Determining the Water Resource Classes and Resource Quality Objectives in the Thukela River Catchment

Project Steering Committee 4
Background Information Document
February 2021

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

PURPOSE OF THIS DOCUMENT

The purpose of this background information document (BID) is to assist members of the Project Steering Committee (PSC) in preparing for the fourth meeting to be held online on 3rd of March 2021.

This BID contains information regarding the evaluation of scenarios configured within the integrated water resource management process so that a subset of catchment scenarios can be recommended towards proposed water resource classes.

This BID should be read in conjunction with Report No: RDM/WMA04/00/CON/CLA/0121, Department of Water and Sanitation, South Africa. January 2021. *Determination of Water Resource Classes and associated Resource Quality Objectives in the Thukela Catchment: Scenarios Evaluation and Proposed Water Resource Classes Report. Draft.*

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STUDY OBJECTIVE

Chapter 3 of the National Water Act, (Act 36 of 1998) provides for the protection of water resources through the implementation of Resource Directed Measures (RDM) which include the classification of water resources, setting the Reserve and determining Resource Quality Objectives (RQOs).

The key aims of this study are to co-ordinate the implementation of the Water Resource Classification System (WRCS) published as Regulation 810 in September 2010 for determination of water resource classes and associated RQOs in the Thukela catchment. The study is linked to the preliminary Reserve determination studies and other water resource management initiatives. Where the preliminary Reserve is available and relevant, the information has been adopted and where needed, within the ambit of this study, gaps have been filled.

The water resource classes and associated RQOs will assist the Department in ensuring that water resources within the Thukela catchment are protected to achieve equitable share in a sustainable manner. In determining classes and associated RQOs, socio-economic factors and ecological goals are being considered, by evaluating the magnitude of impacts in the present, as well as proposed future developments. The water resource classes and associated RQOs will also assist the Department in the authorisation of future water uses, operation and management of the system and the evaluation of the magnitude of the impacts of the present and proposed developments, as well as ensure that economic, social, and ecological goals are attained.

WHERE ARE WE IN THE PROCESS?

Figure 1 outlines the process being followed illustrating the integrated Framework of the Gazetted steps for Classification, Reserve and RQO Determination (DWS, 2017). The current study has completed Step 3 and is moving onto Step 4. This Background Information Document outlines the processes involved in evaluation of the scenarios and proposing draft water resource classes.

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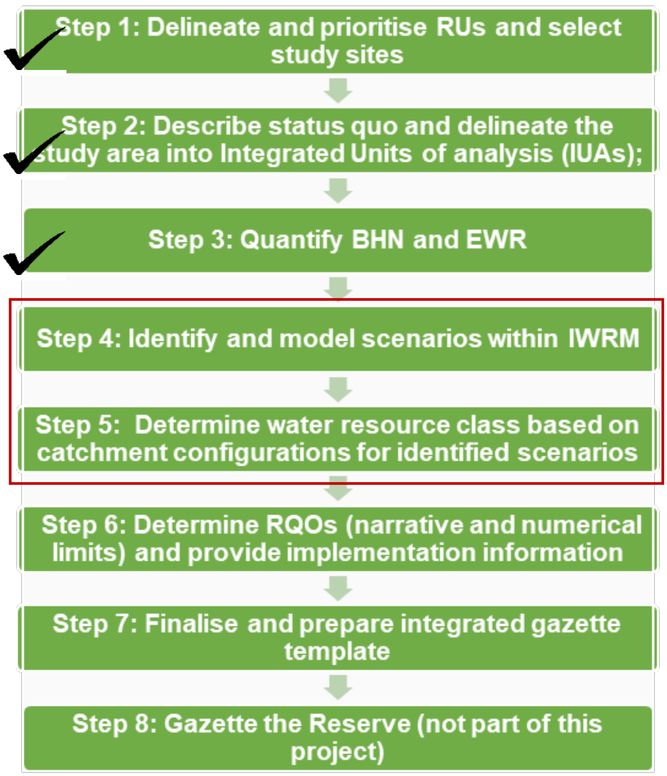

Figure 1: Integrated RDM Process

Scenarios, in the context of water resource management and planning are plausible definitions (settings) or factors (variables) that influence the water balance and water quality in a catchment and the system as a whole.

Each scenario represents an alternative future condition, generally reflecting a change to the present condition. Analysis thereof gives the ability to compare the implications of one scenario against another, with the ultimate aim of selecting the preferred scenario.

EVALUATION OF SCENARIOS WITHIN THE IWRM PROCESS

An integral component of the water resource classification process is the scenario configuration and evaluation, which is an iterative process that assesses the resulting yields of alternate ecological protection categories; conservation targets and future use and development to determine what is most feasible for the Thukela catchment being classified, to support the recommended water resource management class options. The objective of this step is to evaluate scenarios configured that have been incorporated into the integrated water resource management process so that a subset of catchment scenarios can be recommended towards proposed management classes. The scenarios evaluation within the integrated water resource management systems is illustrated in Figure 2 included in this BID.

Biophysical nodes illustrated in Figure 3 were selected for the significant water resources per IUA to quantify the Ecological Water Requirements (EWR) that inform the scenario analysis and the determination of the water resource classes. These nodes are mostly existing EWR sites (key biophysical nodes) where a comprehensive Reserve assessment level was undertaken.

WATER RESOURCE PLANNING ANALYSIS

A summary of the scenarios analysed using the Water Resources Planning Model are illustrated in Tables 1 and 2.

Table 1: Summary of planning scenarios linked to different ecological catchment configurations

Development level	EWR inclusions				
	None	PES	PES +E	TEC	TEC+E
Present	X	X	X	X	X
Medium-Term (2030)	X			X	X
Long -Term (2040 – 2045)	X			X	X

PES: Present Ecological Status; TEC: Target Ecological Category; PES+E: with estuary; TEC+E: with estuary.

Table 2: Scenarios summary description

Scenarios			ID	
1	Current day with all existing major transfers operating based on current rules	Scenario 1N – current no EWR	Sc1N	Sc1
		Scenario 1PR – current with PES, riverine only	Sc1PR	Sc2
		Scenario 1PE – current with PES riverine and estuary	Sc1PE	Sc3
		Scenario 1TR – current with TEC, riverine only	Sc1TR	Sc4
		Scenario 1TE – current with TEC, riverine and estuary	Sc1TE	Sc5
2	Medium-term with all major planned infrastructure (in the construction phase/ well progressed planning stages) before 2030	Scenario 2N – Medium term, no EWR	Sc2N	Sc6
		Scenario 2TR – Medium term, with TEC, riverine only	Sc2TR	Sc7
		Scenario 2TE – Medium term with TEC riverine and estuary	Sc2TE	Sc8
3	Long-term scenario with all major infrastructure implemented and projected water requirements around 2045	Scenario 3N – long term, no EWR	Sc3N	Sc9
		Scenario 3TR – long term with TEC, riverine only	Sc3TR	Sc10
		Scenario 3TE – long term with TEC riverine and estuary	Sc3TE	Sc11

Some iterations of the long term scenario may be required that relate to an irrigation dam on the Mooi River, a new development on the Buffalo River for Newcastle, another phase of the transfer to the Mhlathuze, or the raising of Spioenkop Dam.

ECOLOGICALLY SUSTAINABLE BASE CASE CONFIGURATION (ESBC)

The ESBC scenario, which could permit the maximum water use scenario, requires that the base condition for each water resource is at minimum established as either a D category or as whichever higher category is required to maintain all downstream nodes in at least a D category. However, where the ecological condition requires it, a higher ecological category needs to be set.

The ESBC scenario is established once this base condition is hydrologically and ecologically tested to ensure that it is feasible and can be achieved. In other words, the results will reflect whether the catchment water balance would be in surplus or deficit by implementing a D category EWR. In terms of the Thukela catchment, the D ecological category was not selected as the default ESBC. Rather the selected ecological category per IUA is the Present Ecological State (PES).

Additional to the establishment of the ESBC, the Target Ecological Category (TEC) was also determined as an alternate scenario at the nodes. The TEC is based on the ultimate target to achieve a sustainable system both ecologically and economically, considering the PES and Recommended Ecological Category (REC). Thus, the TEC can be the same as the PES or the REC. Table 9 included at the end of the BID indicates the PES and TEC per node.

WATER RESOURCES MODEL AND ANALYSIS OF MANAGEMENT SCENARIOS

The scenarios were analysed for the maximum hydrological record length available for the total Thukela catchment. This amounted to a record period of 69 years of continuous hydrological analyses and 828 monthly supply time-steps.

The WRPM model was updated with the latest available information from the Integrated Vaal River Reconciliation Strategy (IVRRS) and models, the KZN Reconciliation Strategy and associated linkage with the Lower Thukela Bulk Water Supply Scheme (LTBWSS), and the Umgeni Water Universal Access Plans for supply in the various Water services Authorities (typically district Municipalities), and refined EWRs. The preliminary perspective is that the following users (or some users within these sectors) are projected to experience water supply challenges:

- IUA 1 – some irrigation and the Zaaihoek transfer
- IUA 6 – Irrigation and some domestic supply
- IUA 7 – Irrigation
- IUA 8 – Irrigation near the lower reaches
- IUA 10 – Irrigation and some domestic supply
- IUA 11 – Irrigation and some domestic supply
- IUA 13 – Irrigation and Lower Thukela Bulk Water Supply Scheme phase 2

ECOLOGICAL CONSEQUENCES

Ecological consequences were assessed for scenarios Sc1, Sc6 and Sc9 (Table 3), as these are scenarios without the EWR. For all the other scenarios, either the PES or TEC, requirements were included in the WRPM and should thus provide adequate flows to maintain the present state or the TEC for the rivers. The Fish Invertebrate Flow Habitat Assessment Model (FIFHA) developed by Dr N Kleynhans and C Thirion of the Department of Water and Sanitation’ Resource Quality Information Services (RQIS) in 2016, was used to assess the impact of the resulting flows of the scenarios at key EWR sites. IUA 5 was not assessed as there is no EWR site. IUA 14 was also not assessed as no further developments are foreseen in this IUA.

Table 3: Overall Ecological Consequences

IUA	River	EWR sites	Quaternary catchment	TEC	Overall annual category per scenario		
					Sc1	Sc6	Sc9
1	Buffalo	EWR23_Upper Buffalo	V31D	C	A	A	A
2	Ngagane	May13_EWR3_Ngagane	V31K	C	C/D	C/D	C
3	Buffalo	EWR13_Middle Buffalo	V32H	C/D	C	D	D/E
4	Buffalo	EWR14_Lower Buffalo	V33B	B/C	C/D	C/D	C/D
6	Sundays	EWR7_Upper Sundays	V60C	B/C	C/D	C/D	C/D
7	Mooi	EWR11_Middle Mooi	V20G	B/C	E	E	E
	Nsonge	EWR20_Nsonge	V20C	B/C	D	D	D
8	Mooi	EWR12a_Lower Mooi	V20H	C/D	C	D	D
9	Bushmans	EWR6a_Lower Bushmans	V70G	D	D	D	D
10	Thukela	EWR2_Upper Thukela	V11M	C	D	D	D
11	Klip	EWR22_Klip	V12A	C	B/C	B/C	B/C
12	Thukela	EWR4b_Middle Thukela	V14E	B/C	D	D	D/E
13	Thukela	EWR16_Lower Thukela	V50C	C	D/E	D/E	D

Ecological Category	≥TEC	<TEC-1 EC	<TEC-2 EC	E/F
Colour key	Green	Yellow	Orange	Red

Water Quality

In respect of water quality, the present state determined is not expected to deteriorate for the various scenarios unless the current land use activities and future developments are not managed in a manner to limit pollution, such as is currently experienced from poorly managed domestic wastewater treatment works and decants from abandoned mines.

ESTUARY ASSESSMENT

There are more than 672 dams (large and small) in the Thukela River catchment. According to the DWS hydrographic survey for the large dams in the Thukela catchment, a total of 2 Mm^3 of sediment is trapped on average per year. Sediment yield estimations vary between 227-434 $t/km^2/a$ for the Thukela basin. The majority of the large dams are situated in the upper catchment, thus having very little impact on sediment generated in the middle and lower catchment. A 20% reduction in effective sediment catchment area and an 8% reduction in peak flows for the estuary due to the existing dams, has been calculated.

It was concluded that the current sediment yield is higher than natural due to anthropogenic influence on land cover and land use. It is likely that the sediment yield has decreased since the early 20th century, due to improved farming practices and numerous dams that trap water and sediment. Sediment deposition along the river channel is greater than under natural conditions and is a combined result of increased erosion and reduced flow competence to entrain sediment to the coast.

Mouth closure takes place during low flow conditions when the lateral sediment input from long-shore drift and wave action overwhelm the transport rate of the ebb flow rate. Mouth closure is difficult to predict as it is influenced by river discharge, tidal fluctuations, wave size and lateral sediment transport by longshore currents. For the Thukela Estuary, mouth closures have been recorded for river flows of 7.7 m^3/s and lower, but the relationship is very dynamic due to high sediment influx into the estuary during coastal storm events. Table 5 describes the likely mouth state for various river discharge ranges for the Thukela River.

Table 4 showing likely mouth state for various river discharge ranges for the Thukela River

Flow rate (m^3/s)	Consequence
>10	The mouth will stay open.
5 – 10	The mouth closes occasionally. Water levels build up quickly and breaching occurs probably naturally within 1- 2 days.
2 – 5	Mouth closure occurs more frequently than at flows higher than 5m^3/s, but the mouth breaches normally again within 4 days. This is probably because the water level in the estuary is increased faster than the level of the berm.
1 – 2	Mouth closure will occur. Available data indicates that closures often will be for short periods, but the mouth could stay closed for 15 to 40 days if the berm builds up faster than the water level in the estuary. Mechanical breaching may be required to prevent flooding.
<1	The mouth will normally be closed, with a slow increase in water levels. A higher berm will build up and the mouth is likely to remain closed for periods of up to a few months. Mechanical breaching may be required to prevent flooding.

Mapping for sandbars in the estuary in 2001 and in September 2020, indicates that there are more sandbars in the Thukela Estuary in 2020 compared to 2001. The location of the sandbars is closer to the mouth, suggesting sediment build-up in the lower parts of the estuary. The width of the estuary was narrower along the upper reaches in 2020, possibly a result of vegetation encroachment due to the recent drought and relatively small floods. The mouth bar was narrower for 2020 compared to 2001, suggesting recent coastal erosion.

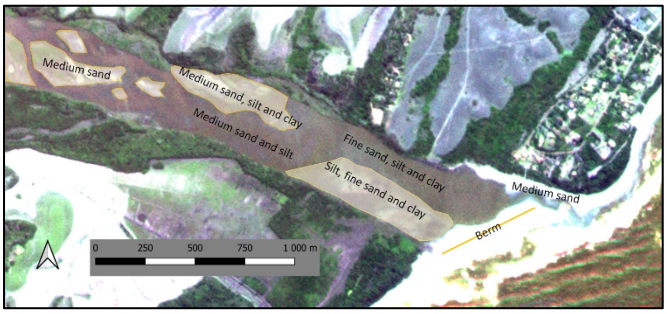

Figure 3 illustrating the main sediment types in the Thukela Estuary in September 2020

It is evident that siltation has occurred in the Thukela Estuary over the last 19 to 24 years. This is likely due to no recent large floods scouring the Thukela Estuary, increased fine sediment input from the catchment and reductions in low flows that can transport the fine sediment through the estuary to the coast.

SOCIO-ECONOMIC CONSEQUENCES

The draft outputs presented in the report will be assessed in a verification and refinement step with the relevant subject specialists. The process involved conducting a Comparative Risk Assessment (CRA) which is an econometric method for defining linkages and identifying ecosystem services (ES) at risk.

The CRA involved defining the following linkages in the chain of causality:

1) **Environmental hazard:** The environmental hazard is the environmental stressor which drives change. The hazard is identified as the input which initiates the chain of causality and is determined through the changes initiated through varying scenarios. Examples in this case include decreased surface water flow through over abstraction from rivers. Note the environmental hazard would vary between ecological infrastructure and across scenarios.
2) **Environmental effect statement:** The environmental effect statement describes the physical impacts that the environmental hazard has on specific ecological infrastructure. In line with the example above, this would describe that decreased surface water flow would modify natural flows processes and restrict primary productivity within the channel and riparian areas.
3) **Risk rating of ecosystem services.** The risk to the flow of ecosystem services is assessed in terms of the likelihood and consequences of impact by the identified environmental effect on the specific ecological infrastructure providing the service.

Ecosystem risk is the function of the likelihood and consequence of a scenario to which EI is exposed. The output of the CRA process is an aggregated risk assessment for each of the scenario-EI-ES combinations for each IUA (see report for details per IUA). Not all of these combinations are valuable, and the results are used to prioritise the key ecosystem services at risk per scenario across all IUA's. The output is thus a prioritised list of risks, with diagnostic and causal descriptions for each priority risk.

The CRA process ranked ecosystem services is based on their risks to specific environmental hazards per IUA. The count of aggregated risk per ecosystem service and IUA can be seen in Tables 5 and 6. Results show key ecosystem services at risk, according to the count of high and extreme risks, in descending order to be freshwater provisioning (Directly used by beneficiaries from natural sources), habitats for species, ecotourism and recreation and food provisioning. These ecosystem services are ranked as being at higher risk of impact as a response to scenario implementation.

Table 5 showing the Count of aggregated risk to ecosystem services as a result of impacts on ecological infrastructure by identified environmental hazards

Ecosystem Services	Aggregated Risk to Ecosystem Service			
	Extreme	High	Medium	Low
Ecotourism & recreation		9	8	12
Educational values		3		26
Food Provisioning		8	7	13
Fresh Water (Natural Sources)	9	11	4	10
Habitats for species		19	7	2
Inspirational Value		3	1	25
Landscape & amenity values		3	8	18
Medicinal resources				29
Raw materials / Fibre			10	19

The IUAs at highest risk based on the count of high and extreme risks, in descending order are 15, 7, 13, 8 and 1 (Table 7). This is generally as a result of significant ecological infrastructure being present together with vulnerable communities that rely on ecosystem services for their wellbeing.

Table 6 showing the count of aggregated risk per IUA to ecosystem services as a result of impacts on ecological infrastructure by identified environmental hazards in the Thukela catchment

IUA	Aggregated Risk to Ecosystem Services per IUA			
	Extreme	High	Medium	Low
1		6	3	8
2			6	13
3		3	3	22
4	1	1	2	6
5	1	3	5	18
6	2	2	4	10
7		9	1	17
8	2	5	2	18
9		5	7	6
10		3	2	4
11		3	2	5
12	1	4	2	3
13	2	6	3	7
15		6	3	16

PROPOSED WATER RESOURCE CLASSES

The approach applied to determining the proposed water resource class for each of the IUAs was to follow the guidelines of the WRCS. In summary the WRCS guidelines recommend that the water resource class be determined based on the ecological categories (EC) of the biophysical nodes residing in an IUA. The preliminary classes per IUA for the ESBC (PES) are set out in Table 8.

Table 7 Summarising preliminary water resource classes

IUA	Catchment area	IUA Water Resource Class associated with scenario
1	Upper Buffalo	III
2	Ngagane River	III
3	Middle Buffalo	III
4	Lower Buffalo	II
5	Blood River	III
6	Sundays River	III
7	Upper Mooi River	III
8	Mooi River	III
9	Middle/Lower Bushmans River	III
10	Upper Thukela River	III
11	Klip River	III
12	Middle Thukela River	III
13	Lower Thukela River	II
14	Escarpment	I
15	Thukela Estuary	III

Hydro nodes requiring higher level of protection

Those hydro nodes within IUAs that have a higher EC than the aggregated IUA EC, and may require a higher level of ecological protection than the IUA ESBC are set out in Table 8.

Table 8 Summarising hydro nodes requiring a higher level of protection

IUA	QC	River	PES	EI/ES	IUA PES
IUA6	V60C	Sundays	**B/C**	M	C
IUA7	V20E	Mooi	**B/C**	M	C
IUA9	V70F	Bushmans	**B/C**	M	C
	V70G	Bushmans	**B/C**	H	
IUA14	V11A	Thukela	**B**	H/VH	B/C
	V11B V11B	Sithene Thonyelana	**B**	M/H	
	V11G V11G	Mlambonja Mhlwazini	**B**	M/H	
	V70A	Bushmans	**B**	H	
	V70B	Nsibidwana	**B**	H	

M: Moderate; H: High; VH: Very High

CONCLUSIONS

The aquatic ecosystems of the Thukela catchment are under stress and on a negative trajectory due to extensive water use for irrigation and domestic purposes in the various catchments, return flows from domestic wastewater treatment works, and from mining activities (operational and abandoned). Large dams and associated transfers to adjacent catchments have an impact on the flows.

In respect of the estuary, the 2020 mouth closure observations show that the period for which the mouth could be closed at a given discharge is variable and uncertain.

It is evident that siltation has occurred in the Thukela Estuary over the last 19 to 24 years. This is likely due to no recent large floods scouring the Thukela Estuary, increased fine sediment input from the catchment and reductions in low flows that can transport the fine sediment through the estuary to the coast. Management of the Thukela River system needs to be improved to prevent the siltation of the estuary. This includes changes to reduce soil erosion in the catchment, allow for higher base flow releases from dams and limit abstraction from the river channel or weirs for the middle and lower catchment.

Ongoing monitoring of the mouth, estuary bathymetry, sediment composition and river discharge for the lower Thukela River and coastal storm intensity will improve our understanding of the system and allow for adaptive management.

NEXT STEPS

The next step in the classification component of the project is a trade-off workshop attended by the relevant specialists and finalisation of the scenarios to inform the final water resource classes.

The next step in the determination of Resource Quality Objectives is the compilation of draft RQOs and numerical limits that will be presented for comment by mid-April 2021.

Photo showing the Umgeni abstraction works on Thukela River.

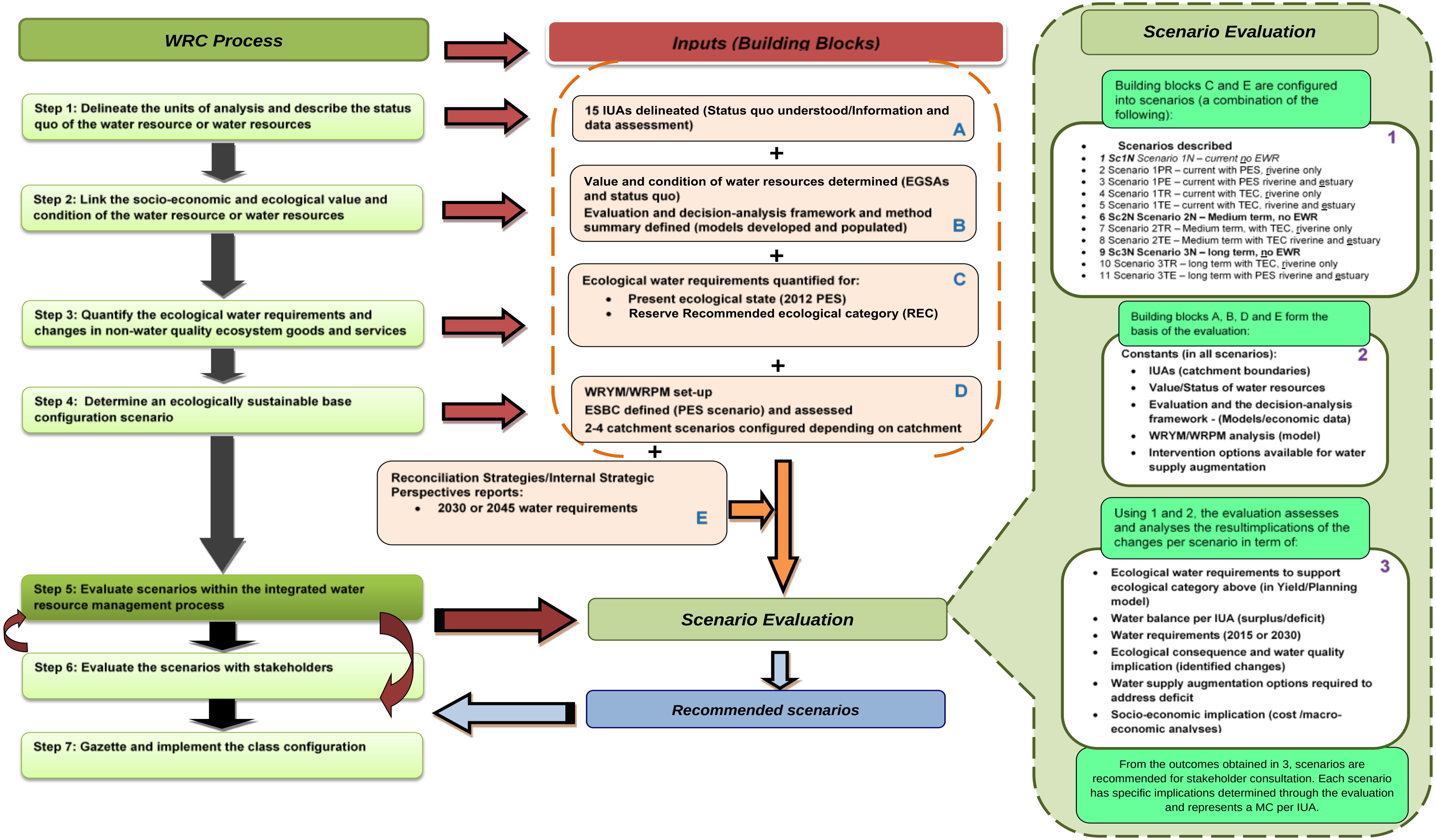

Figure 2: Illustration of scenarios evaluation within the integrated water resource management systems

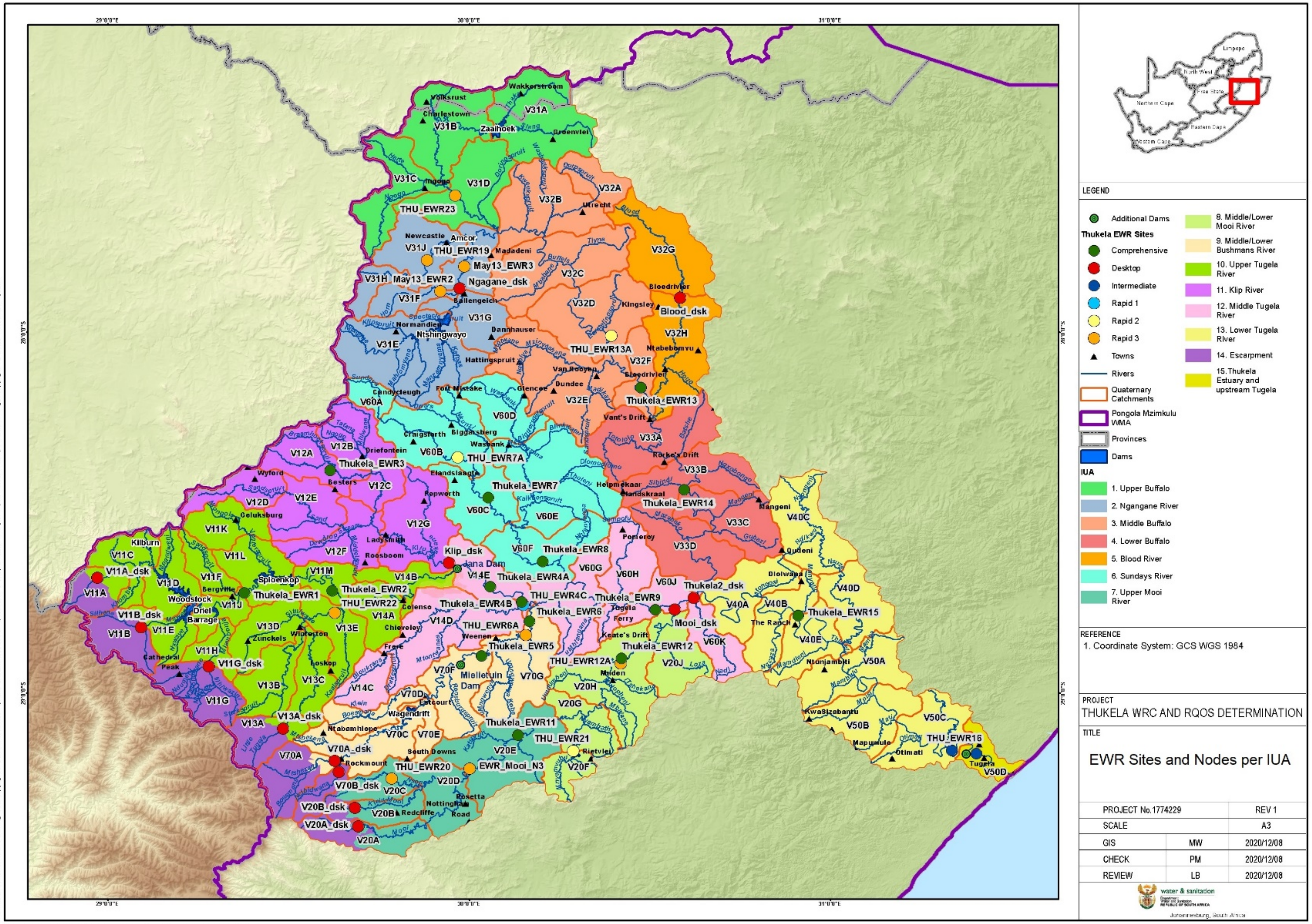

Figure 3: Map showing the Thukela IUAs with EWR sites and hydro nodes

Table 9: ESBC (PES) and TEC for the Thukela catchment

IUA	EWR site	Sub-reach	River	PES	EI/ES	TEC
IUA1	THU_EWR23	V31D-02370	Upper Buffalo	C	High	C
IUA2	May13_EWR2	V31F-02600	Horn	C	Low	C
	THU_EWR19	V31J-02487	Ncandu	C	Very high	B/C
	May13_EWR3	V31G-02618	Ngagane	C	Low	C
	Ngagane_dsk	V31K-02516	Ngagane	C	Moderate/ High	C
IUA3	THU_EWR13A	V32D-02699	Buffalo	D	Moderate/ High	C/D
	Thukela_EWR13	V32F-02707	Buffalo	D	Moderate	C/D
IUA4	Thukela_EWR14	V33B-03090	Buffalo	B/C	High	B/C
IUA5	Blood_dsk	V32H-02834	Blood	C	High	B/C
IUA6	THU_EWR7A	V60B-02826	Sundays	C/D	High	C
	Thukela_EWR7	V60C-03031	Sundays	B/CB	Moderate	C
	Thukela_EWR8	V60F-03210	Sundays	D	Moderate	D
IUA7	THU_EWR20	V20C-03919	Nsonge	C	Very high / High	B/C
	EWR_Mooi_N3	V20E-03884	Mooi	E	Moderate	D
	Thukela_EWR11	V20E-03742	Mooi	B/C	Moderate	B/C
IUA8	THU_EWR21	V20G-03853	Mnyamvubu	C	High	B/C
	THU_EWR12A	V20H-03500	Mooi	C/D	High	C
	Mooi_dsk	V20J-03467	Mooi	C	High	C
IUA9	Thukela_EWR5	V70F-03548	Bushmans	B/C	Moderate	C/D
	THU_EWR6A	V70G-03515	Bushmans	D	High	C/D
	Thukela_EWR6	V70G-03440	Bushmans	B/C	High	C/D
IUA10	Thukela_EWR1	V11L-03301	Thukela	D	Moderate	D
	Thukela_EWR2	V11M-03280	Thukela	C	Moderate	C
	Thukela_EWR3	V13E-03362	Little Thukela	C/D	Moderate	C/D
	Thukela1_dsk	V14B-03296	Thukela	B	High	C

IUA	EWR site	Sub-reach	River	PES	EI/ES	TEC
IUA11	THU_EWR22	V12A-03003	Klip	C	High / Very high	C
	Klip_dsk	V12G-03256	Klip	C	High	C
IUA12	Thukela_EWR4B	V14E-03233	Thukela	C	High	B/C
	Thukela_EWR9	V60J-03395	Thukela	D	Moderate	D
	Thukela2_dsk	V60K-03419	Thukela	C	High	C
IUA13	Thukela_EWR15	V40B-03429	Thukela	C	High	C
	THU_EWR16	V50D-03903	Thukela	C	High / Moderate	C
IUA14	V11A_dsk	V11A-03277	Thukela	B	High / Very high	B
	V11B_dsk	V11B—3410 V11B-03470	Sithene Thonyelana	B	Moderate/ High	B
	V11G_dsk	V11G-03572 V11G-03582	Mlambonja Mhlwazini	B	Moderate / High	B
	V13A_dsk	V13C-03495	Little Thukela	C	High/ Very high	B
	V70A_dsk	V70A-03876	Bushmans	B	High	B
	V70B_dsk	V70B-03927	Nsibidwana	B	High	B
	V20A_dsk	V20A-04023	Mooi	C	High	B
	V20B_dsk	V20B-04034	Little Mooi	C	High	B/C
IUA15	THU_EWR17	V50D-03903	Thukela	C	High	C