15.321	3.964	5.587	0.09		4.055
Jul	12.726	2.787	4.823	0.038		2.825
Aug	10.651	1.938	4.195	0.007		1.944
Sep	9.063	1.52	3.776	0.023		1.543
Total	388.01	114.15	92.12	37.77		151.92

EWR Monthly Rule curve – EWR Site Ri32

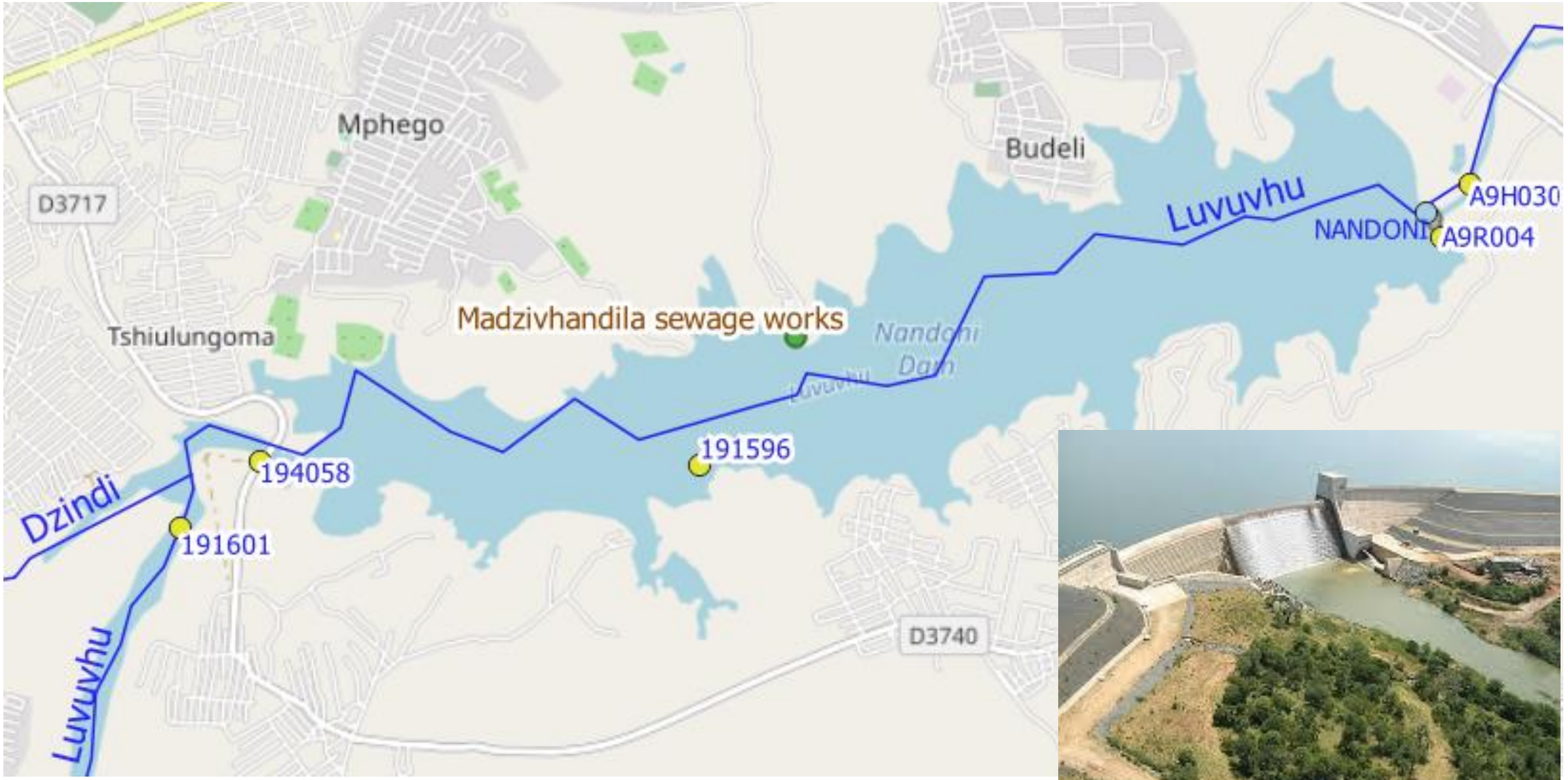
EWR Monthly Rule curve – Nandoni Dam

Monthly Distributions (MCM)						
	Natural	Modified Flows (EWR)				
		Low flows		High flows	Total EWR	
Month	Mean	Maint.	Drought	Maint.	Maint.	
Oct	8.099	0.777	3.204	0.091	0.868	
Nov	11.927	1.655	3.731	0.659	2.314	
Dec	24.511	5.739	6.156	2.981	8.72	
Jan	50.438	11.836	8.993	4.434	16.27	
Feb	79.083	21.101	11.928	4.124	25.225	
Mar	64.405	24.108	13.935	4.491	28.599	
Apr	32.452	13.423	9.574	3.863	17.286	
May	18.145	5.007	6.337	0.408	5.415	
Jun	13.614	2.751	5.018	0.008	2.759	
Jul	11.352	1.752	4.332	0.023	1.775	
Aug	9.526	1.085	3.782	-0.009	1.076	
Sep	8.043	0.806	3.389	-0.002	0.804	
Total	**331.595**	**90.04**	**80.379**	**21.071**	**111.111**	**0**

RQOS FOR LUVUVHU SYSTEM– QUANTITY

- Starting storage – more than the annual requirements for the hydrological year
- Relative wet year EWR taken to represent 80% exceedance probability
- STCC indicate that no curtailment required – if irrigation is not supplied
- As the developments dependent on Nandoni take place the EWR will not be sustained as it is considered high
- Realised EWR monthly rule curve required downstream of Nandoni

RQOS FOR NANDONI DAM



Water quality indicators and rationale

Sub-component	Indicators	Rationale
Nutrients	Total Phosphates (mg/l) Chlorophyll a (µg/l)	Concern is excessive nutrient enrichment, eutrophication, it its impacts on water quality in the dam
Salinity	Electrical Conductivity (EC) (mS/m) Total dissolved salts (TDS) (mg/l)	Concern is fitness for use of water released for irrigation, domestic and industrial water supply.
Pathogens	Escherichia coli, Faecal coliforms	Risk of recreational water users of contracting waterborne diseases.

RQOs for Nandoni Dam: Water quality

Sub-component	Indicator	Narrative RQO	Numerical limits	TPC
Nutrients	Total Phosphates (mg/l) Chlorophyll a (µg/l)	Maintain Nandoni Dam in a mesotrophic state or better in order to protect irrigation water supply to downstream users and rural domestic water users.	Median annual Total Phosphates ≤ 0.047 mg/l Median annual Chlorophyll a ≤ 20 µg/l	Median annual Total Phosphates between 0.036 - 0.047 mg/l Median annual Chlorophyll a between 16- 20 µg/l
Salts	Electrical Conductivity (EC) (mS/m) Total dissolved salts (TDS) (mg/l)	Salt concentrations must be maintained at a level that is not harmful to aquatic ecosystems in the dam and is in an Acceptable fitness for use state for domestic and industrial water supply, and for irrigation water supply.	95%tile EC ≤ 90 mS/m 95%tile TDS ≤ 585 mg/l	95%tile EC between 72 - 90 mS/m 95%tile TDS between 468 - 585 mg/l
Pathogens	Escherichia coli, Faecal coliforms	Nandoni Dam must be maintained in an Acceptable microbiological state that is safe for contact recreational user.	95%tile E coli / Faecal coliforms ≤ 25 cfu/100ml	95%tile E coli / Faecal coliforms between 20 - 25 cfu/100ml

RQOs for Glen Alpine Dam: Water quality

Sub-component	Indicators	Narrative RQO	Numerical RQO	TPC
Nutrients	Total Phosphates (mg/l) Chlorophyll a (µg/l)	Maintain Glen Alpine Dam in a mesotrophic state or better in order to protect irrigation water supply to downstream users and rural domestic water users.	Median annual Total Phosphates ≤ 0.047 mg/l Median annual Chlorophyll a ≤ 20 µg/l	Median annual Total Phosphates between 0.036 - 0.047 mg/l Median annual Chlorophyll a between 16- 20 µg/l
Salts	Electrical Conductivity (EC) (mS/m) Total dissolved salts (TDS) (mg/l)	Salt concentrations must be maintained at a level that is not harmful to aquatic ecosystems in the dam and is in an Acceptable fitness for use state for domestic and industrial water supply, and for irrigation water supply.	95%tile EC ≤ 90 mS/m 95%tile TDS ≤ 585 mg/l	95%tile EC between 72 - 90 mS/m 95%tile TDS between 468 - 585 mg/l
Pathogens	Escherichia coli, Faecal coliforms	Glen Alpine Dam must be maintained in an Acceptable microbiological state that is safe for contact recreational user.	95%tile E coli / Faecal coliforms ≤ 25 cfu/100ml	95%tile E coli / Faecal coliforms between 20 - 25 cfu/100ml

RQOs for Nandoni and Glen Alpine Dam: Fish

Sub-component	Indicator	Narrative RQO	Numerical RQO	TPC
Fish	Fish species diversity	Maintain the fish populations within a balanced species diversity.	Fish populations must be inclusive of families Cyprinidae, Cichlidae and Clariidae.	N/A
	Fish abundance	Maintain fish abundance at a level that fulfils ecosystem services roles of recreational angling and subsistence harvesting.	Maintain a stable catch per unit effort relative to previous surveys undertaken under similar seasons and conditions.	N/A
	Fish health	Fish health to be maintained in a state that allows for consumption and recreational angling.	Overall health of individuals Parasite burden and bacterial infections impacting <1% of the fish population.	Parasite burden and bacterial infections impacting >1% of the fish population.

RQOs for Nandoni and Glen Alpine Dam: Alien Aquatic Plants

Sub-component	Indicator	Narrative RQO	Numerical RQO	TPC
Alien aquatic plant species	Water Quality (Nutrients)	Maintain Nandoni / Glen Alpine Dam in a mesotrophic state or better	Median annual Total Phosphates ≤ 0.047 mg/l	Median annual Total Phosphates > 0.047 mg/l
			Median annual Chlorophyll a ≤ 20 µg/l	Median annual Chlorophyll a > 20 µg/l
	Aerial extent	Maintain low % aerial cover of AIP (Water Hyacinth, Water Lettuce, Water Fern, Kariba Weed, Parrot's Feather) on dam surface and fringe.	Maintain aerial cover of AIP on dam surface below 10%	Maintain aerial cover of AIP on dam surface >10%

Thank you

DETERMINATION OF WATER RESOURCE CLASSES, RESERVE AND RQOS IN THE LIMPOPO (A5-A9) CATCHMENTS & OLIFANTS (B9) CATCHMENT

PROJECT STEERING COMMITTEE MEETING #4

Presented by: James MacKenzie

Date: 1 APRIL 2025

WATER IS LIFE - SANITATION IS DIGNITY

water & sanitation

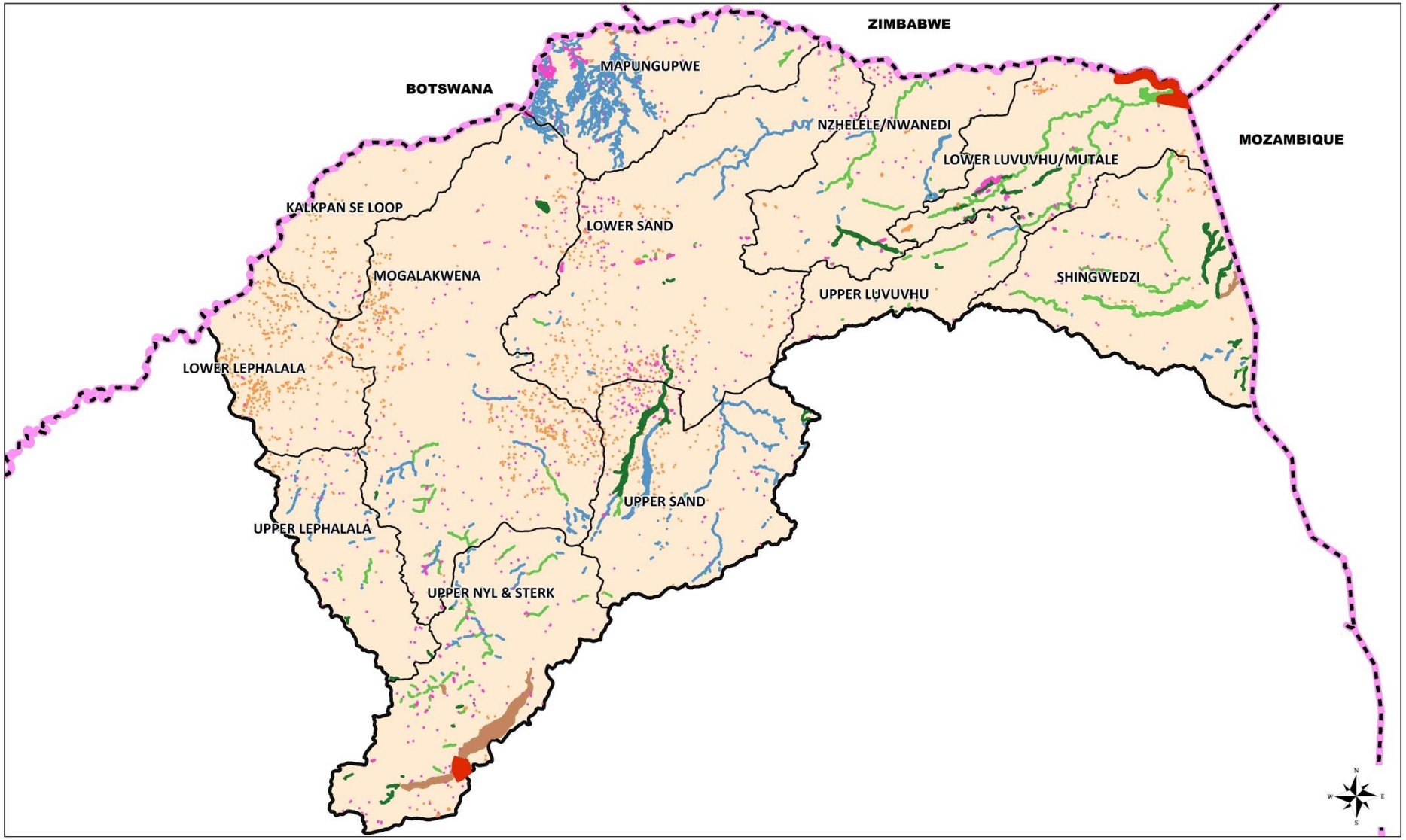
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

2030 NDP

30 YEARS OF FREEDOM
South Africa 1994 - 2024

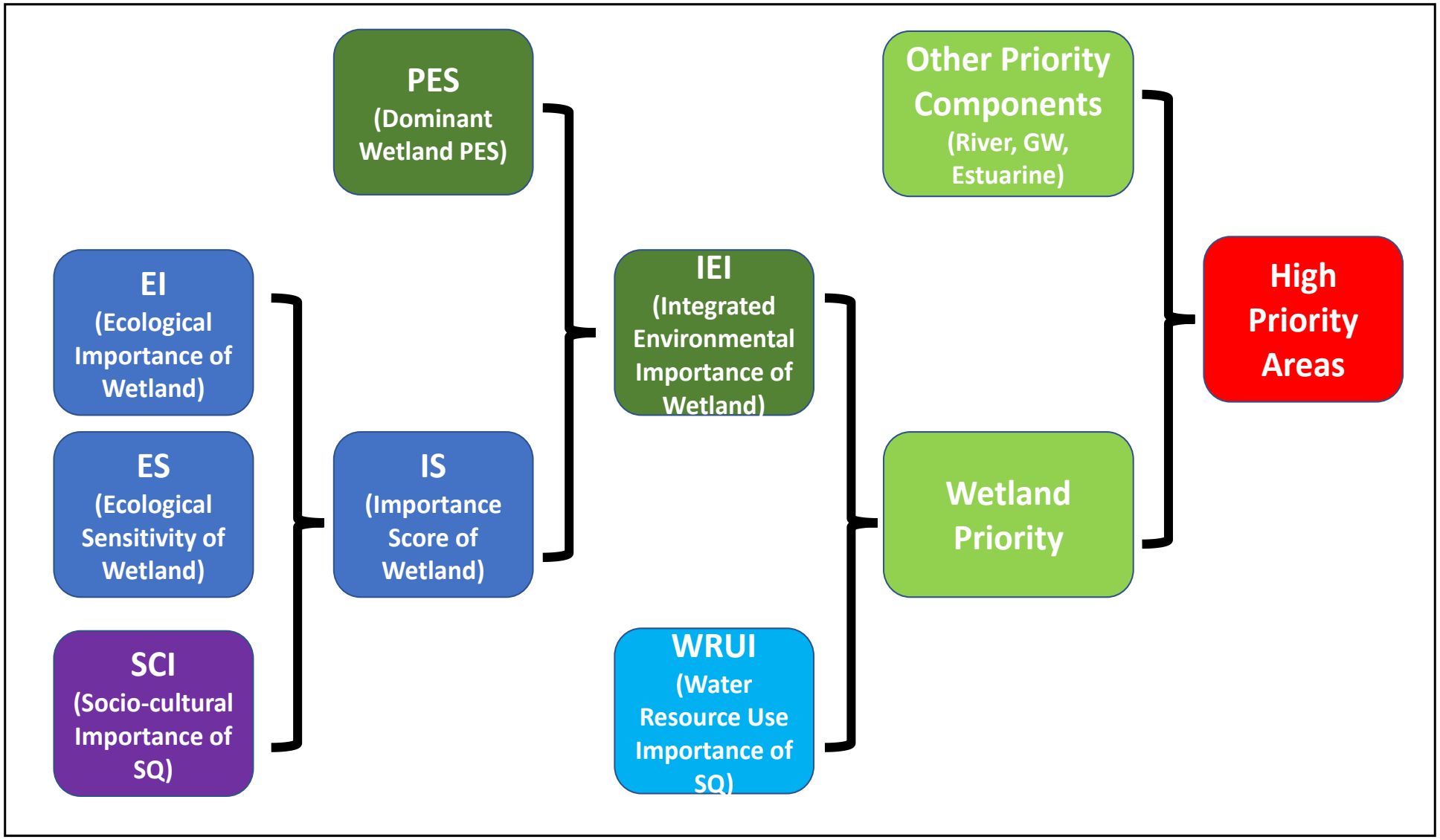
RQOS FOR WETLANDS

WETLANDS IN THE STUDY AREA



- Over 84 000 Ha
- Different HGMs

WETLAND APPROACH: 6-STEP PRIORITISATION



Ecological Importance

The determination of EI considered the following criteria from the following data sources:

- National Biodiversity Assessment (new wetland map, 2018)
  - Diversity of wetland Hydrogeomorphic (HGMs) within quinary catchment - this is a count of different HGMs within the SQ excluding estuaries.
  - Overall extent of wetlands within quinary catchment (Ha per SQ).
- NFEPA (2011)
  - RAMSAR status – any wetland designated as a RAMSAR site would automatically be assigned a VERY HIGH EI.
  - Wetland FEPA status – any wetland denoted as a FEPA wetland was assigned a HIGH EI.
  - Wetland Cluster – does any of the wetlands within the SQ form part of a designated NFEPA wetland cluster.
  - Habitats for rare and endangered species including:
    - Cranes - wetlands (excluding dams) with the majority of its area within a sub-quaternary catchment that has sightings or breeding areas for threatened Wattled Cranes, Grey Crowned Cranes and Blue Cranes.
    - Amphibians - wetlands within 500 m of an IUCN threatened frog / toad point locality.
    - Water Birds - wetlands within 500 m of a threatened waterbird point locality.

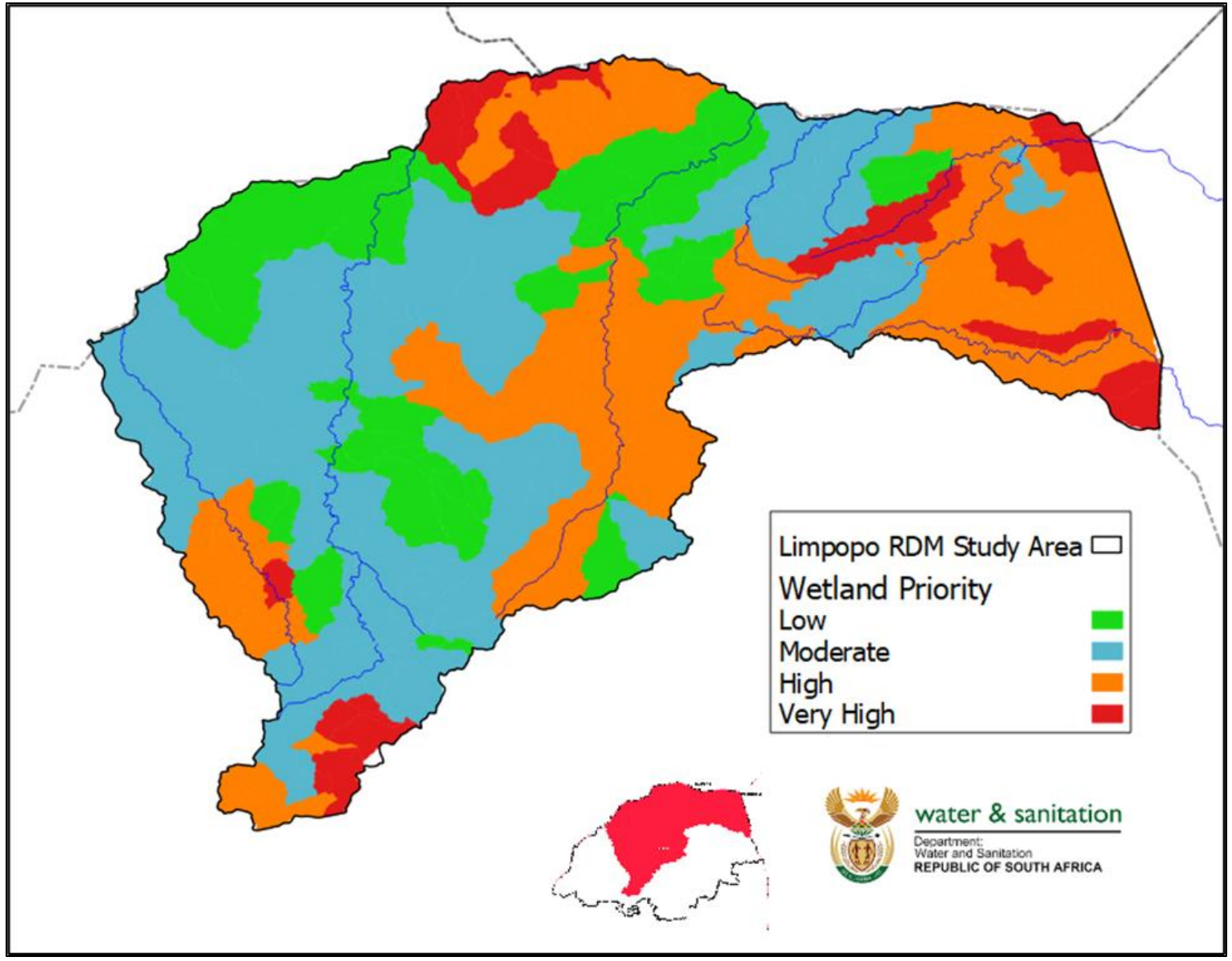
- Known important peatland sites.
- Important Birding Areas (2015) - The Important Bird and Biodiversity Areas (IBA) Programme is a BirdLife International Programme to conserve habitats that are important for birds.
- Regions / Centres of Plant Endemism (Van Wyk & Smith, 2001) – wetland that occur in regions or centres of plant endemism
- Regional Conservation Plans including (eg):
  - Limpopo Conservation Plan, version 2 (2013)
  - KwaZulu Natal - Terrestrial Critical Biodiversity Areas (CBAs) in KZN developed 2010. This is an update to the 2007 terrestrial C-Plan (EKZNW, 2010)
  - Mpumalanga - Mpumalanga Biodiversity Conservation Plan (2006, 2014) comprising the Terrestrial Biodiversity and Freshwater Assessment (Lötter & Ferrar, 2006; Lötter, 2014; MTPA, 2014)

Ecological Sensitivity

The determination of ES considered the following criteria from the following data sources:

- National Biodiversity Assessment (new wetland map, Van Deventer *et al.*, 2018) -
  - Dominant protection level of wetlands within SQR.
  - Dominant threat status of wetlands within SQR.
- Threatened Ecosystems (SANBI, 2011, remaining extent of natural vegetation; NBA 2018 Technical Report Volume 1: Terrestrial Realm).
- Threatened Plant Species within SQ (SANBI, 2009).
- PES/EI/ES (DWS, 2014) – ES score (0 - 5) normalised to 4 for integration with other metrics.

WETLAND APPROACH: PRIORITY



WETLAND APPROACH: PRIORITY

Very High priority wetlands comprised 9.7% of SQs and 37.7% of SQs had High priority wetlands with 52% of SQs with a Moderate and Low priority. The following high priority wetlands were assessed in the field for higher confidence validation / evaluation of the PES, EI and ES:

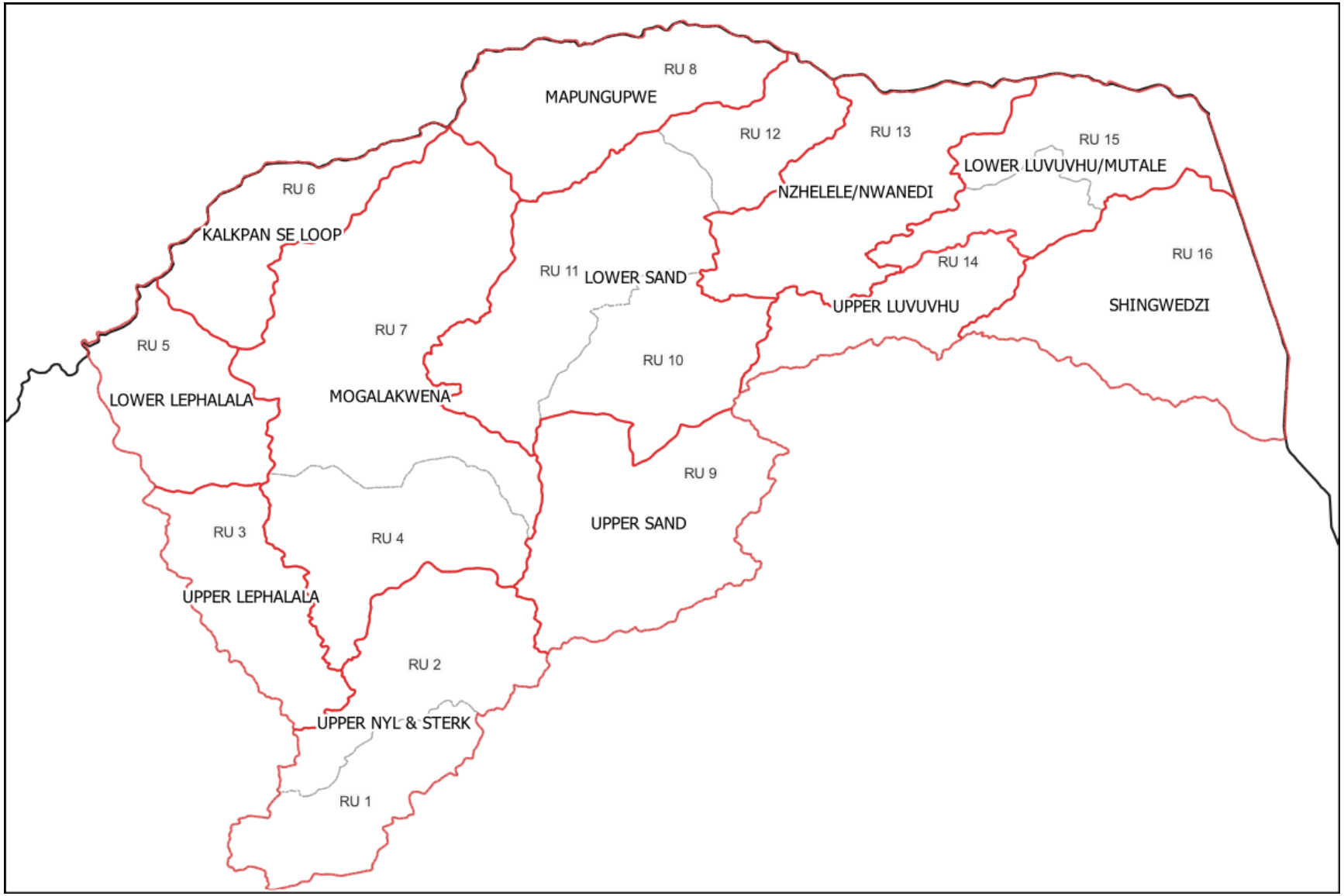
- Luvuvhu Floodplain (Makuleke)
- Nyl River Floodplain
- Wonderkrater
- Nyl Pans
- Maloutswa Floodplain (Mapungubwe)
- Kolope Wetlands
- Lake Fundudzi
- Mutale Wetlands
- Mokamole wetlands – a tributary of the Mogalakwena River
- Thermal spring / Peat domes in KNP (Malahlapanga; Mfayeni)
- Bububu wetlands – a tributary of the Shingwedzi River

WETLAND PES – EI - ES

High Priority Wetland	PES Score	PES Category	EI	ES	REC	Reason for REC	TEC	How to achieve the TEC
Luvuvhu Floodplain (Makuleke)	80	B/C	Very High	High	B	Very High EI supports half category increase	B	Reduce AIP; manage elephant impact
Nyl River Floodplain	65	C	Very High	High	B/C	Very High EI supports half category increase	B/C	Reduce AIP & artificial water storage; manage grazing & trampling pressure
Wonderkrater	80	B/C	Very High	Moderate	B	Very High EI supports half category increase	B	Reduce AIP; manage grazing & trampling pressure
Nyl Pans	57	D	High	High	C/D	High EI supports half category increase	C/D	Improve water quality
Maloutswa Floodplain	66	C	Very High	High	B/C	Very High EI supports half category increase	C	Maintain PES
Kolope Wetlands	90	A/B	Very High	Low	A/B	Maintain PES as already near natural	A/B	Maintain PES
Lake Fundudzi	78	B/C	Very High	High	B	Very High EI supports half category increase	B	Reduce AIP
Mutale Wetlands	62	C/D	Very High	High	C	Very High EI supports half category increase	C	Reduce AIP & sand mining
Mokamole (tributary of the Mogalakwena)	80	B/C	High	High	B	High EI supports half category increase	B/C	Maintain PES
Malahlapanga	78	B/C	Very High	Moderate	B	Very High EI supports half category increase	B/C	Maintain PES
Bububu wetlands (tributary of the Shingwedzi)	97	A	Very High	Moderate	A	Maintain PES as already natural	A	Maintain PES

WETLAND RU PRIORITISATION

The study area comprises 12 IUAs and 16 Rus. Since wetland priority has been done at the SQ scale, prioritisation of IUAs and RUs was done by a summation of SQ's within each catchment with Very High priority. Thus, the frequency of wetlands of Very High priority within respective RUs was used to prioritise RUs.

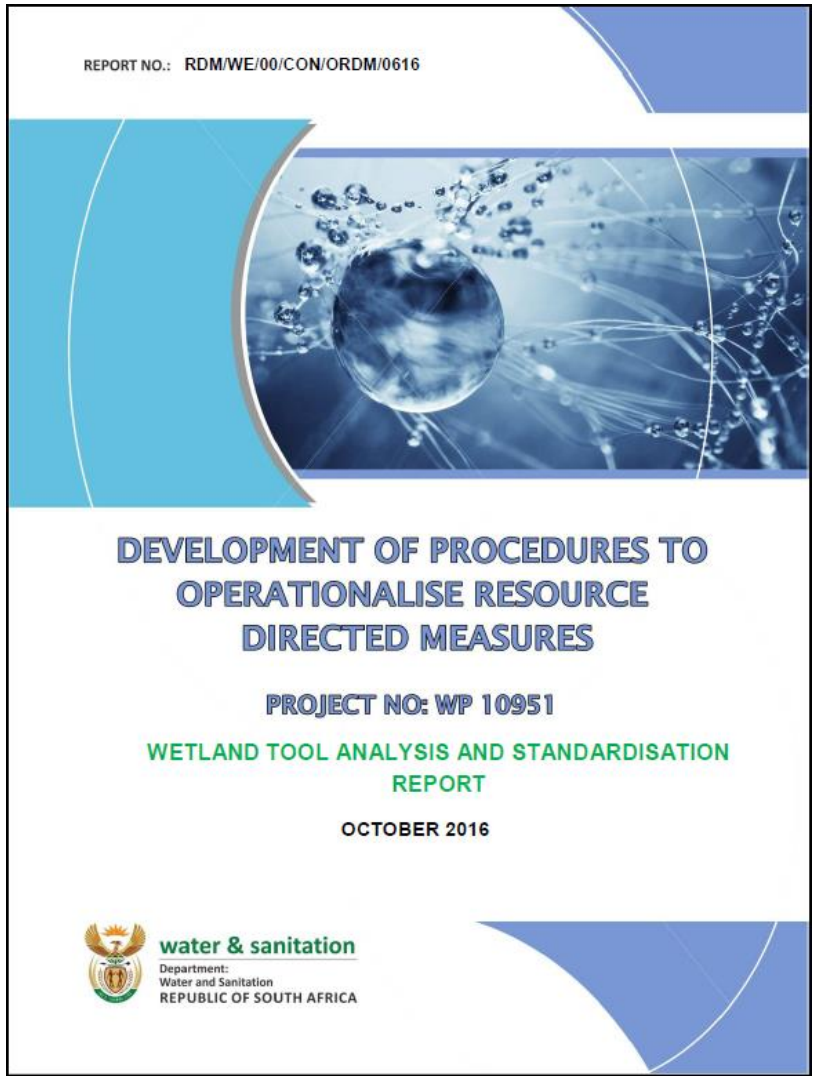


WETLAND RU PRIORITISATION

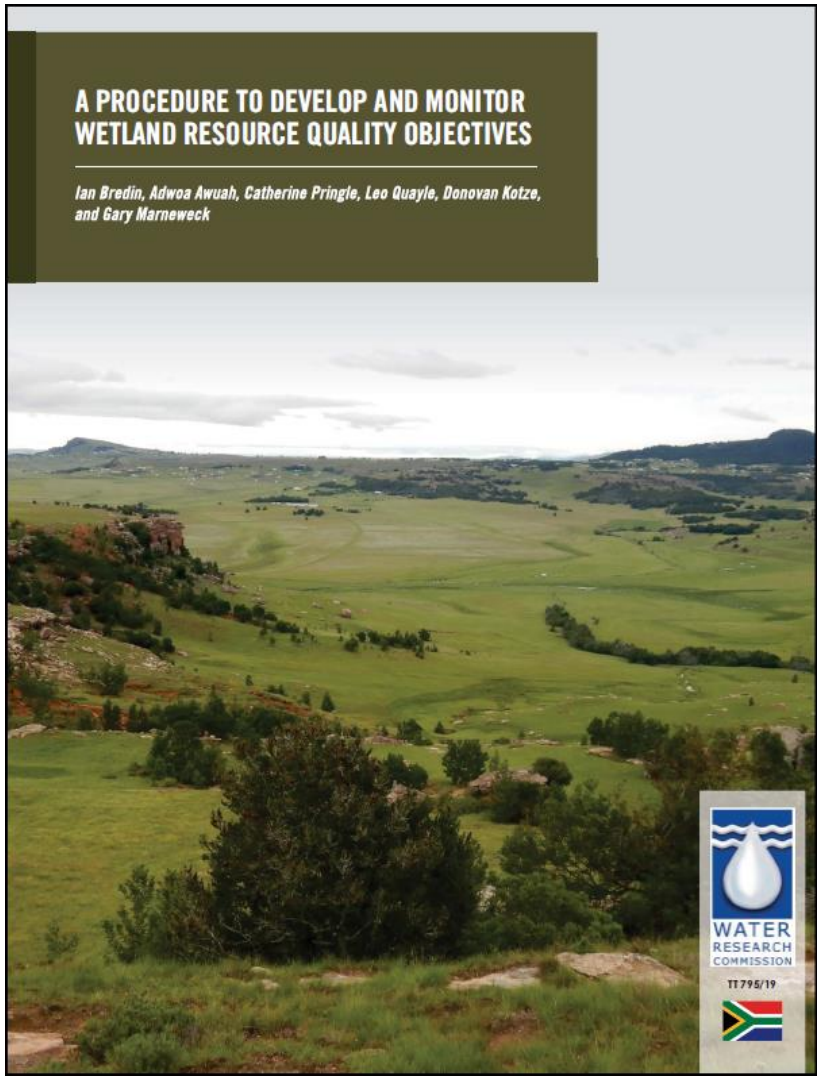
IUA / RU		KALKPAN SE LOOP	LOWER LEPHALALA	LOWER LUVUVHU/ MUTALE		LOWER SAND			MAPUNGUPWE	MOGALAKWENA		NZHELELE/ NWANEDI	SHINGWEDZI	UPPER LEPHALALA	UPPER LUVUVHU	UPPER NYL & STERK		UPPER SAND
Wetland Priority	1	12	1	10		40			13	70		22		8	2	8		7
	2	6	13	23		31			4	71		46	7	24	39	107		24
	3			45		64			24	15		30	69	38	38	19		31
	4			17		3			13	7		5	19	5	3	11		
		RU 6	RU 5	RU 14	RU 15	RU 10	RU 11	RU 12	RU 8	RU 4	RU 7	RU 13	RU 16	RU 3	RU 14	RU 1	RU 2	RU 9
Wetland Priority	1	12	1	2	8	7	21	12	13	31	39	22		8	2		8	7
	2	6	13	13	10	7	19	5	4	32	39	46	7	24	39	31	76	24
	3			18	27	29	25	10	24	8	7	30	69	38	38	12	7	31
	4			9	8		3		13	3	4	5	19	5	3	9	2	

WETLAND RQOs

2016 - Ewart-Smith J, Rountree MW and MacKenzie J.



2019 - Ian Bredin, Adwoa Awuah, Catherine Pringle, Leo Quayle, Donovan Kotze, and Gary Marneweck



STEP 6: Determine RQOs (narrative and numerical limits) and provide implementation information

6.1 RQO SUBCOMPONENTS AND INDICATORS
1. Consolidate all relevant information generated during the process
2. Prioritise sub-components
3. Select indicators for RQOs
4. Select driving variables for water quality

6.2 GROUNDWATER
Per GRU:
1. Identify critical subcomponents (*eg*. stress and use; quality) and select indicators
2. Draft a narrative and/or numerical limits for RQOs

6.3 RIVERS AND ESTUARIES
1. Provide the flow RQO (EWR) as generated in Step 3 for the TEC of High priority RUs
2. Provide habitat and biota RQOs for the sub-components for the TEC of High priority RUs
3. Provide water quality RQOs for High priority water quality RUs
4. Provide broad (desktop level) flow RQOs (EWR) as generated during Step 3 for the TEC of Low and Moderate priority RUs
5. Provide broad habitat RQOs for the TEC of Low and Moderate priority RUs

6.4 WETLANDS
For **high** priority wetland groups
1. Identify and assess flow and non-flow re impacts
2. Select sub-components for RQO determination and monitoring
3. Identify indicators that represent sub-components
4. Provide water quality RQOs for High pric water quality wetlands
5. Develop narrative RQOs for indicators
6. Develop numerical RQOs in support of narrative RQOs

6.5 IMPLEMENTATION
1. Prepare an implementation report
2. Include recommendations *re*. monitoring network (location, frequency, data retrieval and synthesis, *etc*.)
3. Recommend linkages with other institutions (*eg*. environmental, local government, *etc*.)

- RQOs for high priority RUs available for gazetting
- Information for a DWS implementation plan available

Linkages with other institutions (eg. environmental, local government)

6.4 WETLANDS

For **high** priority wetland groups
1. Identify and assess flow and non-flow related impacts
2. Select sub-components for RQO determination and monitoring
3. Identify indicators that represent sub-components
4. Provide water quality RQOs for High priority water quality wetlands
5. Develop narrative RQOs for indicators
6. Develop numerical RQOs in support of narrative RQOs

WETLAND RQOS: PROCESS

2019 (INR)

- Step 1: Identify potentially significant wetland resources;
- Step 2: Identify, verify and prioritize wetland resources to inform the delineation of Resource Units;
- Step 3: Desktop delineation, Present Ecological State and Importance and Sensitivity of Priority Wetland Resources to determine the Recommended Ecological Category and to inform the delineation of Resource Units;
- Step 4: Determine sub-components and indicators; and
- Step 5: Set Resource Quality Objectives, and numerical criteria, and provide implementation information

PROCESS: DEFINE NARRATIVE & NUMERICAL RQOs

When setting RQOs for wetlands the underlying aim is to describe (narrative)and where possible quantify (numeric) the following:

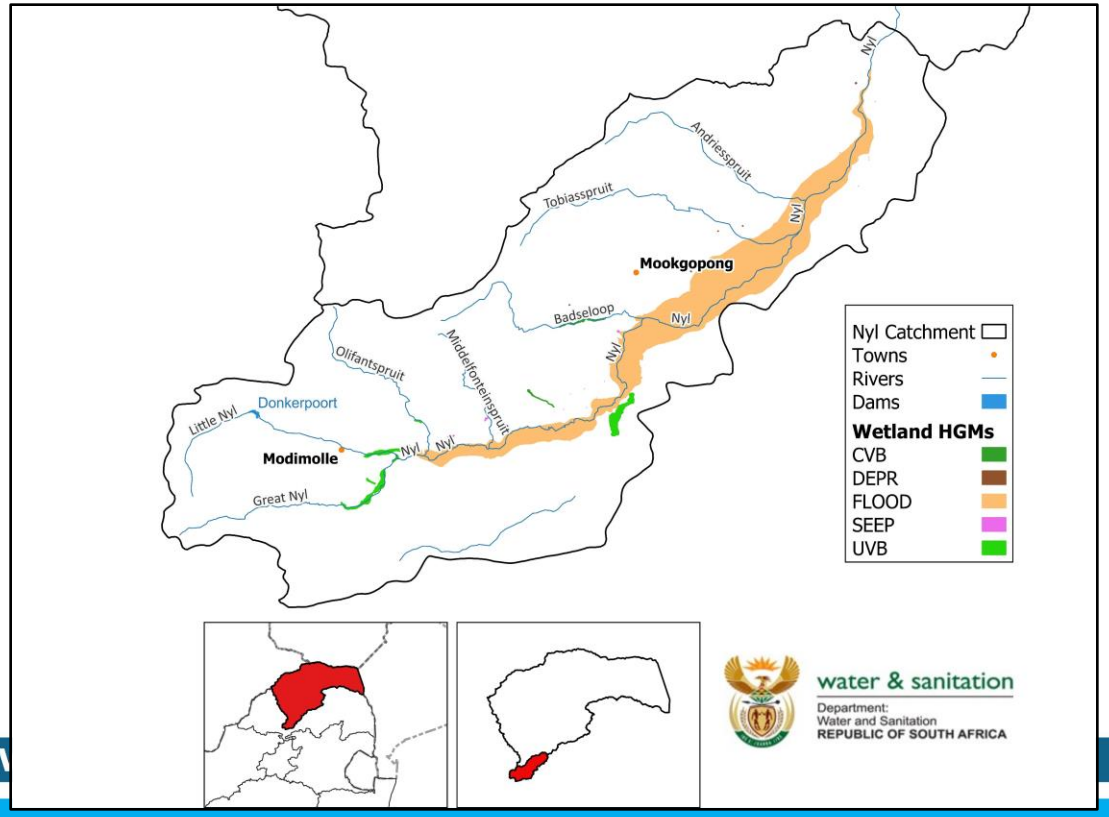
- What defines the wetland
- What drives the wetland
- What maintains the wetland
- What impacts the wetland
- What benefits does the wetland provide

WETLAND RQOS: COMPONENTS & SUB-COMPONENTS

Components	Sub-components
Quantity	Water inputs
	Water distribution and retention patterns
Quality	Nutrients
	Salts
	System variables
	Toxics
	Microbial determinands
Habitat	Present Ecological State (PES)
	Geomorphology
	Wetland Vegetation
Biota	Fish
	Plant species
	Mammals
	Birds
	Amphibians & reptiles
	Periphyton
	Aquatic Invertebrates
	Diatoms

Wetland RQOs: e.g. – Nyl Floodplain

Components	Method used for assessment	PES% Score	Ecological Category
Hydrology PES	WET-Health Hydro Module	65 %	**C**
Geomorphology PES	WET-Health Geomorph Module	73 %	**C**
Water quality PES	Wetland-IHI WQ Module	79 %	**B/C**
Vegetation PES	WET-Health Veg Module	58 %	**C/D**
Overall Wetland PES	WET-Health default weightings	65 %	**C**



Wetland RQOs: e.g. – Nyl Floodplain

No.	Legend Colour	2018 NLC Class Name	Area (Ha)	Cover (%)
1		Contiguous (indigenous) Forest (*combined* very	0.0	0.0
2		Contiguous Low Forest & Thicket (*combined cla*	9.8	0.1
3		Dense Forest & Woodland (35 - 75% cc)	906.0	4.7
4		Open Woodland (10 - 35% cc)	10901.8	56.3
5		Contiguous & Dense Planted Forest (*combined*	1.6	0.0
6		Open & Sparse Planted Forest	2.0	0.0
7		Temporary Unplanted Forest	0.0	0.0
8		Low Shrubland (other regions)	0.0	0.0
9		Low Shrubland (Fynbos)	0.0	0.0
10		Low Shrubland (Succulent Karoo)	0.0	0.0
11		Low Shrubland (Nama Karoo)	0.0	0.0
12		Sparsely Wooded Grassland (5 - 10% cc)	0.0	0.0
13		Natural Grassland	1972.0	10.2
14		Natural Rivers	1.2	0.0
15		Natural Estuaries & Lagoons	0.0	0.0
16		Natural Ocean, Coastal	0.0	0.0
17		Natural Lakes	0.0	0.0
18		Natural Pans (flooded @ obsv time)	0.1	0.0
19		Artificial Dams (incl. canals)	23.5	0.1
20		Artificial Sewage Ponds	0.0	0.0
21		Artificial Flooded Mine Pits	0.1	0.0
22		Herbaceous Wetlands (currently mapped)	1445.7	7.5
23		Herbaceous Wetlands (previous mapped extent)	651.5	3.4
24		Mangrove Wetlands	0.0	0.0
25		Natural Rock Surfaces	0.0	0.0

No. L2	Legend Colour	2020 NLC Class Name (Level 2)	Area (Ha)	Cover (%)
1		Natural Wooded Land	11817.5	61.0
2		Planted Forest	3.6	0.0
3		Shrubs	0.0	0.0
4		Karoo & Fynbos Shrubland	0.0	0.0
5		Natural Grassland	1972.0	10.2
6		Natural Water bodies	1.3	0.0
7		Artificial Water bodies	23.6	0.1
8		Herbaceous Wetlands	2097.3	10.8
9		Woody Wetlands	0.0	0.0
10		Consolidated	0.0	0.0
11		Unconsolidated	5.8	0.0
12		Permanent Crops	0.6	0.0
13		Temporal Crops	2554.0	13.2
14		Fallow Lands & Old Fields	872.0	4.5
15		Residential	20.2	0.1
16		Village	0.4	0.0
17		Smallholding	0.0	0.0
18		Urban Vegetation	0.7	0.0
19		Commercial	0.0	0.0
20		Industrial	1.3	0.0
21		Transport	6.7	0.0
22		Surface Infrastructure	0.0	0.0
23		Extraction Sites	1.1	0.0
24		Mine Waste & Resource D	0.0	0.0
			19378.104	100.0

No. L1	Legend Colour	2020 NLC Class Name (Level 1)	Area (Ha)	Cover (%)
1		Forest Land	11821.1	61.0
2		Shrubland	0.0	0.0
3		Grassland	1972.0	10.2
4		Waterbodies	25.0	0.1
5		Wetlands	2097.3	10.8
6		Barren Land	5.8	0.0
7		Cultivated	3426.5	17.7
8		Built-up	29.3	0.2
9		Mines & Quarries	1.1	0.0
			19378.104	100

WETLAND RQOS: NYL FLOODPLAIN

Component	Subcomponent	Indicator	RQO		TPC
			Narrative	Numerical	
The RQOs outlined below for the Nyl River floodplain (including Nylsvley), are to maintain a B/C category (TEC), with a percentage score of at least 78%, and the EI should remain Very High and the ES High.					
Water quantity	Water Inputs	Hydrology (EWR)	Floods are necessary to inundate the floodplain thereby providing the wetting regime required for supporting the floodplain vegetation and dependent biota. The quantity and timing of inputs, and the distribution and retention patterns within the wetland must be maintained to avoid the loss of wetland hydrological function. The EWR determined for the floodplain should be implemented.	The EWR determined for the floodplain should be implemented: The flood requirements are: · an annual flood of 3 - 5 m3/s · a 1:2 year flood of 16 - 20 m3/s with a duration of 3 to 4 months · a 1:3 year flood of 28 - 30 m3/s with a duration of 50 to 90 days · a 1:5 year flood of 45 - 50 m3/s with a duration of 90 to -150 days.	Flood peaks beyond the specified range OR reduced return interval of occurrence for specified floods
	Water distribution and retention patterns	Flooding by damming with the wetland	The current extent of damming within the wetland complex should not be permitted to increase.	The extent of damming within the delineated wetland area should not exceed 23Ha.	The extent of damming within the delineated wetland area > 23Ha

WETLAND RQOS: NYL FLOODPLAIN

Component	Subcomponent	Indicator	RQO		TPC
			Narrative	Numerical	
Habitat	Wetland vegetation structure / composition	Extent of woody vegetation on the floodplain	Woody vegetation should not be permitted to encroach onto the floodplain	N/A	
		Extent of natural grassland within the wetland complex (land cover classes 12-13; NLC, 2020) together with the extent of herbaceous wetlands (land cover classes 22-23, 2020)	The current extent of natural grassland together with herbaceous wetland should not decline.	The current extent of natural grassland together with herbaceous wetland should not decline below 4070Ha.	The combined extent of natural grassland and herbaceous wetlands < 4070Ha (excluding water bodies)
	Habitat fragmentation with the wetland delineation	Extent of alien invasive plants within the wetland / complex	Dense patches of alien invasive plant species should be prevented from establishing within the wetland complex.	Dense patches of alien invasive plant species should not exceed 5% of the wetland area.	Dense patches of alien invasive plant species > 5% of the wetland area
			Dense patches of alien invasive plant species should be prevented from establishing within the Ramsar site (Nylsvley Nature Reserve).	Dense patches of alien invasive plant species should not exceed 0% of the wetland area within the Ramsar site (Nylsvley Nature Reserve).	Dense patches of alien invasive plant species > 0% of the wetland area within the Ramsar site (Nylsvley Nature Reserve)
		Developments within the wetland complex (includes mines and quarries, SANLC classes 68-72, built-up areas, infrastructure, canals, furrows and trenching , SANLC classes 47-67)	Wetland habitat loss or fragmentation due to developments should not be permitted within the wetland complex*	The aerial extent of developments within the delineated wetland area shall not exceed 0Ha*	The aerial extent of developments within the delineated wetland area > 0Ha*
		Land cover classes denoted to cultivated areas within the wetland complex (classes 32-46 & 73, 2020)	Wetland habitat loss due to direct agricultural activities, including grazing, and croplands should not be permitted to increase in extent within the wetland complex. *	The aerial extent of agricultural activities, including grazing, and croplands within the delineated wetland area shall not exceed 3430Ha. *	The aerial extent of agricultural activities, including croplands within the delineated wetland area > 390Ha*

* Includes 200m buffer

WETLAND RQOS: NYL FLOODPLAIN

Component	Subcomponent	Indicator	RQO		TPC
			Narrative	Numerical	
Habitat / Biota	Protection	Protected areas / Conservation	Nylsvley Nature Reserve (a portion of the floodplain) should remain under the provincial protection of conservation.	100% of the Nylsvley Nature Reserve (a portion of the floodplain) should remain protected by conservation, such that it also remains a Ramsar site and IBA.	< 100% of the Nylsvley Nature Reserve protected by conservation
		Ramsar wetland	Nylsvley Nature Reserve (a portion of the floodplain) should retain qualities to uphold its Ramsar status as a wetland of international importance.		
		Important birding area	Nylsvley Nature Reserve (a portion of the floodplain) should remain an IBA (Important Birding Area).		

WETLAND RQOS: NYL FLOODPLAIN

Component	Subcomponent	Indicator	RQO		TPC
			Narrative	Numerical	
Biota	Birds	Threatened bird species (water / wetland-dependent)	Breeding populations of threatened species should be maintained. These include Rufous bellied Heron (Butroides rufiventris), Little Bittern (Ixobrychus minutus), Dwarf Bittern (Ixobychus sturmiz), Bittern (Botaurus stellaris), Pygmy Goose (Nettapus auritus), Baillon's Crake (Porzana pusilla), Striped Crake (Aenigmatolimnas marginalis) and Black Stork (Ciconia nigra) .	The number of threatened bird species that use the floodplain for breeding during the flood season should be at least 8	The number of threatened bird species that use the floodplain for breeding during the flood season < 8
		Waterbird species diversity	The number of bird species (includes residents and migrants) that utilise the floodplain should be maintained.	The number of bird species that utilise the floodplain should be at least 102 species.	The number of bird species that utilise the floodplain should < 102 species
	Fish	Species diversity in the floodplain during flooding	The number of fish species that occur on the floodplain during flooding should be maintained.	The number of fish species that occur in the floodplain during floods should be at least 10 species.	The number of fish species that occur in the floodplain during floods < 10 species
	Amphibians	Amphibian species diversity	The number of amphibian species that utilise the floodplain should be maintained.	The number of amphibian species that utilise the floodplain in the wet season should be at least 11.	The number of amphibian species that utilise the floodplain in the wet season < 11

WETLAND RQOS: NYL FLOODPLAIN

Component	Subcomponent	Indicator	RQO		TPC
			Narrative	Numerical	
Biota	Vegetation	Alian invasive plants	The wetland complex should be maintained by removal of perennial alien plant species.	Dense patches of alien invasive plant species should not exceed 5% of the wetland area.	Dense patches of alien invasive plant species > 5% of the wetland area
		Threatened plants species	The floodplain is the only location in South Africa where wild rice (Oryza longistaminata; VU) grows and provides an important breeding ground for frogs and toads after rain and during floods. As such, Wild Rice populations should be maintained within the floodplain.	The aerial extent of Oryza longistaminata on the floodplain should correspond to the flooding regime:	Reduced aerial extent of Oryza longistaminata flooding as follows:
				· 50-59 % (area) of floodplain grasses inundated during an annual flood of 3 - 5 m3/s (at Nylsvley - central region)	· < 50-59 % (area) of floodplain grasses inundated during an annual flood of 3 - 5 m3/s (at Nylsvley - central region)
				· 80-89 % (area) of floodplain grasses inundated during a 1:2 year flood of 16 - 20 m3/s with a duration of 3 to 4 months (at Nylsvely - central region)	·< 80-89 % (area) of floodplain grasses inundated during a 1:2 year flood of 16 - 20 m3/s with a duration of 3 to 4 months (at Nylsvely - central region)
				· 80-89 % (area) of floodplain grasses inundated during a 1:3 year flood of 28 - 30 m3/s with a duration of 50 to 90 days (at Nylsvely - central region)	· < 80-89 % (area) of floodplain grasses inundated during a 1:3 year flood of 28 - 30 m3/s with a duration of 50 to 90 days (at Nylsvely - central region)
				· 90-99 % (area) of floodplain grasses inundated during a 1:5 year flood of 45 - 50 m3/s with a duration of 90 to -150 days (at Nylsvely - central region)	· < 90-99 % (area) of floodplain grasses inundated during a 1:5 year flood of 45 - 50 m3/s with a duration of 90 to -150 days (at Nylsvely - central region)
		Plant species diversity within the wetland complex	The number of plant species that occur within the floodplain and are water or wetland-dependent should be maintained.	The number of plant species that occur within the floodplain and are water or wetland-dependent should be at least 35.	The number of plant species that occur within the floodplain and are water or wetland-dependent < 35

WETLAND RQOS: NYL FLOODPLAIN

Component	Subcomponent	Indicator	RQO		TPC
			Narrative	Numerical	
Water quality	Salts	Electrical conductivity (mS/m)	Water quality in the Nyl River and the tributaries that feed the floodplain should maintain the TEC (C).	95th percentile EC < 85 mS/m	95th percentile EC > 85 mS/m
	System variables	pH		5.6 >=pH<= 9.2	pH >9.2 or pH < 5.6
	Nutrients	Total inorganic nitrogen (TIN) (mg/l)		Median TIN < 2.24 mg/l	Median TIN > 2.24 mg/l
		Orthophosphate (mg/l)		Median PO4-P < 0.09 mg/l	Median PO4-P > 0.09 mg/l
		Ammonia (NH3-N) (mg/l)		Median NH3-N < 0.073 mg/l	Median NH3-N > 0.073 mg/l

Wetland RQOs: e.g. – Luvuvhu Floodplain

Components	Method used for assessment	PES% Score	Ecological Category
Hydrology PES	WET-Health Hydro Module	70 %	C
Geomorphology PES	WET-Health Geomorph Module	90 %	A/B
Water quality PES	Wetland-IHI WQ Module	71 %	C
Vegetation PES	WET-Health Veg Module	87 %	B
Overall Wetland PES	WET-Health default weightings	80 %	B/C

Wetland RQOs: Luvuvhu Floodplain

Component	Subcomponent	Indicator	RQO Narrative	RQO Numerical	TPC
The RQOs outlined below for the Luvuvhu Floodplain (Makuleke) - river & floodplain complex with pans, are to maintain a B category (TEC), with a percentage score of at least 82%, and the EI should remain Very High and the ES High.					
Water quantity	Water Inputs	Hydrology (EWR)	Maintenance of perenniality, seasonality and wet and dry season baseflows is required to provide the necessary wetting regime required for supporting wetland components. The quantity and timing of inputs, depth to groundwater. and the distribution and retention patterns within the wetland must be maintained to avoid the loss of wetland hydrological function.	The EWR determined for the upstream Luvuvhu River site should be implemented (not shown here) i.e. main channel must remain perennial, and the EWR for the floodplain component (floods) is shown below.	Failure to implement the EWR determined for the upstream Luvuvhu River site OR loss of perenniality of the main channel

Floods. Flood can occur in the month before or after the month indicated

	Within year floods <1:2 years				Inter annual floods >=1:2 years			
Flood Class	Class1	Class2	Class3	Class4	1:2 year	1:5 year	1:10 year	1:20 year
Ave peak discharge (m^3/s)	11.1	23.4	50.4	88.7	200	593	1029	1660
Ave duration (days)	4	6	8	10	10	15	20	34
Number	2	2	2	1	As per return period			
Oct								
Nov	1							
Dec	1	1						
Jan		1	1		1	1	1	1
Feb				1				
Mar			1					
Apr	1							
May								
Jun								
Jul								
Aug								
Sep								

Flood peaks beyond the specified range OR reduced return interval of occurrence for specified floods

Wetland RQOs: Luvuvhu Floodplain

Component	Subcomponent	Indicator	RQO		TPC
			Narrative	Numerical	
Water Quantity	Water Inputs	Depth to ground water on the floodplain	The average depth to groundwater across the floodplain should remain shallow to support phreatophytic vegetation communities and pan levels.	The average depth to groundwater should range between 2.5m and 4.5m and should only extent to 6.5m during natural droughts.	The average depth to groundwater > 4.5m
	Water distribution and retention patterns	Flooding by damming with the wetland	Maintain the absence of artificial damming within the wetland complex (excludes pans).	Artificial damming within the delineated wetland area shall not exceed 0Ha (excludes pans).	Artificial damming within the delineated wetland area > 0Ha (excludes pans)
		Pan water level regime	Pan water level regimes are dependent on flooding regimes and rainfall for infilling. The return period for floods required by different pans should be adhered to as far as possible according to the EWR determined for pans.	The EWR determined for the floodplain component including pans should be implemented (See above).	Failure to implement the EWR determined for the floodplain component including pans

Wetland RQOs: Luvuvhu Floodplain

Component	Subcomponent	Indicator	RQO		TPC
			Narrative	Numerical	
Habitat	Wetland vegetation structure / composition	Extent of natural wooded land within the wetland complex (land cover classes 1-4, 2020)	The extent of natural wooded land within the wetland complex should remain a dominant component of overall vegetation	The extent of natural wooded land within the wetland complex should not decline below 2600Ha.	The extent of natural wooded land within the wetland complex < 2600Ha
		Extent of herbaceous wetlands (land cover classes 22-23, 2020)	The extent of herbaceous wetlands should not decline.	The extent of herbaceous wetlands should not decline below 49.6Ha.	The extent of herbaceous wetlands < 49.6Ha
	Habitat fragmentation with the wetland delineation	Extent of alien invasive plants within the wetland / complex	Dense patches of alien invasive plant species should be prevented from establishing within the wetland complex.	Dense patches of alien invasive plant species should not exceed 2% of the wetland area.	Dense patches of alien invasive plant species > 2% of the wetland area
		Developments within the wetland complex (includes mines and quarries, SANLC classes 68-72, built-up areas, infrastructure, canals, furrows and trenching , SANLC classes 47-67)	Wetland habitat loss or fragmentation due to developments should not be permitted within the wetland complex.*	The aerial extent of developments within the delineated wetland area shall not exceed 0Ha.	The aerial extent of developments within the delineated wetland area > 0Ha
		Land cover classes denoted to cultivated areas within the wetland complex (classes 32-46 & 73, 2020)	Wetland habitat loss due to direct agricultural activities and croplands should not be permitted within the wetland complex.	The aerial extent of agricultural activities and croplands within the delineated wetland area shall not exceed 0Ha.	The aerial extent of agricultural activities and croplands within the delineated wetland area > 0Ha

* Includes 200m buffer

Wetland RQOs: Luvuvhu Floodplain

Component	Subcomponent	Indicator	RQO		TPC
			Narrative	Numerical	
Habitat / Biota	Protection	Protected areas / Conservation	The wetland complex should remain under the national protection of conservation.	100% of the delineated wetland complex should remain protected by conservation, such that it also remains a Ramsar site and IBA.	< 100% of the delineated wetland complex protected by conservation
		Ramsar wetland	The wetland complex should retain qualities to uphold its Ramsar status as a wetland of international importance.		
		Important birding area	The wetland complex should remain an IBA (Important Birding Area).		

Wetland RQOs: Luvuvhu Floodplain

Component	Subcomponent	Indicator	RQO		TPC
			Narrative	Numerical	
Biota	Birds	Threatened bird species (water / wetland / riparian-dependent)	Populations of Pels Fishing Owl (Scotopelia peli) White Crowned Lapwing (Vanellus albiceps) Black Stork (Ciconia nigra), Yellow billed Stork (Mycteria ibis), Open billed stork (Anastomus lamelligerus), Saddle-billed Stork (Ephippiorhynchus senegalensis), Great White Pelican (Pelecanus onocrotalus), Greater Painted-Snipe (Rostratula benghalensis) and Pygmy Goose (Nettapus auritus) should be maintained within the wetland complex.	9 listed species should occur during the wet season	< 9 listed species during the wet season
		Bird species diversity within the wetland complex	The number of bird species (includes residents and migrants) that utilise the Luvuvhu River and its floodplain and pans should be maintained.	The number of bird species that utilise the Luvuvhu River and its floodplain and pans should be at least 450 species.	The number of bird species that utilise the Luvuvhu River and its floodplain and pans < 450 species
	Mammals	Elephant abundance	The abundance of elephants within the wetland complex should be strategically and adaptively managed to promote conservation targets for all species, and overall vegetation health.	N/A	
		Hippo abundance (VU)	The main Luvuvhu River and perennial and near-perennial pans within the floodplain should continue to supports pods of Hippopotamus (Hippopotamus amphibius, VU). The Luvuvhu main channel should remain perennial to maintain critical hippo habitats, especially during the dry season.	N/A	

Wetland RQOs: Luvuvhu Floodplain

Component	Subcomponent	Indicator	RQO		TPC
			Narrative	Numerical	
Biota	Reptiles	Crocodile abundance (VU)	The main Luvuvhu River and perennial and near-perennial pans within the floodplain should continue to supports Nile Crocodiles (Crocodylus niloticus, VU). The Luvuvhu main channel should remain perennial to maintain critical crocodile habitats, especially during the dry season.	N/A	
		Threatened reptile species (water-dependent)	The Nile crocodile (Crocodylus niloticus, CITES App. II; SA Red Data: Vulnerable) and African python (Python sebae, CITES App. II; SA Red Data: Vulnerable), should both remain an integral part of the wetland complex.	2 listed species should remain present within the wetland complex	< 2 listed species remain present within the wetland complex
	Fish	Species diversity in the Luvuvhu River and perennial pans	The number of fish species that occur in the Luvuvhu River and perennial pans should be maintained, and alien fish species should be kept as low as possible (especially Tilapia niloticus)	The number of fish species that occur in the Luvuvhu River and perennial pans should be at least 26 indigenous species in the wet season.	The number of fish species that occur in the Luvuvhu River and perennial pans < 26 indigenous species in the wet season
	Amphibians	Frogs and toads (species diversity)	The number of amphibian species that occur along the Luvuvhu River and within its floodplain and pans should be maintained.	The number of amphibian species that occur along the Luvuvhu River and within its floodplain and pans should be at least 30 species in the wet season.	The number of amphibian species that occur along the Luvuvhu River and within its floodplain and pans < 30 species in the wet season
	Vegetation	Alian invasive plants	The wetland complex should be maintained by removal of perennial alien plant species, especially Mimosa pigra.	There should be zero occurrence of Mimosa pigra within the wetland complex.	Presence of Mimosa pigra within the wetland complex
		Plant species diversity within the wetland complex	The number of plant species that occur along the Luvuvhu River and within its floodplain and pans should be maintained.	The number of plant species that occur along the Luvuvhu River and within its floodplain and pans should be at least 250 species.	The number of plant species that occur along the Luvuvhu River and within its floodplain and pans < 250 species

Wetland RQOs: Luvuvhu Floodplain

Component	Subcomponent	Indicator	RQO		TPC
			Narrative	Numerical	
Water quality	Salts	Electrical conductivity (mS/m)	Water quality in the main Luvuvhu River channel should maintain the TEC (B/C).	95th percentile EC < 70 mS/m	95th percentile EC > 70 mS/m
	System Variables	pH		5.75 >= pH <= 9.0	pH < 5.75 or pH > 9.0
	Nutrients	Total inorganic nitrogen (TIN) (mg/l)		Median TIN < 1.90 mg/l	Median TIN > 1.90 mg/l
		Orthophosphate (mg/l)		Median PO4-P < 0.075 mg/l	Median PO4-P > 0.075 mg/l
		Ammonia (NH3-N) (mg/l)		Median NH3-N < 0.044 mg/l	Median NH3-N > 0.044 mg/l

THANK YOU!

DETERMINATION OF WATER RESOURCE CLASSES, RESERVE AND RQOS IN THE LIMPOPO (A5-A9) CATCHMENTS & OLIFANTS (B9) CATCHMENT

PROJECT STEERING COMMITTEE MEETING #4

Presented by: Martin Holland

Date: 1 APRIL 2025

WATER IS LIFE - SANITATION IS DIGNITY

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

2030 NDP

30 YEARS OF FREEDOM
South Africa 1994 - 2024

RQOS FOR GROUNDWATER

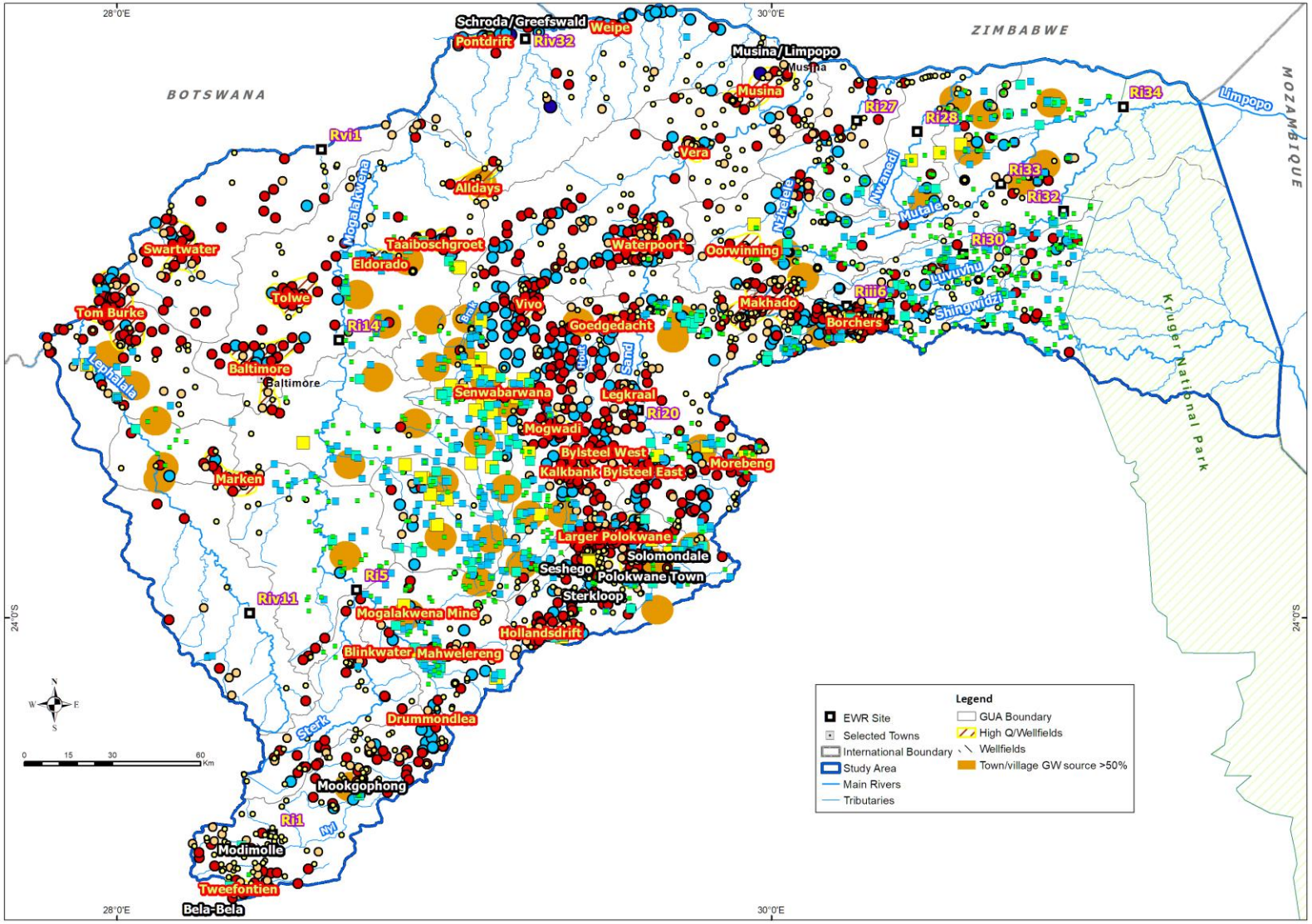
Groundwater Resource Unit Prioritisation

- Framework for RU prioritisation focusses on the prioritisation of river RUs
- Set of criteria and sub-criteria appropriate to groundwater were selected for the groundwater prioritisation
- Main criteria is summarized as:
  - Importance for (human) users: groundwater is relied upon as a “sole supply source” in several areas, in addition to, commercial agriculture, industrial abstraction.
  - Level of surface water – groundwater interaction
  - Presence of priority wetlands that are likely to be groundwater-fed is also included as sub-criteria
  - Risk of abstraction that is not maintainable, or of water quality impacts (e.g., medium to long-term declining trends).
  - Practical Considerations – Availability of groundwater quality and water level monitoring data

Groundwater Resource Unit Prioritisation

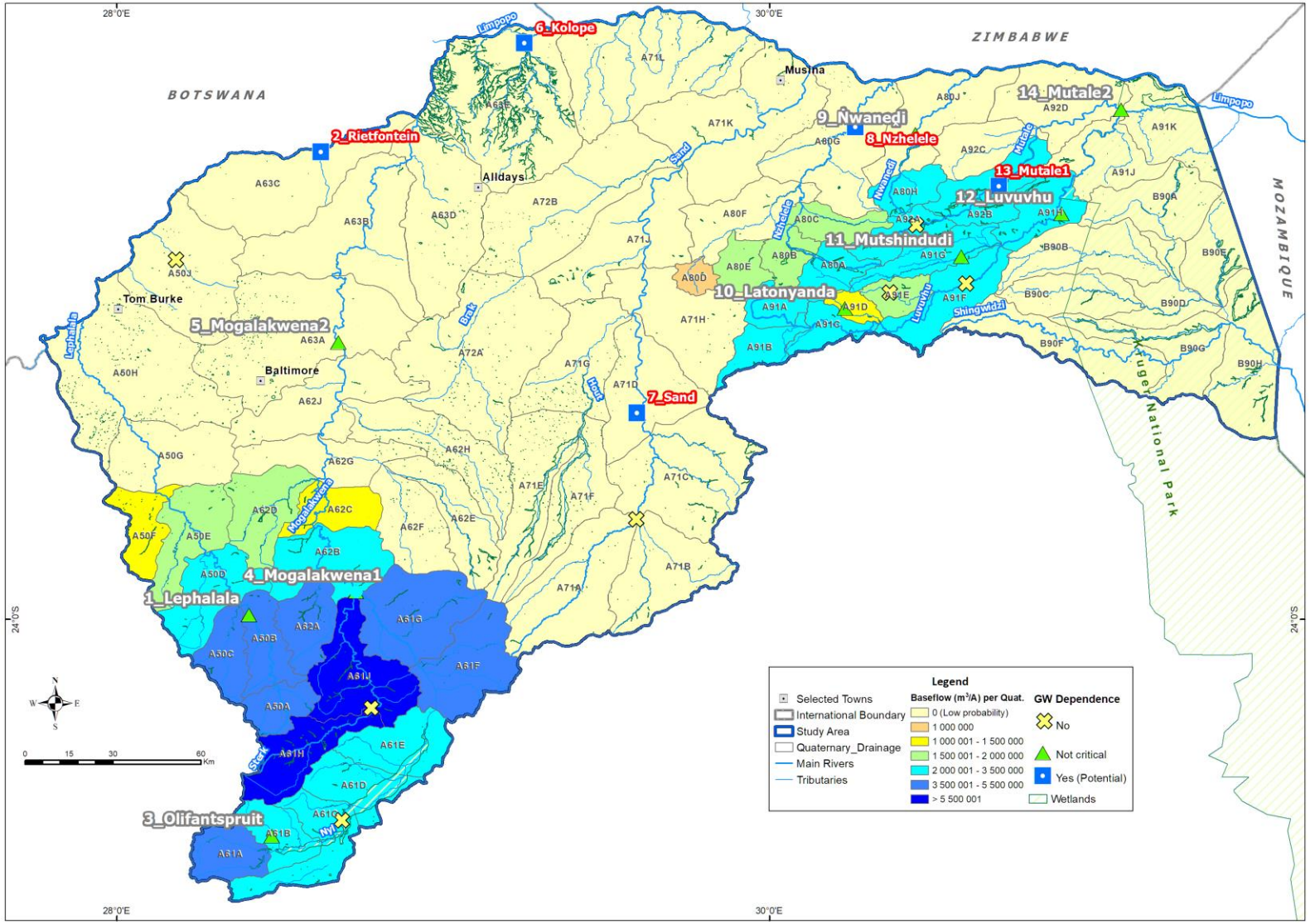
Importance for users

- GW schemes, SWSA, contributing to the economy (commercial etc.)



Groundwater Resource Unit Prioritisation

- Surface water – groundwater interaction (and wetlands)
- The study area comprises a nearly 50% split between perennial and ephemeral rivers
- Overall low baseflow potential
- The distribution of groundwater contribution to baseflow closely correlates with the distribution of recharge.
- Limited EWR sites with a degree of groundwater dependence

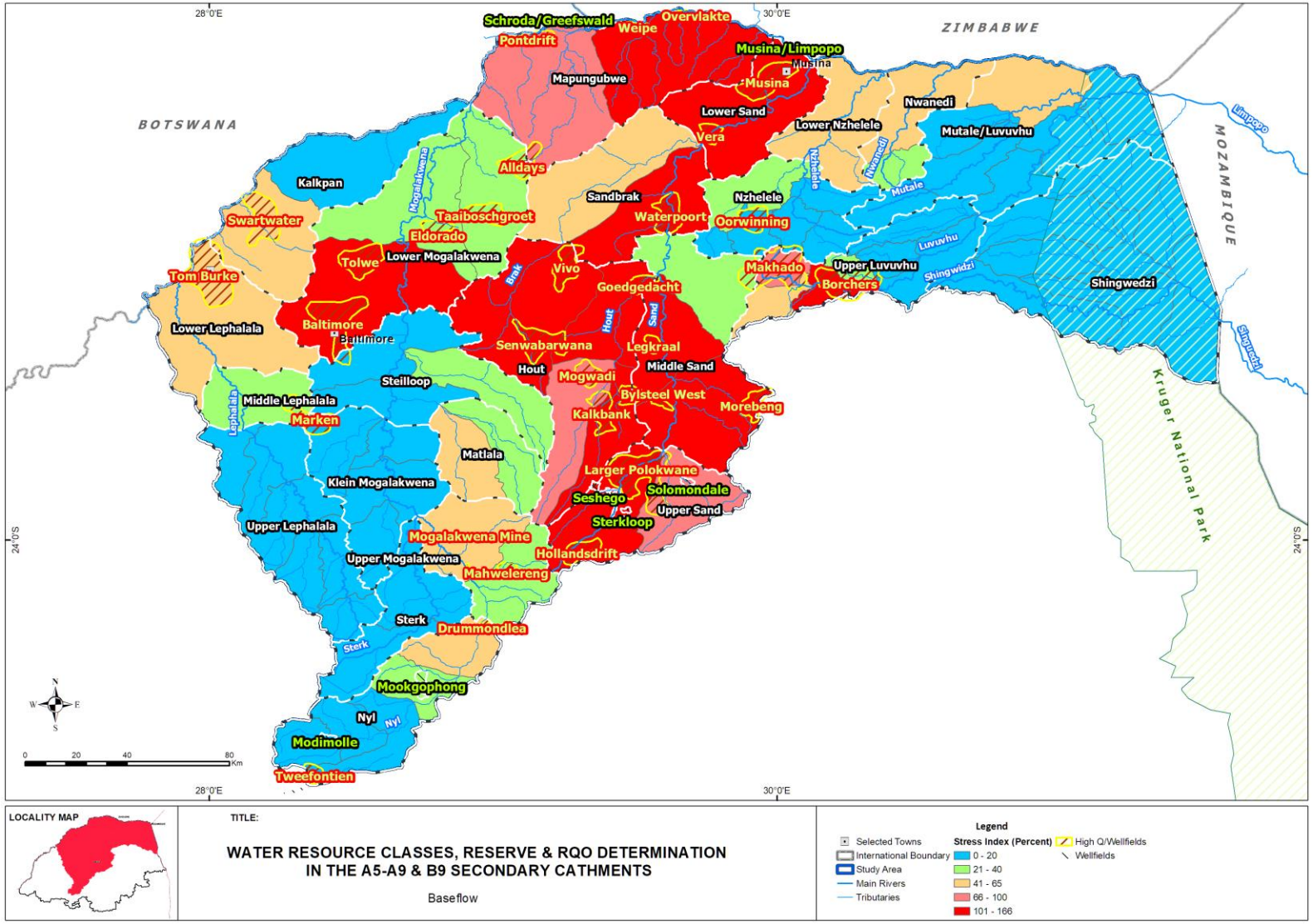


Groundwater Resource Unit Prioritisation

Threat posed to users

- Presence of high stress category
- Fraction of how much of the groundwater recharge [volume] is used

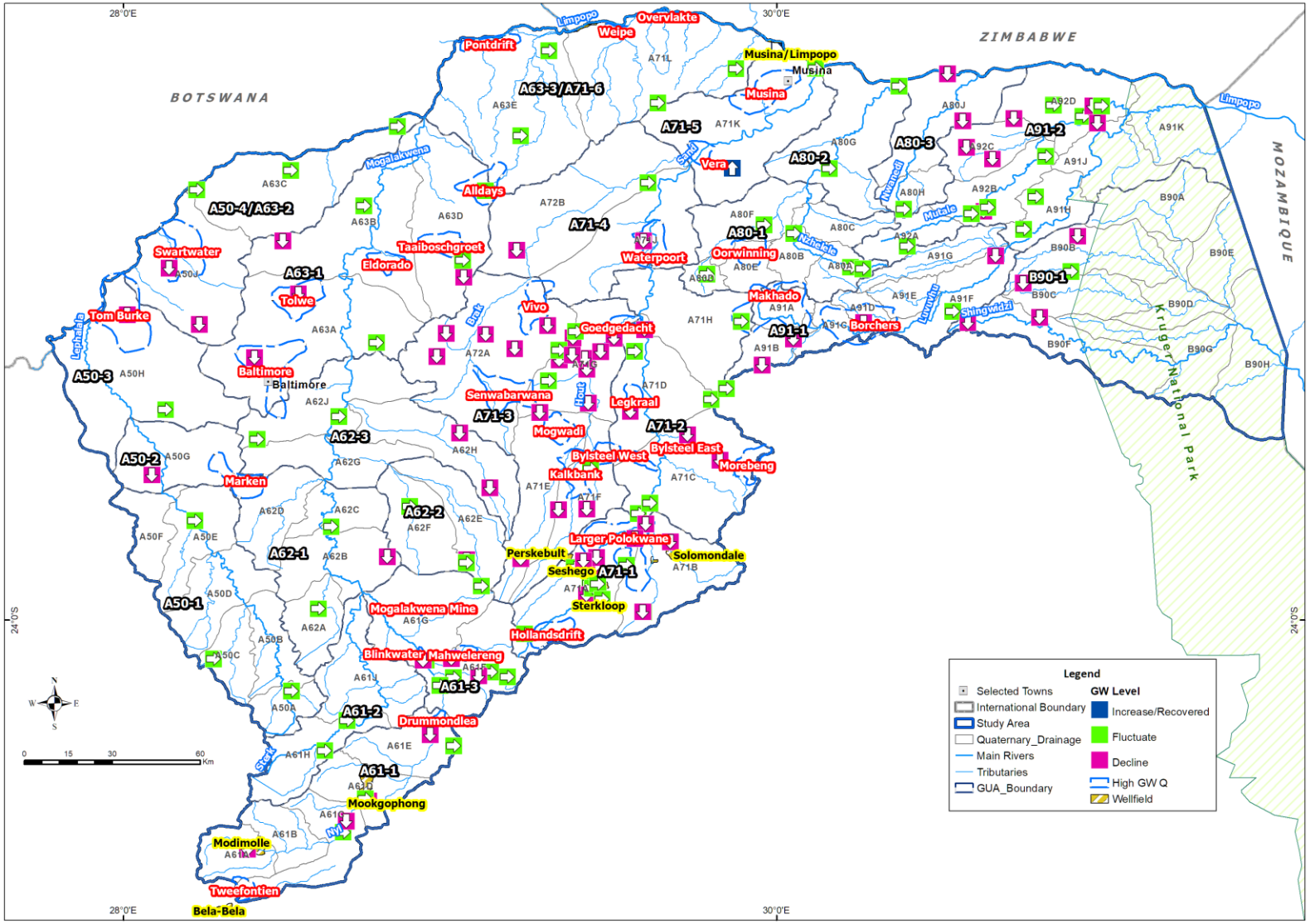
Index	Description
< 0.20 (20 %)	Low
0.20 (20 %) - 0.40 (40 %)	Moderate
0.40 (40 %) - 0.65 (65%)	Moderate to High
0.65 (65 %) - 0.95 (95%) High	High
> 0.95 (95 %)	Critical



Groundwater Resource Unit Prioritisation

Practical considerations – available trend data

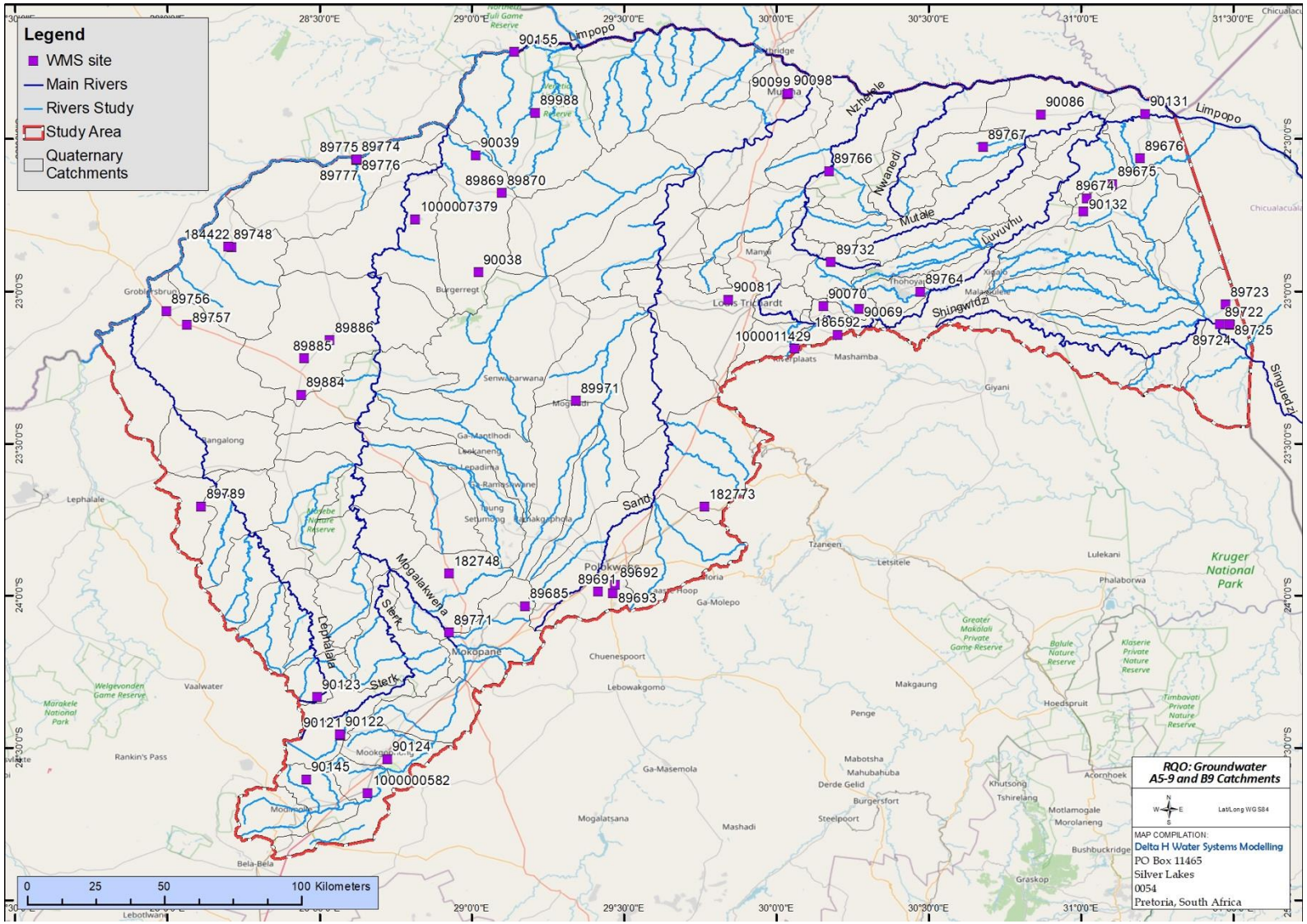
- Long-term water level data
- Fluctuate (average) or Decline



Groundwater Resource Unit Prioritisation

Practical considerations – available trend data

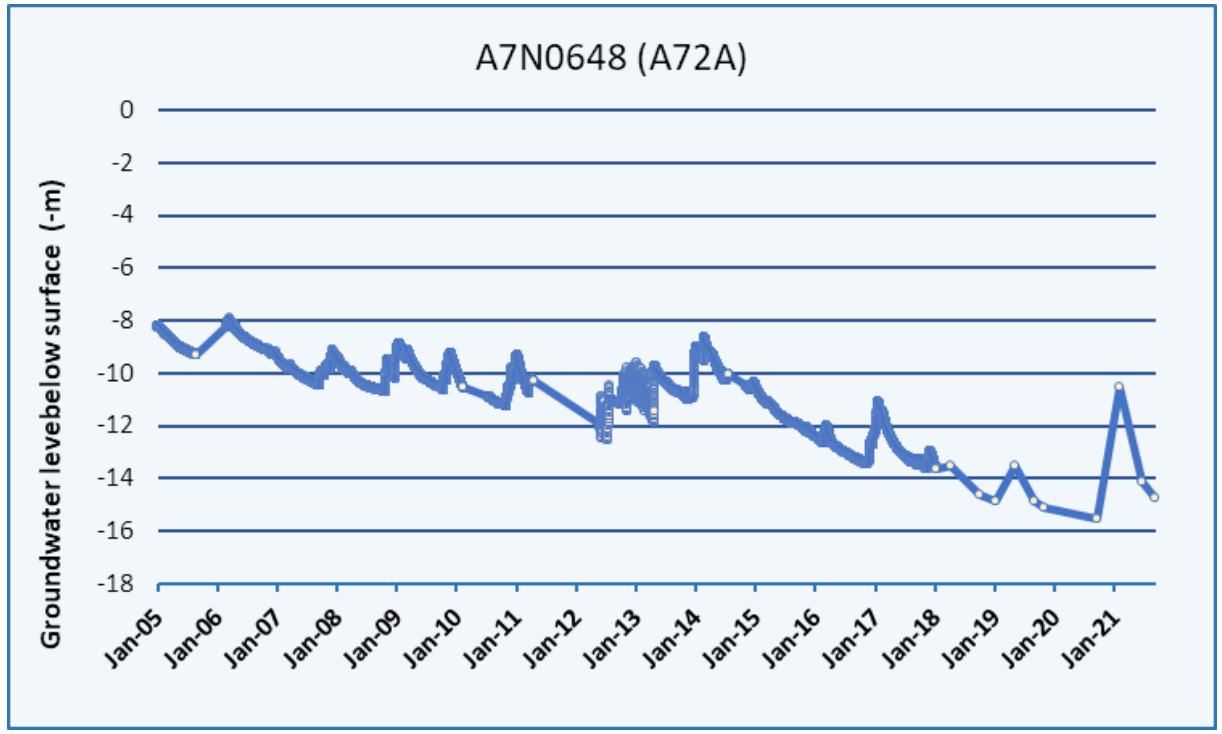
- Long-term water quality data

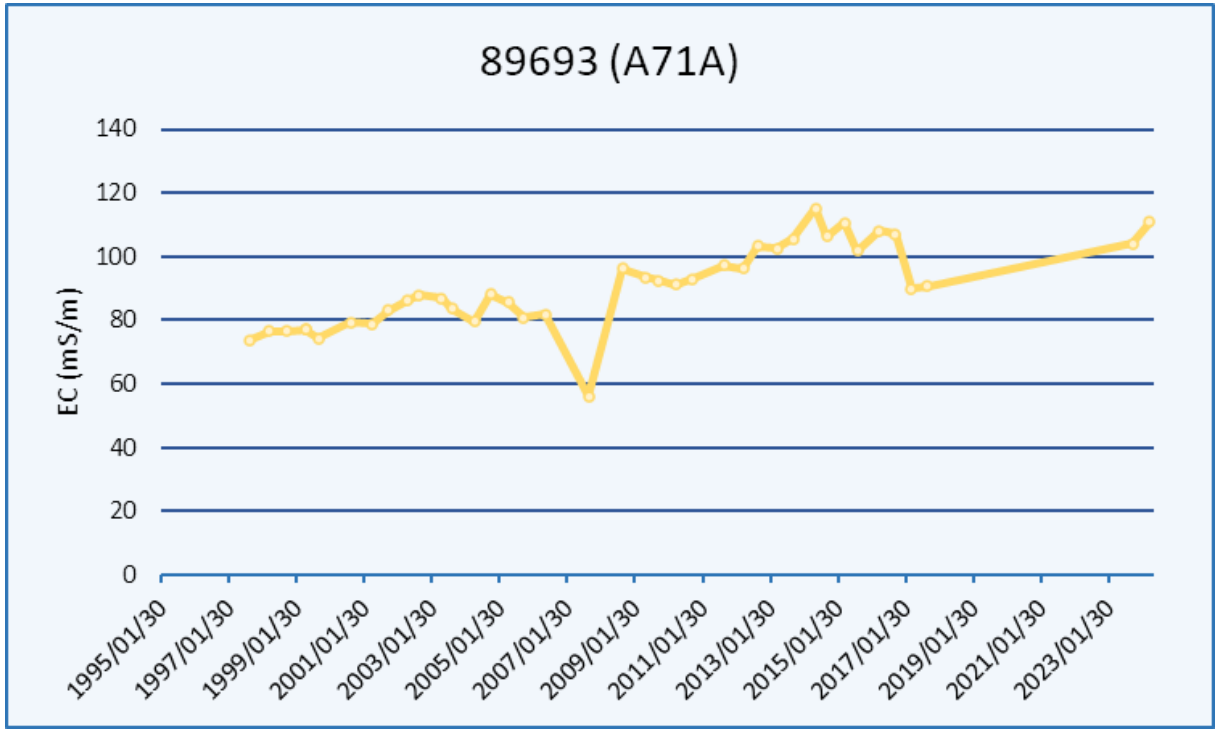


Groundwater Resource Unit Prioritisation

Threat posed to users

- Medium to Long-term trends (both water levels and quality)





Groundwater Resource Unit Prioritisation

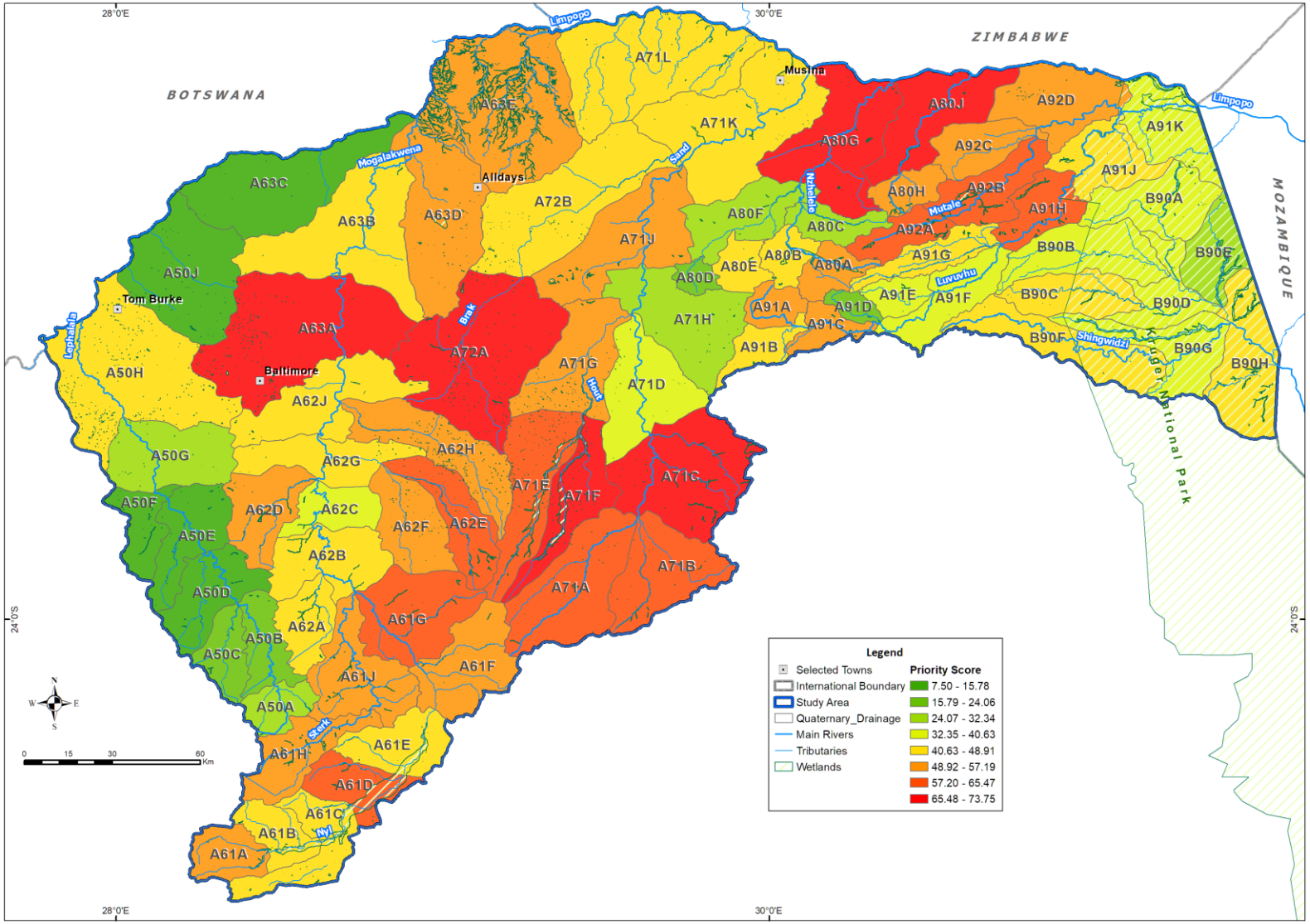
Rating/Weighting Table

- The final resource unit prioritization rating score (0- 100, low to high) has been divided into three categories from 1 (not priority), 2 (low priority), 3 (high priority).
- The categories were based on the distribution of the final scores, and a cut-off value of >50.0 (out of 100) was selected as representative of high priority 3 - link

Criterion	Weights (%)	Sub-criteria	Weights (%) (equivalent points)	Rating guidelines
Importance for users	25	Rus most important in supporting 'sole-supply' settlements	60 (15 points)	0 – RUs which do not have groundwater supply schems 0.5 – RUs supporting some groundwater supply schems (1-2) 1 – RUs supporting several groundwater supply schems (>2)
		RUs within strategic water source areas for groundwater (high groundwater availability & strategic use)	20 (5 points)	0 - RUs outside of SWSA-gw 1 – RUs within SWSA-gw
		RUs most important in supporting activities contributing to economy (GDP, job creation) (e.g. commercial agriculture, industrial abstraction, bulk abstraction by water authorities)	20 (5 points)	0 – RUs which do not directly support any activities which contribute to economy [as indicated by <0.1l/s/km2] 0.5 – RUs which moderately support activities which provide a contribution to economy [as indicated by 0.1-0.3l/s/km2] 1 – RUs which significantly support activities which contribute to the economy [as indicated by >0.3l/s/km2]
Threat posed to users	30	Medium to Long-term declining trend in water or piezometric levels	35 (10.5 points)	0 – RUs where no trend is visible, or where no data is available to assess trend 0.5 – RUs where short-term trend is potentially visible, or minor 1 – RUs where long-term trend is visible
		Medium to Long-term increasing trend in natural water quality	35 (10.5 points)	0 – RUs where no trend is visible, or where no data is available to assess trend 0.5 – RUs where short-term trend is potentially visible, or minor 1 – RUs where long-term trend is visible
		Presence of high stress category (currently)	15 (4.5 points)	0 – RUs where stress is low (category I) 0.5 – RUs where stress is moderate (category II) 1 – RUs where stress is high (category III)
		Presence of high stress category (future)	15 (4.5 points)	0 – RUs where stress is low (category I) 0.5 – RUs where stress is moderate (category II) 1 – RUs where stress is high (category III)
Practical Considerations	15	Availability of water quality monitoring data (WMS monitoring boreholes) located within RU?	50 (7.5 points)	0 – RUs where no resource quality information exists 0.5 – RUs for which a moderate level of resource quality information exists (1-7 points) 1 – RUs for which there is a good availability of resource quality information (>7 points)
		Availability of water level monitoring data (DWA monitoring boreholes) located within RU?	50 (7.5 points)	0 – RUs where no water level information exists 0.5 – RUs for which a moderate level of water level information exists (1-3 points) 1 – RUs for which there is a good availability of water level information (>3 points)
Level of surface water – groundwater interaction	30	Relevance of groundwater contribution to maintain required low flow conditions	50 (15 points)	0 – RUs without relevant groundwater contribution (low GWBF/EWR) (GWBF/RE < 4%) 0.5 – RUs where groundwater contribution supports low flow condition (GWBF/RE moderate, 4-25%) 1 – RUs where groundwater contribution is crucial to maintain low flow condition (GWBF/RE moderate, >25%)
		Relevance of groundwater contribution to maintain priority groundwater-dependent ecology	50 (15 points)	0 – RUs without potential groundwater-dependent systems (e.g.wetlands) 0.5 – RUs with some potential groundwater-dependent systems (e.g.wetlands) (<200ha) 1 – RUs with potential of groundwater-dependent systems (e.g.wetlands) (>200ha)

Groundwater Resource Unit Prioritisation

Spatial map of prioritized areas



Groundwater Resource Unit Prioritisation

Prioritization results (example)

Quat	RU Priority (1 to 3)	Criteria:	Importance for users			Threat posed to users				Practical considerations		Level of SW-GW interaction		Priority
		Criteria weight:	25			30				15		30		
		Sub-criteria weight:	60	20	20	35	35	15	15	50	50	50	50	
		Score	Supporting Groundwater Schemes	Presence of SWSA-gw	Supporting economic activities	Declining trend in water or piezometric levels	Increasing trend in water quality	Presence of high stress category (current)	Presence of high stress category (future)	Availability of water level monitoring data	Availability of water quality monitoring data	Relevance of groundwater to maintain low flow conditions	Relevance of groundwater contribution to potential GPE	
A80A	3	54.0	1	1	0.5	0.5	0	0	0	0.5	1	0	1	Pr.
A80B	2	44.3	1	1	0.5	0.5	0.5	0	0	0.5	1	0	0	
A80C	2	28.8	1	0	0.5	0	0	0	0	0.5	1	0	0	
A80D	2	20.0	0.5	1	0	0	0	0	0	0.5	0.5	0	0	
A80E	2	44.3	1	1	0.5	0.5	0.5	0	0	0.5	1	0	0	
A80F	2	31.8	1	0	0.5	0	0	0.5	1	0.5	0.5	0	0	Pr.
A80G	3	70.8	1	0	0.5	0.5	0	0.5	1	0.5	1	1	1	Pr.
A80H	3	56.5	1	0	0.5	0.5	0	0	0	0.5	1	1	0.5	
A80J	3	73.5	1	0	0	0.5	0.5	0.5	1	0.5	1	1	1	Pr.
A91A	3	57.0	0.5	1	0.5	1	0	1	1	0.5	0.5	1	0	Pr.
A91B	2	48.3	0.5	1	1	0	0	0.5	0.5	0.5	1	1	0	Pr.
A91C	3	50.5	0.5	1	1	0.5	0	1	1	0.5	1	0.5	0	Pr.
A91D	2	20.0	0.5	0	1	0	0	0	0	0.5	0.5	0	0	
A91E	2	39.0	0.5	1	0.5	0.5	0	0	0	0.5	1	0.5	0	Pr.
A91F	2	36.0	1	0	0	0	0	0	0.5	0.5	1	0.5	0	Pr.
A91G	2	46.3	1	1	0	0.5	0	0	0.5	0.5	1	0	0.5	Pr.
A91H	3	63.8	1	0	0	0.5	0	0	0.5	0.5	1	1	1	Pr.
A91J	2	42.8	0.5	0	0	0.5	0	0	0	0.5	0.5	0.5	1	
A91K	2	33.8	0	0	0	0	0	0	0	1	0.5	0.5	1	
A92A	3	59.0	1	1	0	0.5	0	0	0	0.5	1	0.5	1	
A92B	3	60.0	1	0	0	0	0	0	0	1	1	1	1	Pr.
A92C	3	55.5	1	0	0	0.5	0.5	0	0	1	1	1	0	Pr.
A92D	2	49.5	1	0	0	0	0.5	0.5	1	1	1	0.5	0	Pr.
B90A	2	39.0	0.5	0	0	0.5	0	0	0	1	0.5	0	1	
B90B	2	35.3	0.5	0	0	0.5	0	0	0	1	1	0.5	0	Pr.
B90C	2	48.0	0.5	0	0	0.5	0.5	0	0	1	1	0.5	0.5	

Groundwater Sub-component prioritisation and indicator selection

Component	Sub-Component (Key)	Rationale for sub-component choice	Indicator Selection
Quantity	Abstraction (available yield)	Whilst exploiting groundwater storage is acceptable for managing drought, and could be acceptable for short periods (e.g., high demand periods), over the long-term, groundwater use should be sustainable for all users and the environment. The RQO essentially implies that groundwater mining is considered unacceptable in the long-term. Implementation of this RQO requires the authority to isolate the cause of groundwater level decline and identify over-abstraction (unacceptable) from transition to new dynamic equilibrium (unavoidable), drought and climate change (unavoidable).	Groundwater Levels: (Seasonal abstraction) water level recovers from abstraction impact during wet season, under consideration of climate change and drought cycles. (Permanent abstraction) water level decline stabilises under consideration of aquifer response time.
Quantity	Discharge	Groundwater use should be sustainable for all users and the environment. In areas where groundwater and surface water are hydraulically connected, it is assumed that the reversal of the natural gradient with surface water could have unacceptable impacts. Where groundwater discharges to surface water, groundwater abstraction close to surface water (distance dependent on aquifer diffusivity), or groundwater abstraction rates that reduce aquifer water levels beneath that of the river, would reverse the gradient towards the river, and surface water would be 'lost' to groundwater (indirect recharge).	Groundwater Levels: Relative water levels between groundwater and surface water (in mamsl) (i.e., losing or gaining streams)
Quantity	Low flow in river	It is assumed that (a portion of) the low flow is derived from groundwater. Whilst all abstraction reduces natural discharge to some extent and at some point, in time, it would be unacceptable for abstraction to cause groundwater discharge to reduce below the maintenance low flow value, at locations that have been identified as having higher dependence on groundwater.	Gauging Flows: Compliance with the low flow requirements in the river
Quality	Nutrients, Salts	Groundwater management measures must ensure groundwater quality is protected. The parameters selected will support identification of a variety of pollution sources (captured in increase in salts) (e.g., mining), agricultural pollution (fertilisers) and industrial, domestic and animal sewage. The numerical values represent the 95 percentiles for the listed aquifer within the Groundwater Resource Unit. This is taken as a limit of acceptable deviation from natural background. Where insufficient data exists to establish robust statistics for an aquifer within an area, numerical values are either taken from the same aquifer in neighbouring areas or from data for the same	Groundwater Quality: NO_3 (as N) and EC
Quality	Pathogens	Groundwater management measures must ensure groundwater quality is protected. The parameters selected will support identification of pollution from wastewater (pathogens) and other bacteriological sources. The numerical value is based on drinking water quality standards.	Groundwater Quality: E-coli, Total Coliform

Groundwater Resource Quality Objectives (upper Sand IUA, GRU A71-1)

Quat	Aquifer	Description (of prioritised resource units)	Component and sub-component	Indicator	RQO Narrative	RQO Numeric
A71A	Turfloop Granite fractured aquifers Hout River Gneiss and weathered and fractured aquifer Alluvial aquifers	High groundwater use to support economic activities. Hosts Polokwane (i.e. Sand River) wellfields.	Abstraction (Available Yield)	Groundwater Levels: (Seasonal abstraction) water level recovers from abstraction impact during wet season, under consideration of climate change and drought cycles. (Permanent abstraction) water level decline stabilises under consideration of aquifer response time.	Groundwater use should be sustainable for all users and the environment	n/a
			Discharge	Groundwater Levels: Relative water levels between groundwater and surface water (in mamsl) (i.e., losing or gaining streams)	The natural gradient between groundwater and surface water should be maintained	n/a
			Groundwater Quality:	NO^3 (as N) and EC	Groundwater should be fit for domestic use after treatment; and groundwater quality shall not show a deteriorating trend from natural background	< 10 mg/l and < 100 mS/m
				E.coli and Total Coliform	Groundwater should be fit for domestic use after treatment; and groundwater quality shall not show a deteriorating trend from natural background	0 counts / 100ml and <10 counts / 100ml
A71B	Turfloop Granite fractured aquifers Hout River Gneiss and weathered and fractured aquifer Alluvial aquifers	High groundwater use to support economic activities (Several wellfields, groundwater schemes and rural water supply).	Abstraction (Available Yield)	Groundwater Levels: (Seasonal abstraction) water level recovers from abstraction impact during wet season, under consideration of climate change and drought cycles. (Permanent abstraction) water level decline stabilises under consideration of aquifer response time.	Groundwater use should be sustainable for all users and the environment	n/a
			Discharge	Groundwater Levels: Relative water levels between groundwater and surface water (in mamsl) (i.e., losing or gaining streams)	The natural gradient between groundwater and surface water should be maintained	n/a
			Groundwater Quality:	NO^3 (as N) and EC	Groundwater should be fit for domestic use after treatment; and groundwater quality shall not show a deteriorating trend from natural background	< 10 mg/l and < 100 mS/m
				E.coli and Total Coliform	Groundwater should be fit for domestic use after treatment; and groundwater quality shall not show a deteriorating trend from natural background	0 counts / 100ml and <10 counts / 100ml

Groundwater Resource Quality Objectives (Nyl River Valley IUA, GRU A61-1)

Quat	Aquifer	Description (of prioritised resource units)	Component and sub-component	Indicator	RQO Narrative	RQO Numeric
A61A	Waterberg Group, comprising of sedimentary and metamorphic rocks weathered and fractured aquifer	High groundwater use to support groundwater schemes and Modimolle wellfield. GW play a moderate role in supporting baseflow.	Abstraction (Available Yield)	Groundwater Levels: (Seasonal abstraction) water level recovers from abstraction impact during wet season, under consideration of climate change and drought cycles. (Permanent abstraction) water level decline stabilises under consideration of aquifer response time.	Groundwater use should be sustainable for all users and the environment	n/a
			Discharge	Groundwater Levels: Relative water levels between groundwater and surface water (in mamsl) (i.e., losing or gaining streams)	The natural gradient between groundwater and surface water should be maintained	n/a
A61B		Low to Moderate groundwater use to support rural water supply. GW play a moderate role in supporting baseflow (and wetlands).	Abstraction (Available Yield)	Groundwater Levels: (Seasonal abstraction) water level recovers from abstraction impact during wet season, under consideration of climate change and drought cycles. (Permanent abstraction) water level decline stabilises under consideration of aquifer response time.	Groundwater use should be sustainable for all users and the environment	n/a
			Discharge	Groundwater Levels: Relative water levels between groundwater and surface water (in mamsl) (i.e., losing or gaining streams)	The natural gradient between groundwater and surface water should be maintained	n/a
			Low flow in river	Compliance with the low flow requirements in the river (as per riverine RQO)	Maintain the low flow requirements in the river	Refer to RRU-Ri1 (Olifantspruit RQO)
A61C		Low to Moderate groundwater use to support rural water supply. GW play a moderate role in supporting baseflow (and Nylsvlei).	Abstraction (Available Yield)	Groundwater Levels: (Seasonal abstraction) water level recovers from abstraction impact during wet season, under consideration of climate change and drought cycles. (Permanent abstraction) water level decline stabilises under consideration of aquifer response time.	Groundwater use should be sustainable for all users and the environment	n/a
			Discharge	Groundwater Levels: Relative water levels between groundwater and surface water (in mamsl) (i.e., losing or gaining streams)	The natural gradient between groundwater and surface water should be maintained	n/a

Groundwater Resource Quality Objectives (Nyl River Valley IUA, GRU A61-1)

Quat	Aquifer	Description (of prioritised resource units)	Component and sub-component	Indicator	RQO Narrative	RQO Numeric
A61D	Upper Nyl River Valley alluvial aquifers and Karoo weathered aquifer	Low to Moderate groundwater use to support groundwater schemes and Mookgophong wellfield. GW play a moderate role in supporting baseflow (and wetlands).	Abstraction (Available Yield)	Groundwater Levels: (Seasonal abstraction) water level recovers from abstraction impact during wet season, under consideration of climate change and drought cycles. (Permanent abstraction) water level decline stabilises under consideration of aquifer response time.	Groundwater use should be sustainable for all users and the environment	n/a
			Discharge	Groundwater Levels: Relative water levels between groundwater and surface water (in mamsl) (i.e., losing or gaining streams)	The natural gradient between groundwater and surface water should be maintained	n/a
			Groundwater Quality:	NO^3 (as N) and EC	Groundwater should be fit for domestic use after treatment; and groundwater quality shall not show a deteriorating trend from natural background	< 1 mg/l and < 70 mS/m
				E.coli and Total Coliform	Groundwater should be fit for domestic use after treatment; and groundwater quality shall not show a deteriorating trend from natural background	0 counts / 100ml and <10 counts / 100ml
A61E	Upper Nyl River Valley alluvial aquifers and Karoo weathered aquifer Gabbro-Norite (weathered and fractured aquifer, i.e., secondary) aquifers overlain by a weathered horizon of variable thickness)	Moderate groundwater use to support groundwater schemes/wellfields and rural water supply. GW play a moderate role in supporting baseflow (and wetlands).	Abstraction (Available Yield)	Groundwater Levels: (Seasonal abstraction) water level recovers from abstraction impact during wet season, under consideration of climate change and drought cycles. (Permanent abstraction) water level decline stabilises under consideration of aquifer response time.	Groundwater use should be sustainable for all users and the environment	n/a
			Discharge	Groundwater Levels: Relative water levels between groundwater and surface water (in mamsl) (i.e., losing or gaining streams)	The natural gradient between groundwater and surface water should be maintained	n/a
			Groundwater Quality:	NO^3 (as N) and EC	Groundwater should be fit for domestic use after treatment; and groundwater quality shall not show a deteriorating trend from natural background	< 10 mg/l and < 150 mS/m
				E.coli and Total Coliform	Groundwater should be fit for domestic use after treatment; and groundwater quality shall not show a deteriorating trend from natural background	0 counts / 100ml and <10 counts / 100ml

THANK YOU!