water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

2030 NDP

DETERMINATION OF WATER RESOURCE CLASSES AND ASSOCIATED RESOURCE QUALITY OBJECTIVES IN THE THUKELA CATCHMENT: BACKGROUND

PSC MEETING 03

Presented by:
Golder Associates

Date: 26 November 2020

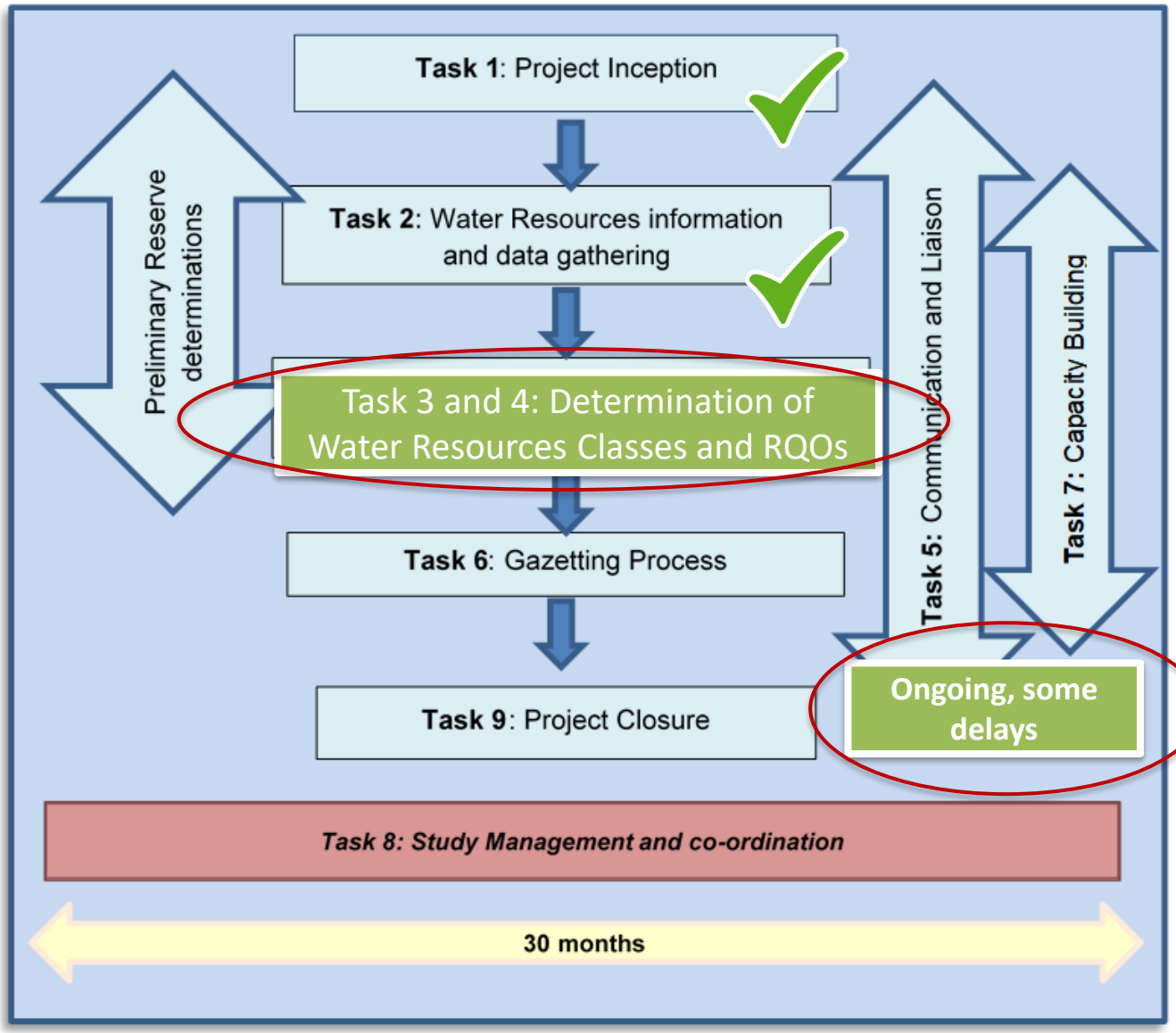
Overview of Presentation

1. Progress against study tasks
2. Project Status: Deliverable 7
    - Resource Units Delineation and Prioritisation Report
3. Project Status: Deliverable 9
    - Sub-components Prioritisation and Indicators Selection Report
4. Project Status: Deliverable 8
    - Ecological Water Requirements Report
5. Task 5: Communication and Liaison
6. Task 7: Capacity Building Activities
7. Next Steps

Progress against study tasks

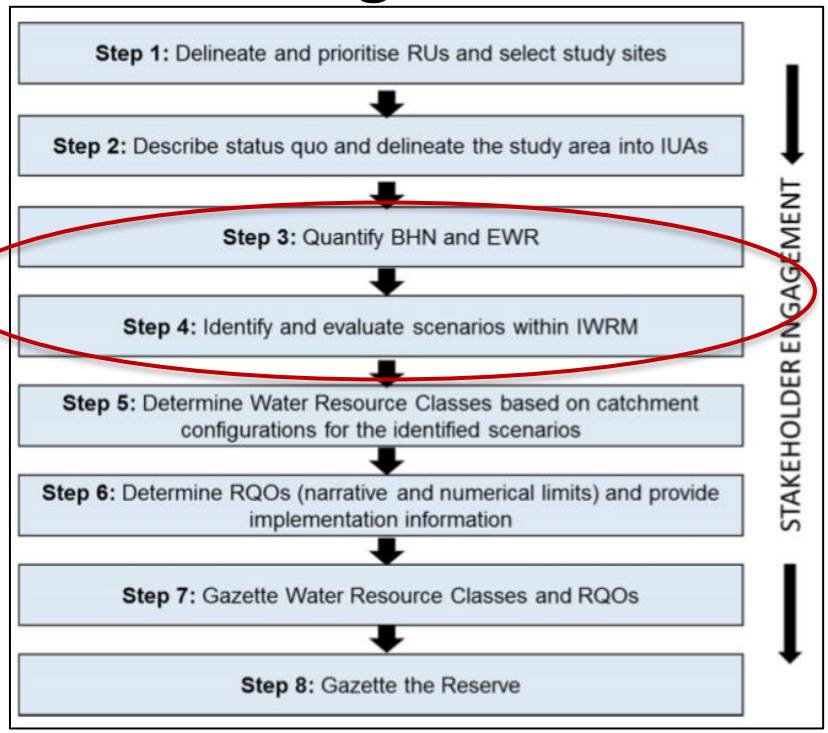
SPECIALISTS

- Groundwater
- Hydrology
- Hydraulics
- Wetlands
- Estuaries
- Socio-economics



Technical tasks: Tasks 3 and 4

Integrated



WRC

- Delineate the units of analysis and describe the status quo of the water resource or water resources;
- Link the socio-economic and ecological value and condition of the water resource or water resources;
- Quantify the ecological water requirements;
- Determine an ecologically sustainable base configuration scenario;
- Evaluate scenarios within the integrated water resource management process;
- Evaluate the scenarios with stakeholders; and
- Gazette and implement the class configuration

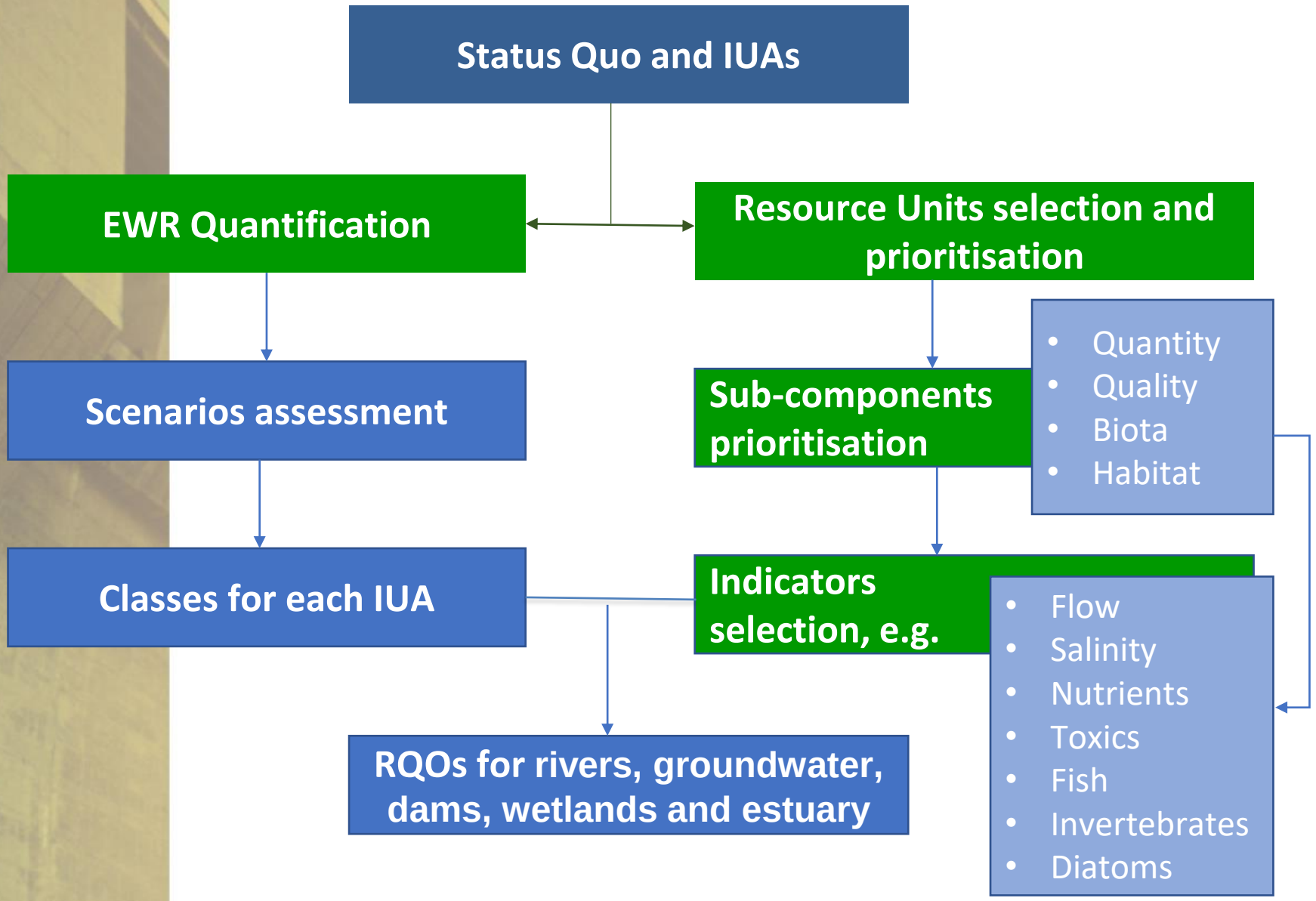
RQOs

- Delineate the integrated units of analysis and define the resource units;
- Prioritise and select preliminary resource units for RQO determination;
- Prioritise sub-components for RQO determination and select indicators for monitoring;
- Develop draft resource quality objectives and numerical limits;
- Agree on resource units, RQOs and numerical limits with stakeholders;
- Finalise and gazette RQOs.

High level programme

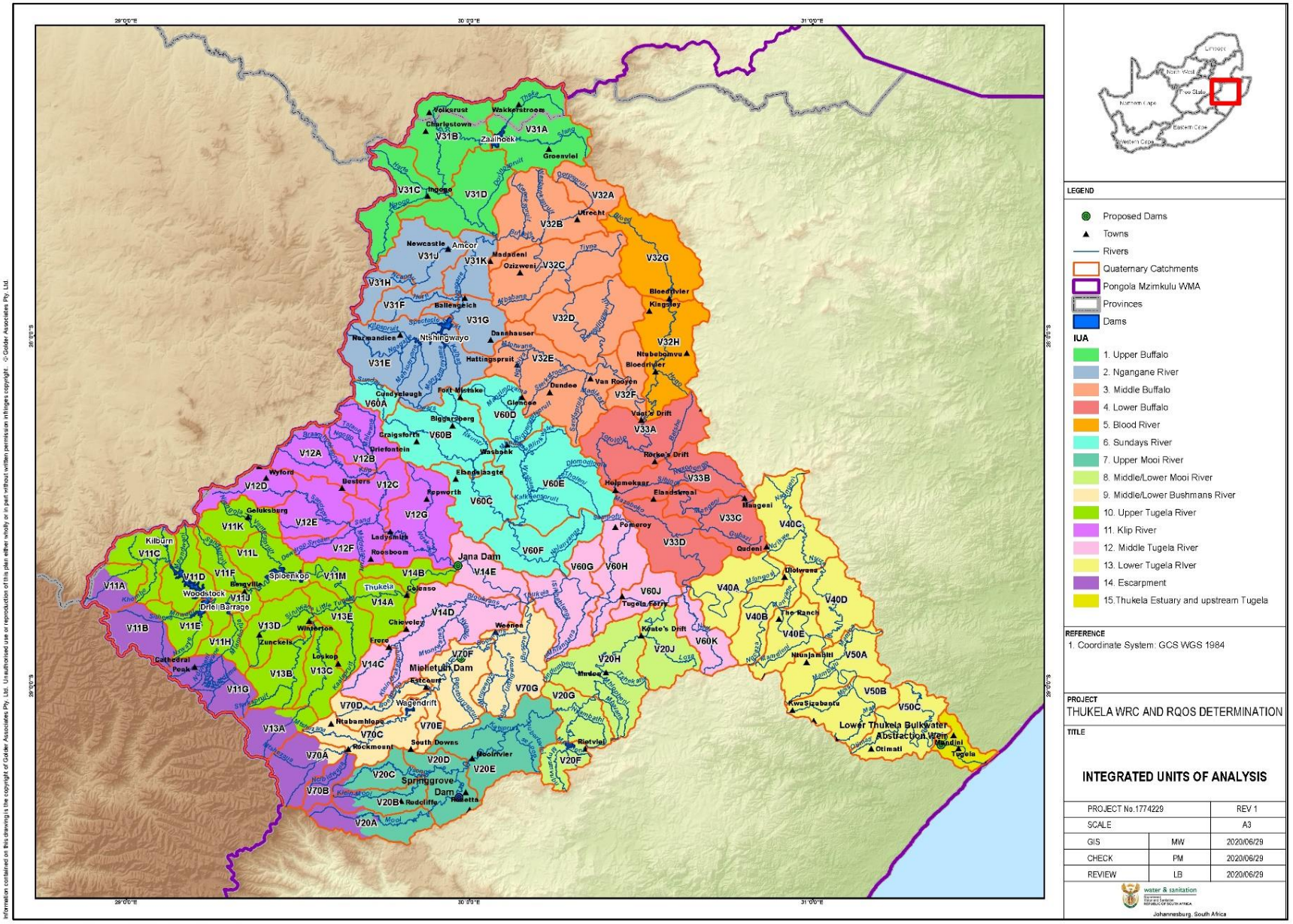
Task		Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22
Month		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	Project Inception																														
2	Information and Data Gathering																														
3	Determination of Water Resource Classes																														
4	Determination of Resource Quality Objectives																														
5	Gazetting Process																														
6	Communication and Liaison																														
7	Capacity Building																														
8	Study Management																														

- Technical tasks on track – according to project schedule
- Have caught up with the capacity building to a large extent
- Two PSC meetings held, PSC 3 – 26th November 2020


Status Quo and IUAs
EWR Quantification
Resource Units selection and prioritisation
Scenarios assessment
Sub-components prioritisation
Quantity
Quality
Biota
Habitat
Classes for each IUA
Indicators selection, e.g.
Flow
Salinity
Nutrients
Toxics
Fish
Invertebrates
Diatoms
RQOs for rivers, groundwater, dams, wetlands and estuary

RESOURCE UNITS DELINEATION AND PRIORITISATION

Integrated Units of Analysis (IUA)



Approach to delineating RUs

- From an ecological perspective, rivers should be viewed as continuous longitudinal systems.
- Impacts that occur in upstream reaches are likely to affect downstream processes.
- It would not be appropriate to set the same RQOs for the headwaters of a river as for the lowland reaches.
- RU = section of a river that frequently has different natural flow patterns, reacts differently to stress according to sensitivity, and requires individual specifications of the ecological requirements and associated RQOs appropriate for that reach, as compared to the rest of the river.
- Delineation is done primarily on a biophysical basis, and where the hydrology, geomorphic characteristics (*i.e.* geomorphic zone), water quality attributes and river size remain relatively similar, a RU can be defined.

RU delineation approach

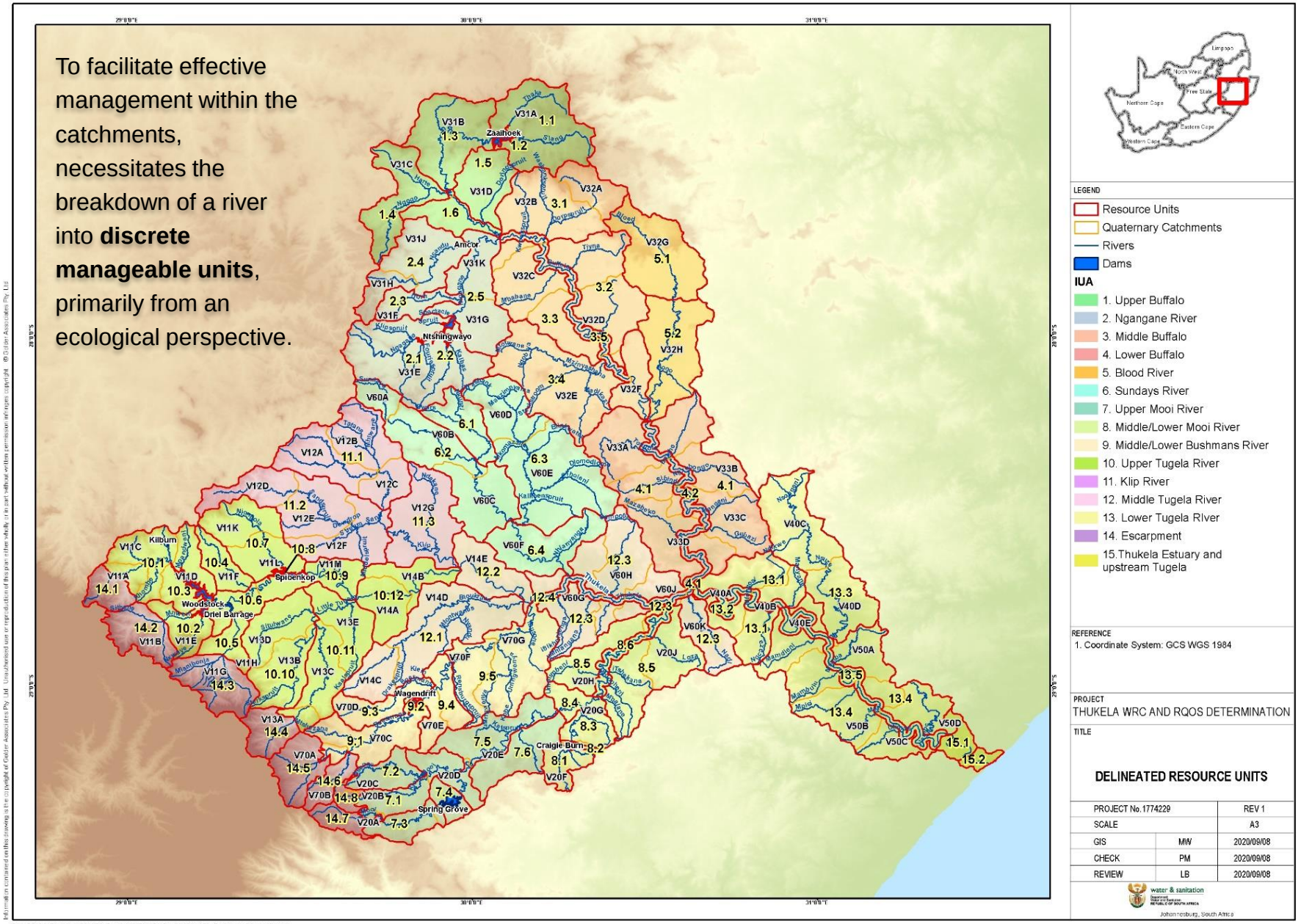
Delineation is done based on assessment of the following considerations and components:

- IUA boundaries, quaternary and sub-quaternary boundaries - alignment to the water resource classification and is of relevance from a management and implementation perspective.
- EWR sites and location of biophysical nodes - relevant from an ecological point of view (EWR sites) and important in meeting the classification ecological categories to be specified at the nodes. The nodes are of relevance in setting water quality and flow related resource quality objectives.
- Water resource management classes to be set: Considered to determine the level of protection required within an IUA.
- PES/EIS desktop assessment of sub-quinary reaches: to determine the reaches that require higher protection / improved.
- Ecological condition (based on the EWR and node information) – understanding and implementation of the Reserve.

RU delineation approach (continued)

- Protected and conservation areas – may require RQOs that support the conservation status.
- Operation of the system: regulation and management from a system point of view dams, and their influence of the river surface water flow, transfers and strategic water resources.
- Water quality status/condition of the resources influences the delineation of the resource units in terms of where specific RQOs would be required for specific user requirements (including ecological requirements).
- Land use and anthropogenic activities – nature, intensity, scale, type and extent of impact
- User dependence: the reliance of users on the water resources for domestic water supply.
- Groundwater units: the priority groundwater resources and their importance to the system and users.
- Wetlands: priority wetland areas and systems and their importance from their value, support to the ecosystem and services they provide, and to the users; and
- Expert knowledge of the catchment area and system.

Resource Units Delineated



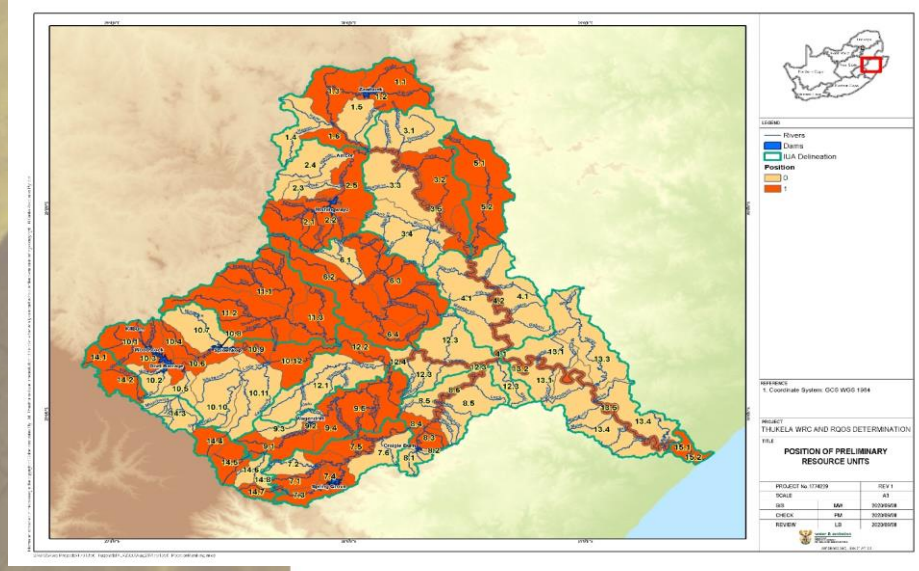
RU prioritisation

- The rationalisation process for RU selection and prioritisation is based on a decision support tool that has been developed to guide and support the process.
- Multi-criteria decision analyses approach to assess the importance of monitoring each RU as part of management operations to identify important RUs.
- The criteria assessed per RU:
  - Position of RUs within an IUA,
  - Importance of the RU to users,
  - Threat posed to water resource quality for users,
  - Threat posed to water resource quality for the environment,
  - Ecological considerations,
  - Practical Constraints, and
  - Management Considerations.

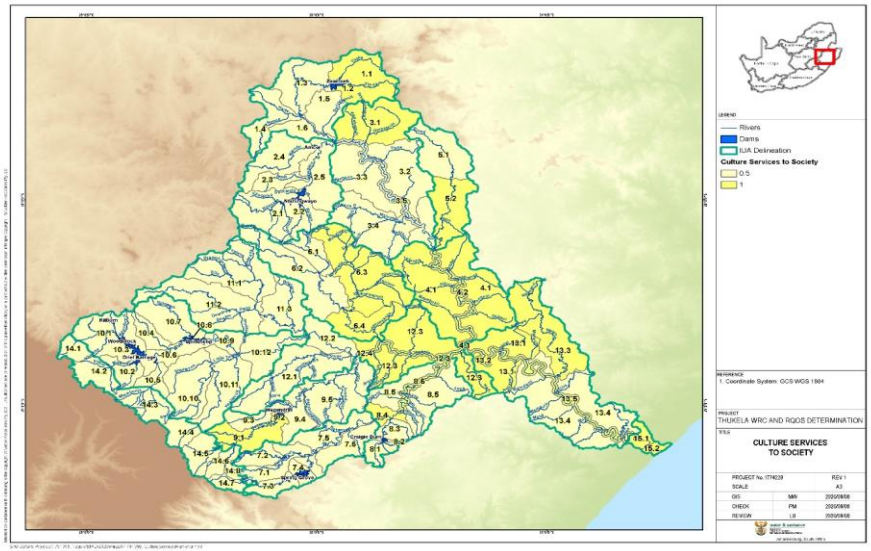
Criteria used for prioritisation

Criterion	Description and Reasoning	Sub-criteria rated per criterion per RU (0: low, 0.5: moderate or 1: high)
Position of RU within IUA	This is the first criterion that is considered within the RU Prioritisation Tool. Resource Units on large main stem rivers at the downstream end of the IUAs are located at the edge of socio-economic zones where user requirements are likely to differ. Such Resource Units also aggregate the upstream impacts from the entire IUA and thus enable the assessment of management performance at meeting objectives (including the gazetted IUA Class) for the upstream catchment. These RU thus receive high prioritisation in the Tool. It is important to note that estuaries will always be prioritised in this way (DWA, 2011).	Resource Units located on large main stem river at the downstream end of the IUA (IUA outlet node)
Assessment of the importance of each Resource Unit to users	This is the second criterion assessed and considers both current and future use. The tool assesses a number of sub-criteria relevant to different user considerations.	Resource units which provide important cultural services to society Resource units which are important in supporting livelihoods of significant vulnerable communities Resource units which are important in meeting strategic requirements and international obligations Resource units that provide supporting and regulating services Resource units most important in supporting activities contributing to the economy (GDP & job creation) in the catchment (e.g. commercial agriculture, industrial abstractions, and bulk abstractions by water authorities)
Level of threat posed to the water resource quality for users	This assessment considers the risk of the water resources to the users. Resource units which are threatened or are likely to be threatened by current or future activities should be monitored (most likely to be impacted by high risk activities)	Level of threat posed to users
Ecological importance	This criterion is assessed to identify resource units that are important from an ecological perspective. A range of attributes relative to the water resource are considered.	Ecological Importance and Sensitivity Categories (EIS) Present Ecological State (PES) and Nested Ecological category (NEC) National Freshwater Ecosystem Priority Areas Priority habitats/species identified in provincial conservation plans
Threat posed to the water resource quality for the environment	This criterion is assessed to identify RUs which are threatened or are likely to be threatened by current or future activities that should be monitored due to the risk posed to the ecological elements of the water resource. This considers those RUs most likely to be impacted by high risk activities.	Level of threat posed to the ecological components of the resource unit
Management considerations	This criterion requires the assessment of RUs where management actions should be prioritised. This applies to RUs or reaches where it is necessary to monitor the effectiveness of measures implemented to improve status quo.	Resource Units with PES lower than a D category or lower than the accepted gazetted category (NEC)
Practical considerations	In addition to the above practical considerations are also considered if RQOs can be determined and monitored.	Availability of EWR site data or other monitoring data (RHP, DWA gauging weirs) located within reach Accessibility of resource units for monitoring Safety risk associated with monitoring resource unit

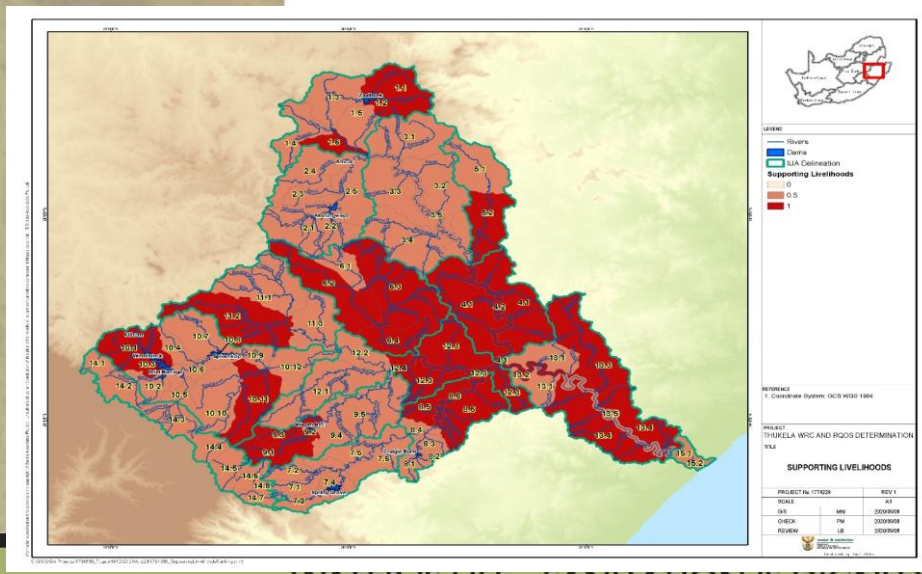
Ranking of Position of RU



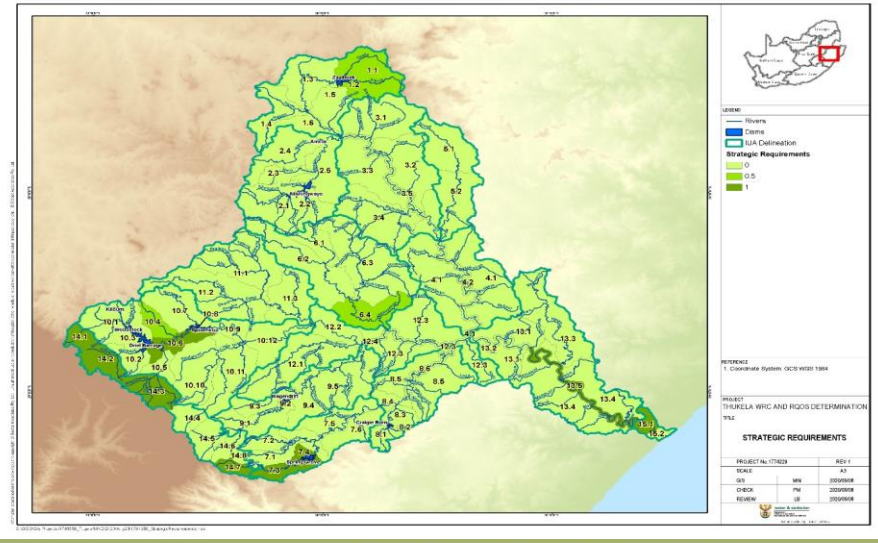
Ranking of Cultural services to society



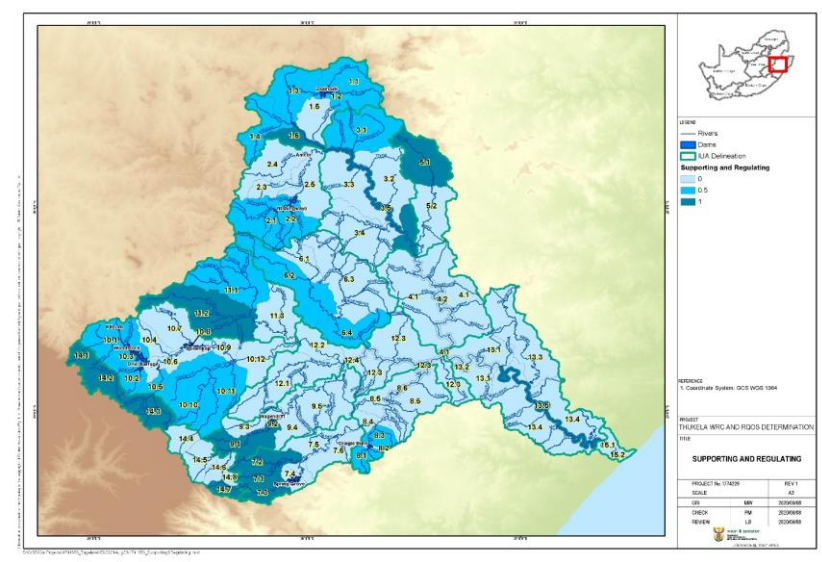
Ranking of Supporting livelihoods



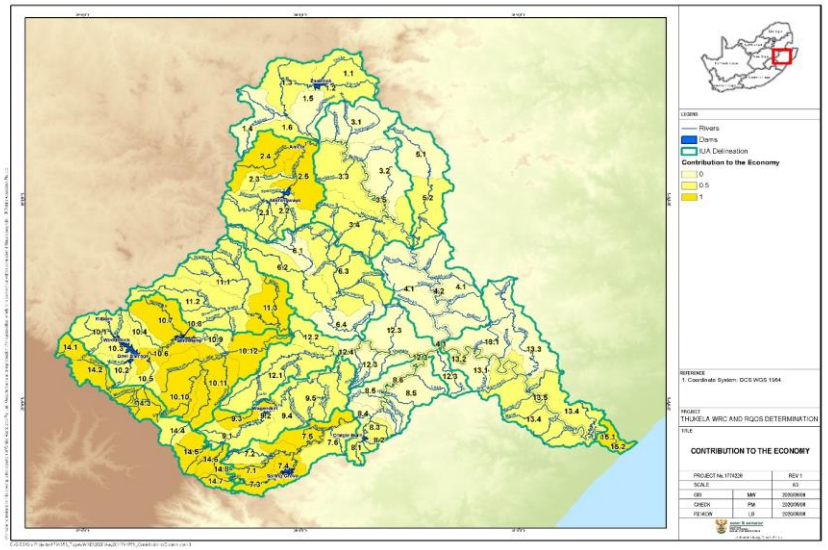
Ranking of Strategic requirements



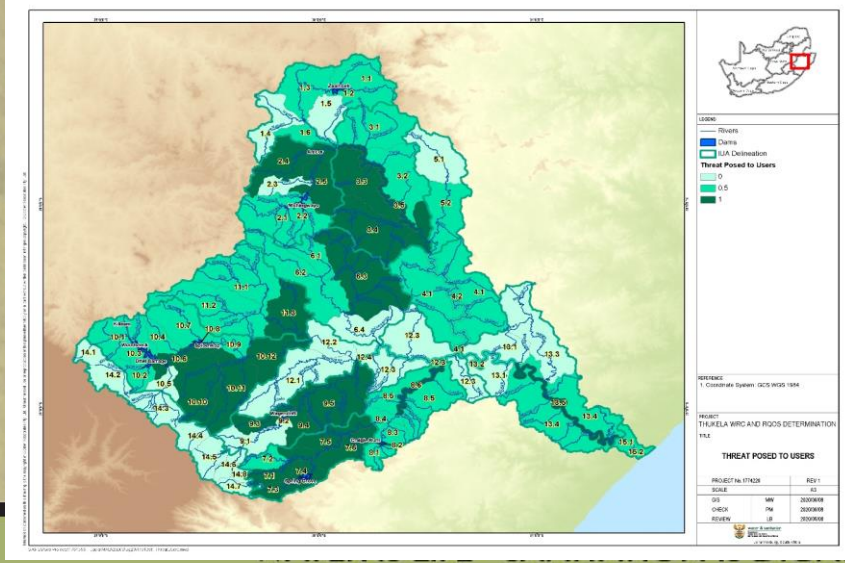
Ranking of Supporting and regulating services



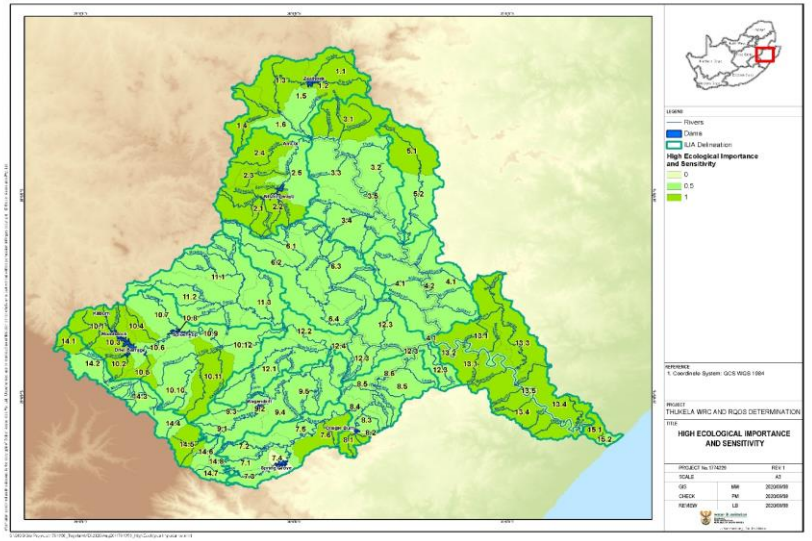
Ranking of Contribution to the economy



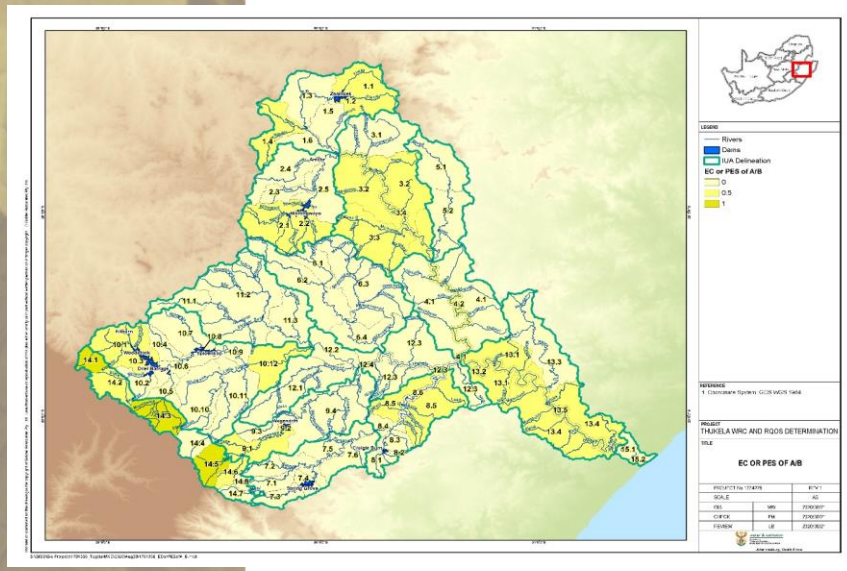
Ranking of Threat posed to users



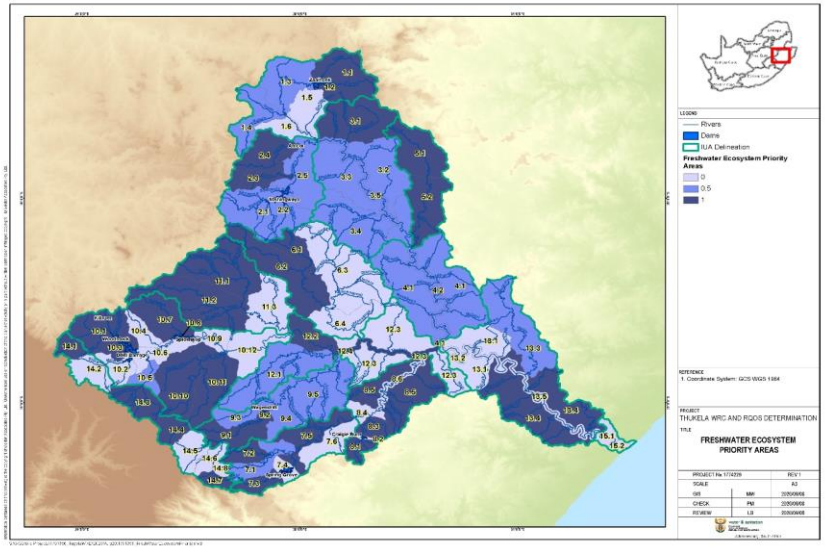
Ranking of High Ecological importance and Sensitivity



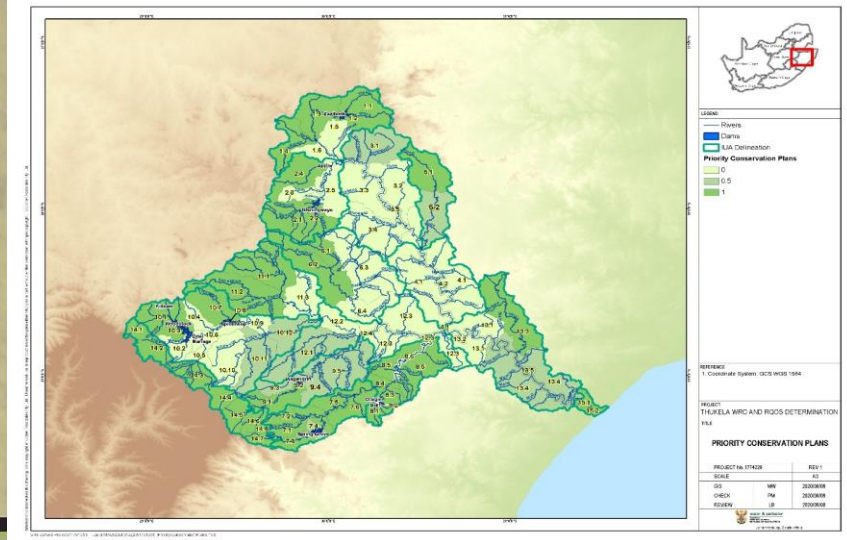
Ranking of EC or PES of A/B



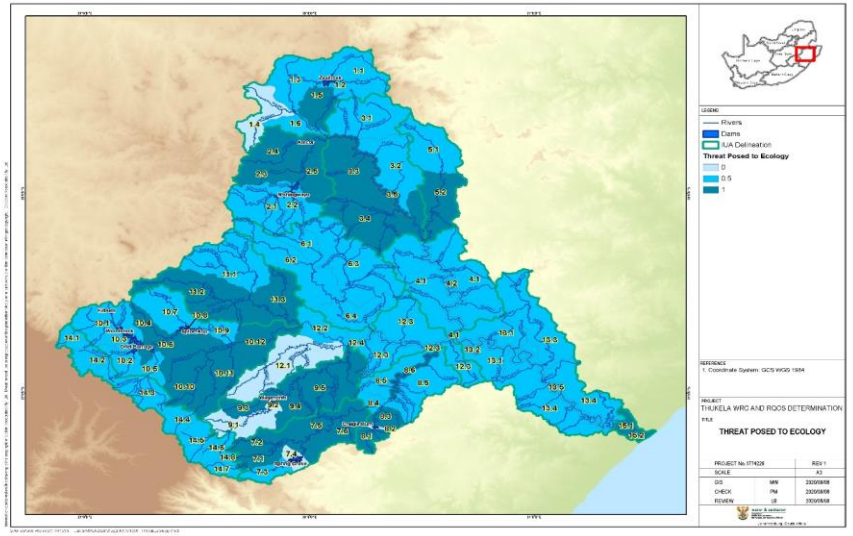
Ranking of Freshwater Ecosystem Priority Areas



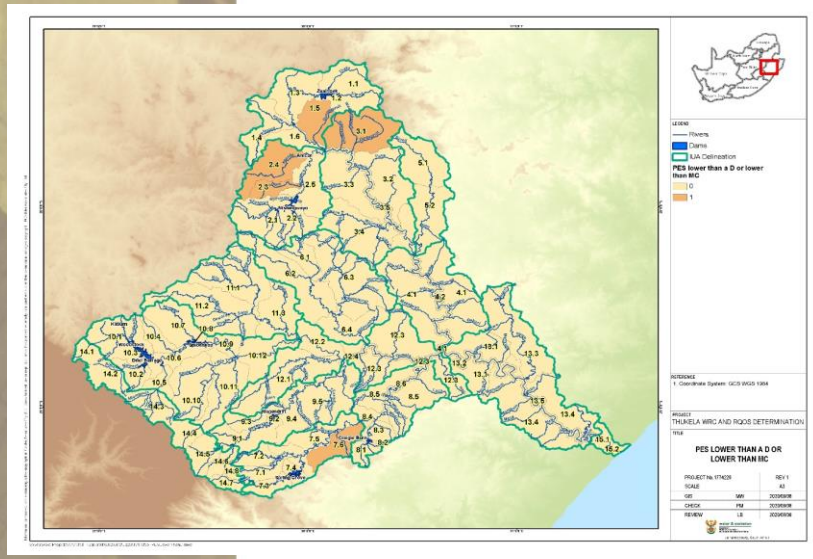
Ranking of Priority conservation plans



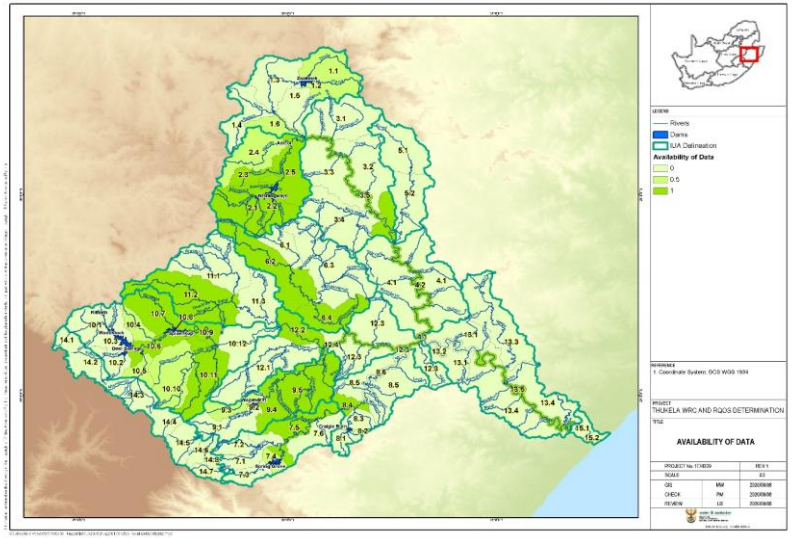
Ranking of Threat posed to ecology



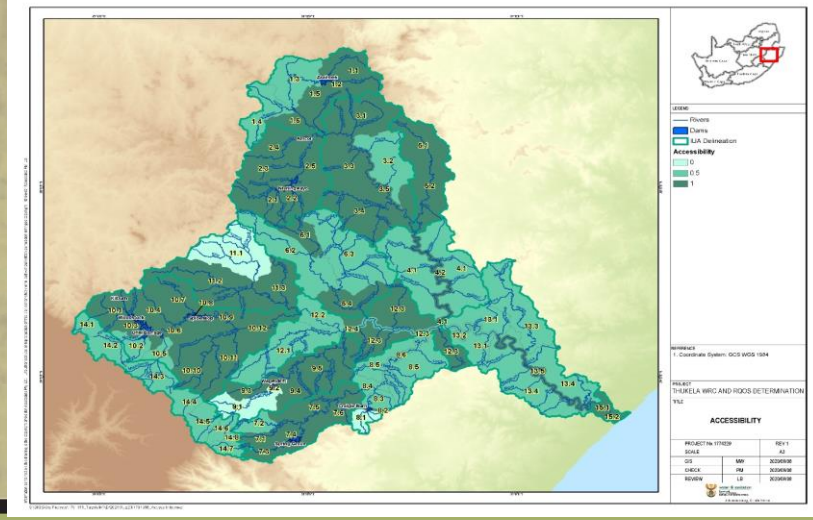
Ranking of PES lower than a D or lower than MC



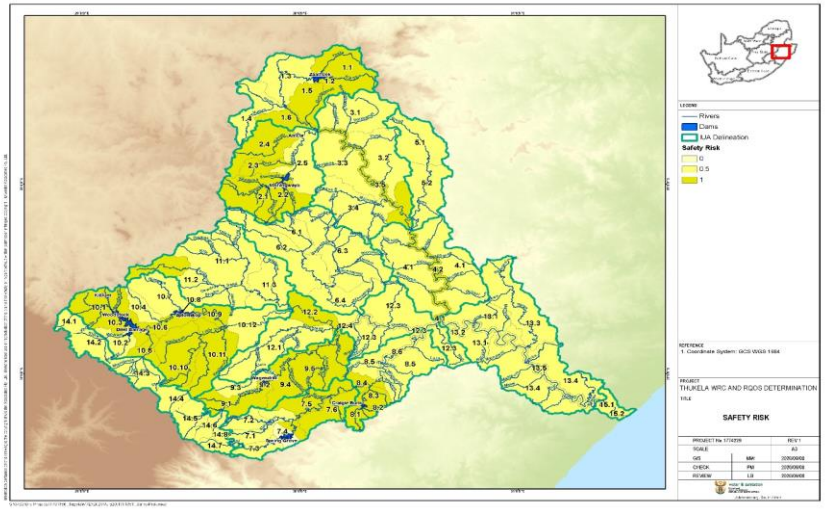
Ranking of Availability of data



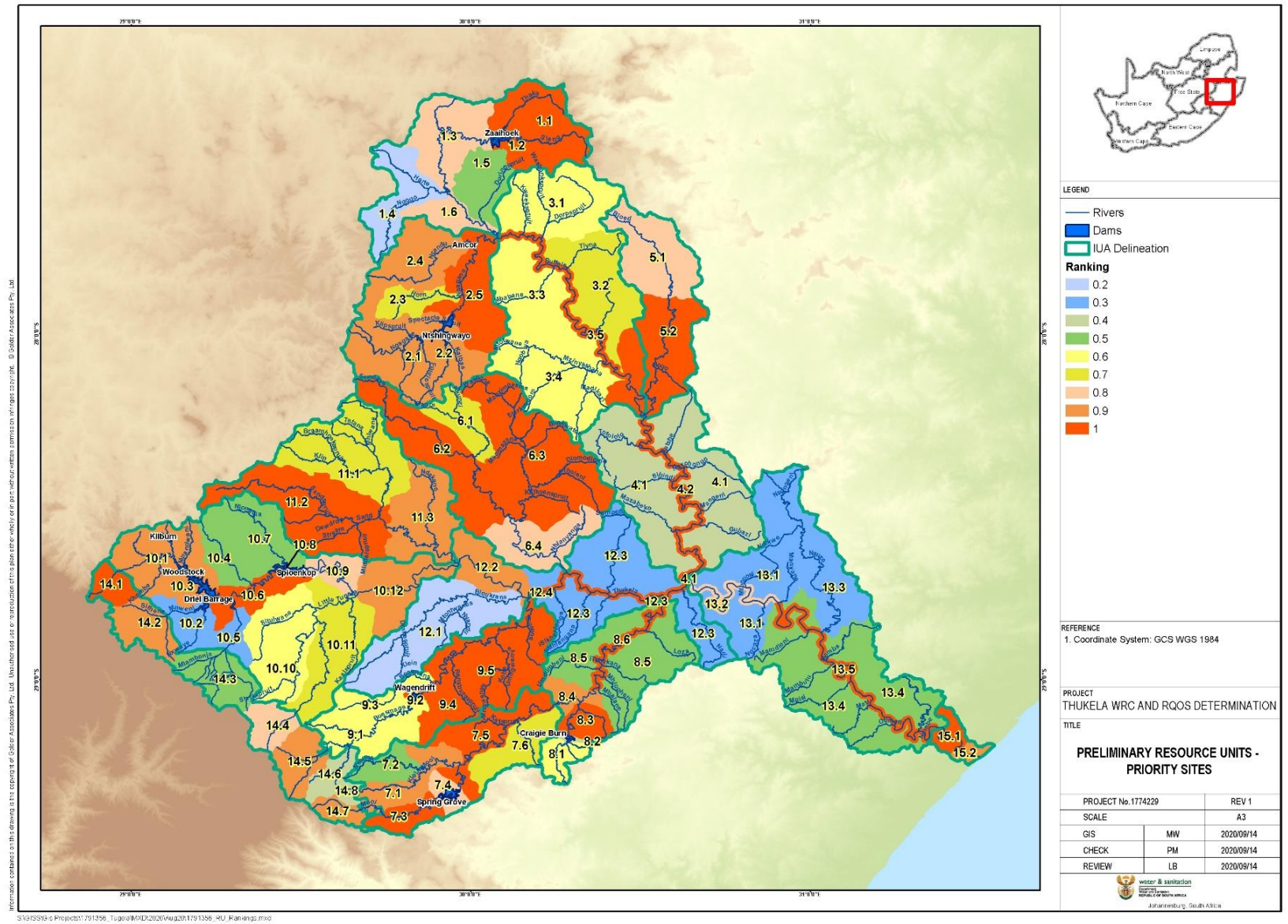
Ranking of Accessibility for monitoring



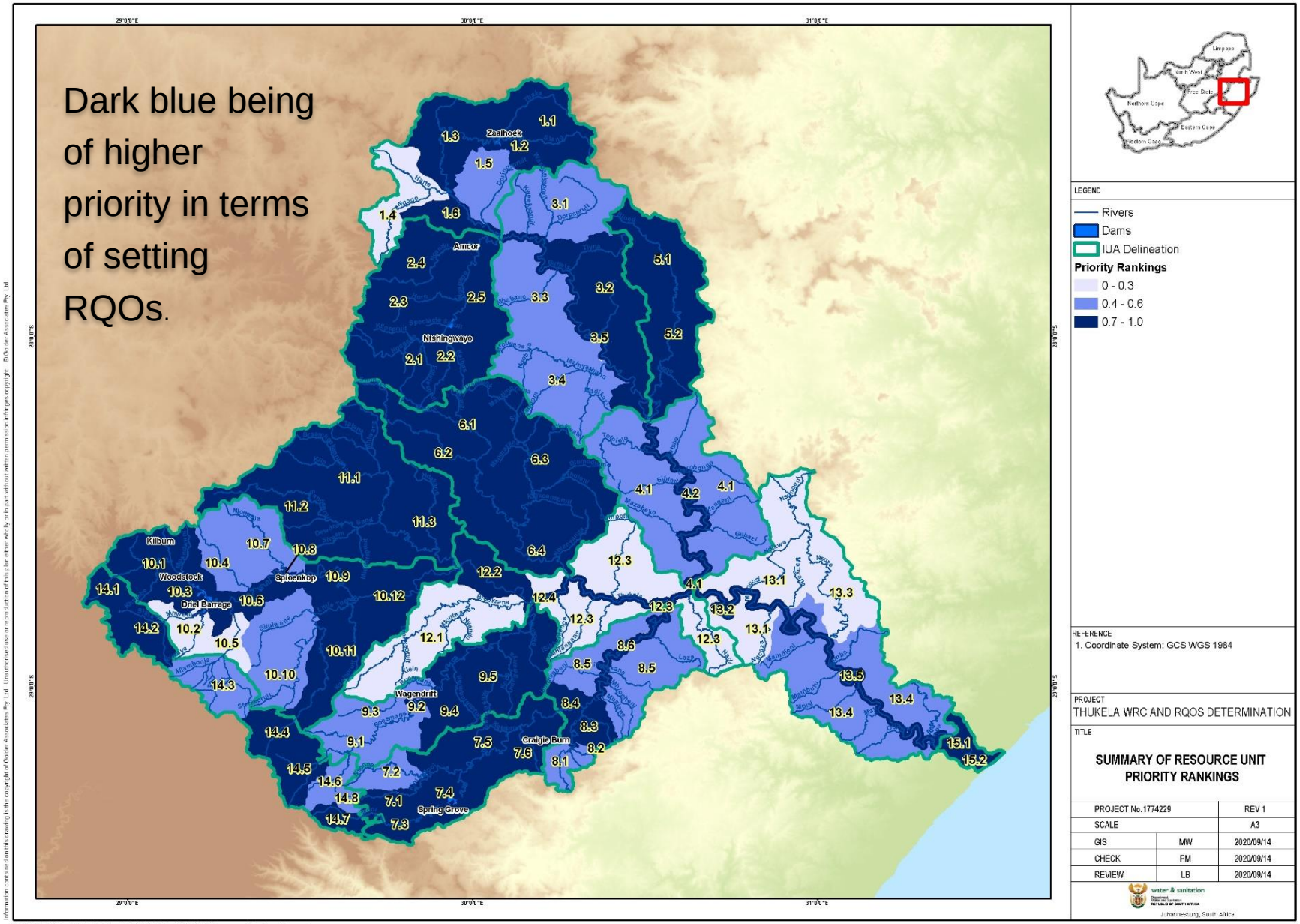
Ranking of Safety risk



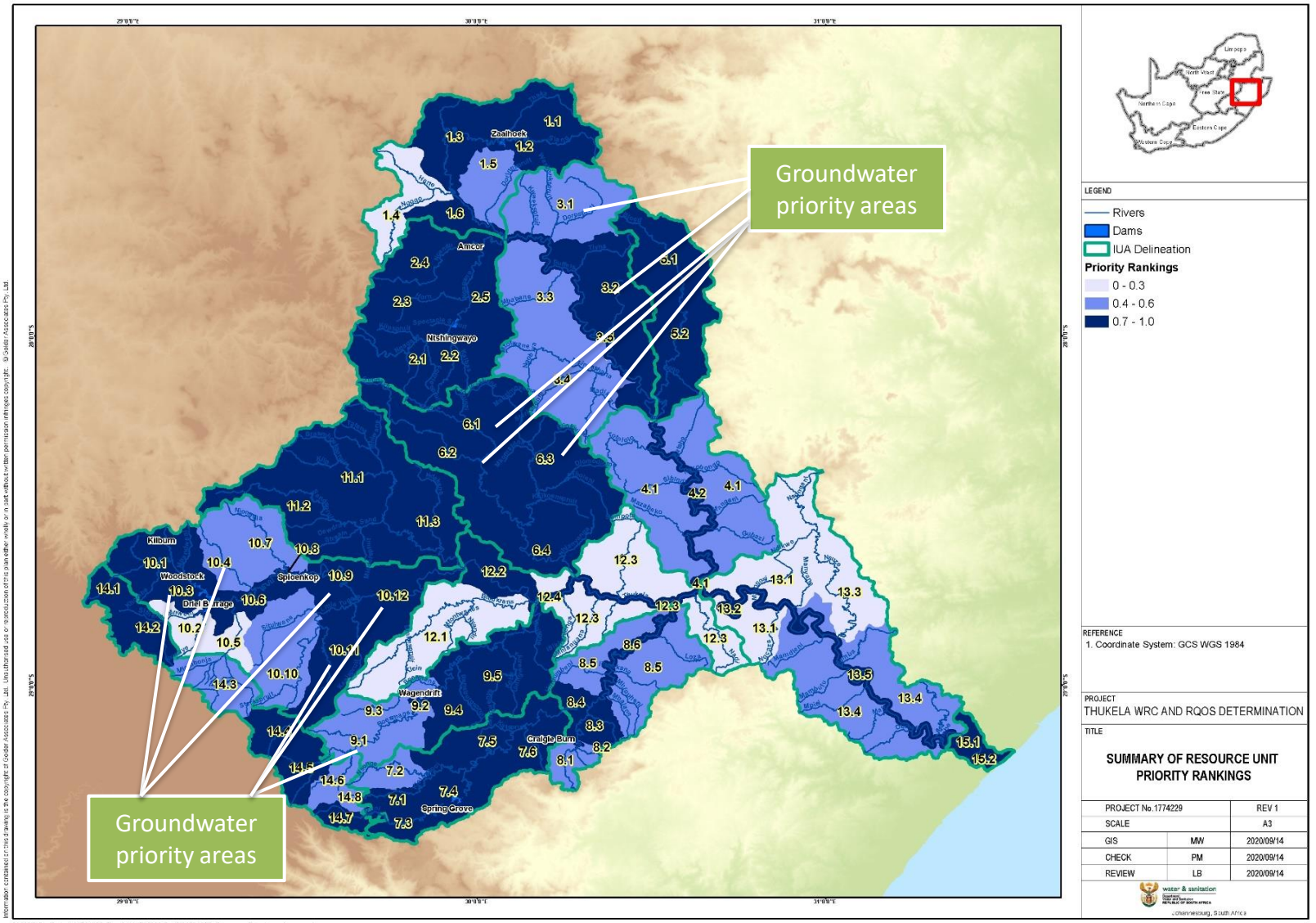
RU priority rankings



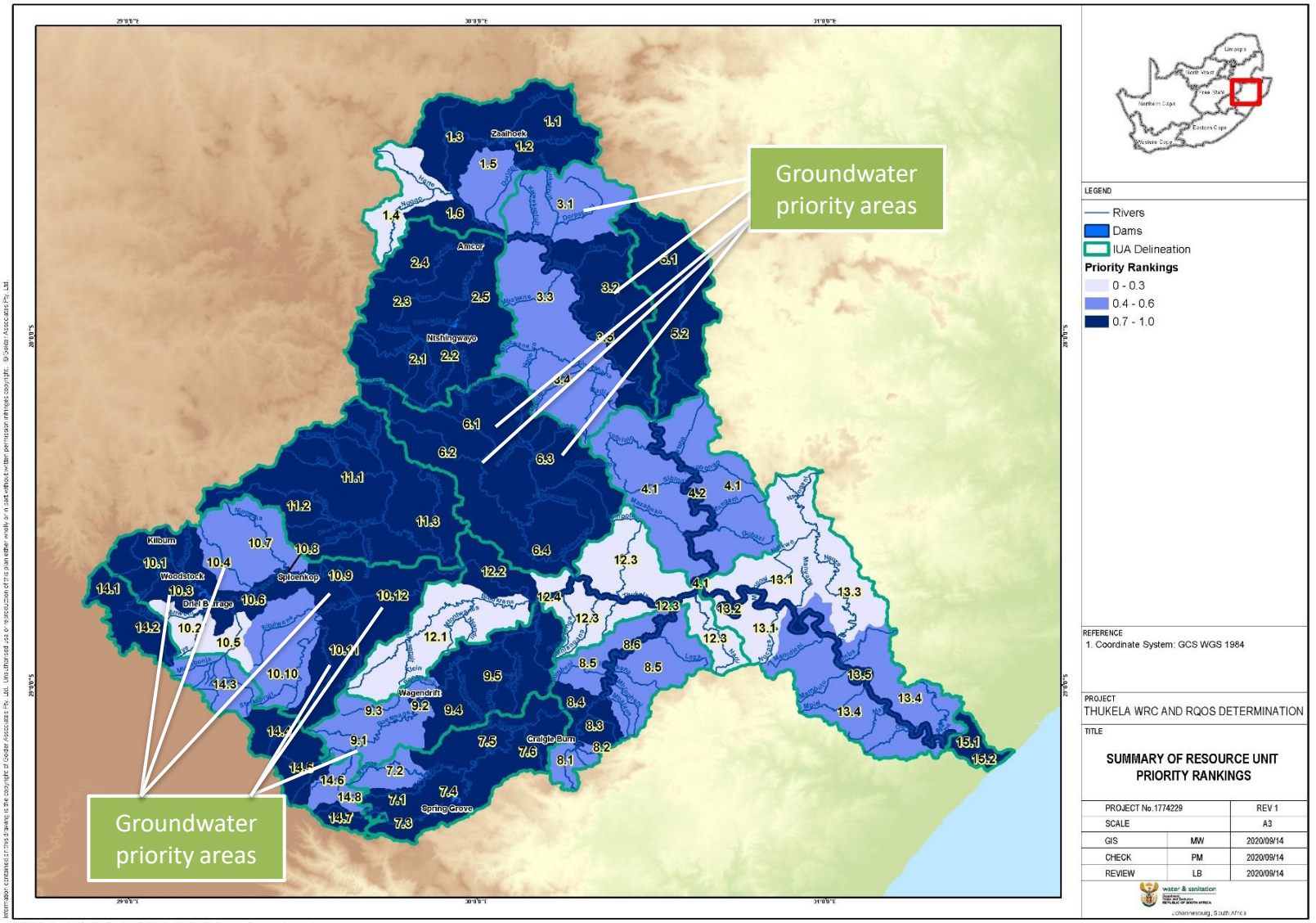
RU prioritisation



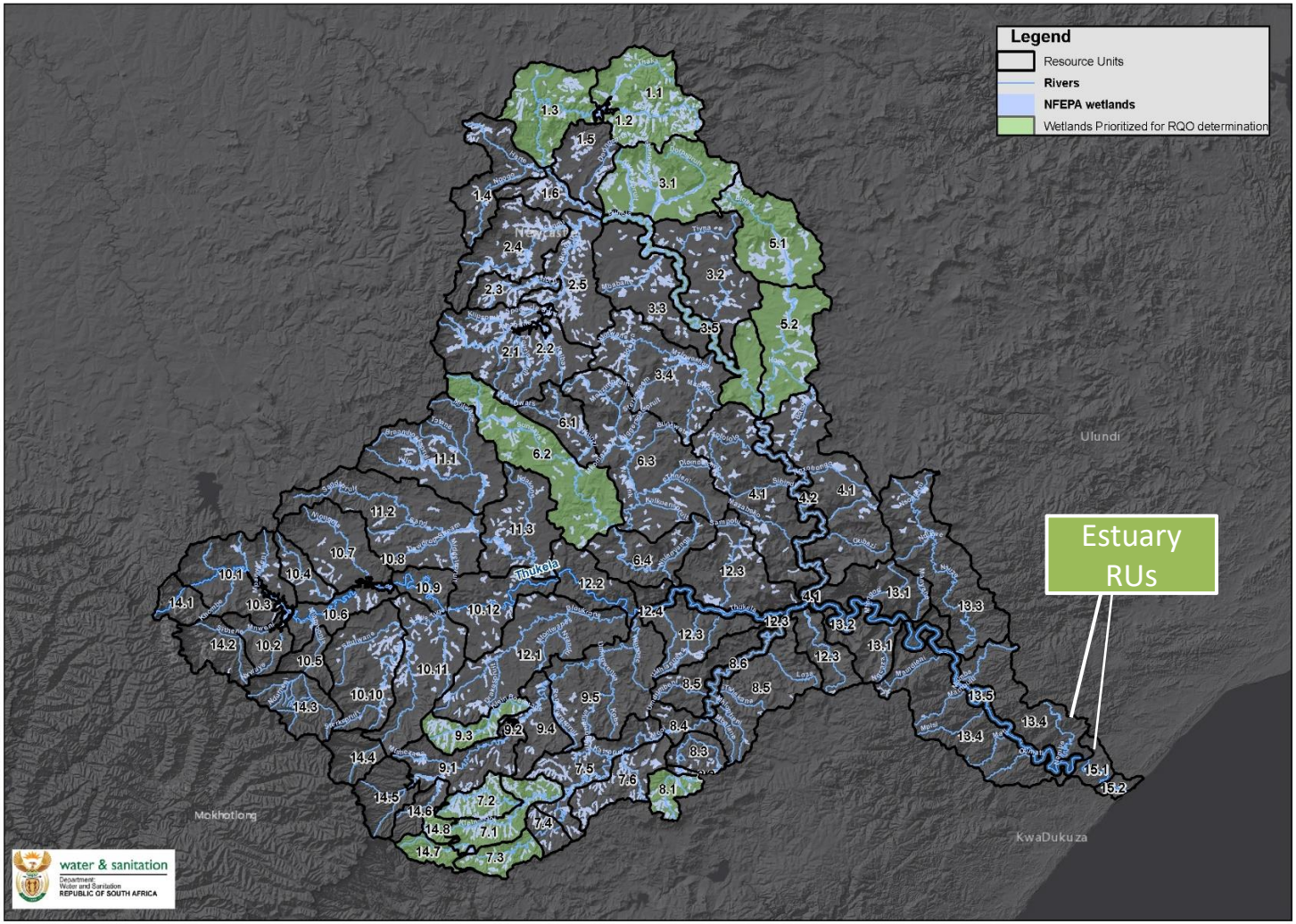
Groundwater prioritised areas



Prioritised Resource Units



Priority wetlands and Estuary



SUBCOMPONENTS PRIORITISATION AND INDICATORS SELECTION

In summary

- Seventy-five surface water resource RUs (rivers and wetlands) were delineated,
- Overall, 54 RUs have been prioritised,
- Six dam RUs have been delineated and prioritised,
- Groundwater priority RU areas were identified with areas of high stress index and aquifers of strategic importance identified in IUA 2, IUA 3, IUA 5, IUA 7, IUA 8, IUA 10, and IUA 11,
- Twelve wetland clusters have been prioritised in the catchment area, and
- The Estuary comprises two RUs, both prioritised.

Approach to the Prioritisation of Sub-components and Selection of Indicators

- Prioritise sub-components for RQO determination and select indicators for monitoring
- The five water resource components addressed for the Thukela catchments include rivers, dams, groundwater, wetlands, and estuary components.

Sub-components include:

- Quantity
  - Low Flows
  - High Flows
- Quality
  - Nutrients
  - Salts
  - Systems variables
  - Toxics
  - Pathogens
- Habitat
  - Instream habitat
  - Riparian habitat
- Biota
  - Fish
  - Aquatic and riparian plant species
  - Mammals
  - Birds
  - Amphibians and reptiles
  - Periphyton
  - Aquatic invertebrates
  - Diatoms

Wetlands sub-components

- Wetlands provide a range of services including flood attenuation, stream flow regulation, sediment trapping, erosion control and water quality enhancement services.
- Maintenance and enhancement of wetland functioning is therefore required to ensure that these key ecosystem services necessary to meet societal and environmental requirements are not undermined or lost at a catchment scale. Prioritisation of sub-components is based on no net loss' principles, conservation plans, wetland types (inferred functionality) and species targets; as well as being related to ecological specifications (protection, management, mitigation, and monitoring).
- The evaluation and prioritisation of the sub-components focused primarily on the availability of data.
- For all prioritised wetlands the sub-components Quality, Quantity and Habitat were selected for RQO development. Biota was included as a sub-component where available species data was available to support RQO development.

Groundwater sub-components

The following components will be assessed in identifying measurable sub-components and indicators for groundwater:

- Hydrogeological characteristics,
- Local aquifer conditions, such as interaction with wetlands and surface water sources, to specify distances between these areas and potential groundwater abstraction points (*i.e*. borehole/ well fields),
- Borehole yield classes were used to select high and low yielding aquifer systems within the demarcated groundwater units,
- Areas where high groundwater use occurs have been noted using the National Groundwater Resources Assessment Phase II information. These values were incorporated to define the potential balance between groundwater recharge and use (based on the stress factor) to obtain future groundwater level trends. The idea is to define an annual groundwater level recession value which can be used as a defined parameter for an aquifer's RQO status in terms of yield sustainability, and
- Groundwater quality.

- Quantity (abstraction),
- Aquifer water level,
- Water quality, and
- Protection zones

Estuary

For the estuary, the following sub-components and Indicators have been considered.

- **Quantity**
  - Low Flows
  - High Flows (Floods)
- **Hydrodynamics**
  - Mouth Condition
  - Abiotic states
- **Quality**
  - Salinity
  - Dissolved inorganic nitrogen
  - Dissolved inorganic phosphate
  - Water clarity
  - Dissolved oxygen
  - Toxic substances
  - Pathogens
- **Physical Habitat**
  - Intertidal
  - Subtidal
  - Substrate type
- **Biota**
  - Microalgae
  - Macrophytes
  - Invertebrates
  - Fish
  - Birds

Rivers and dams components

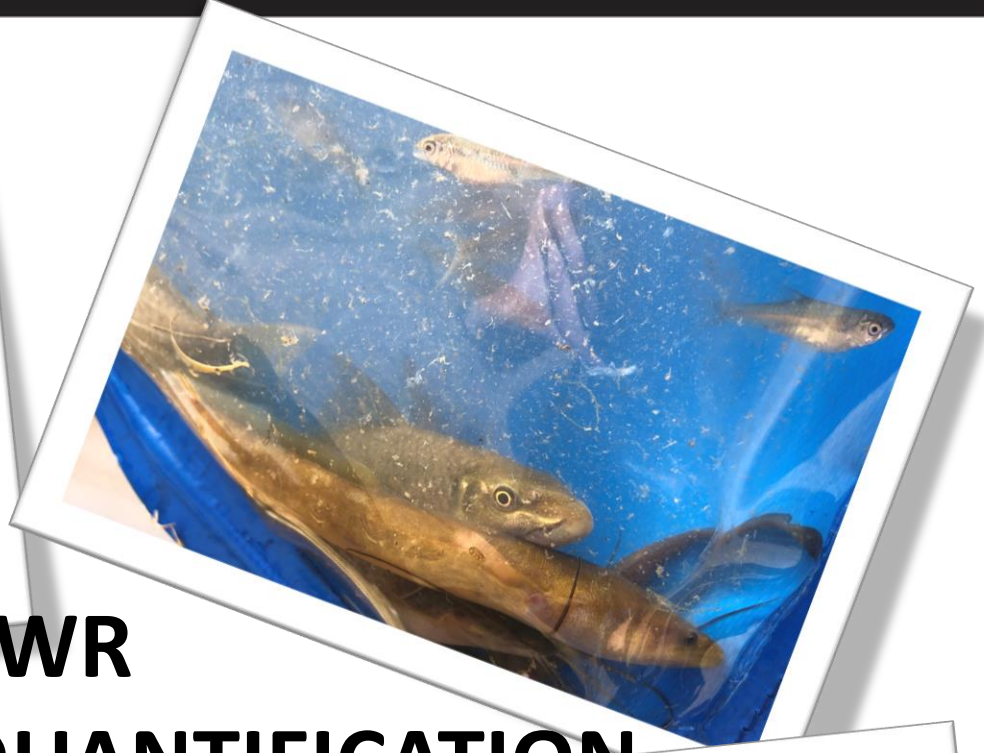
The four aspects that were assessed/evaluated per RU include:

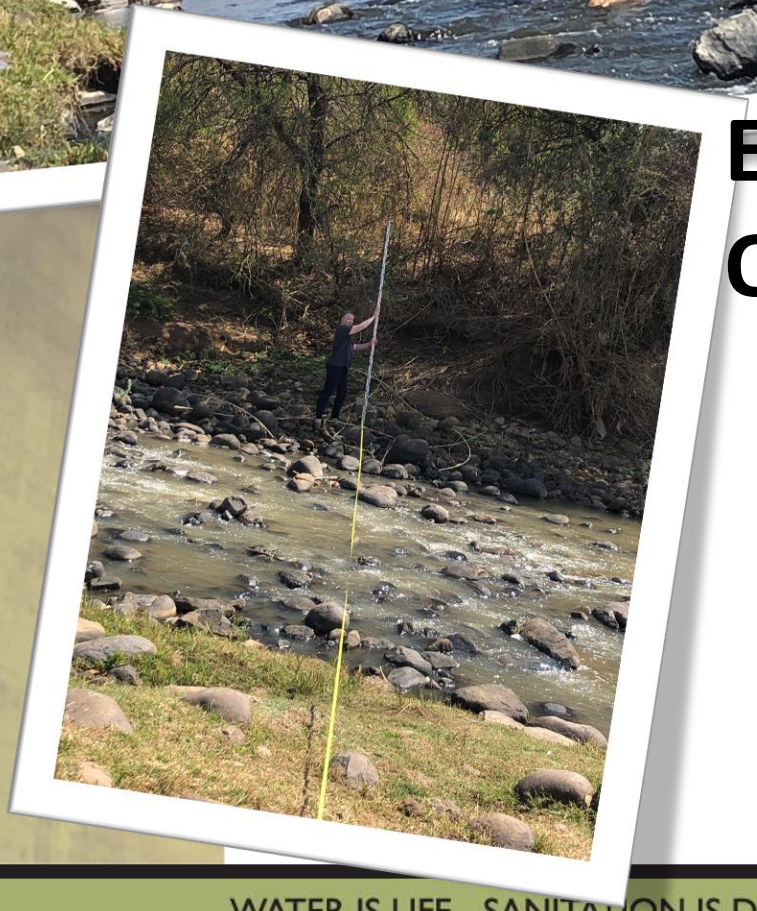
- Identification and assessment of the impact of current and anticipated future use on water resource components,
- Identification of requirements of important user groups,
- Selection of sub-components for RQO determination, and
- Establishment of the desired direction of change for selected sub-components

Example of using the sub-components prioritisation tool

Consolidation of the results

Resource Unit	Sub-component	User specification	Ecological specification	Integrated Measure	Rationale	Indicator	Key impacts identified	Sub-component prioritised	Protection required
1.1 Wetland resource unit: Wakkerstroom	Low flows			✓	A flow measurement in the river will provide an indication if the required maintenance flows are being met.	Base flows	PES B Potential Groenvlei Agri-village within the wetland areas leading to return flows and agricultural pollution. Unmanaged grazing leading to erosion. Sewage works within wetland areas discharging poor quality effluent.	Quantity, Quality, Habitat, Biota	Wetlands protection to support birdlife and assist with flood protection.
	High flows (floods)								
	Nutrients			✓	These variables are indicators of nutrient enrichment of water resources (N:P ratios).	Phosphates, Nitrate			
	Salts	✓			These variables will give a fitness for use for users.	Total Dissolved Solids			
	Pathogens								
	System Variables								
	Toxics								
	Fish		✓		Provides an assessment index of the reference fish assemblage and the indication of the response of the constituent species of the assemblage.	FRAI			
	Instream		✓		Indicator of ecological integrity.	Index of Habitat Integrity (IHI) Rapid Habitat Assessment Method (RHAM).			
	Riparian habitat		✓		Indicator of ecological integrity.	Index of Habitat Integrity (IHI), Vegetation Response Assessment Index (VEGRAI).			
	Aquatic riparian plant species		✓		Indicator of ecological integrity.	Index of wetland vegetation			
	Mammals								
	Birds		✓		The suitability of this catchment area of river and wetlands for aquatic bird populations must be maintained.	Indicator bird species and population.			
	Amphibians/Reptiles								
	Periphyton								
	Aquatic invertebrates		✓		The MIRAI is an assessment index of the reference invertebrate's assemblage and the response of the constituent species of the assemblage	Macroinvertebrate Response Assessment Index (MIRAI)			
	Diatoms			✓	Integrated indicator of pollution	SPI			





EWR QUANTIFICATION

Quantification of Ecological Water Requirements (EWR) Report

- Describes the approaches, methods and models used to determine the EWR for priority rivers in the Thukela catchment at selected sites.
- Various levels of detail as described in volume 3 of the RDM methodology of 1999 (DWAF, 1999).
- Where available and applicable, information from previous Reserve studies was utilised and updated with new information from field surveys undertaken during September 2020.

Comprehensive/ Intermediate	Rapid 3	Rapid 2	Rapid 1	Desktop
Dry and post-wet season surveys Hydraulics Fish Macroinvertebrates Riparian vegetation Geomorphology Hydrology Water quality	Dry season survey Hydraulics Fish Macroinvertebrates Rapid Habitat Integrity Assessment Hydrology Water quality	Dry season survey Discharge only Fish Macroinvertebrates Rapid Habitat Integrity Assessment Hydrology Water quality	Dry season survey Fish Macroinvertebrates Rapid Habitat Integrity Assessment	No surveys Desktop PES/EI/ES results Hydrology

Approach

(i) New rapid 1, 2 and 3 assessments (surveys in September 2020) included the following:

- Information collected during the field surveys (Hydraulics, Fish, Macroinvertebrates, Rapid Habitat Integrity Assessment Hydrology and water quality),
- Results from the Eco-classification process (Present Ecological State (PES), Ecological Importance (EI), Ecological Sensitivity (ES) and Recommended Ecological Category (REC),
- Desktop Reserve Model (DRM) within SPATSIM for the integration of data produced from the surveys and Eco-classification to quantify the EWRs,
- Results from the hydraulic modelling (cross-sectional profile and discharge) to evaluate the DRM requirements, and
- Evaluation of the water quality at specific selected sites where quality was identified as an issue.

(ii) Revisit of existing EWR sites from previous studies (mainly 2003 comprehensive sites). The surveys at these sites were undertaken to assess the PES due to increased or proposed new water uses in the upper catchments, e.g. Mooi River with the Spring Grove Dam that was constructed after the 2003 study.

(iii) River reaches where no existing EWR sites are present (e.g. Upper Thukela after Thukela and Little Thukela confluence, Blood River IUA). These have been undertaken on a desktop level, using the Desktop PES/EI/ES results as no additional information was available.

(iv) IUA14 has been defined as the Escarpment IUA with most of the river reaches in protected areas. The EWR for these have been undertaken on a desktop level, using the Desktop PES/EI/ES results as no additional information was available.

(v) Extrapolation to the outlets of IUAs where the existing EWR sites are not at the outlet. The information from the lowest EWR site in the IUA has been used for the extrapolation.

(vi) The results from all the other existing EWR sites where no additional information was obtained have been accepted as is and the adjustments were made where the hydrology used in this study differed significantly.

EWR sites per IUA

IUA	Existing/ new	River	Quaternary	Level
1	THU_EWR23	Upper Buffalo	V31D	Rapid 3
2	May13_EWR2	Horn	V31F	Rapid 3
	THU_EWR19	Ncandu	V31J	Rapid 3
	May13_EWR3	Ngagane	V31K	Rapid 3
	Ngagane_dsk	Lower Ngagane	V31K	Desktop
3	THU_EWR13A	Middle Buffalo	V32F	Rapid 2
	Thukela_EWR13	Middle Buffalo	V32H	Comprehensive
4	Thukela_EWR14	Lower Buffalo	V33B	Comprehensive
5	Blood_dsk	Blood	V32H	Desktop
6	THU_EWR7A	Upper Sundays	V60B	Rapid 2
	Thukela_EWR7	Upper Sundays	V60C	Comprehensive
	Thukela_EWR8	Lower Sundays	V60F	Comprehensive
7	THU_EWR20	Nsonge/ Hlatikulu	V20C	Rapid 3
	EWR_Mooi_N3	Mooi	V20E	Rapid 3
	Thukela_EWR11	Mooi	V20G	Comprehensive
8	THU_EWR21	Mnyamvubu	V20G	Rapid 2
	THU_EWR12A	Mooi	V20H	Rapid 3
	Thukela_EWR12	Mooi	V20H	Comprehensive
	Mooi_dsk	Mooi	V20J	Desktop
9	Thukela_EWR5	Middle Bushmans	V70F	Comprehensive
	THU_EWR6A	Lower Bushmans	V70G	Rapid 3
	Thukela_EWR6	Lower Bushmans	V70G	Comprehensive
10	Thukela_EWR1	Upper Thukela	V11J	Comprehensive
	Thukela_EWR2	Upper Thukela	V11M	Comprehensive
	Thukela_EWR3	Little Thukela	V13E	Comprehensive
	Thukela1_dsk	Thukela	V14B	Desktop
11	THU_EWR22	Klip	V12A	Rapid 3
	Klip_dsk	Klip	V12G	Desktop
12	Thukela_EWR4A	Middle Thukela	V14E	Comprehensive
	Thukela_EWR4B	Middle Thukela	V14E	Comprehensive
	THU_EWR4C	Middle Thukela	V14E	Rapid 1
	Thukela_EWR9	Middle Thukela	V60J	Comprehensive
	Thukela2_dsk	Middle Thukela	V60K	Desktop
13	Thukela_EWR15	Lower Thukela	V40B	Comprehensive
	THU_EWR16	Lower Thukela	V50C	Intermediate
14	V11A_dsk	Thukela	V11A	Desktop
	V11B_dsk	Mnweni	V11B	Desktop
	V11G_dsk	Mlambonja	V11G	Desktop
	V13A_dsk	Little Thukela	V13A	Desktop
	V70A_dsk	Bushmans	V70A	Desktop
	V70B_dsk	Nsibidwana	V70B	Desktop
	V20A_dsk	Mooi	V20A	Desktop
	V20B_dsk	Little Mooi	V20B	Desktop
15	THU_EWR17	Lower Thukela	V50D	Intermediate

Proposed Target Ecological Categories (TEC) at each site were defined for the scenario analysis and determination of ecological consequences, taking into account the system requirements (dam release capacities, user requirements and yields of dams) at each of the EWR sites

DATA COLLECTION AND MODELLING

EWR site evaluation

Rapid 3:

- THU_EWR23: Upper Buffalo (V31D)
- THU_EWR19: Ncandu River (V31J)
- THU_EWR20: Nsonge River (V20C)
- THU_EWR22: Klip River (V12A)
- THU_EWR12A: Mooi River (V20H)
- THU_EWR6A: Lower Bushmans River (V70G)

Rapid 2:

- THU_EWR21: Mnyamvubu River (V20G) THU_EWR13A: Middle Buffalo River (V32D)
- THU_EWR7A: Upper Sundays River (V60B)

Rapid 1:

- THU_EWR4C: Middle Thukela (V14E)

Component	Confidence Score*	Advantages	Disadvantages
THU_EWR23: Upper Buffalo in V31D (Rapid 3)			
Hydraulics	2	Easily accessible, section is fairly straight.	Weir structure upstream of section. Higher flows experienced.
Fish	3	Possible biotope representivity under normal low flow conditions	Poor biotope presence lower diversity – only 3 of 8 expected species, tolerant spp. present.
Macro-nvertebrates	3	All three biotopes present (SIC/SOOC, marginal VEG and GSM) Two sensitive taxa recorded during present conditions for aquatic macroinvertebrates included *Baetidae* > 2 sp (QV:12) and *Heptageniidae* (Flatheaded mayflies) (QV:13). Overall IHAS score (70%) representing Good habitat availability for aquatic macroinvertebrates. Number of taxa: 22 Total SASS5 Score: 120	The flow conditions and water levels were not representative for the dry season owing to potential discharges upstream. High algae present smothering habitats and transforming a potential good SIC/SOOC biotope into a homogenous habitat that supports far less biota. ASPT score of 5.5 overall representing a community of tolerant taxa.

Hydraulics

- EWR cross section was selected,
- A survey of the cross-sectional profile of the EWR site was carried out,
- Longitudinal water slope was surveyed,
- Discharge was measured,
- GPS co-ordinates of the site were captured, and
- EWR site photographs were taken.
- Modelling was carried out using the measured data, as well as two modelled points to develop stage discharge curves. The following data is required for the modelling: y (maximum flow depth), n (resistance coefficient), S (slope), Q (discharge), A (area) and WP (wetted perimeter).

EWR site	River	Discharge Q (m^3/s)	Maximum flow depth (m)	Manning's resistance, *n*	Surface Slope, S m/m)	Ave. Velocity, V (m/s)
THU_EWR23	Upper Buffalo	1.240	0.580	0.324	0.045	0.272
THU_EWR19	Ncandu	0.083	0.175	0.243	0.028	0.134
THU_EWR20	Nsonge	0.085	0.120	0.227	0.007	0.090
THU_EWR22	Klip	0.089	0.245	0.297	0.011	0.073
THU_EWR12A	Mooi	0.189	0.190	0.409	0.023	0.108
THU_EWR6A	Bushmans	0.189	0.385	0.262	0.004	0.057

Depth/discharge relationship: $y = aQ^b + c$

Fish

Some of the benefits of using fish as ecological indicators include:

- fish are well known and easily related to by people;
- the requirements and responses of fishes to changes in the state of environmental variables is also well documented, and used in a range of measures or indices that can be applied to manage the ecosystems in which they live;
- fish are relatively easy to sample and identify in the field; and
- sampling for fish is relatively inexpensive and can be undertaken fairly rapidly.

Fish surveys were undertaken at selected EWR sites. Electro-narcosis (conducting an electric current into the water, which immobilises the fish momentarily) was applied using an electro-fishing apparatus to sample all the available fish biotopes (i.e. the combinations of velocity-depth classes and available cover types).

Fish species are categorised in the FRAI model according to an **intolerance rating that take trophic preferences and specialisation into account, as well as all the flow, habitat, and water quality requirements**.
The ratings are then formulated into a relative FRAI index value, which is grouped into one of six descriptive fish assemblage integrity index classes.

Macroinvertebrates and IHI

- Macroinvertebrate diversity and abundances were measured using the South African Scoring System Version 5 (SASS5) - measures aquatic macroinvertebrate presence data at a family taxon level. Each taxon is allocated a sensitivity value between 1 and 15 according to its perceived sensitivity to water quality changes (with 1 being the least sensitive and 15 the most sensitive)

- Historical data (from the River Health Sites and PES/EI/ES databases and other data sources) and specialist knowledge were used to determine reference conditions.

- DWS Macroinvertebrate Response Assessment Index (MIRAI) uses SASS5 and pre-determined reference condition data to determine the macroinvertebrate Ecological Condition of a site.

- Integrated Habitat Integrity assessment (IHI): a rapid habitat integrity assessment was undertaken at each of the selected EWR sites - is used as a surrogate during a rapid study when a riparian vegetation assessment is not undertaken. The habitat integrity assessments were conducted using the procedure described by Kleynhans, 1996 and the latest IHI DWS model. The habitat integrity was evaluated taking flow related impacts of the upstream catchment into account.

Hydrological data

IUA	EWR site name	River	Quaternary catchment	Natural MAR (10^6m^3)
1	THU_EWR23*	Upper Buffalo	V31D	221.96
2	May13_EWR2	Horn	V31F	21.61
	THU_EWR19*	Ncandu	V31J	50.83
	May13_EWR3	Ngagane	V31K	160.12
	Ngagane_dsk	Lower Ngagane	V31K	240.84
3	THU_EWR13A	Middle Buffalo	V32F	626.68
	Thukela_EWR13	Middle Buffalo	V32H	695.05
4	Thukela_EWR14	Lower Buffalo	V33B	831.09
5	Blood_dsk	Blood	V32H	94.71
6	THU_EWR7A	Upper Sundays	V60B	50.69
	Thukela_EWR7	Upper Sundays	V60C	90.28
	Thukela_EWR8	Lower Sundays	V60F	197.03
7	THU_EWR20*	Nsonge/ Hlatikulu	V20C	27.13
	EWR_Mooi_N3	Mooi	V20E	265.81
	Thukela_EWR11	Mooi	V20G	301.14
8	THU_EWR21	Mnyamvubu	V20G	31.71
	THU_EWR12A*	Mooi	V20H	361.85
	Mooi_dsk	Mooi	V20J	388.66
9	Thukela_EWR5	Middle Bushmans	V70F	281.45
	THU_EWR6A*	Lower Bushmans	V70G	298.37
	Thukela_EWR6	Lower Bushmans	V70G	303.14
10	Thukela_EWR1	Upper Thukela	V11J	705.42
	Thukela_EWR2	Upper Thukela	V11M	798.40
	Thukela_EWR3	Little Thukela	V13E	285.20
	Thukela1_dsk	Thukela	V14B	1145.20
11	THU_EWR22*	Klip	V12A	52.44
	Klip_dsk	Klip	V12G	253.09
12	Thukela_EWR4A, B, C	Middle Thukela	V14E	1423.83
	Thukela_EWR9	Middle Thukela	V60J	2050.76
	Thukela2_dsk	Middle Thukela	V60K	2461.22
13	Thukela_EWR15	Lower Thukela	V40B	3424.00
	THU_EWR16	Lower Thukela	V50C	3679.97
14	V11A_dsk	Thukela	V11A	66.90
	V11B_dsk	Sithene, Thonyelana	V11B	142.69
	V11G_dsk	Mlambonja, Mhlwazini	V11G	191.99
	V13A_dsk	Little Thukela	V13A	82.32
	V70A_dsk	Bushmans	V70A	113.46
	V70B_dsk	Nsibidwana	V70B	44.16
	V20A_dsk	Mooi	V20A	42.90
	V20B_dsk	Little Mooi	V20B	10.32
15	THU_EWR17	Lower Thukela	V50D	3690.53

- The natural hydrology at all the EWR sites were obtained from the WRPM model and is based on a number of studies undertaken for the major tributaries of the Thukela River (included in the Status Quo report)
- The natural flow time series obtained from these studies for the period 1925 to 1994 were used and adjusted by catchment area to obtain the natural flows at the EWR sites.

Quantification of EWRs

Ecoclassification includes:

(i) Definition of the reference conditions,

(ii) Determination of the present ecological state (Ecostatus model for each component and integrated),

(iii) Verification of the desktop Ecological Sensitivity and Ecological Integrity with actual surveyed data,

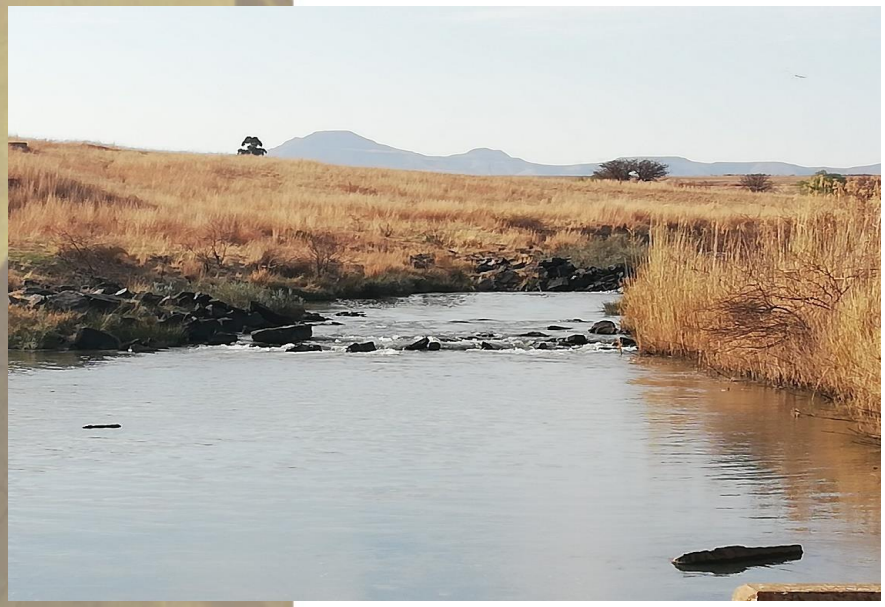
(iv) Determination of the trends, and

(v) Integration of all of the above to determine the REC and TEC.

The quantification of the EWRs used the Desktop Reserve Model (DRM) (SPATSIM, version 2.12) to calculate the Ecological Water Requirements (quantity) for the PES and TEC at the EWR sites.

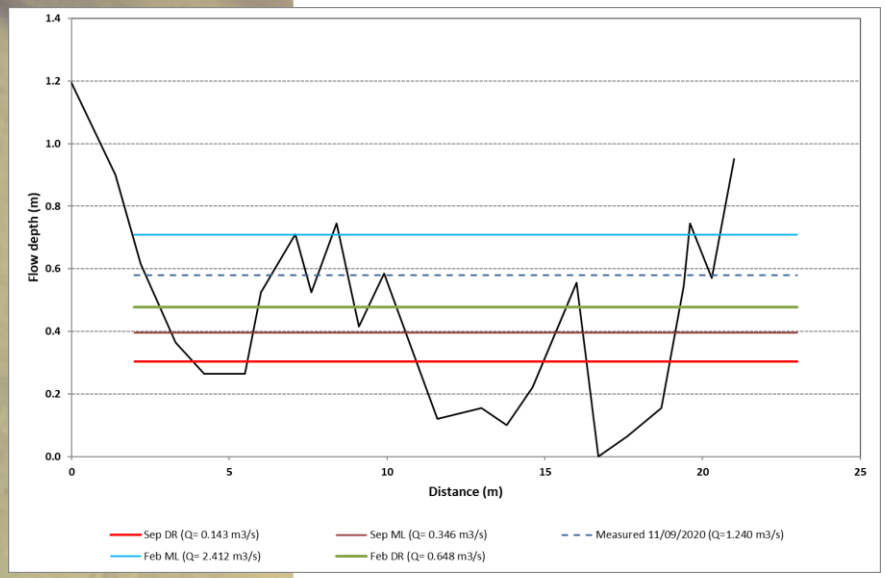
EWR RESULTS

THU_EWR23: Upper Buffalo River in V31D



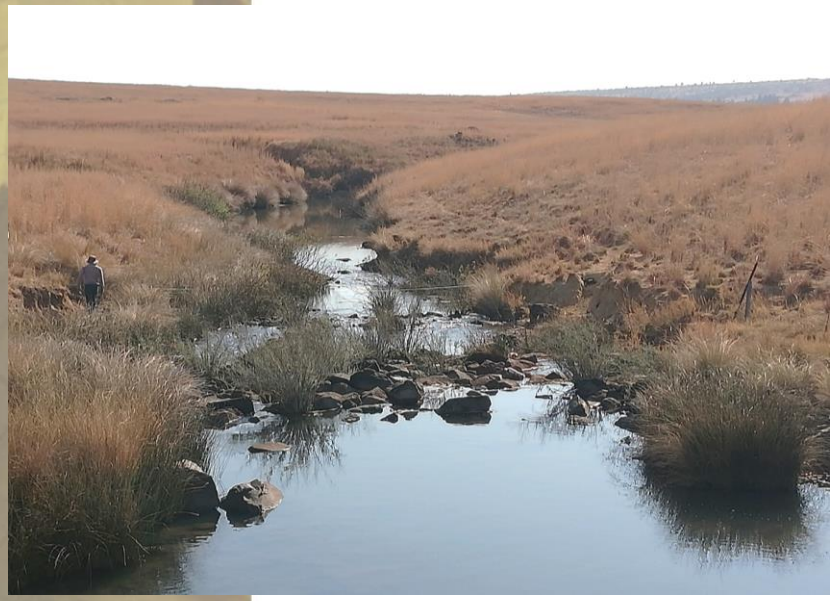
Component	PES	Importance	REC	Trend	TEC
Fish	C	EI = High ES = High		Negative	Rationale: Releases are governed by operating rule for Zaaihoek Dam. Reach has constant unnatural high flow. Present status to be maintained.
Macroinvertebrates	C			Stable	
HI: Instream	D			Stable	
HI: Riparian	B			Stable	
ECOSTATUS	C	High	C		C

The final step is the quantification of the EWR and includes the conversion of the EWR flow data for a TEC of a C category to hydraulic conditions at the EWR site (i.e. depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. The maintenance and drought flows were examined for August and February. August is the month with the lowest maintenance flow *(i.e.* base-flow) and February is the month with the highest maintenance flow conditions.



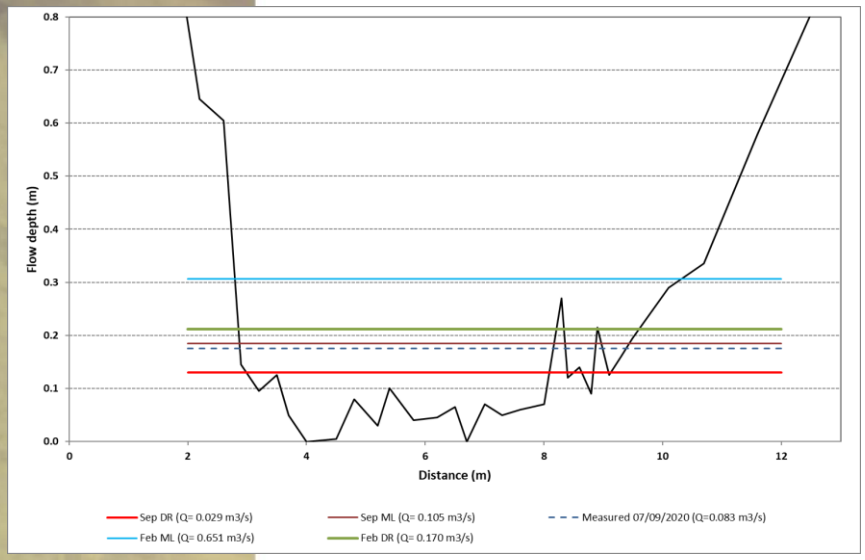
Quaternary Catchment	V31D
River	Upper Buffalo
EWR Site Co-ordinates	-27.6221; 29.9617
Present Ecological State	C
Target Ecological Category	C
NMAR at EWR site	221.96
Total EWR	52.033 (23.44 %MAR)
Maintenance Low flows	33.134 (14.93 %MAR)
Drought Low flows	8.559 (3.86 %MAR)
Maintenance High flows	18.900 (8.51 %MAR)
Overall confidence	Low to medium

THU_EWR19: Ncandu River in V31J



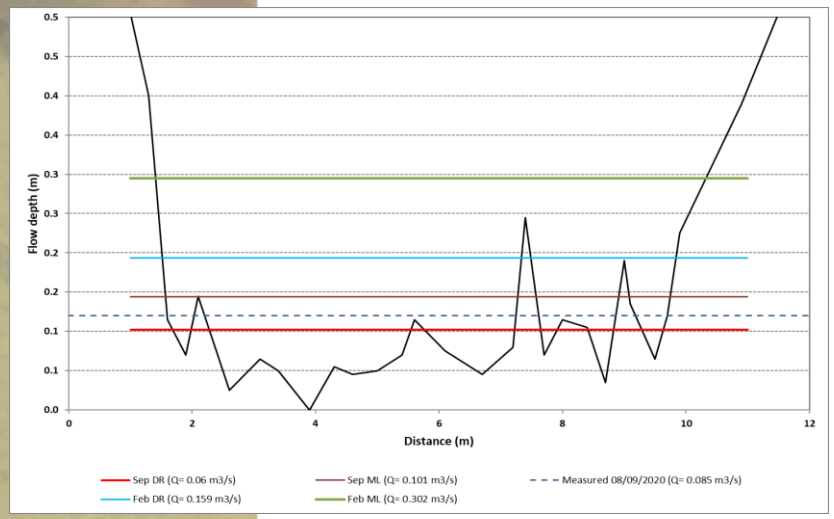
Component	PES	Importance	REC	Trend	TEC
Fish	C/D	EI = ES = Very High		Stable	Rationale: Improvement in PES can be achieved by management of upstream land use practices. Impacts are non-flow are water driven.
Macroinvertebrates	B/C			Stable	
HI: Instream	B			Stable	
HI: Riparian	B			Stable	
ECOSTATUS	**C**	Very High	B		B/C

The final step is the quantification of the EWR and include the conversion of the EWR flow data for a TEC of a B/C category to hydraulic conditions at the EWR site (i.e. depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. The maintenance and drought flows were examined for July and February. July is the month with the lowest maintenance flow (*i.e.* base-flow) and February is the month with the highest maintenance flow conditions.



Quaternary Catchment	V31J	
River	Ncandu	
EWR Site Co-ordinates	-27.8017; 29.8840	
NMAR at EWR site	50.83	
Ecological Category	PES=C	TEC=B/C
Total EWR	11.820 (23.25 %MAR)	14.926 (29.36 %MAR)
Maintenance Low flows	6.326 (12.45 %MAR)	8.782 (17.28 %MAR)
Drought Low flows	2.007 (3.95 %MAR)	2.007 (3.95 %MAR)
Maintenance High flows	5.494 (10.81 %MAR)	6.144 (12.09 %MAR)
Overall confidence	Low to medium	

THU_EWR20: Nsonge (Hlatikulu) River in V20C

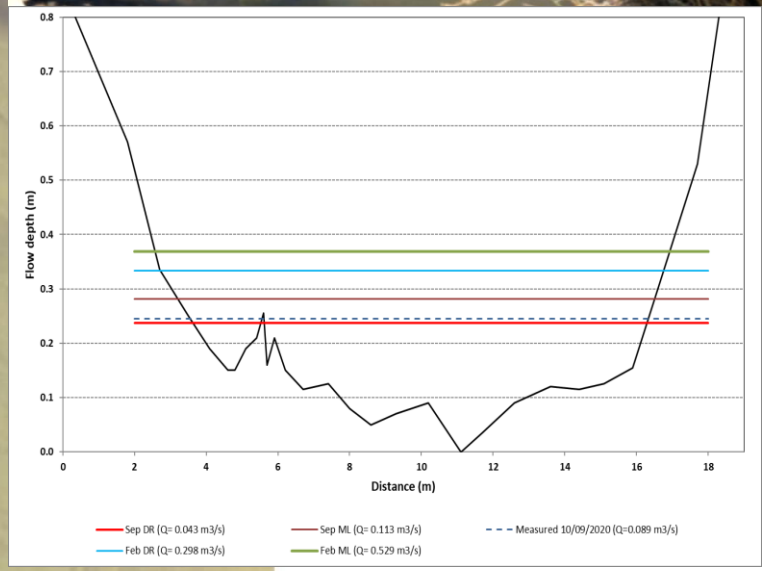


Component	PES	Importance	REC	Trend	TEC
Fish	C	EI = Very High ES = High		Stable but changing	Rationale: Management of upstream activities and limitation on abstraction required to achieve ecological category.
Macroinvertebrates	D			Stable	
HI: Instream	C			Stable	
HI: Riparian	B			Stable	
ECOSTATUS	C	High	B/C		B/C

The final step is the quantification of the EWR and include the conversion of the EWR flow data for a TEC of a B/C category to hydraulic conditions at the EWR site (i.e. depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. The maintenance and drought flows were examined for July and February. July is the month with the lowest maintenance flow (i.e. base-flow) and February is the month with the highest maintenance flow conditions

Quaternary Catchment	V20C	
River	Nsonge (Hlatikulu)	
EWR Site Co-ordinates	-29.2377; 29.7853	
NMAR at EWR site	27.13	
Ecological Category	PES=C	TEC=B/C
Total EWR	6.195 (22.84 %MAR)	7.864 (28.99 %MAR)
Maintenance Low flows	3.884 (14.32 %MAR)	5.351 (19.73 %MAR)
Drought Low flows	2.941 (10.84 %MAR)	2.941 (10.84 %MAR)
Maintenance High flows	2.310 (8.52 %MAR)	2.513 (9.26 %MAR)
Overall confidence	Low to medium	

THU_EWR22: Klip River in V12A



Component	PES	Importance	REC	Trend	TEC
Fish	C	EI = High ES = Very High		Stable	Rationale: Ecological condition driven by ant5hropogenic activities. Predominantly non-flow and water impacts that require management of upstream activities.
Macroinvertebrates	C			Stable	
HI: Instream	C			Stable	
HI: Riparian	C/D			Negative	
ECOSTATUS	C	High	B/C		C

The final step is the quantification of the EWR and include the conversion of the EWR flow data for a TEC of a B/C category to hydraulic conditions at the EWR site (i.e. depths and flow velocities at discharges measured in m^3/s) using a hydraulic model. The maintenance and drought flows were examined for July and February. August is the month with the lowest maintenance flow (i.e. base-flow) and February is the month with the highest maintenance flow conditions.

Quaternary Catchment	V12A
River	Klip
EWR Site Co-ordinates	-28.3952; 29.7197
Present Ecological State	C
Target Ecological Category	C
NMAR at EWR site	52.44
Total EWR	13.271 (25.31 %MAR)
Maintenance Low flows	7.085 (13.51 %MAR)
Drought Low flows	2.988 (5.70 %MAR)
Maintenance High flows	6.186 (11.80 %MAR)
Overall confidence	Low to medium

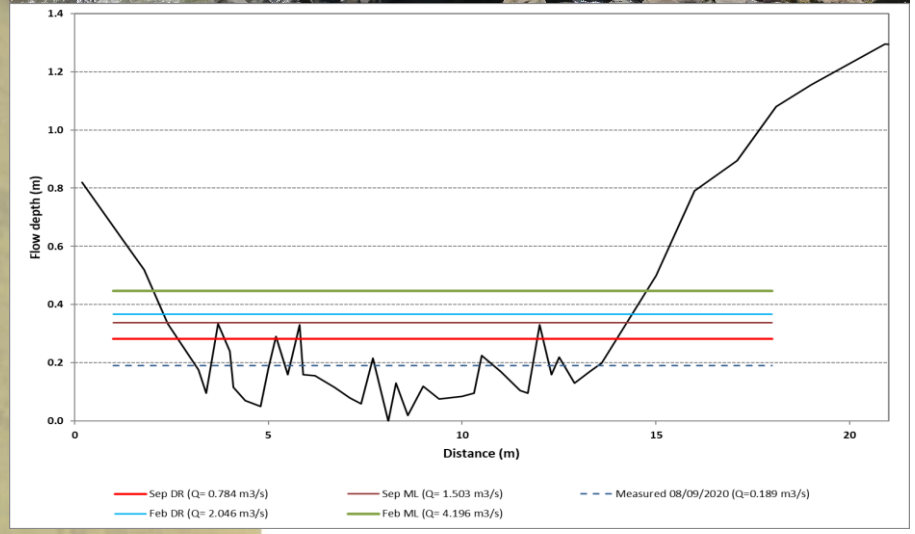
THU_EWR21: Mnyamvubu River in V20G (Rapid 2)

Component	PES	Importance	REC	Trend	TEC
Fish	C/D	EI = High ES = High		Negative	Rationale: Freshets and pools needed to support habitat. Additional flow releases need from dam.
Macroinvertebrates	C			Stable	
HI: Instream	D			Stable	
HI: Riparian	B			Negative	
ECOSTATUS	C	High	B/C		B/C

As no hydraulic cross-sectional survey was done, the DRM results for maintenance and drought flows for a TEC of B/C and a PES of C were accepted

Quaternary Catchment	V20G	
River	Mnyamvubu	
EWR Site Co-ordinates	-29.1610; 30.2884	
NMAR at EWR site	31.71	
Ecological Category	TEC=B/C	PES=C
Total EWR	8.869 (27.97 %MAR)	7.007 (22.10 %MAR)
Maintenance Low flows	5.771 (18.20 %MAR)	4.184 (13.20 %MAR)
Drought Low flows	2.125 (6.70 %MAR)	2.125 (6.70 %MAR)
Maintenance High flows	3.098 (9.77 %MAR)	2.824 (8.91 %MAR)
Overall confidence	Low	

Re-visit of 2003 Comprehensive sites
THU_EWR12A and 2003 Thukela_EWR12: Mooi River in V20H

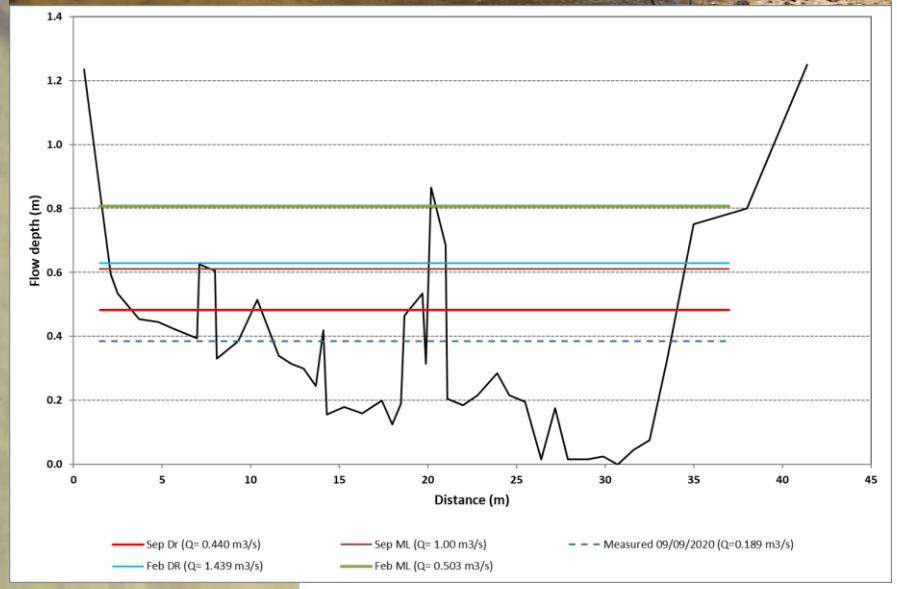


Component	PES	Importance	REC	Trend	TEC
Fish	C/D	EI = High ES = High		Decllining	Rationale: Impacts are water quality related. Improved management of upstream sewage works, cattle feedlots and dairy farms required.
Macroinvertebrates	C			Stable	
HI: Instream	D			Negative	
HI: Riparian	C/D			Stable	
ECOSTATUS	C/D	High	C		C

As the PES of the Mooi River at THU_EWR12A was determined as a C/D category, the requirements were also determined for the PES. The same aspects were considered as for the C category, namely velocities for flow sensitive macroinvertebrates and depths for fish

Quaternary Catchment	V20H	
River	Mooi	
EWR Site Co-ordinates	-28.9193; 30.4189	
NMAR at EWR site	361.85	
Ecological Category	TEC=C	PES=C/D
Total EWR	116.610 (32.23 %MAR)	98.755 (27.29 %MAR)
Maintenance Low flows	76.070 (21.02 %MAR)	58.214 (16.09 %MAR)
Drought Low flows	37.691 (10.42 %MAR)	37.691 (10.42 %MAR)
Maintenance High flows	40.541 (11.20 %MAR)	40.541 (11.20 %MAR)
Overall confidence	Medium	

THU_EWR6A - 2003 Thukela_EWR6: Lower Bushmans River in V70G

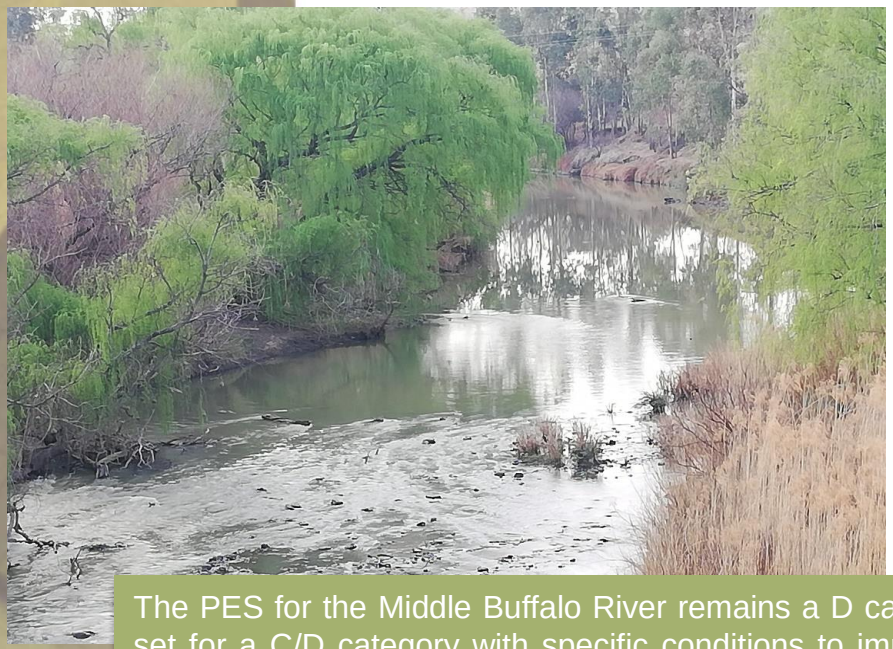


Component	PES	Importance	REC	Trend	TEC
Fish	D	EI = High ES = High		Negative	Rationale:
Macroinvertebrates	C/D			Stable	Flow and water quality impacts are present.
HI: Instream	D			Negative	Upstream improvements in sources of water pollution are required.
HI: Riparian	D			Negative	
ECOSTATUS	D	High	C		C/D

As the PES of the Lower Bushmans River at THU_EWR6A was determined as a D category, the requirements were also determined for the PES. The same aspects were considered as for the C/D category, namely velocities for flow sensitive macroinvertebrates and depths for fish.

Quaternary Catchment	V70G			
River	Lower Bushmans			
EWR Site Co-ordinates	-28.8483; 30.1496		-28.801; 30.167	
NMAR at EWR site	298.37		303.14	
Target Ecological Category	TEC=C/D	PES=D	TEC=C/D	PES=B/C
Total EWR	103.377 (34.65 %MAR)	87.162 (29.21 %MAR)	135.621 (44.74 %MAR)	97.382 (32.12 %MAR)
Maintenance Low flows	51.377 (17.22 %MAR)	35.162 (11.78 %MAR)	67.338 (22.21 %MAR)	40.076 (13.22 %MAR)
Drought Low flows	21.952 (7.36 %MAR)	21.952 (7.36 %MAR)	21.135 (6.97 %MAR)	20.876 (6.89 %MAR)
Maintenance High flows	52.000 (17.43 %MAR)	52.000 (17.43 %MAR)	68.283 (22.53 %MAR)	57.306 (18.90 %MAR)
Overall confidence	Low-Medium		Medium	

THU_EWR13A (Rapid 2) and 2003 Thukela_EWR13: Middle Buffalo River in V32F



Component	PES	Importance	REC	Trend	TEC
Fish	C/D	EI = Moderate ES = High		Stable	Rationale:
Macroinvertebrates	D			Stable	Water quality impacts are influencing habitat heath. Management of the upstream water quality impacts will drive an improvement in ecological condition.
HI: Instream	D			Stable	
HI: Riparian	E			Negative	
ECOSTATUS	D		C/D		C/D

The PES for the Middle Buffalo River remains a D category with a negative trend. It was recommended that the TEC be set for a C/D category with specific conditions to improve the non-flow impacts (stabilisation of banks, alien vegetation removal and ensure WWTWs are functioning to remove the organic matter from the river)

Quaternary Catchment	V32D		V32F	
River	Middle Buffalo			
EWR site name	THU_EWR13A		Thukela_EWR13	
EWR Site Co-ordinates	-28.0107; 30.3931		-28.153; 30.476	
NMAR at EWR site	626.68		695.05	
Ecological Category	TEC=C/D	PES=D	TEC=C/D	PES=D
Total EWR	100.616 (16.06 %MAR)	118.311 (18.88 %MAR)	132.098 (19.01 %MAR)	111.762 (16.08 %MAR)
Maintenance Low flows	24.759 (3.95 %MAR)	42.454 (6.77 %MAR)	47.082 (6.77 %MAR)	27.340 (3.93 %MAR)
Drought Low flows	22.432 (3.58 %MAR)	22.432 (3.58 %MAR)	25.309 (3.64 %MAR)	24.766 (3.56 %MAR)
Maintenance High flows	75.857 (12.10 %MAR)	75.857 (12.10 %MAR)	85.015 (12.23 %MAR)	84.421 (12.15 %MAR)
Overall confidence	Low		Medium-high	

THU_EWR7A (Rapid 2) and 2003 Thukela_EWR7: Upper Sundays River in V60B

Component	PES	Importance	REC	Trend	TEC
Fish	C	EI = High ES = High		Stable/ negative	Rationale: Ecological condition is driven by land use activities and poor water quality. Improvement is required.
Macroinvertebrates	C			Stable	
HI: Instream	C			Stable	
HI: Riparian	D			Negative	
ECOSTATUS	C/D		C		C

As no hydraulic cross-sectional survey was done, the DRM results for maintenance and drought flows for a TEC of C were compared to those specified for the 2003 EWR site (Thukela_EWR7). This EWR site is situated lower down on the Sundays River with a large tributary (Nkunzi River) entering the Sundays River between the two EWR sites. Thus, the characteristics used to determine the EWR in 2003 for Thukela_EWR7 (maintenance low flows, drought flows and floods/ freshets) were used to determine the EWR at this site for a PEC of a C/D category and a TEC of a C.

Quaternary Catchment	V60B		V60C	
River	Upper Sundays			
EWR site name	THU_EWR7A		Thukela_EWR7	
EWR Site Co-ordinates	-28.3479; 29.9682		-28.458; 30.053	
NMAR at EWR site	50.69		90.28	
Ecological Category	PES=C/D	TEC=C	PES=B/C	TEC=C
Total EWR	14.646 (28.90 %MAR)	15.958 (31.48 %MAR)	33.173 (36.74 %MAR)	28.531 (31.60 %MAR)
Maintenance Low flows	5.485 (10.82 %MAR)	6.797 (13.41 %MAR)	16.783 (18.59 %MAR)	12.141 (13.45 %MAR)
Drought Low flows	2.869 (5.66 %MAR)	2.869 (5.66 %MAR)	5.139 (5.69 %MAR)	5.085 (5.63 %MAR)
Maintenance High flows	9.161 (18.07 %MAR)	9.161 (18.07 %MAR)	16.390 (18.15 %MAR)	16.390 (18.15 %MAR)
Overall confidence	Low		Medium-high	

THU_EWR 4C (Rapid 1) and 2003 Thukela 4A & B: Middle Thukela River in V14E

Component	PES	Importance	REC	Trend	TEC
Fish	C	EI = High ES = High		Stable	Rationale: Flow and non-flow impacts present. Improved flow and water quality required to improve ecological condition.
Macroinvertebrates	C			Stable	
HI: Instream	D			Stable	
HI: Riparian	C			Negative	
ECOSTATUS	C		B/C		B/C

The PES as determined using the results from the re-surveying is a C category compared to the 2003 PES of a B/C. As the REC of the 2003 was a B/C, it was recommended that the Middle Thukela River be managed for a TEC of a B/C category.

As no hydraulic cross-sectional survey was done, the results from the 2003 EWR site (Thukela_EWR4B) for maintenance and drought flows for a B/C were used for this site.

Quaternary Catchment	V14E	
River	Middle Thukela	
EWR site name	Thukela_EWR4B (THU_EWR4C)	
EWR Site Co-ordinates	-28.747; 30.145	
NMAR at EWR site	1423.83	
Ecological Category	PES=C	TEC=B/C
Total EWR	357.201 (25.09 %MAR)	404.231 (28.39 %MAR)
Maintenance Low flows	129.373 (9.09 %MAR)	176.403 (12.39 %MAR)
Drought Low flows	97.099 (6.82 %MAR)	97.584 (6.85 %MAR)
Maintenance High flows	227.828 (16.00 %MAR)	227.828 (16.00 %MAR)
Overall confidence	Medium to high	

IUAs with no EWR sites
Blood River in V32H (Blood_dsk)

No EWR site was selected on the Blood River as this is mainly a flood plain system, especially in the upper reaches of the system. Thus, the present state and recommended/ target ecological categories have been specified by the wetland component of this study

Component	PES	Importance	REC	TEC Rationale
Wetland*				
Desktop (V32H-02834)	C	EI = High ES = High	B/C	B/C – The impacts are mostly from abstraction of water and small dams for irrigation in the upper reaches, with community water use in the middle to lower reaches. The instream habitats and continuity have been modified due to a large weir in the lower reaches for water provision to the communities. With both the EI and ES being high, the PES of a C would not provide adequate flows to contribute to the lower Buffalo River in IUA5 with a TEC of a B/C.
ECOSTATUS	C	High	B/C	B/C

Quaternary Catchment	V32H	
River	Blood	
EWR Site Co-ordinates	Outlet of V32H	
NMAR at EWR site	94.714	
Ecological Category	PES=C	TEC=B/C
Total EWR	20.232 (21.36 %MAR)	26.473 (27.95 %MAR)
Maintenance Low flows	11.829 (12.49 %MAR)	16.502 (17.42 %MAR)
Drought Low flows	6.014 (6.35 %MAR)	6.017 (6.35 %MAR)
Maintenance High flows	8.403 (8.87 %MAR)	9.971 (10.53 %MAR)
Overall confidence	Low	

The DRM model was used to determine the final EWR for the Blood River at the outlet of quaternary catchment V32H. The maintenance low flow and drought flows were adjusted upwards as these were very low for both the B/C and C categories

Upper Thukela River in V14B (Thukela1_dsk)

No EWR site was selected for this reach of the Thukela River, although a number of access points to the river were visited. This was due to the free-flowing nature of the Thukela River in this reach before it enters the gorge area. The back water caused by the uThukela transfer weir also limited finding a suitable EWR site

Component	PES	Importance	REC	TEC Rationale
Desktop (V14B-03296)	B	EI = High ES = High	B	C Quantity: The impacts are mostly from abstraction of water for irrigation in the upper reaches, with the uThukela Transfer Weir toward the lower end of the reach. The instream habitats and continuity have been modified due to this large weir for water transfer. Quality: The impacts are associated with agricultural activities and intensive irrigation in the catchment. In addition, the discharge of poorly treated domestic wastewater from the town of Colenso and localised settlements does contribute to organic load. Highly salinity is observed. Although both the EI and ES are high, the PES of a B would not be attainable due to the pressure of water use and impacts on the water quality on this reach. Thus, a TEC of a C was accepted.
ECOSTATUS	B	High	B	C

Quaternary Catchment	V14B	
River	Thukela	
EWR Site Co-ordinates	Outlet of V14B	
NMAR at EWR site	1145.20	
Ecological Category	PES=B	TEC=C
Total EWR	450.844 (39.37 %MAR)	357.329 (31.20 %MAR)
Maintenance Low flows	220.294 (19.24 %MAR)	126.780 (11.07 %MAR)
Drought Low flows	48.097 (4.20 %MAR)	48.097 (4.20 %MAR)
Maintenance High flows	230.550 (20.13 %MAR)	230.550 (20.13 %MAR)
Overall confidence	Low	

IUA14: Escarpment Areas

The DRM was used, with the final selected TEC, to determine the EWR at all the outlet sites for the rivers as in the table below. No adjustments were made to the EWRs as only desktop information was available

Site name	River	PES	Importance	REC	TEC
V11A_dsk	Thukela	B	High / Very high	B	B
V11B_dsk	Sithene/ Thonyelana	B	Moderate/ High	B	B
V11G_dsk	Mlambonja/ Mhlwazini	B	Moderate / High	B	B
V13A_dsk	Little Thukela	C	High/ Very high	B	B
V70A_dsk	Bushmans	B	High	B	B
V70B_dsk	Ncibidwana	B	High	B	B
V20A_dsk	Mooi	C	High	B	B
V20B_dsk	Little Mooi	C	High	B/C	B/C

IUA 14: Escarpment
Summary of the final EWR results (flows in million m^3 per annum)

Quaternary Catchment	River	PES	TEC	NMAR	Total EWR	Maintenance Low flows	Drought Low flows	Maintenance High flows	Overall confidence
V11A	Thukela	B	B	66.90	25.637 (38.32 %MAR)	19.698 (29.45 %MAR)	6.078 (9.09 %MAR)	5.939 (8.88 %MAR)	Low
V11B	Sithene/ Thonyelana	B	B	142.69	54.686 (38.32 %MAR)	42.017 (29.45 %MAR)	12.965 (9.09 %MAR)	12.669 (8.88 %MAR)	Low
V11G	Mlambonja/ Mhlwazini	B	B	191.99	72.971 (38.01 %MAR)	55.748 (29.04 %MAR)	16.575 (8.63 %MAR)	17.223 (8.97 %MAR)	Low
V13A	Little Thukela	C		82.32	19.038 (23.13 %MAR)	12.224 (14.85 %MAR)	7.098 (8.62 %MAR)	6.814 (8.28 %MAR)	Low
			B		29.172 (35.44 %MAR)	21.002 (25.51 %MAR)	7.098 (8.62 %MAR)	8.170 (9.92 %MAR)	Low
V70A	Bushmans	B	B	113.46	40.524 (35.72 %MAR)	29.404 (25.92 %MAR)	9.844 (8.68 %MAR)	11.120 (9.80 %MAR)	Low
V70B	Ncibidwana	B	B	44.16	15.773 (35.72 %MAR)	11.445 (25.92 %MAR)	3.831 (8.68 %MAR)	4.328 (9.80 %MAR)	Low
V20A	Mooi	C		42.90	9.736 (22.69 %MAR)	6.029 (14.05 %MAR)	3.716 (8.66 %MAR)	3.707 (8.52 %MAR)	Low
			B		14.806 (34.51 %MAR)	10.352 (24.13 %MAR)	3.716 (8.66 %MAR)	4.454 (10.38 %MAR)	Low
V20B	Little Mooi	C		10.32	2.358 (22.84 %MAR)	1.478 (14.32 %MAR)	0.893 (8.65 %MAR)	0.879 (8.52 %MAR)	Low
			B/C		2.993 (28.99 %MAR)	2.037 (19.73 %MAR)	0.893 (8.65 %MAR)	0.956 (9.26 %MAR)	Low

Extrapolation to outlets of IUAs

Extrapolation was undertaken for those IUAs where the existing or new EWR sites are not close to the outlet. The characteristics and results from the lowest EWR site in the IUA were used to determine the EWR with the DRM. The Desktop PES/EI/ES results were used to determine the final TEC. The following tables summarises the final TEC and rationale as well as the requirements per site.

Site name	River/ Reach	PES	EI / ES	REC	TEC	Comments
Ngagane_dsk	Ngagane V31K-02516	C	Moderate / High	C	C	Use Ngagane (May13_EWR3) to extrapolate. No adjustments made to DRM output
Mooi_dsk	Mooi V20J-03467	C	High / High	C	C	Use THU_EWR12A to extrapolate for ML, Drought, and freshets/ floods. No MAR adjustments made as only a small seasonal tributary (Loza River) enters between two sites
Klip_dsk	Klip V12G-03256	C	High / High	B/C	C	Use THU_EWR22 (Upper Klip) to extrapolate for ML and drought flows. Accept DRM freshets
Thukela2_dsk	Thukela V60K-03419	C	High/ High	B/C	C	Use Thukela_EWR15 to extrapolate EWR, check floods against Thukela_EWR9 and THU_EWR12A

Quaternary Catchment	River	PES	TEC	NMAR	Total EWR	Maintenance Low flows	Drought Low flows	Maintenance High flows	Overall confidence
V31K	Ngagane	C	C	240.84	49.018 (20.35 %MAR)	23.328 (9.69 %MAR)	8.943 (3.71 %MAR)	25.689 (10.67 %MAR)	Low
V20J	Mooi	C	C	388.66	121.614 (31.29 %MAR)	81.939 (21.08 %MAR)	40.676 (10.47 %MAR)	39.675 (10.21 %MAR)	Low to medium
V12G	Klip	C	C	253.09	64.352 (25.43 %MAR)	34.292 (13.55 %MAR)	14.429 (5.70 %MAR)	30.060 (11.88 %MAR)	Low
V60K	Thukela	C	C	2461.22	660.126 (26.82 %MAR)	313.781 (12.75 %MAR)	128.076 (5.20 %MAR)	346.345 (14.07 %MAR)	Low

Existing EWR Sites

The results from existing EWR sites from previous studies were used without any changes. Where the nMAR that was used during the previous studies changed substantially with the accepted natural hydrology for this study, adjustments were made accordingly. If the nMAR accepted for this study is lower than the original study nMAR, it will result in higher percentages of EWR required. However, the actual flows required will be the same as for the initial study. Also, if the PES or TEC have changed due to additional information available from RHP or other surveying, the requirements were adjusted. The following tables summarises the final categories and the requirements per site.

Site name	River/ Reach	PES	Importance	REC	TEC
May13_EWR2	Horn	C	Low	C	C
May13_EWR3	Ngagane	C	Low	C	C
Thukela_EWR14	Lower Buffalo	B/C	High	B	B/C
Thukela_EWR8	Lower Sundays	D	Moderate	D	D
EWR_Mooi_N3	Mooi	E	Moderate	D	D
Thukela_EWR11	Mooi	B/C	Moderate	B/C	B/C
Thukela_EWR5	Middle Bushmans	B/C	Moderate	B/C	C/D
Thukela_EWR1	Upper Thukela	D	Moderate	D	D
Thukela_EWR2	Upper Thukela	C	Moderate	C	C
Thukela_EWR3	Little Thukela	C/D	Moderate	C/D	C/D
Thukela_EWR9	Middle Thukela	D	Moderate	D	D
Thukela_EWR15	Lower Thukela	C	High	C	C
THU_EWR16	Lower Thukela	C	High/ Moderate	C	C
THU_EWR17	Lower Thukela	C	High	C	C

Existing EWR Sites: Summary of the final EWR results (flows in million m^3 per annum)

Site Name	River	NMAR	PES	TEC	Total EWR	Maintenance Low flows	Drought Low flows	Maintenance High flows
May13_EWR2	Horn	21.61	C	C	7.272 (33.65 %MAR)	4.936 (22.84 %MAR)	0.756 (3.50 %MAR)	2.336 (10.81 %MAR)
May13_EWR3	Ngagane	160.12*	C	C	38.315 (23.93 %MAR)	21.325 (13.32 %MAR)	8.149 (5.09 %MAR)	16.990 (10.61 %MAR)
Thukela_EWR14	Lower Buffalo	831.09	B/C	B/C	193.144 (23.24 %MAR)	84.272 (10.14 %MAR)	19.413 (2.34 %MAR)	108.873 (13.10 %MAR)
Thukela_EWR8	Lower Sundays	197.03	D	D	38.522 (19.55 %MAR)	13.302 (6.75 %MAR)	8.963 (4.55 %MAR)	25.220 (12.80 %MAR)
EWR_Mooi_N3	Mooi	265.81*	E	D	53.863 (20.26 %MAR)	32.847 (12.36 %MAR)	19.747 (7.43 %MAR)	21.016 (7.91 %MAR)
Thukela_EWR11	Mooi	301.14*	B/C	B/C	120.638 (40.06 %MAR)	74.526 (24.75 %MAR)	18.267 (6.07 %MAR)	46.112 (15.31 %MAR)
Thukela_EWR5	Middle Bushmans	281.45	B/C		127.643 (45.35 %MAR)	62.934 (22.36 %MAR)	19.751 (7.02 %MAR)	64.709 (22.99 %MAR)
				C/D	92.046 (32.70 %MAR)	37.454 (13.31 %MAR)	19.509 (6.93 %MAR)	54.592 (19.40 %MAR)
Thukela_EWR1	Upper Thukela	705.42	D	D	122.076 (17.31 %MAR)	49.671 (7.04 %MAR)	44.729 (6.34 %MAR)	72.405 (10.26 %MAR)
Thukela_EWR2	Upper Thukela	798.40	C	C	218.492 (27.37 %MAR)	88.819 (11.12 %MAR)	33.815 (4.24 %MAR)	129.673 (16.24 %MAR)
Thukela_EWR3	Little Thukela	285.20	C/D	C/D	70.474 (24.71 %MAR)	31.698 (11.11 %MAR)	18.223 (6.39 %MAR)	38.776 (13.60 %MAR)
Thukela_EWR9	Middle Thukela	2050.76	D	D	415.403 (20.26 %MAR)	125.168 (6.10 %MAR)	69.552 (3.39 %MAR)	290.235 (14.15 %MAR)
Thukela_EWR15	Lower Thukela	3424.0*	C	C	773.383 (22.59 %MAR)	436.933 (12.76 %MAR)	177.716 5.19 %MAR)	336.449 9.83 %MAR)
THU_EWR16	Lower Thukela	3679.97*	C	C	1391.959 (37.83 %MAR)	685.337 (18.62 %MAR)	351.013 (9.54 %MAR)	706.622 (19.20 %MAR)
THU_EWR17	Lower Thukela	3690.53*	C	C	1394.652 (37.79 %MAR)	688.029 (18.64 %MAR)	352.547 (9.55 %MAR)	706.622 (19.15 %MAR)

WATER QUALITY

In situ WQ data

EWR site	River	Temp (°C)	EC (mS/m)	pH	Observation
THU_EWR23	Upper Buffalo	14.8	14.2	7.6	High algae present. Nutrient and organic load impacts are noticeable. High Silt load in system.
THU_EWR19	Ncandu	17.3	14.92	7.82	High siltation, erosion and high algae observed.
THU_EWR20	Nsonge	19.7	15.2	7.2	Pollution by cattle and localised erosion. High silt observed.
THU_EWR22	Klip	16.9	23.1	7.82	Lots of string algae on rocks. High siltation. Organic pollution.
THU_EWR12A	Lower Mooi	22.2	47.6	8.3	High algae (fibrous) and siltation.
THU_EWR6A	Bushmans	20.3	40.4	7.9	High organic load impact. Local users describe discolouration of water. Water had an acidic odour. High algae and siltation.
THU_EWR21	Mnyamvubu	17.3	17.2	7.5	High algae
THU_EWR13A	Middle Buffalo	19.5	31.6	7.61	High reed growth, siltation, nutrient impacts.
THU_EWR7A	Sundays	20.5	30.8	8.2	Erosion, significant impacts by cattle grazing. High nutrients.
THU_EWR4C	Middle Thukela	24.9	21.5	8.32	High algae

Laboratory data and diatoms

Based on the analysis of the water chemistry and comparison to the ecological specifications, a qualitative indication of water quality PES was undertaken. At most sites, nutrients are a problem and resulting in eutrophic systems. This was is aligned to high algal growth noted at most sites. An analysis of diatoms was also undertaken. Diatoms are the unicellular algal group widely used as indicators of river and wetland health. They provide a rapid response to specific physico-chemical conditions in water and are an indication of change. Their presence or absence (indicator taxa) can be used to detect conditions such as eutrophication, organic enrichment, salinization, and changes in pH. The ecological water quality for all sites reflect moderate to good condition, except for the Buffalo River EWR.

Sample site	Water quality condition and driver (Water chemistry)		Diatoms (Specific Pollution Index)	
Buffalo River EWR13a	E	Nutrients	D	Poor
Mooi EWR12a	B	Nutrients	C/D	Moderate
Mnyamvubu EWR21	B	Nutrients	B	Good
Nsonge EWR20	B	Nutrients	B	Good
Bushmans EWR6a	C	Nutrients	C	Moderate
Klip Upstream EWR22	C	Nutrients	C/D	Moderate
Tugela EWR4C	C	Toxics - Aluminium	C/D	Moderate
Sundays EWR7a	C/D	Toxics - Aluminium	C	Moderate
Buffalo River EWR23	D	Nutrients, Toxics - Aluminium	C	Moderate
Ncandu EWR19	B	Nutrients	Not sampled	

Next steps

- Finalisation of Preliminary Resource Units Report
- Finalisation of Ecological Water Requirements Report
- Report for Review: Sub-components prioritization and indicators selection Report
- Scenarios and draft Water Resources Classes Report: 14 January 2021