**DEPARTMENT OF WATER AND SANITATION**

**Chief Directorate: Water Ecosystems**

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

## WATER RESOURCES INFORMATION AND GAP ANALYSIS REPORT WP 11255

**Study Report No.**

**RDM/WMA04/00/CON/CLA/0120**

**February 2020**

**FINAL**

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**Bold** type indicates this report.

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| 2.0 | RDM/WMA04/00/CON/CLA/0120 | Water Resources Information and Gap Analysis Report |
| | | |
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# TERMINOLOGY AND ABBREVIATIONS

| Acronym | Description |
|---|---|
| BID | Background Information Document |
| BHN | Basic Human Needs |
| CD: WE | Chief Directorate: Water Ecosystems |
| CR | Critically Endangered |
| DWAF | Department of Water Affairs and Forestry |
| DWS | Department of Water and Sanitation |
| EC | Ecological Category |
| EcoSpecs | Ecological Specifications |
| EGSAs | Ecosystem Goods, Services and Attributes |
| ERC | Ecological Recommended Category |
| ES | Ecosystem Services |
| ESFs | Ecosystem Service Frameworks |
| EIS | Ecological Importance and Sensitivity |
| EWR | Ecological Water Requirements |
| FDC | Flow Duration Curves |
| FEGS-CS | Final Ecosystem Goods and Services Classification System |
| GDP | Gross Domestic Product |
| GHS | General Household Survey |
| GGP | Gross Geographic Product |
| HGM | Hydrogeomorphic |
| IUA | Integrated Unit of Analysis |
| IWRM | Integrated Water Resource Management |
| IWRMP | Integrated Water Resources Management Plan |
| LSS | Large Sample Survey |
| MEA | Millennium Ecosystem Assessment |

| Acronym | Description |
|---|---|
| NGO | Non- Governmental Organisation |
| NWA | National Water Act |
| PA | Protected Areas |
| PES | Present Ecological Sate |
| PMC | Project Management Committee |
| PSC | Project Steering Committee |
| PSP | Professional Service Provider |
| REC | Recommended Ecological Category |
| RQOs | Resource Quality Objectives |
| RDM | Resource Directed Measures |
| Rus | Resource Units |
| SeCT | Socio-Economic Classification Tool |
| TEEB | The Economics of Ecosystems and Biodiversity |
| TOR | Terms of Reference |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| WMA | Water Management Area |
| WRCS | Water Resource Classification System |
| WRPM | Water Resource Planning Model |
| WRYM | Water Resource Yield Model |

# EXECUTIVE SUMMARY

The Chief Directorate: Water Ecosystems has recently commissioned the study for the determination of Water Resource Classes and associated Resource Quality Objectives in the Thukela Catchment.

The study area is the catchment of the Thukela River illustrated below. The Thukela catchment drains an area of 29 040 km$^2$, rising on the escarpment of the Drakensberg and flowing approximately 512 km through the eastern slopes, the midlands and discharges into the Indian Ocean.

The Thukela catchment has two main drainage systems: Upper Thukela and Buffalo rivers. This is attributed to the great Thukela Fault which runs in an east-west direction through the catchment as far as Colenso. The topography of the Thukela River Catchment varies dramatically, ranging from very steep areas to gentle slopes. The Thukela catchment lies predominantly in the KwaZulu-Natal Province, except for a narrow strip in the extreme north which falls in Mpumalanga Province.

The main topographic feature in the water management area is the Drakensberg Mountain Range in the west, which also demarcates the continental divide between the rivers flowing eastward to the Indian Ocean, notably the Thukela River, and the Orange/Vaal River basin with its outflow to the Atlantic Ocean. The climate is strongly influenced by the topography and ranges from cool in the mountains to subtropical at the coast. Mean annual rainfall is in the range of 600 mm to approximately 1 500 mm. As a result of the rainfall distribution and topography, most of the runoff originates in the vicinity of the escarpment and in the upper reaches of tributaries, where waterfalls are a significant feature and portions of the catchment fall into the Strategic Water Source Areas of which a small portion of the Drakensburg are classified as Protected Areas.

The Thukela River catchment is the largest river system within the Pongola to Mtamvuma Water Management Area (WMA 4) (and in KwaZulu-Natal). The system includes small to large sub-catchment areas with the Thukela River flowing directly into the Indian Ocean via the Thukela estuary, situated some 95 km north of Durban.

This study focuses on the classification of significant water resources in the Thukela. The available information will be used to prioritise their significance in the catchment and highlight the importance to associated water resource systems.

- **Rivers**: The significant rivers to be classified within defined integrated unit of analysis (IUA) will be identified and confirmed during the status quo phase. This will, as a first step, comprise the main stem rivers with associated tributaries in each sub-catchment within the Thukela River catchment including:
  - Thukela River (upper –V10, lower – V40, V50);
  - Buffalo River (V30);
  - Mooi River (V20);
  - Sundays River (V60), and
  - Bushmans River (V70).

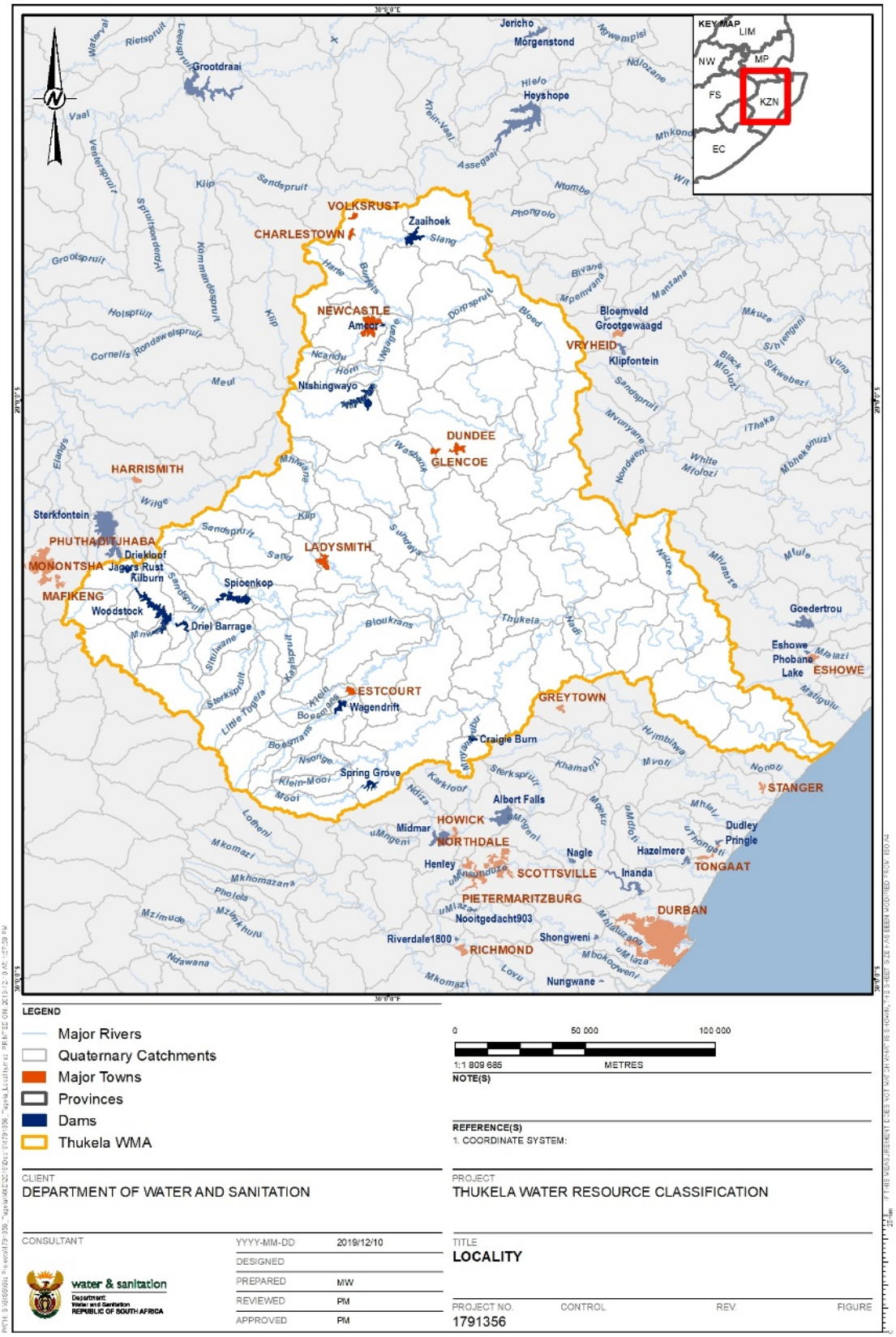


**Figure E1: Study location**

Additional considerations such as existing dams or priority river reaches for future water resource developments or protection purposes will refine these IUAs. Large wetland systems and groundwater areas contributing significantly to the base flows of the rivers will be included as part of the consideration of IUA delineation.

- **Wetlands**:

  Use will be made of existing GIS resources such as the National Wetland Map 5 (Van Deventer *et al*., 2018), the NFEPA wetland layer (Nel *et al*., 2011) and other literature on wetlands of the area to identify significant wetland resources in the Thukela catchment. Depending on the resolution of available imagery, this will be complimented with desktop mapping of the Priority Wetlands where appropriate in areas where the wetland coverage is poor. Information from available reports related to key wetlands in the catchment will also be used to support this.

  A Priority Wetland map and list of the most important or Priority Wetlands/Wetland systems will be compiled which will be taken through to RQO development.

- **Groundwater**:

  The groundwater aquifer systems in the Thukela River catchment are classified into three (3) groups:

  *(1) Fractured Aquifer yield ranges – Low (0.1 to 0.5) to Moderate (0.5 to 2.0 ℓ/s):*

  *(2) Fractured and Weathered Aquifer yield ranges – Insignificant (<0.1 ℓ/s) to High (2.0 to 5.0 ℓ/s): and*

  *(3) Primary (Intergranular) Aquifers.*

The Thukela River catchment was the subject of a number of large catchment studies up to 2005, with limited water resource studies over the past decade (since 2009). This study is specifically reliant on the outputs of the preliminary Reserve studies undertaken for the rivers, groundwater and Thukela estuary, and on the system models developed for the catchment.

Considering the outcomes of this preliminary information assessment and the outcomes of the field visit undertaken during November 2019, the following five additional sites have been identified as Rapid Reserve sites for which assessments will need to be undertaken for the Thukela Catchment, to fill gaps in EWRs.

**Identified rivers for Rapid Reserve assessments**

| Site | River | Quaternary Catchment | Relevance |
|---|---|---|---|
| 1 | Upper Buffalo | V31D | Zaaihoek Dam upstream on the Slang River (tributary of Buffalo) with no EWR determined to be released from the dam. Existing EWR site on Buffalo are after the Ngagane confluence |

| | | | |
|---|---|---|---|
| 2 | Mooi | V20J | New site on bottom end of the Mooi just before the confluence with Thukela. EWR 11 too high on Mooi river to account for downstream reach and impacts of Craigie Burns Dam. |
| 3 | Klip River (one site either just downstream of the flood control dam in V12C or below Ladysmith, V12G) | V12C or V12G | To provide information on the possible impact of reduced floods on the Thukela River at the proposed Jana Dam (at confluence of Klip and Thukela Rivers) |
| 4 | Little Mooi | V20B or V20D | Water resource developments planned (farm dams and increased irrigation) to determine the impact of water availability in the lower Mooi |
| 5 | Nzuse | V40D | Only a few significant tributaries in the lower Thukela with little/ no biological information available |

Based on the information review and analysis that has been undertaken on understanding the availability, accessibility and usefulness of the information and data sources applicable to Thukela catchments, it is clear that gaps do exist. In the last ten years studies in the Thukela Catchment have been limited and not to the extent needed to support all aspects of the classification and RQO setting process.

However, based on the specialists' knowledge of the system, both in the project team and within the networks of the project team, and potential for other additional data/ information to be made available from external sources, the gaps can be addressed adequately to determine water resource classes and RQOs. Best available and reasonable data and information sources will be used to meet the objectives of the study.

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# 1 INTRODUCTION

## 1.1 BACKGROUND

The Chief Directorate: Water Ecosystems has initiated a study for the determination of Water Resource Classes and associated Resource Quality Objectives in the Thukela Catchment.

Water Resource Classification, the Reserve and Resource Quality Objectives (RQOs) are protection-based measures that make up Resource Directed Measures (RDM), the protection principles contained in Chapter 3 of the National Water Act (Act No. 36 of 1998). The implementation of the classification system is intended to ensure comprehensive protection of all water resources. An important consideration in the determination of RDM is that they should be technically sound, scientifically credible, practical and affordable. Once the water resources class and the Reserve have been established, RQOs are established to give effect to these.

## 1.2 PURPOSE OF THE STUDY

It is understood that the main objectives of the study are to determine appropriate water resource classes and Resource Quality Objectives (RQOs) for all significant water resources in the Thukela River catchment that would facilitate sustainable use of the water resources while maintaining ecological integrity, specifically maintaining or improving the present ecological state of the water resources.

The key aims of this study are thus to co-ordinate the implementation of the Water Resource Classification System (WRCS) (Regulation 810) and to undertake the implementation of the RQO determination procedure (7 step process) in the Thukela Catchment. The study team understands that this study is linked to the previous Reserve determination studies and other water resource management initiatives.

It is recognised that the successful determination of the water resource classes and RQOs will depend on the integration of a number of disciplines in respect of water resources with the water uses and the needs of the water users present in the catchment, through consultative processes. Specialist technical assessment and stakeholder engagement are key components of the process.

## 1.3 PURPOSE OF THE REPORT

The purpose of the report is to document the identified key gaps relevant to the determination of the water resource classes and RQOs in the Thukela Catchment, based on current information and data from previous studies undertaken.

## 1.4 STUDY AREA

The study area is the catchment of the Thukela River illustrated in Figure 1. The Thukela Catchment drains an area of 29 040 km$^2$, rising on the escarpment of the Drakensberg and flowing approximately 512 km through the eastern slopes, the midlands and discharging into the Indian Ocean.

The Thukela Catchment has two main drainage systems: Upper Thukela and Buffalo rivers. This is attributed to the great Thukela Fault which runs in an east-west direction through the catchment as far as Colenso. The topography of the Thukela River Catchment varies dramatically, ranging from steep areas to gentle slopes. The Thukela Catchment lies

predominantly in the KwaZulu-Natal Province, except for a narrow strip in the extreme north which falls in Mpumalanga Province.

The main topographic feature in the water management area is the Drakensberg Mountain Range in the west, which also demarcates the continental divide between the rivers flowing eastward to the Indian Ocean, notably the Thukela River, and the Orange/Vaal River basin with its outflow to the Atlantic Ocean. The climate is strongly influenced by the topography and ranges from cool in the mountains to subtropical at the coast. Mean annual rainfall is in the range of 600 mm to approximately 1 500 mm. As a result of the rainfall distribution and topography, most of the runoff originates in the vicinity of the escarpment and in the upper reaches of tributaries, where waterfalls are a significant feature.

The Thukela River catchment is the largest river system within the Pongola to Mtamvuma Water Management Area (WMA 4) (and in KwaZulu-Natal) (Figure 2).The system includes small to large sub-catchments with the Thukela River flowing directly into the Indian Ocean via the Thukela estuary, situated some 95 km north of Durban. A small portion of the Upper Thukela River falls within the Protected Areas (PA).

The main river rises above Bergville. Major tributaries flowing into the Thukela River from the north include:

- The Klip River, which passes through Ladysmith,
- The Sundays River, and
- The Buffalo River, which rises above Newcastle.

Major tributaries into the Thukela River from the south include:

- The Little Thukela River,
- The Bloukrans River,
- The Bushmans River passing though Estcourt, and
- The Mooi River.

The resources of the Thukela River are predominantly used to support requirements for water in other parts of the country, with large transfers of water to neighbouring catchments. The river is relied upon for transfers into the Vaal System, and to the Mhlatuze catchment to its north and Mooi-Mgeni system its south (Thukela pipeline project). The major dams within the catchment include Woodstock, Spioenkop, Zaaihoek, Driel Barrage, Ntshingwayo, Craigie Burn, Quedusizi, Spring Grove and Wagendrift Dams. However, for the most part, the Thukela River remains largely unregulated. The Ingula Pump Storage scheme is also located in the headwaters of the Klip River. The catchment includes the major towns of Newscastle, Dundee, Ladysmith and Escourt. Most people in the catchment are dependent on agriculture for their livelihood. Subsistence farming is practised on communal land, which covers much of the catchment area. The catchment also includes a paper mill at Mandini, close to the estuary. Irrigation is a significant water use and occurs mainly in the upper reaches of the catchment. Coal mining is also predominant in the Thukela Catchment. The main mining area is the Buffalo River catchment. A number of other commodities such as sand and dolerite are also mined. The economy of the Newcastle area is heavily dependent on the mining activity.

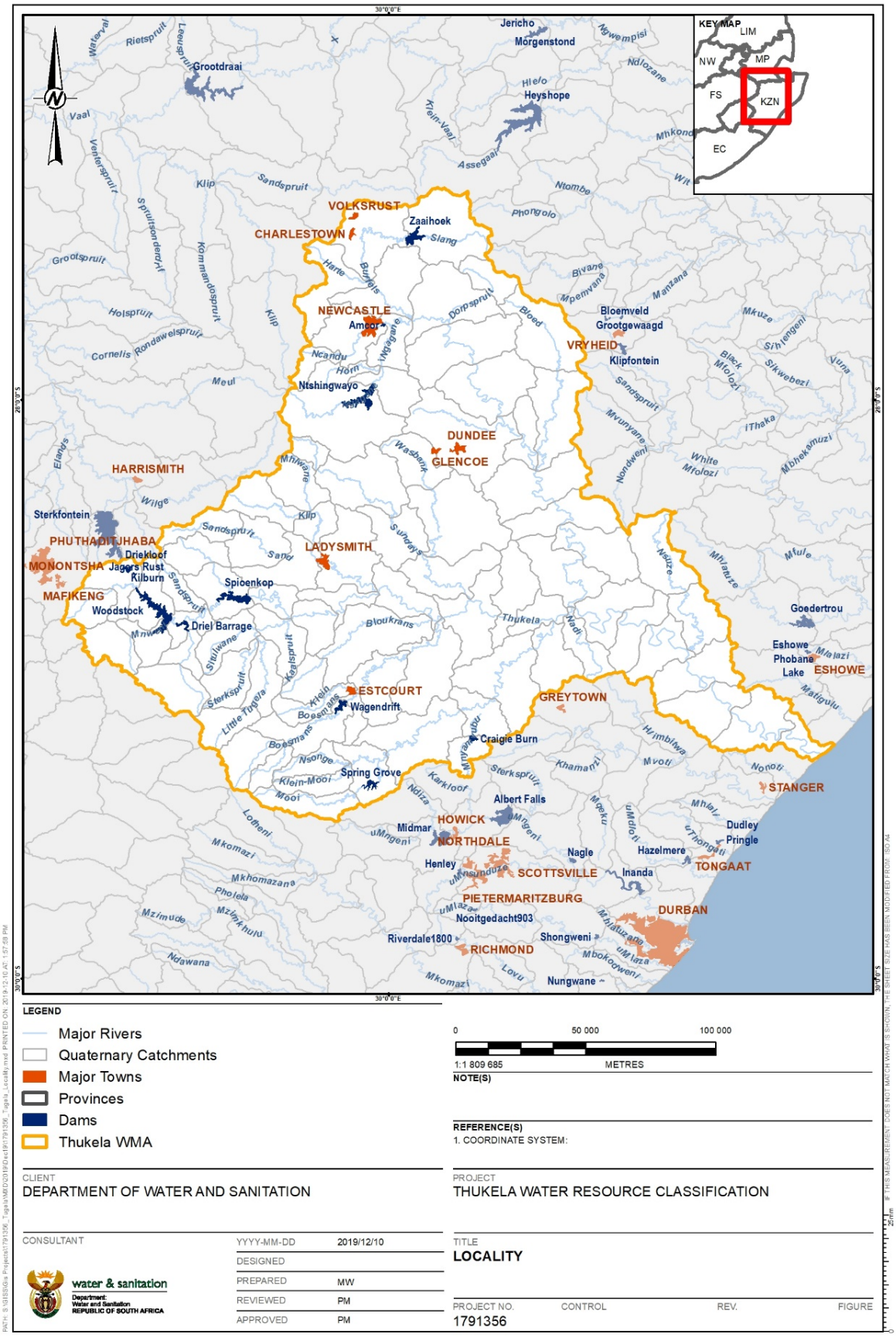


**Figure 1: Thukela Catchment – Study Area**

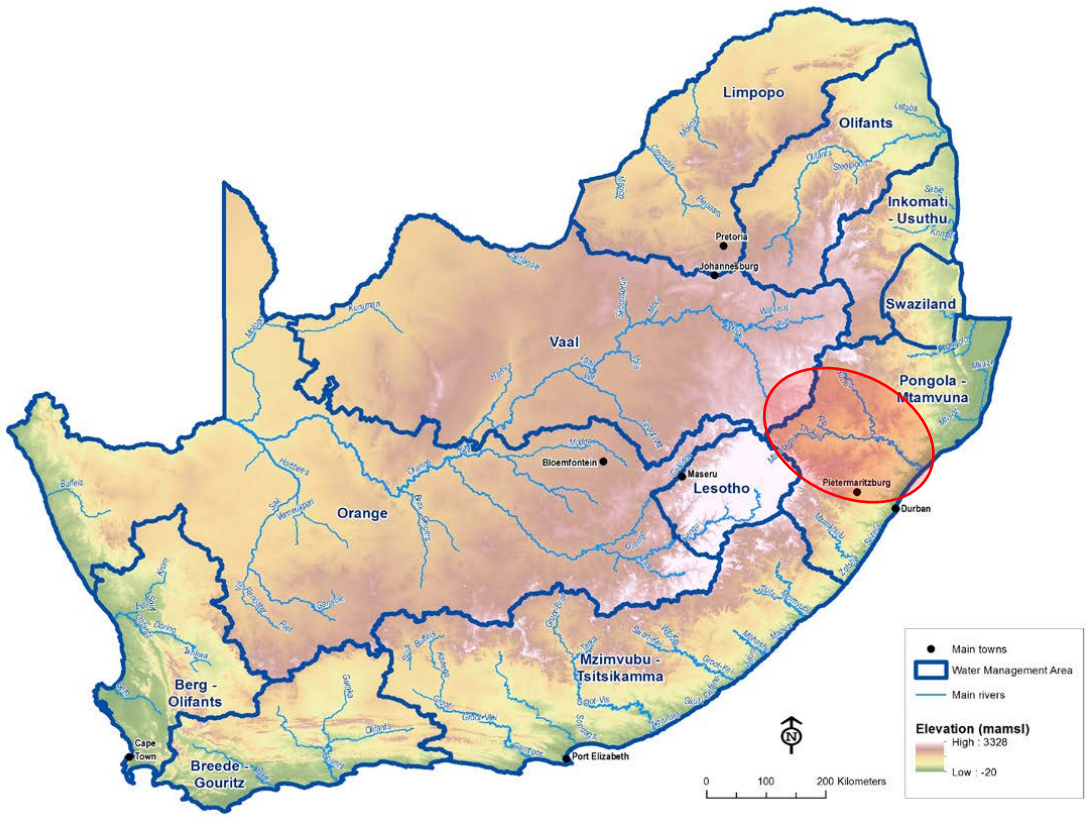


**Figure 2: Thukela Catchment within the Pongola to Mtamvuma WMA**

For water resource planning and management purposes, four sub-areas were identified for the catchment based on the location of sub-catchments, homogeneity of natural characteristics, location of pertinent water infrastructure such as dams, and economic development (DWS, 2004). These are described in Table 1.

**Table 1: Sub-catchments of the Thukela Catchment (DWS, 2004)**

| Sub-catchment | Description | Tertiary drainage regions | Catchment area (km$^2$) |
|---|---|---|---|
| **Upper Thukela** | The catchment of the Thukela River to just upstream of the confluence of the Bushmans River | V11, V12, V13 and V14 | 7645 |
| **Mooi/Sundays/ Bushmans** | The catchment of the Mooi, Bushmans and Sundays rivers as well as of smaller tributaries, down to the confluence of the Thukela River. | V20, V60, V70 | 8496 |
| **Buffalo** | The catchment of the Buffalo River down to the confluence | V31, V32 and V33 | 9803 |

| Sub-catchment | Description | Tertiary drainage regions | Catchment area (km$^2$) |
|---|---|---|---|
| | with the Thukela River | | |
| **Lower Thukela** | The catchment of the Thukela River between the confluence of the Buffalo River and the Indian Ocean | V40 and V50 | 3102 |

## 1.6 STUDY METHODOLOGY

The aim of this study is two-fold:

1. To co-ordinate the implementation of the Water Resource Classification System (WRCS) in order to classify all significant water resources in the Thukela Catchment; and
2. To determine Resource Quality Objectives (RQOs) for the water resource systems.

While this study is highly technical, it is supported by extensive stakeholder engagement and consultation.

The project approach and methodology that will be applied is in accordance with the 7-step process of the WRCS outlined in Regulation 810, the DWS manual 'Procedures to Develop and Implement RQOs' (DWA, 2011), and the integrated process outlined in the recently completed study, 'Development of Procedures to operationalise Resource Directed Measures (DWS, 2017).

There are 8 main components that will be addressed through the study:

1. Filling in of information gaps related to the preliminary Reserve determination studies, EWRs in the Thukela Catchment and the water resource models;
2. Status quo assessment of the catchment aspects including water resource quality, water resource issues, existing monitoring programmes, infrastructure, institutional environment, socio-economics, sectoral water uses and water users;
3. Delineation of Integrated Units of Analysis (IUAs), priority resource units and identification of the key biophysical nodes;
4. Determining the water resource class by integration of the economic, social and ecological goals through a suitable analytical decision-making system (trade-offs) and specifically the modelling of identified scenarios to determine practicality;
5. Application of the RQO procedure to determine the RQOs including resource unit delineation, sub-component and indicator prioritisation and numerical limits;
6. Implementation of stakeholder engagement, co-operative governance and consultation processes;
7. Preparation of the gazette templates; and
8. Study management.

## 1.7 WATER RESOURCE COMPONENTS

This study focuses on the classification of significant water resources in the Thukela. The available information will be used to prioritise their significance in the catchment and highlight the importance to associated water resource systems.

- **Rivers**: The significant rivers to be classified within defined integrated unit of analysis (IUA) will be identified and confirmed during the status quo phase. This will, as a first step, comprise the main stem rivers with associated tributaries in each sub-catchment within the Thukela River catchment including:
  - Thukela River (upper –V10, lower – V40, V50);
  - Buffalo River (V30);
  - Mooi River (V20);
  - Sundays River (V60), and
  - Bushmans River (V70).

  Additional considerations such as existing dams or priority river reaches for future water resource developments or protection purposes will refine these IUAs. Large wetland systems and groundwater areas contributing significantly to the base flows of the rivers will be included as part of the consideration of IUA delineation.

- **Wetlands**:

  Use will be made of existing GIS resources such as the National Wetland Map 5 (Van Deventer et al., 2018), the NFEPA wetland layer (Nel et al., 2011) and other literature on wetlands of the area to identify significant wetland resources in the Thukela catchment. Depending on the resolution of available imagery, this will be complimented with desktop mapping of the Priority Wetlands where appropriate in areas where the wetland coverage is poor. Information from available reports related to key wetlands in the catchment will also be used to support this.

  A Priority Wetland map and list of the most important or Priority Wetlands/Wetland systems will be compiled which will be taken through to RQO development.

- **Groundwater**:

  The groundwater aquifer systems (viz. resources) in the Thukela River catchment are classified into three (3) groups:

  *(1) Fractured Aquifer yield ranges – Low (0.1 to 0.5) to Moderate (0.5 to 2.0 ℓ/s):*

  Included in this category are the so-called dolerite contact zone aquifer systems (DCZ). A large portion of the Thukela River catchment contains sediments of the Karoo Supergroup Age. During the last phases of the Gondwana Land Break-Up (Jurassic: 160 to180 Ma), late Jurassic Age dolerite intrusions formed a complex array of intruded dykes and sills which represent so-called Dolerite Contact Zone aquifers – in some cases these contact zones could produce significant yields (>5 ℓ/s).

  *(2) Fractured and Weathered Aquifer yield ranges – Insignificant (<0.1 ℓ/s) to High (2.0 to 5.0 ℓ/s):*

This aquifer system grouping represents the largest percentage of aquifer systems in the Thukela River catchment (~60 to 70%).

*(3) Primary (Intergranular) Aquifers:*

These aquifers are confined to a narrow zone along the coast and the middle reaches of the Thukela, Sundays and Buffalo rivers (DWAF, 2009).

The Thukela River catchment consists of 88 quaternary catchments. Given the distribution of the above-mentioned aquifer systems, groundwater resource unit delineation was a complex procedure. It is proposed that the basic unit for these units be based on existing surface and groundwater demarcations as per the 2009 Reserve Determination Study (DWAF, 2009). Where possible, the smallest Groundwater Resource Unit (GRU) should be grouped together according to (i) geology, (ii) topography, (iii) recharge signature, and (iv) groundwater use to align to the surface water Resource Units demarcations. It is, however, important to note that the basic quaternary catchment groundwater component of the Reserve assessment is not available.

- **Estuary:**
  Thukela Estuary: The Estuarine Functional Zone (EFZ), or Resource Unit (RU), that was demarcated in terms of the 2004 Thukela Estuarine Flow Requirements study (DWAF, 2004).

# 2 INFORMATION REVIEW

## 2.1 PREVIOUS STUDIES

The Thukela River catchment was the subject of a number of large catchment studies up to 2005, with limited water resource studies over the past decade (since 2009). This study is specifically reliant on the outputs of the preliminary Reserve studies undertaken for the rivers, groundwater and Thukela Estuary, and on the system models developed for the catchment.

Other relevant studies/ reports have been reviewed in terms of serving as potential information sources. Table 2 lists available key and relevant sources of information available to the study and their usefulness and applicability in terms of the classification and RQO determination process.

**Table 2: Previous studies conducted in the Thukela River Catchment**

| Year | Study name | Integrated Process - Applicability | Comment |
|---|---|---|---|
| 2003 | Thukela Water Management Area: Overview of Water Resources Availability and Utilisation | Step 2: Status quo assessment and delineate study area into IUAs | Supporting information to catchment understanding and water resource situation assessment (somewhat – outdated) |
| 2004 | Thukela Water Management Area: Internal Strategic Perspective | Step 2: Status quo assessment and delineate study area into IUAs<br>Step 4: Identification and evaluation of scenarios | Supporting information to catchment perspective<br>Basis to developing planning scenarios (strategic perspectives) (somewhat outdated). |
| | Comprehensive Rivers Reserve Determination Study | Step 3: Quantify BHN and EWR<br>Step 4: Evaluation of scenarios<br>Step 6: Determine RQOs | Key input to the Rivers Classification Process (EWR sites and preliminary reserve information and hydrology used at that time)<br>The availability of data and models is a potential challenge, especially the results from the hydraulics surveys.<br>Biological information from this study is outdated and key sites will have to be re-sampled |
| | Thukela Estuarine Flow Requirement Report – Reserve Determination Study - Thukela River System. | Step 3: Quantify BHN and EWR<br>Step 4: Evaluation of scenarios | Key input to the Estuary Classification Process.<br>The availability of data and models is a potential challenge. |
| | Thukela Estuarine Flow Requirement Report – Reserve Determination Study - Thukela River System: Appendices to Thukela estuarine flow requirements. | | |

| Year | Study name | Integrated Process - Applicability | Comment |
|---|---|---|---|
| 1989 - 2005 *Thukela Water Project* | Thukela Vaal Transfer Scheme: Pre-feasibility Study | Step 2: Status quo assessment and delineate study area into IUAs<br>Step 4: Identification and evaluation of scenarios | Supporting information to water resource analysis.<br>Input to identification and development of the scenarios.<br>Yield Model configured<br>Confirmation of water demand volumes required.<br>Direction on the planning horizon is necessary. |
| | Thukela Vaal Transfer Scheme: Interim Study | | |
| | Vaal River System Analysis Update Study | | |
| | Thukela Water Project: Feasibility Study | | |
| | Thukela Water Project Decision Support Phase | | |
| 2005 | Towards a Classification System of Significant Water Resources with a Case Study of the Thukela River (MSc Thesis – HH Pienaar)♦. | Step 2: Status quo assessment | Background information |
| 1997 | Mkomazi-Mooi-Mgeni System Analysis Study | Step 2: Status quo assessment<br>Step 4: Identification and evaluation of scenarios | Key inputs to the Mooi component of the Thukela Catchment as well as yield analysis against which to compare new work and yield impacts.<br>Yield and Planning models configured |
| 1999 and 2013 | Desktop PES and EIS Study and rapid 3 assessments for selected rivers in V31 | Step 2: Status quo assessment and delineate study area into IUAs<br>Step 3: Quantify BHN and EWR<br>Step 6: Determine RQOs | Key input into determining status quo in terms of ecological and biophysical elements (somewhat outdated).<br>Focus of biological sampling was on Ngagane River (tributary of Buffalo), rest of results based on a desktop assessment.<br>Limited recent biological data available for rest of the Thukela Catchment |

| Year | Study name | Integrated Process - Applicability | Comment |
|---|---|---|---|
| 2011 | Lower Thukela Feasibility study for Umgeni Water | Step 2: Status quo assessment and delineate study area into IUAs | Supporting information to water resource analysis - details on the recently completed abstraction at Mandeni. |
| 2013 | Drought operating rules for the Buffalo River system | Step 4: Identification and evaluation of scenarios | Update of the drought operating rules of the western part of the catchment – input to Yield analysis |
| 2009 | Groundwater Reserve Determination Study in the Thukela Catchment: High level Assessment | Step 2: Status quo assessment and delineate study area into IUA's (in this case Groundwater Resource Units).<br>Step 5: Resource Class based on aquifer status (quality and stress factor).<br>Step 6: Determine RQOs (narrative and numerical limits) and provide implementation information. | Key input to classification process and RQO development for groundwater.<br>Level of detail is not available to the extent required. |
| 2009 | Water reconciliation strategy study for KZN coastal metropolitan areas | Step 4: Identification and evaluation of scenarios | Input to water resource analysis, and development of planning scenarios and yield analysis. |
| 2011 | All Towns Reconciliation Strategies for towns and water supply systems in the catchment. | Step 2: Status quo assessment and delineate study area into IUAs<br>Step 4: Identification and evaluation of scenarios | A review of the water supply systems in the various catchments will provide information on possible future plans in the smaller centres that may be overlooked in the larger studies. |

| Year | Study name | Integrated Process - Applicability | Comment |
|---|---|---|---|
| 2017 | Holistic ecological risk and environmental water requirement assessment of the lower Thukela River and eMandeni Stream (intermediate Reserve at EWR16) | Step 3: Quantify BHN and EWR<br>Step 4: Identification and evaluation of scenarios<br>Step 6: Determine RQOs | Updated information to EWR 16 site - and preliminary Reserve. – input to EWR quantification |
| 2017 | Roy Point Mine Reserve study – Ngagane and Knockbrex Stream in V31 | Step 3: Quantify BHN and EWR<br>Step 6: Determine RQOs | Rapid Reserve determination – input to EWR quantification |
| 2019 | Mooi-Mgeni Hydrology Update Study by Umgeni Water | Step 2: Status quo assessment<br>Step 4: Identification and evaluation of scenarios | Hydrology updated for the Mooi portion of the Thukela up until 2017. |

## 2.2 RESERVE STUDIES

Step 3 of the WRC process requires the quantification of the ecological water requirements (EWRs) and basic human needs (BHN) which is reliant on the preliminary Reserve determinations undertaken. A number of Reserve studies have been undertaken since 2003 on various level of detail. The most significant study was the comprehensive study undertaken during 2001 to 2003, for the rivers and estuary. A groundwater Reserve high level assessment was completed in 2009.

### 2.2.1 Rivers

The Thukela preliminary Reserve included 17 Ecological Water Requirement (EWR) sites, nine in the upper Thukela Catchment and tributaries and eight sites in the Lower Thukela Catchment. A number of rapid Reserve determinations were undertaken between 2002 and 2005. However, no reports were available for these studies. Rapid assessments were undertaken for the Ngagane, Horn, Ncandu and Ncone Rivers in 2013 and for the Mooi River just upstream of the existing comprehensive site Thukela_10 in V20E during 2019. An intermediate assessment was undertaken during 2017 for the lower Thukela River at Thukela_16 and two additional sites just downstream of the new abstraction weir in quaternary catchment V50D.

The sites and level of assessments are listed in Table 3 and shown in Figure 3.

**Table 3: EWR sites and Rapid assessments undertaken in the Thukela Catchment**

| Name/ Identification | River | Quaternary catchment | Level | Year |
|---|---|---|---|---|
| Thukela_1, Bergville | Thukela | V11J | Comprehensive | 2003 |
| Thukela_2, Skietdrift | Thukela | V11M | Comprehensive | 2003 |
| Thukela_3, Klein Thukela | Little Thukela | V13E | Comprehensive | 2003 |
| Thukela_4A, Zingela | Thukela | V14E | Comprehensive | 2003 |
| Thukela_4B, Thukela Estates | Thukela | V14E | Comprehensive | 2003 |
| Thukela_10, Caravan Park | Mooi | V20E | Comprehensive | 2003 |
| Thukela_11, Mooi Falls | Mooi | V20E | Comprehensive | 2003 |
| Thukela_12, Gracelands | Mooi | V20H | Comprehensive | 2003 |
| Thukela_13, Upper Buffalo | Buffalo | V32F | Comprehensive | 2003 |
| Thukela_14, Lower Buffalo | Buffalo | V33C | Comprehensive | 2003 |
| Thukela_15, Jameson's Drift | Thukela | V40E | Comprehensive | 2003 |
| Thukela_16, Mandini | Thukela | V50C | Comprehensive; revised in 2017 | 2003 |

| Name/ Identification | River | Quaternary catchment | Level | Year |
|---|---|---|---|---|
| | | | with an intermediate assessment | |
| Thukela_7, Upper Sundays | Sundays | V60C | Comprehensive | 2003 |
| Thukela_8, Lower Sundays | Sundays | V60F: | Comprehensive | 2003 |
| Thukela_9, Thukela Ferry | Thukela | V60J | Comprehensive | 2003 |
| Thukela_5, Weenen NR | Boesmans | V70F | Comprehensive | 2003 |
| Thukela_6, Darkest Africa | Boesmans | V70G | Comprehensive | 2003 |
| Thu_EWR17 | Thukela | V50D | Intermediate | 2017 |
| Thu_EWR18 | Thukela | V50D | Intermediate | 2017 |
| V11C | Khombe | V11C | Rapid III | 2005 |
| V11D | Mpandweni | V11D | Rapid III | 2005 |
| EWR2, Venterspruit | Venterspruit | V11K | Rapid III | 2005 |
| EWR3, Klipspruit | Klipspruit | V12A | Rapid | tbc |
| V12A | Braamhoekspruit | V12A | Rapid III | 2005 |
| Klein Thukela | Little Thukela | V13C | Rapid III | 2002 |
| V20A | Mooi | V20A | Rapid III | 2002 |
| EWR4 | Hlatikhulu | V20C | Rapid III | 2005 |
| EWR_Mooi_N3 | Mooi | V20D | Rapid III | 2012, 2019 |
| V31E, May13_EWR1 | Ngagane | V31E | Rapid I | 2013 |
| V31F, May13_EWR2 | Horn | V31F | Rapid III | 2013 |
| V31H | Ncandu | V31H | Rapid III | 2005 |
| V31K, May13_EWR3 | Ngagane | V31K | Rapid III | 2013 |
| Kno_up | Knockbrex | V31K | Rapid II | 2017 |
| Kno_down | Knockbrex | V31K | Rapid II | 2017 |
| Ncone | Ncone | V32H | Rapid III | 2012 |
| EMAN2 | eMandeni Stream | V50D | Rapid III | 2017 |

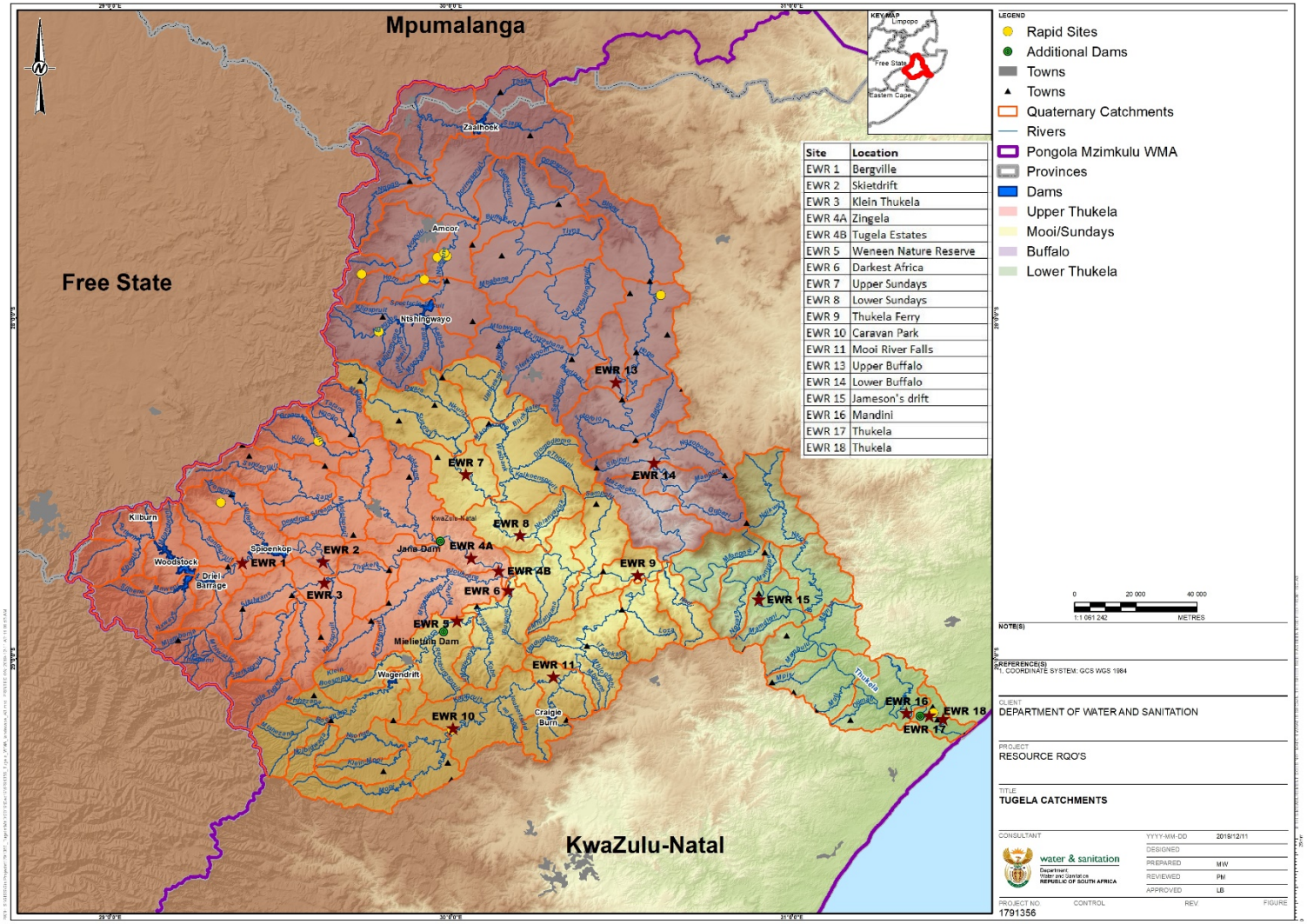


**Figure 3: Location of EWR sites and Rapid assessments undertaken in the Thukela Catchment**

An assessment of the preliminary Reserve Studies indicates that although the data and information elements that are necessary for quantifying the Ecological Water Requirement (EWR) are available for the main stem rivers, most of these are outdated (biological data) as the studies were done in 2003. The only three areas where more recent results are available are at (i) Thukela_16 with the 2017 intermediate assessment, (ii) Ngagane River and tributaries that were assessed on a Rapid III level in 2013 and (iii) upstream of Thukela_10 on the Mooi River with the results of the 2019 rapid 3 assessment.

The following can be summarised in terms of the information review for the EWR sites:

- The approach followed during the 2003 Comprehensive Reserve Determination study focused on Ecological Water Requirement (EWR) sites on the main stem and major tributaries. Small, more sensitive and un-impacted tributaries were not part of the study. Thus, EWR information for some of the smaller tributaries is lacking,
- Biological data is outdated and thus the PES for most of the existing sites might have changed since 2003 due to water resource developments or other anthropogenic impacts,
- The assessment approaches, models and interpretations for most of the ecological components were developed post 2003 and a number of new models for the interpretation of the data and determination of the PES and EWRs are now available,
- Limited additional biological sampling has been undertaken for the main stem Thukela River, major tributaries or even the smaller tributaries since 2003,
- An initial assessment of the existing EWR sites and possible IUAs indicated that the following rivers might require the selection of new EWR sites:
    i. Buffalo River upstream of the confluence with the Ngagane River as the first EWR site on the Buffalo River is much lower down (Thukela_13) just before the Bloed River confluence. This new site will also provide an indication of the operation of Zaaihoek Dam on the ecological state of the upper Buffalo River;
    ii. The site on the Bloed River was initially included, but after the field visit undertaken during the week of 11-15 November 2019, it was agreed that the wetlands in this area are extensive and should drive the classification and RQO determination for the Bloed River;
    iii. Klip River downstream of Ladysmith to provide information on the impact of the flood control dam on the system and possible reduced yield from the proposed Jana Dam at the confluence of the Klip and Thukela rivers;
    iv. Klein Mooi River upstream of the confluence with the Mooi River to evaluate the impact of proposed new farm dams on the upper Mooi River system;
    v. Mooi River just before the confluence with the Thukela River as the existing EWR sites are in the upper and middle catchment and no sites downstream of Craigie Burn Dam on the Mnyamvubu River; and
    vi. Nsuze River, tributary of the lower Thukela River as very few substantial tributaries occur in this reach of the river.

- Additional sites might be required after the finalisation of the IUAs, resource units and selection of hydronodes.
- The following existing sites should be included as key sites where possible biological and hydraulics surveys should be undertaken:
  i. Main stem Thukela River: Thukela_2, Thukela_4, Thukela_9, Thukela_15 and Thukela_16;
  ii. Mooi River: Thukela_10 (new site EWR3_Mooi_N3);
  iii. Bushmans River: Thukela_5;
  iv. Buffalo River: Thukela_14, May13_EWR1 on the Ngagane River;
  v. Sundays River: Thukela_8; and
  vi. Lower Thukela River: Thukela_15 and Thukela_16.
- The preliminary water quality Reserve has been determined at the Comprehensive EWR sites; however, due to increased development the water quality has changed at some of the sites and will have to be revised to inform the classification process and the determinationof RQOs,
- The BHN requirements were determined as a component of the Comprehensive Reserve Determination for Thukela Catchment. The population figures used were based on the 1996 National Census. The estimated growth in these populations were determined up to 2020. The latest available census data of 2011, related to the people still directly dependent on the water resources for their subsistence use, will be compared to the preliminary Reserve BHN requirements, and
- No reports/ data are available for many of the Rapid Reserve determination assessments that were undertaken during 2002-2005.

### 2.2.2 Groundwater

Determination of the groundwater component of the water resources Reserve was conducted by Dennis *et al* (DWAF, 2009) and is regarded as the most recent assessment thereof. Although the authors claimed that the Reserve determination could be regarded as a “high level assessment” it is noted that there are some short falls for a “Comprehensive Reserve” as per guidelines of Parsons and Wentzel, 2005.

The detailed determinations aimed to produce a satisfactory associated confidence level based on site-specific information generated by specialists. Although for example, a few local hydrocensus surveys were done to upgrade the water quality data coverage, the water management area is too large to determine representative aquifer hydraulic characteristics, (*i.e.* based on physical aquifer test pumping).

There is also a scarcity of long-term water level time series data for the WMA to support rainfall-recharge assessments. However, the 2009 Reserve determination indicated that critical groundwater stress conditions, and poor resource classification are present in a

number of the resource units. It was recommended that detailed groundwater assessments of these RUs be conducted to the level required for a Comprehensive Reserve determination.

The 2009 study also included a Groundwater Resource Classification assessment – although summarized under the Reserve groundwater resource units. The criteria for the classification was based on the current (Viz. 2009) status of the groundwater quality and aquifer saturation (i.e. water level elevations WRT aquifer depth). Groundwater quality in the lower rainfall areas, which coincides with the downstream sections of the WMA, is poorer – concurrently with the presence of the lower sedimentary sequence of the Karoo Supergroup formations. In addition, the Sundays and northern Buffalo catchments are affected by redundant coal mine drainage and industrial/ agricultural wastes.

The 2009 Groundwater Reserve Determination for the Thukela catchment indicated that four (4) of the 25 RUs were classified (Present Status Category) as D and E, Moderately (II) to Highly stressed respectively. These RUs only cover the upstream sections of the Upper Thukela, Buffalo and Mooi rivers. Except for limited groundwater reserves in the Lower Thukela River RU: TRU-Y (consisting of quaternary catchment V50D – Thukela River Mouth), the remaining quaternary catchment groundwater Reserve components (i.e. Allocable Volume) of the Thukela WMA are still above 1.5 $Mm^3/a$. Quaternary catchments bordering the Drakensberg Mountain Ranges were classified as pristine groundwater reserve conditions.

The following can be summarised in terms of the information review for (i) the groundwater resource Classification scope and (ii) preliminary groundwater component of the Reserve:

(i) Classification scope (usage–quality status–vulnerability/impact): All RU's are classified as Good to Fair. TRU-S (tributaries of the Buffalo River) has been classified as a Class D category.

(ii) The groundwater component of the Reserve (expressed as [preliminary] Allocable groundwater values in $Mm^3/a$): All RU's, except TRU-F (Upper Thukela) and TRU-S (Upper Buffalo), are not stressed in terms of allocable groundwater resources.

Classification and RQO's for TRU-F and TRU-S will have to be re-evaluated. These two GRUs comprise eight (8) quaternary catchments.

### 2.2.3 Estuary

An intermediate level Ecological Water Requirements (EWR) study was conducted during the period 2001-2004 and Thukela Estuarine Flow Requirements Report (Volume 1) published in 2004 (DWAF, 2004), which included specialist reports (Volume 2) in nine appendices. The assessment of the preliminary Reserve studies indicates that there is a large amount of data and information related to the abiotic drivers and biotic responses used to determine the EWR for the Thukela Estuary.

Based on available information and a once off study during a low flow period in August 2001, the preliminary Reserve assessment indicated that the overall estuarine health score was 70, which translates into a Present Ecological State of C (moderately modified). The estuarine health score was determined using the Estuarine Health Index that takes into consideration the abiotic drivers (hydrology, hydrodynamics and mouth condition, water quality, and physical

habitat alteration) and biotic responses (microalgae, macrophytes, invertebrates, fish, and birds).

The Thukela Estuary was allocated an Estuary Importance score of 76, which falls within the 60 – 80 range, indicating that the estuary is important. Of the five criteria contributing to the importance rating, functional importance was allocated a score of 100 because of the movement corridor provided by the estuary for river invertebrates that breed in the marine environment and the roosting area provided for marine or coastal birds. At the time of the Estuarine Freshwater Requirements study, the Ecological Reserve Category (ERC), based on the estuary's PES, was determined to be a PES + 1; *i.e*. a Category B. If it was not possible to achieve this state, then a best attainable state of a Category C would be the minimum requirement.

The following is noted in terms of the information review of the Preliminary Reserve:

- *Hydrology*

The hydrology of the Thukela Estuary for the preliminary Reserve was determined using topographical data collected by the Department of Water Affairs and Forestry (DWAF) in November 1996; full details provided in Huizinga and Van Niekerk (1997). These data include cross sections of the beaches adjacent to the estuary mouth and of the estuary from the mouth to the old N2 Bridge. There were no data available on berm height during closed mouth conditions.

Sediment loads into the Thukela Estuary have been determined using a sediment load-discharge rating curve obtained from sediment samples collected between 1971 and 1984 at the Mandini gauging station (V5H002 – 29°38'26"E; 31°23'31"S) by DWAF. Sediment yields from other parts of the Thukela catchment are available from Dollar (2001) and Rooseboom (1992) (DWAF, 2004).

River discharge data for the estuary were obtained from the Mandini gauging station (V5H002); the station gauged discharge from a catchment area of 28 920 $km^2$ (DWAF, 2004). Although the DWAF (2004) report indicated that water level recordings were being collected inside the mouth of the Thukela Estuary since 12 November 1999, the data appear to be sporadic at times and full details are included in an unpublished report by Huizinga and Van Niekerk (1997). River flow and mouth condition data provided by SAPPI Mandini, provided for the period 10/1991 – 09/1995 (DWAF, 2004), indicate that mouth closure periods were short, and only occurred when river flows were 7.7 $m^3/s$ and lower.

Water column salinity profiles obtained for 29/10/1992 (low tide), 06/11/1997 (low tide), 20/08/2001 (low and high tides), and 12/02/2002 (low and high tides) provide an indication of salinity penetration into the estuary at a range of flows (< 5 – 40 $m^3/s$) and tidal stages.

- *Water quality*

The relationship between salinity and river flow in the Thukela Estuary has been based on measurements made in October 1992, May 1996, November 1997, August 2001 and February

2002 (DWAF, 2004). The relationships between salinity and other water quality variables (excluding nutrients) were obtained from three full estuarine surveys; May 1996, August 2001 and February 2002 (DWAF, 2004). The water quality variables included temperature (ºC), pH, total suspended solids (mg/L), and dissolved oxygen (mg/L). Salinity-nutrient relationships were drawn from nutrient concentrations measured throughout the estuary on 30 May 1996 and 20 August 2001. The nutrients included nitrate/nitrite-N (Total Oxidised Nitrogen), reactive phosphate-P, total ammonia-N (ammonium plus ammonia), and reactive silicate-Si. In addition to the measurements made throughout the estuary, sea and river concentrations were included from measurements made on 21 August 2002.

Continuous water quality measurements in the river were measured at a maximum of four sites located just upstream of the estuary; Mandini gauging station (V5H002), and three SAPPI monitoring sites (John Ross Bridge (north), Ultimatum Tree, and Havelock Farm) (Table 4).

Temperature data were available for Thukela Estuary EWR study for the period January 1997 to October 2001 (DWAF, 2004). These data sourced exclusively from SAPPI long-term monitoring sites (Table 4), showed clear seasonal fluctuations in temperature. River water pH was available from all four monitoring sites where the Mandini gauging station data were used for reference (1977-1985) and present (1995-2001) conditions (DWAF, 2004). Total suspended solids and turbidity measurements are limited to sampling sessions of the estuary on 30 May 1996, 20 August 2001 and 12 February 2002; there has been no regular monitoring of these parameters upstream of the estuary. Dissolved oxygen and Chemical Oxygen Demand (COD) were measured at the three SAPPI long-term monitoring sites and not at the Mandini gauging station.

**Table 4: Availability of water quality data from four long-term sampling sites upstream of the Thukela Estuary for the 2001-2004 EWR study (DWAF, 2004)**

| Sampling site upstream Estuary | Temperature | pH | TSS/turbidity | Dissolved oxygen |
|---|---|---|---|---|
| Mandini gauging station | ✗ | ✓ | ✗ | ✗ |
| John Ross Bridge | ✓ | ✓ | ✗ | ✓ |
| Ultimatum Tree | ✓ | ✓ | ✗ | ✓ |
| Havelock Farm | ✓ | ✓ | ✗ | ✓ |

Monthly nitrite/nitrate-N, reactive phosphate-P and reactive silicate-Si concentrations from the Mandini gauging station showed that there were no significant differences between the reference period (1977-1985) and the period that represented the present state (1995-2001) (DWAF, 2004). Total ammonia-N concentration was not measured at the Mandini gauging station, so concentrations used in the DWAF (2004) EWR study were based on those collected in the fresh upper reaches in May 1996 and August 2001.

Trace metals have been collected from the sediments in the Thukela Estuary during May 1996 (two sites) and August 2001 (six sites)

- *Sediment dynamics*

The impacts of two proposed dams in the Thukela River catchment on hydrodynamics and sediments in the estuary were determined based on river flow simulations and sediment yields for the entire catchment. The study determined that existing dams had decreased the average peak discharge of floods by 8% and the addition of two dams (Jana Dam on the Thukela River and Mielietuin Dam on Bushmans River) would decrease the peaks to 19%. An estimated increase in sediment yield from ~200 Ton/km$^2$ (reference) to ~400 Ton/km$^2$ (present) is likely to have decreased the length of the estuary from 8.5 km to 5.0 km and made the estuary shallower. It was determined to be unlikely that the additional dams would affect sediment equilibrium in the estuary from present, although the estuary would most likely become narrower, shorter and shallower.

- *Microalgae*

Microalgae, which are differentiated into free-floating (phytoplankton) and benthic, are essential primary producers in estuaries. Changes in water quality and river flow can bring about measurable changes in the abundance (measured using chlorophyll *a* as an index) and community composition. There has only been a single sampling session (August 2001) of microalgae in the Thukela Estuary, which formed the basis of the DWAF (2004) EWR study. Phytoplankton were collected from six sites along the length of the estuary at half metre depth intervals.

Benthic microalgae were collected from the intertidal and subtidal zones of four sites along the length of the estuary. Chlorophyll *a* biomass ranged from 2.5 to 20.5 µg/g (units can be converted to mg/m$^2$ by multiplying the values by 1.67; Snow, 2008). Diatoms collected from all sites were used for community analyses and consisted of cells that inhabit coarse-grained sand (episammic) and fine mud (epipelic).

- *Macrophytes*

A vegetation map of the present distribution of macrophytes was compiled using botanical surveys that were conducted in June 1996 and August 2001. The estuary has a relatively small area of macrophytes, which was dominated by freshwater-associated species such as the common reed (*Phragmites australis*; 20.4 ha), sedge (*Schoenoplectus scirpoides*, 19.7 ha) and swamp forest (*Barringtonia racemose* and *Hibiscus tiliaceus*; 0.3 ha). The study described clear shifts in community structure from reference and predicted changes related to changes in flow with the construction of two additional dams in the river catchment.

- *Macroinvertebrates*

The present status of the Thukela Estuary using macroinvertebrates (> 0.5 mm) was predominantly determined using results from monthly samples from 12 sites collected during

the period April 1997 to March 1998, and from six sites during two sampling sessions in August 2001 and February 2002 (DWAF, 2004; Part 1). Densities of all representative taxa were listed (abundance) and detailed community analyses conducted. Although the number of macroinvertebrates of the system were not as diverse or abundant as other local estuaries, they were not depauperate and provide a vital food source to higher trophic levels. The macroinvertebrate community was dominated throughout by freshwater species and just five of the species contributed 75% of the overall abundance. The study did highlight the very dynamic nature of the system where sediment type and geomorphology of the channel changed spatially and temporally.

The zooplankton were only sampled in August 2001 and February 2002 at three sites (lower, middle and upper estuary) up to 2.3 km from the mouth, coinciding with low and high flows, respectively (DWAF, 2004; Part 2). Intrusion of seawater during August 2001 introduced a much more diverse and coastal marine community of zooplankton of high abundance; similar to that found in the nearby Mhlatuze Estuary (DWAF, 2004). High flow in February 2002 caused a large decrease in zooplankters, which were dominated by freshwater species.

Prawn traps and beam trawls were conducted at three sites (lower, middle and upper estuary) up to 2.3 km from the mouth in August 2001 and February 2002 (DWAF, 2004; Part 3) to assess the macrocrustacean community in the Thukela Estuary. Detailed descriptions of the macrocrustaceans present, dominated by a variety of prawn species, and their habitat preferences were provided.

- *Fish*

Fish community, in relation to river flow, is well studied in the Thukela Estuary with gillnet studies conducted in May 1996, February 1997 and February 1999, and seine net studies in July 1986, May 1996, February 1997 and February 1999; a minimum of eight seine samples along the length of the estuary were conducted on each sampling trip. The studies showed that high river flows (>50 m3/s) prevented the intrusion of saline water into the estuary and limited the nursery areas available to many marine fish species. Being a river mouth, the estuary does not support a rich or diverse community of ichthyofauna. As river flow decreases, the study showed a clear increase in the Fish Recruitment Index scores up to a point where mouth closure was predicted.

- *Birds*

A comprehensive assessment of the current status of avifauna of the Thukela Estuary was based on bird counts conducted in June 1996, 1997-1998 (12 monthly counts), August 2001 and February 2002. The DWAF (2004) assessment found that the aquatic bird community of the estuary was relatively diverse and consisted of palaearctic migrant and resident populations. The estuary does provide feeding and roosting areas, providing habitat to birds that have been displaced from surrounding areas that have been impacted by human activities. The backing up of water and flooding of suitable roosting and feeding habits as a result of reduced river flow and mouth closure is the biggest threat facing the Thukela Estuary bird community.

The following can be summarised in terms of the information review for the Thukela Estuary preliminary Reserve:

- The last full hydrological study, including a comprehensive geomorphological assessment, was last conducted by DWAF in 1996; detailed information is available in Huizinga and Van Niekerk (1997). This study is 24 years old and a repeat is required to determine if there have been changes in hydrodynamics and geomorphology. A reduction in river flow and increased sediment yield were predicted to make the estuary narrower, shallower and shorter (DWAF, 2004).
- The EWR study highlighted that the mouth of the estuary closes more frequently, albeit for intervals of a few days, compared to natural. No studies have been conducted when the estuary has closed to determine the effect of mouth closure on the biogeochemistry and the migration of fauna between the river, estuary and marine environments.
- Water column salinity profiles and associated physico-chemical parameters were limited to flows of approximately 5 and 40 $m^3/s$. A maximum intrusion of saline water was 3.5 km at the lowest river flows.
- Long-term monitoring of a number of key physico-chemical parameters have been measured at four sites upstream of the Thukela Estuary; Mandini Gauging Station (DWAF) and three sites between the gauging station and the estuary (SAPPI).
- Long-term monitoring of nutrients include nitrate/nitrite-N, reactive phosphate-P and reactive silicate-Si but studies of ammonia-N are limited. Additional studies of nutrients in the estuary are needed to determine if there have been changes in water quality.
- Average pH increased from circumneutral (reference = 7.1) to weakly alkaline (present = 8.2); additional sampling is required to determine if there have been further changes. An increase in temperature and pH can result in a higher proportion of ammonium becoming transformed into the ammonia posing a threat to instream fauna.
- The EWR study found loads of suspended, fibre-like material in the estuary and a distinct peak in chemical oxygen demand linked to hypoxic conditions in the estuary. A comprehensive study of total suspended solids and oxygen concentrations is needed to determine the source of these solids.
- The phytoplankton abundance and community composition of the once-off microalgal study indicated a heavily modified estuary; an additional study is needed to confirm the findings and check for changes.
- The area covered by macrophytes was small and dynamic, supporting the growth of a few freshwater-associated species of plants. No saltmarsh or mangroves were present.
- The dynamic nature of the freshwater-dominated estuary does not support a high diversity or abundance of macroinvertebrates, but these are still an important source of food to animals from higher trophic levels such as fish and birds. The EWR study highlighted the importance of the estuary as a nursery area and breeding habitat for a number of species of prawns, a conduit for anguillid eels, and for providing roosting and feeding habitats for Palaearctic migrant and resident bird populations.

- Mouth closure related to reduced river flow and flood peaks pose the greatest risk to the fauna and flora of the Thukela Estuary.

## 2.3 MODELLING

The classification process is reliant on the modelling undertaken through previous studies.

A preliminary review of past and current studies has been conducted to confirm what existing water resources models, and associated study reports, have been completed for the Thukela Catchment. In particular, emphasis was placed on determining whether the DWS developed Water Resource Yield and Planning models (WRYM &WRPM) have been utilised. These mass balance models are used for determining water yields, system balances and assessing the impacts of development scenarios, and have also been used during the classification of water resources in other regions.

The Thukela is modelled as part of the integrated Vaal River System, within the WRPM. In this model, the focus and greater detail is on the current transfers out of the Thukela to the Vaal. However, all sub-catchments within the Thukela are included, at varying levels of detail.

Similar to the integrated Vaal River System set up, WRYM models were configured for the Thukela Water Project in 2003. This WRYM has two separate configurations, one for the Thukela and one specifically for the Mooi sub-catchment. The unit catchments and level of detail for the WRYM setup are similar to the portion of the Thukela in the Vaal WRPM and thought to have been the building blocks for the latter Vaal WRPM configuration.

Additional to the above-mentioned system configurations, for the total Thukela Catchment, models have been developed for portions of the Thukela Catchment as part of other studies in recent years. These are summarised in Table 5.

**Table 5: Summary of relevant water resources models and studies**

| No. | Study name | Date | Portion of Thukela | Model Configured | Hydrology period | Comment |
|---|---|---|---|---|---|---|
| ***Studies with System Models*** | | | | | | |
| 1 | Vaal AOA | June 2011 | Whole Thukela plus neighbouring Vaal, Usuthu, etc. | WRPM | 1930 - 1993 | Hydrology period limited by overlap of all catchments |
| 2 | TWP (Thukela Water Project) | April 2003 | Whole Thukela | WRYM | 1925 - 1994 | |
| 3 | Mooi Mgeni Hydro Update | July 2019 | Mooi River down to confluence | WRYM & WRPM | 1925 - 2017 | Recent study for Umgeni Water |
| 4 | Buffalo Annual Operating Analysis | May 2019 | Buffalo down to V33C | WRYM & WRPM | 1920 - 2004 | WRPM more updated. |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | WRYM at 2013 level |
| ***Studies without System models*** | | | | | | |
| 5 | All-Towns Recon Strategies | 2011 and 2013 | uMzinyathi, Amajuba & uThukela DMs – main towns and schemes | Method of assessment TBC | Method of assessment TBC | Local water balances at towns were the focus. |
| 6 | Thukela ISP | 2004 | Whole Catchment | N/A | N/A | Study on main attributes & water balance of system. |
| 7 | Water Resources 2012 (by WRC) | 2012 | Whole Thukela | WRSM2000 | 1920 - 2009 | National study with possible limitations in detail possible in Thukela. |

Water requirements associated with water abstractions and return flows as well as land-uses that utilise water resources, are typically available in reports associated with these studies, as well as embedded in the model configurations themselves.

Again, as a result of a lack of a single catchment scale focused water resources strategy, the available information of water use in the catchment varies, spatially and temporally. Additional sources of information for water requirements and return flows in the catchment not linked to a specific modelling study are:

- The Validation and Verification studies and process that is being completed for the Thukela catchment.
- The WARMS database that is maintained by the DWS.

These two sources of information should assist in better identifying water use in the catchment, and in particular, licenced water uses. Neither of these two sources of information are however directly available to the public, and it will be required that the appropriate Directorate at the DWS assists with the provision of this information. It must also be noted that the study team recognises the sensitivity of this data, and the intention is not to scrutinise or report on individual users but to lump the data at appropriate sub-catchment scale for modelling purposes.

# 3 INFORMATION ASSESSMENT AND GAP IDENTIFICATION

An assessment of data availability and accessibility, as well as analysis of the available information for the Thukela Catchment was undertaken for the various components that comprise the classification and RQO processes. The steps to be undertaken as required in terms of the 7 step WRCS process are indicated in Figure 4, and the results of the data and information assessment, as well as the potential gaps identified that may influence this process, are discussed in the sections to follow.

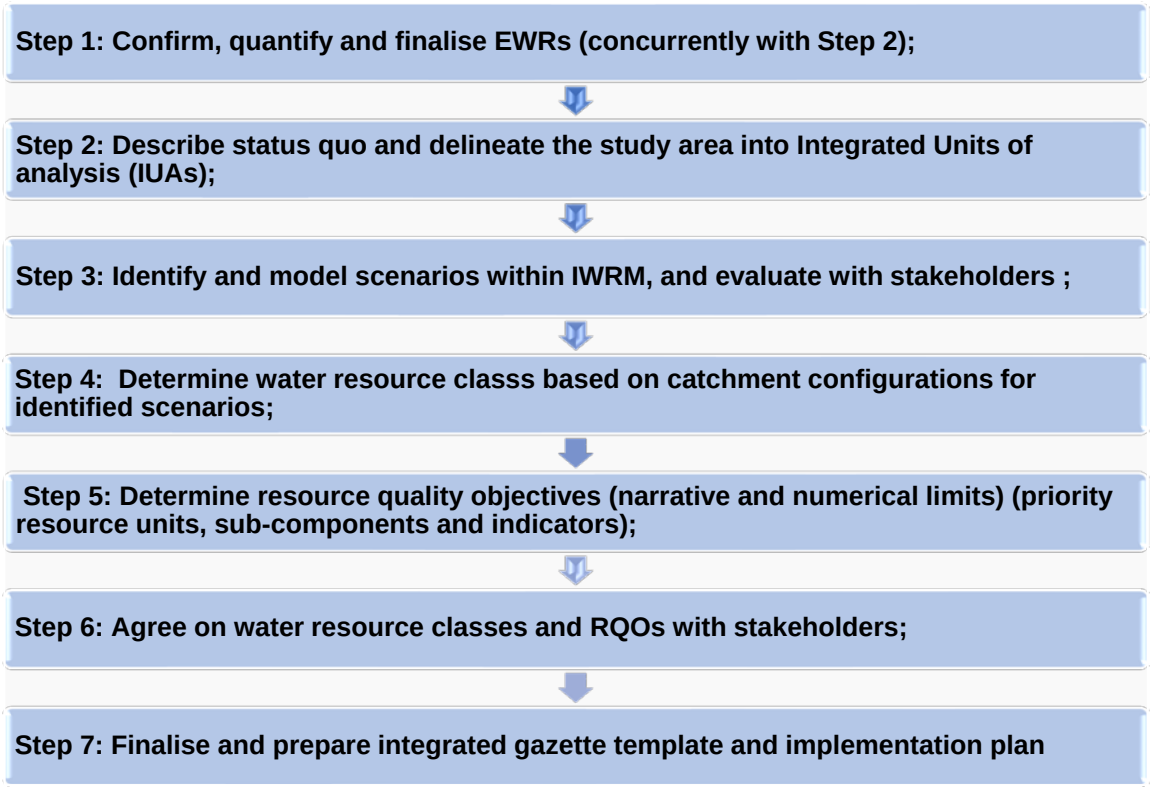


**Figure 4: Water resource classes and RQOs determination in the Thukela Catchment (integrated process in adherence to Regulation 810 of Government Gazette 33541**)

## 3.1 Rivers

The assessment of the data and information availability for the rivers component is described in Table 6, with the gap analysis summary detailed in Table 7.

**Table 6: Data/Information availability for the Rivers Component**

| Aspect | Data Availability | Suitability (confidence) | Other Sources |
|---|---|---|---|
| Site information: EWR site details | Yes | Available for all the studies undertaken since 2002.<br>In some cases (2002-2005) only site locations are available | |

| Aspect | Data Availability | Suitability (confidence) | Other Sources |
|---|---|---|---|
| EWRs (comprehensive sites) | Yes | Good coverage of the main stem and major tributaries with limited sites on smaller tributaries | Rapid and intermediate assessment undertaken since 2002 |
| Rule and Tab tables | Yes | Might have to adjust for existing sites depending on the changes to PES and REC and the base/ reference hydrology | |
| BHN | Yes | Low confidence; however, if the 2011 Census data with growth estimates to 2020 is used, the confidence levels should increase to moderate | Census 2011 |
| Water Quality Ecological specifications | Yes, but limited and often outdated | Moderate confidence in most areas, however, where development has taken place the confidence may be low. | External monitoring data, where made available |
| Biota | Yes | Outdated data for most of the systems except Thukela_16, Ngagane River and upper Mooi River | Some data from River Health Programme, UKZN, Mngeni Water Board or private consultants/ NGOs might be available |
| Riparian vegetation | No | Approach used in comprehensive study was updated | Can use IHI as a surrogate at the selected key sites |
| Rapid Reserve assessment | Yes, limited to more recent studies | Only available for a few recent (2013-2019) studies | |
| PES/ EI/ ES | Yes | Provides a good indication of the state, sensitivity and importance of the smaller tributaries that were not assessed as | 2013 PES/ EIS updated study |

| Aspect | Data Availability | Suitability (confidence) | Other Sources |
|---|---|---|---|
| | | part of the previous studies | |
| Site information: EWR site details | Yes | Available for all the studies undertaken since 2002.<br>In some cases (2002-2005) only site locations are available | |
| EWRs (comprehensive sites) | Yes | Good coverage of the main stem and major tributaries with limited sites on smaller tributaries | Rapid and intermediate assessment undertaken since 2002 |
| Water Quality | Yes | Moderate confidence on major tributaries but is limited on smaller tributaries and at the headwaters of catchments. | External monitoring data, where made available |

### 3.1.1 Water Quality

The Department's Resource Quality Information Services (RIQS) water quality database, the Water Management System (WMS) will be used as the primary source of the water quality data for the analysis. In terms of water quality data assessment the water quality monitoring stations and related information are largely concentrated on main stem rivers and tributaries. Data gaps do potentially exist for the smaller tributary catchments which are identified as high PES and ecological importance and sensitivity. Monitoring points may not be located in prioritised RUs and also the adequacy and reliability of data might be a gap.

Water user requirements and water quality impacts need to be understood. A number of localised water quality issues around the towns and related to agricultural practices have been highlighted. This is key to understanding the extent of impacted areas and to the development of RQOs and numerical limits. Lack of recent monitoring information may impact on the process. In addition, the lack of available baseline water quality monitoring data in some catchment areas is a gap.

The WMS database primarily includes monitoring data for Electrical Conductivity (EC), Total Dissolved Salts (TDS), pH, Sodium, Magnesium, Calcium, Hardness, Potassium, Fluoride, Chloride, Sulphate, Phosphate as P, Total Alkalinity as $CaCO_3$, Ammonium as N, Nitrate + Nitrite as N, COD, and *E. coli*. No trace metal or organic analysis is performed as part of this routine monitoring. For the purposes of this study, the certain indicator variables will be used to assess status quo and for RQO determination.

The monitoring points of the National Chemical Monitoring Programme (NCMP) (WMS data) within the Thukela catchment are primarily located on the main stem Tugela River and the major tributaries (Bushmans, Buffalo, Mooi and Sundays Rivers). 196 registered points on the WMS have been monitored since 2000, however the frequency and extent of monitoring varies considerably. Details of the monitoring site information is described in Appendix 1 and their locations are shown in Figure 5. A challenge posed for the classification study is the determination of the water quality status at more remote sites where no monitoring is currently undertaken – specifically if a sub-node is identified in a smaller tributary catchment with a high PES/EIS.

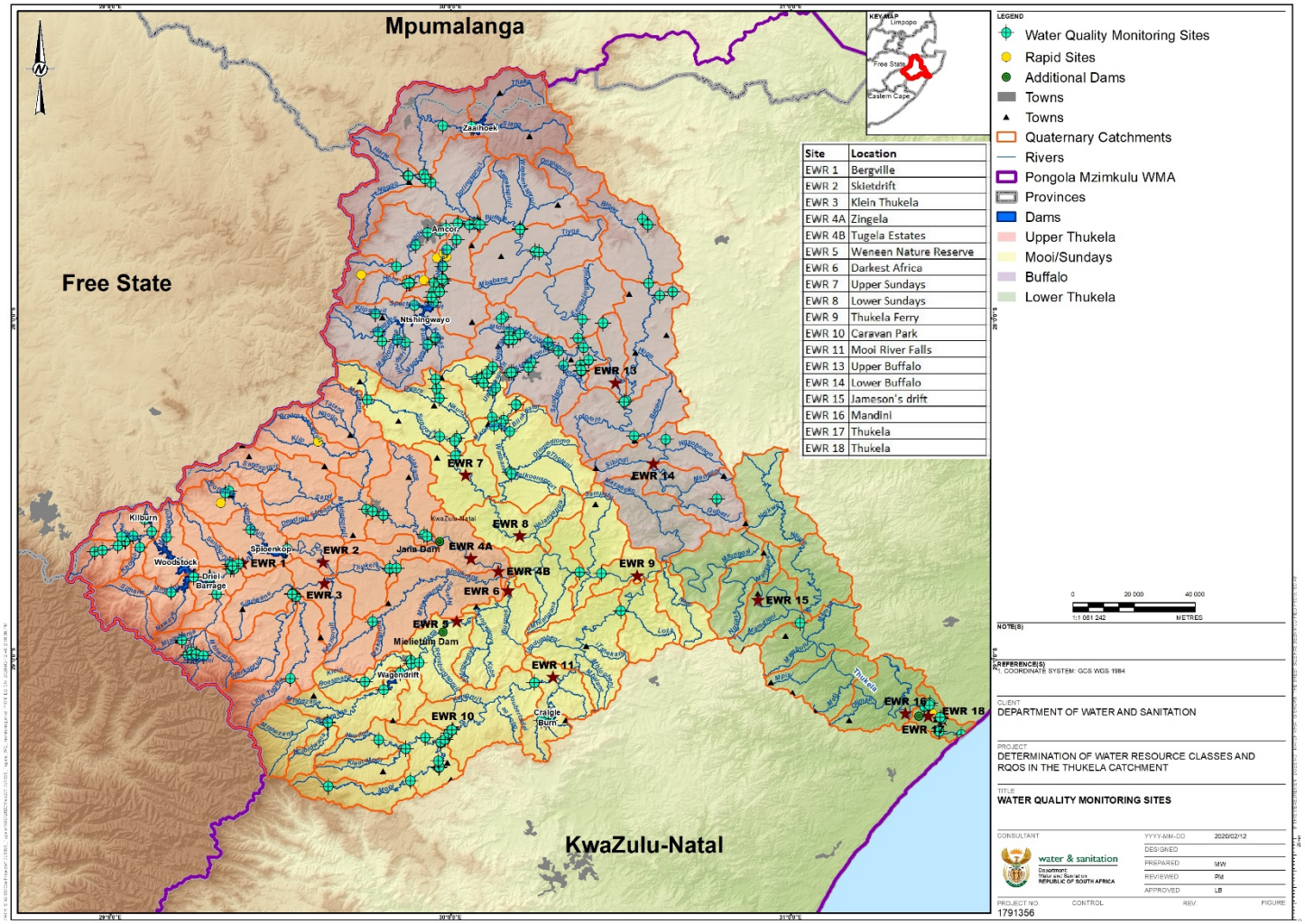


**Figure 5: Location of water quality monitoring sites in the Thukela catchment**

**Table 7: Gap analysis based on information assessment**

| Aspect | Gap Identified | Potential Consequence to outputs | Proposed Intervention |
|---|---|---|---|
| Hydraulics | Unavailability of data and modelling results from previous 2003 Reserve Study. | Inaccuracy in EWR quantification and scenario modelling.<br>Additional Budget requirement for 2 weeks in field and additional modelling to re-survey the existing sites. | Selection of only key EWR sites based on priorities in terms of IUA and hydronode selection to reduce the number of sites required for re-survey. |
| BHN | Outdated population figures | Inaccurate BHN provision in scenario assessment, influence the setting of WRC | Update population in terms of the 2011 census |
| EWRs for the system | No EWR sites and preliminary Reserve for sub-catchments within the Thukela Catchment i.e. Upper Buffalo, upper Mooi River, | Gap in the scenario modelling for these catchments in terms of IWRM context. | Rapid assessments are proposed to be undertaken at additional sites to address potential EWR gaps. |
| PES | Validity of PES as preliminary Reserve was undertaken in 2003 (16 years ago). Confirmation of PES at EWR sites required. | Inaccurate configuration and EWR quantification.<br>Inaccuracy in RQO determination | Biological surveys at key existing EWR sites to provide current information for the confirmation of the present state of the water resources. |
| Riparian vegetation | Approach used in 2003 been revised totally | Inaccurate data for the determination of the EWRs | Use rapid IHI assessment as surrogate |
| Rule and tab tables | Changes to the reference hydrology | Inaccurate results of EWR quantification and scenario analysis | Comparisons between reference hydrology used during 2003 and that chosen for this study and to adjust the tables |
| Catchment scenarios | Not available for entire Thukela catchment as no reconciliation strategy was undertaken | Possible gaps in the scenario modelling for some planned water resource developments in the catchment. | Discussions with water resource and municipal managers and other role players to ensure all possible water resource developments are identified and included in the scenarios |
| Water Quality | Limited or lack of baseline monitoring data on some | Impacted areas/hotspots maybe be missed, or | Some further data sources will be |

| Aspect | Gap Identified | Potential Consequence to outputs | Proposed Intervention |
|---|---|---|---|
| | rivers. Water quality impacts at local scale are not understood. | adequate protection measures maybe not be identified if is not available to indicate status. | investigated to obtain additional water quality monitoring data such as those of the local municipalities and mines in the WMA, or other programmes. |

The available data, and that which will be sourced and used in the study will allow classification of the water resources and the associated RQOs that will be set will therefore be realistic and achievable.

### 3.1.2 Proposed additional sites

Based on the preliminary information assessment the following five additional sites have been identified as Rapid Reserve assessments to be undertaken for the Thukela Catchment to (Table 8) fill gaps in EWRs.

**Table 8: Identified rivers for Rapid Reserve assessments**

| Site | River | Quaternary Catchment | Relevance |
|---|---|---|---|
| 1 | Upper Buffalo | V31D | Zaaihoek Dam upstream on the Slang River (tributary of Buffalo) with no EWR determined to be released from the dam. Existing EWR site on Buffalo are after the Ngagane confluence |
| 2 | Mooi | V20J | New site on bottom end of the Mooi just before the confluence with Thukela. EWR 11 too high on Mooi river to account for downstream reach and impacts of Craigie Burns Dam. |
| 3 | Klip River (one site either just downstream of the flood control dam in V12C or below Ladysmith, V12G) | V12C or V12G | To provide information on the possible impact of reduced floods on the Thukela River at the proposed Jana Dam (at confluence of Klip and Thukela Rivers) |
| 4 | Little Mooi | V20B or V20D | Water resource developments planned (farm dams and increased irrigation) to determine the impact of water availability in the lower Mooi |
| 5 | Nzuse | V40D | Only a few significant tributaries in the lower Thukela with little/ no biological information available |

## 3.2 Water Resource Modelling

The review of data and information availability to undertake the water resource modelling for the scenario evaluation step of the classification process is described in Table 9 and the gaps identified are summarised in Table 10.

**Table 9: Data/Information availability for the water resources modelling**

| Aspect | Data Availability | Suitability (confidence) | Other Sources |
|---|---|---|---|
| WRPM | Yes (but only older versions) | Newer data in this model, but more complex to utilise | WRPM for the latest Vaal Reconciliation and Annual Operating analysis (AOA) to be provided by DWS to compare with versions currently obtained by study team |
| WRYM | Yes (but only partial portions of the Thukela (Mooi and Buffalo) currently obtained by Study team | A more suitable model for the purposes of the classification study, but data in the available WRYM models is more dated that the WRPM | |
| Model versions | Various | Various model versions available and can be used. Most suitable for the classification to be confirmed through comparison of hydrology data. | |
| Development data (demands) | DWS to provide some studies, which are not readily available on the DWS website | Information on irrigation water use in Thukela is dated. Information from WARMS and validation and verification required to improve confidence. | |
| Hydrology | Yes | Data available from different sources with different record lengths | |
| System configuration | Yes | Old system configurations but sufficient for purposes of the study. | |
| Network setup | Yes | Most studies have diagrams that can be utilised, but some might be dated. Will require checks by the study team | |

| Aspect | Data Availability | Suitability (confidence) | Other Sources |
|---|---|---|---|
| Water supply volumes | Partial | Modelled supply available in some older model set-ups. Actual supply volumes required to check against model assumptions. | Actual water transfer volumes and supply to main users need to be obtained from the DWS or checked if available on hydstra page. |
| Water reconciliation assessment for catchment | No | Not applicable | Reconciliation for the KZN Metropolitan Areas; All Towns Water Balance assessments. |

**Table 10: Gaps analysis of water resource modelling component based on information assessment**

| Aspect | Gap Identified | Potential Consequence to outputs | Proposed Intervention |
|---|---|---|---|
| WRPM | Currently available complete WRPM or WRYM configurations are dated, or not focused on the whole catchment. | | Certain sub-catchments are well studied with updated hydrology and models. An updated complete single model will have to be built. |
| WRYM | | | |
| Planning scenarios | Various planning scenarios for different parts of the catchment linked to different strategies | Multiple scenarios may not talk to each other, or require lots of different scenarios – unnecessary complexity | Development long term planning options/scenarios will have to be generated to determine possible changes in water resources supply and demands. |
| Water supply volumes (current future) | Water supply volumes (in particular) water transfers, not explicitly documented and embedded in past model simulation results. | Water transfer volumes (biggest water use in the catchment) need to be fixed for the future. | A meeting with the DWS planning team to discuss the appropriate source for this data. |
| Reconciliation strategy | No strategy has been developed for the Thukela catchment | Address planning scenarios and water supply into the future as described above | |
| Municipal Urban Water requirements | No current and agreed upon water requirements and projects for the | Inaccurate water requirement projections in the scenario analysis will | The All Towns Study strategies the Thukela Water Project will be a source of some of this data. In addition, |

| Aspect | Gap Identified | Potential Consequence to outputs | Proposed Intervention |
|---|---|---|---|
| | municipal areas within the catchment | influence the water balance. | available current projections from the District Municipalities will be sought. |

Based on the above tables, it is necessary to confirm with the DWS on the future scenarios for neighbouring catchments and their water transfer needs from the Thukela. A meeting with the DWS, Directorate National Water Resources Planning was held on Tuesday, 14th January 2020, to gain direction in this regard. The guidance obtained at this meeting on the future scenarios will be confirmed through a scenario definition document that will be compiled and distributed for review as part of the next study task.

Thereafter the main key activity will require a single combined WRPM or WRYM set-up to be configured, pulling the best data from the various studies.

The choice between the WRPM and WRYM will be dependent on how the water transfers need to be simulated (based on neighbouring catchments demands), and this should be confirmed through the scenario definition.

An additional activity will be to confirm the hydrology to be used, as this will also impact the modelling.

### 3.3 Hydrology

The hydrology was developed for the period 1925 to 1994, for the whole Thukela Catchment, as included in studies numbered 1 and 2 in Table 5. The Thukela was sub-divided into 46 sub-catchments as part of the development of this hydrology. These modelling catchments are included in as taken from DWAF (2003).

Additional hydrology is available for the Mooi River portion of the Thukela, at both the modelling catchment scale presented in Figure 6, as well as at a quaternary catchment level for the period 1925 to 2017.

Hydrology has also been developed at a quaternary scale for the Buffalo catchment up to V33C for the period 1920 to 2004.

As such, the longest overlapping period of all catchments within the Thukela is for the period 1925 to 1994. If the external catchments as part of the Integrated Vaal River System are also considered, should the full WRPM be used, then the longest overlapping period of all associated catchments is from 1930 to 1993.

While not a catchment focused study, the Water Resources (WR2012) study by the Water Research Commission, updated all hydrology in the country to 2009 levels. There are however concerns about the level of detail possible at national scale, and it is thus recommended that hydrology generated from studies focused on the Thukela Catchment are considered even though they are not as long. As the WR2012 data also does not cover the recent drought, the additional data (1994 to 2009) will not help factor in the drought between 2013 and 2016.

Along these lines, the Mooi-Mgeni Hydrology Update Study (Umgeni Water, 2019) covered this period and noted that while the drought in the 2013 to 2016 period was severe, it is not the critical period for the Mgeni or upper Mooi catchment. It is not certain if this is a reality for other parts of the Thukela Catchment.

To confirm the best hydrology to use, it is recommended that a comparison be conducted to test the difference in record length. This will be done by comparing flow duration curves (FDCs) for select catchments to establish if there are differences in FDC for different record periods. The following record periods will be considered:

- 1920 to 1994 (for all hydrology sets)
- 1920 to 2009 (for the WR2012 data and any other focus studies, *i.e*. Mooi and Buffalo)
- 1920 to 2017 (for the Mooi catchment that has recently been updated).

Based on the proposed task, the FDCs will be compared. It is recommended that this be done for three select modelling sub-catchments, with one on the Mooi, one in the Buffalo, and one on the Thukela main stem.

If there are no meaningful difference in FDCs, then the hydrology from the catchment specific studies already built into the WRYM and WRPM will be utilised. If there are significant differences, then a discussion will be held with the DWS to confirm which set is more suitable.

The gaps identified with regard to hydrology data are indicated in Table 11.

**Table 11: Gaps analysis of hydrology data based on information assessment**

| Aspect | Gap Identified | Potential Consequence to outputs | Proposed Intervention |
|---|---|---|---|
| Record period and longest overlapping period | Data in models currently only extends to 1994 | The last 25 years hydrology not included in hydrological records. | A comparison with other more recent national studies to evaluate differences as described in above section. |
| Land use modelling | Older hydrology makes use of older modelling methods for land uses, e.g. stream flow reduction activities. | Limited as the model will be run in historic mode and the newer methods are more relevant to stochastic analysis | No intervention required. |

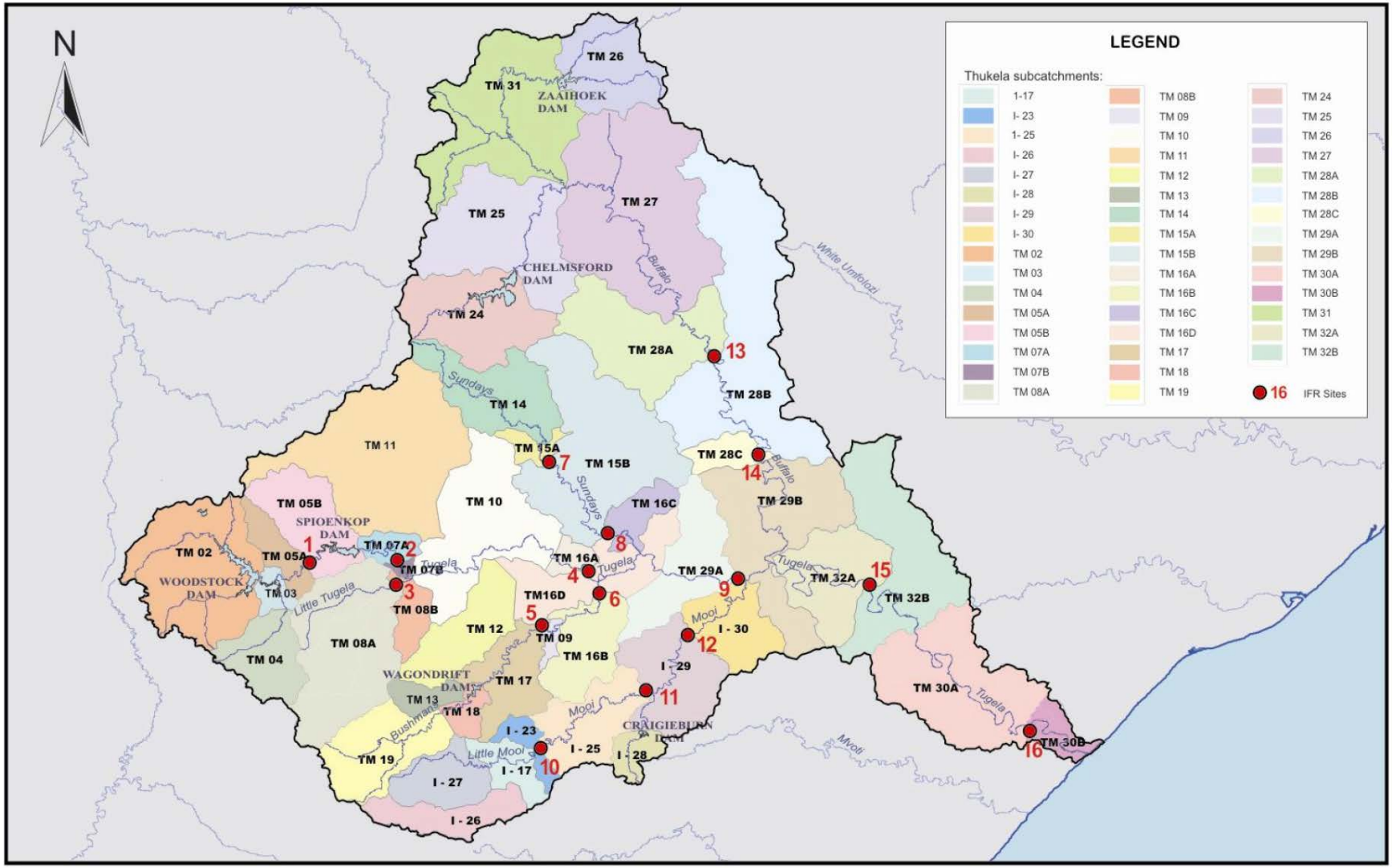


**Figure 6: Hydrological modelling units of the Thukela Catchment (data from 1925 – 1994)**

## 3.4 Wetlands

The assessment of the data and information availability for the wetlands component is described in Table 12 and the gaps identified are summarised in Table 13.

**Table 12: Data/Information availability for Wetlands component**

| Aspect | Data Availability | Suitability (confidence) | Other Sources |
|---|---|---|---|
| Wetland identification | National Wetland Map 5 (Van Deventer *et al*., 2018) - (GIS layer)<br>NFEPA wetland layer (Nel *et al*., 2011) - (GIS layer) | Low to medium confidence and requires desktop verification of key systems using available imagery | None<br>Available imagery of the catchment (for the purpose of identifying gaps in the databases and/or verifying the existing data where appropriate) |
| Wetland delineation | As above | Low confidence as all desktop mapping | |
| Wetland typing | As above | Low to medium confidence but requires desktop verification of key systems | |
| Wetland categorisation (PES and IS) | PES or similar surrogate data only available for some systems and at a desktop level. No IS data available. | Low confidence | More detailed studies of specific wetland systems if available |
| Initial Priority Wetland identification | Old hard copy maps from Begg (1989). | High confidence but requires updated mapping and PES assessments | |
| Additional Priority Wetland identification | Supported by the above plus SANBI (2013) and Macfarlane and Atkinson (2015). | Medium to high confidence but probably requires updated mapping and PES assessments | Other wetland studies or knowledge of specific systems as recommended or identified during the stakeholder workshops |

**Table 13: Gap analysis of Wetlands component based on the information assessment**

| Aspect | Gap Identified | Potential Consequence to outputs | Proposed Intervention |
|---|---|---|---|
| Mapping of Priority wetlands | Integrated GIS layer | | To be developed as part of study |
| Delineation and typing of Priority Wetlands | Delineation and typing mostly available at a desktop level only | Will require updating for all the Priority Wetlands | Updated desktop mapping of the Priority Wetlands to be undertaken as part of study where appropriate |
| Ecological categorisation of the Priority Wetlands | Present Ecological State (PES) and Importance and Sensitivity (IS) information is not available for most systems. | Information available for determining the REC or BAS is limited or not available in most cases | Surrogate databases and information sources will be used where appropriate to derive general state and importance and sensitivity indicators where possible. This will be used to derive the REC and TEC where appropriate / possible. |

While there is existing information on the general extent and distribution of wetlands in the catchment, this is mostly limited to desktop studies. More detailed information is available for some key wetlands (see for example Begg, 1989), but this is not supported by available GIS-based mapping or available updated PES and IS assessments. The lack of field verified ecological categorisation of most wetland systems means that there is a requirement as part of this study to derive PES and IS scores for the Priority Wetlands using surrogate databases and information (for desktop PES for example, see Kotze, 2016). As ecological categorisation derived from desktop-based surrogate information is not always an accurate representation of what is actually on the ground, this limits the confidence in the derived categories. As there is scope for limited field verification as part of this study, an attempt will be made to at least try to verify some of the desktop assessment and modelling results. This will however be limited by the quality of most recent available imagery, the access to the Priority Wetlands or sections of wetlands, time available in the field, and the rapid field assessment methods applied.

Similarly the constraints related to the available, and even updated, desktop mapping do not always enable the identification of all the Hydrogeomorphic (HGM) units (as modified from Brinson, 1993; and Kotze *et al*., 2007; and according to SANBI, 2009) applicable to a particular wetland or wetland system. Nor do they always provide an accurate delineation of the boundaries of the wetland systems. Also, the grouping of wetland HGM units necessary for

the desktop derived ecological categorisation may over-simplify the ecological state of a particular wetland complex.

Limited to no flow or water quality data (especially updated information) is available for the wetland systems in the catchment and the same is expected for the Priority Wetlands. In some cases, surrogate information from the river and groundwater components/studies may be able to be used for the Priority Wetlands, but this is expected to be limited. RQO's for the wetlands will thus mostly, if not all, be qualitative and confidence in these is expected to be low based on the limitations imposed by the existing information. In addition methods for the development and monitoring of wetland RQO's can be complex (see Bredin *et al*., 2019) and are largely still in their infancy and this will pose its own challenges in regard to the wetland component of the overall study. It is envisaged that the integration of information from the surface water, water quality and groundwater components/studies will be necessary to support the wetland component which will, to some extent, assist with the process.

Despite the above-mentioned limitations, it is envisaged that the identification of Priority Wetlands and the development of an integrated Priority Wetland GIS layer together with updated desktop delineations and desktop categorisations of these will be an important supplement to determining the relevant water resource classes of sections of the catchment. However, it must be reiterated that inherent in a wetland study of this nature are the limitations/risks related to the lack of more comprehensive field verified information.

### 3.5 Thukela Estuary

The assessment of the data and information availability for the estuary component is described in Table 14 and the gaps identified are summarised in Table 15.

**Table 14: Data/Information availability for the Estuary component**

| Aspect | Data Availability | Suitability (confidence) |
|---|---|---|
| River inflow/base flows | Yes | High |
| Water Quality | Yes | Physico-chemistry: Medium (low for closed mouth conditions)<br>Nutrients, TSS and DO (low) |
| Microalgae | Yes | Medium (low for closed mouth conditions) |
| Macrophytes | Yes | High (low for closed mouth conditions) |
| Invertebrates | Yes | Zooplankton and macrocrustacean: Medium (low for closed mouth conditions)<br>Macroinvertebrates: High (low for closed mouth conditions) |
| Fish | Yes | Medium (low for closed mouth conditions) |
| Birds | Yes | Medium (low for closed mouth conditions) |
| EWRs | Yes | Medium |

| Aspect | Data Availability | Suitability (confidence) |
|---|---|---|
| Hydrodynamics data | Yes | High (DWAF, 2004) but may be outdated |
| Sediment Processes | Yes | High (DWAF, 2004) but may be outdated |

**Table 15: Gaps analysis of the Estuary component based on the information assessment**

| Aspect | Gap Identified | Potential Consequence to outputs | Proposed Intervention |
|---|---|---|---|
| Hydrology | Based on topographical data collected by DWAF in 1996; includes beach and estuary cross sections. Data could be outdated. | Error that has developed over time related to EWR. | Update hydrological information by conducting a geomorphological assessment of the estuary (to the extent possible within scope of study). |
| Closed mouth conditions | No available information related to berm height, salinity profiles, water quality, and all biotic components during mouth closure. | Low confidence in EWR (DWAF, 2004) leading to possible exaggerated environmental response. | Conduct assessment of abiotic drivers and biotic responses during a closed mouth event. |
| Delineation | The upper boundary of the estuary is ~6 km from mouth (DWAF, 2004). Estuary is now included in an MPA that stretches to ~8.5 km from mouth. | Management strategy of the estuary needs to be amended to include additional 2.5 km. | Delineation of the estuary needs to be amended to include MPA boundaries. |
| PES | PES was set as Ecological Category C (estuarine health score = 70) (DWAF, 2004). Estuary now falls within boundaries of an MPA*; i.e.* is classified as protected and should be restored to and maintained in either an A category or the Best Attainable State (BAS). | Management strategy of the estuary needs to be amended to include rules associated with the MPA unless it is decided that the estuary can only be managed at BAS. | Determine the highest level that the estuary can be managed. |
| Limited abiotic and biotic information | EWR was based on limited salinity, nutrient, dissolved oxygen, TSS/turbidity, pH, trace metals, microalgae, and zooplankton profiles. | Lower accuracy, based on low-confidence information, of EWR. | Conduct at least one other assessment of abiotic drivers and biotic responses. |

| Aspect | Gap Identified | Potential Consequence to outputs | Proposed Intervention |
|---|---|---|---|
| Lack of knowledge pollution sources | Elevated nutrient concentrations and suspended solids were recorded downstream of the Mandini gauging station, but the source/s were unknown (DWAF, 2004). | Mitigation of pollution is limited within estuary management strategy. | Conduct review of recent literature to determine sources and loads of pollutants and suggest mitigation measures. This contribute to measures used to improve PES. |

### 3.6 Groundwater

The previous groundwater GDRM based study on the Thukela Catchment was done in 2009 (DWAF, 2009) and means that current GRDM-related datasets are not representative of the current groundwater conditions. For example, Basic Human Need figures (2001 census data) had to be raised (annual growth rate of 1.5%) for the groundwater Reserve Component study to provide a realistic 2009 perspective of the Basic Human Need requirements. This will also need to be done for this study to give a more accurate reflection of the current Basic Human Needs figures.

The assessment of the data and information availability for the groundwater component is described in Table 16 and the gaps identified are summarised in Table 17.

**Table 16: Data/ Information availability for the groundwater component**

| Aspect | Data Availability | Suitability (confidence) | Other Sources |
|---|---|---|---|
| Groundwater recharge | GRA II – probably not representative anymore; and<br>DWAF (2009) assessment (based on chloride mass balance principle). | Moderate (will have to consider impact of drier climate on rainfall depths since 2009). | None, not on catchment scale – some isolated studies/ cases might be available.<br>Vegter (1995) dataset could be consulted, however, climate variability may have altered the original algorithm variables. |
| BHN Reserve (Groundwater♦) | Only 2011 population figures – consider an annual growth of 1.5%/a. | Moderate to high. | Most recent population assessment. |
| Groundwater quality status | Adequate coverage of WMA based on pre-1995 dataset. | Moderate (50 %) to high (75%). | CHART dataset (low coverage); and<br>Site specific investigations. |

| Aspect | Data Availability | Suitability (confidence) | Other Sources |
|---|---|---|---|
| Water level Depths | Yes, National Groundwater Archive. | Moderate to High (depending on actual coverage). | CHART dataset; and local project reports. |
| Groundwater contributions to river baseflows | Limited, but possible at EWR sites.<br>2009 Dataset in DWAF Report, (2009). | Small percentage of catchment suitable for assessments. | Updated stream flow separation process could be considered. |
| Groundwater use | 2009 Reserve Dataset in DWAF Report, (2009) as per Herold Method (GRDM). | Moderate, considering the impact on the groundwater recharge since 2009 (probably drier conditions). | GRAII Dataset. |
| Groundwater use (and Stress Index variables) | GRA II, GRIP and GDRM. | Moderate to low: Historic rainfall and groundwater use datasets outdated – pre 2005. | More recent assessments (i.e. DWAF, 2009, but not fully verified). |
| Resource Units | A GIS approach followed (DWAF, 2009). | Moderate, but a percentage increased based on the latest WARMS dataset could address this shortfall. | None |
| Reserve | WARMS dataset from KZN Regional Office | Low to moderate (if verifications were conducted). | None |
| Resource Units | Yes | High | None |
| Reserve – High-Level Assessment. | Only on a resource unit level – no quaternary level dataset available. | Limited to an Intermediate Level. | Limited areas/ hotspots only. |
| Aquifer Saturation status | Limited | Low | Water level data – KZN Regional Office. |
| Quantitative Stress | Yes (2009 groundwater Reserve component). | Moderate to high (if representative/updated WARMS dataset is available. | Water use data from KZN Regional Office. |
| ♦ A groundwater dependence rate (%) of the population per quaternary catchment will be calculated using on average 25 ℓ/cap $d^{-1}$ (rural regions) to 65 ℓ/cap $d^{-1}$ (towns reliant on groundwater). | | | |

**Table 17: Gap analysis of the groundwater component based on the information assessment**

| Aspect | Gap Identified | Potential Consequence to outputs | Proposed Intervention |
|---|---|---|---|
| Groundwater use | WARMS dataset is not thoroughly updated, not verified. | Resource classification might be underestimated.<br>RQOs might be out of alignment with actual groundwater status in catchment. | Open up for verification per quaternary catchments |
| Water levels | There is a significant absence of long-term water level time series datasets. | Incorrect aquifer saturation<br>levels – narratives and numerical limits might be incorrect. | Delineation of so-called "hotspot" areas where specific investigations might be required for verification of the implementation protocols. |
| Groundwater Quality | Limited demarcation of potential groundwater pollution sources, such as, redundant mines/ industries; | Serious "hotspots" might be overseen. | Land use mapping in those areas where "hotspots" might be present/ developing; should be verified with field observations. |
| | Limited time-series groundwater quality information | Inability to indicate long-term changes due to climate variation and anthropogenic development/ impacts. | WMS at DWS will be screened for updated water quality data. |
| Demarcation of surface water-groundwater interaction | Absent, especially in the primary aquifer systems present in the middle reaches of the major river channel. | Hydraulic attributes to assess this interdependence may hamper quantification of such interactions. | Probably only necessary to qualify these areas as "potential hotspots" and propose management protocols (narratives with specific numerical limits). |
| Hotspots | Limited information on areas (viz. quaternary catchments) where groundwater yield and/or quality may be stressed. | Gaps in generating a concerned status, or hotspot condition. | GIS dataset on land use activities would be required – verified with field inspections. |
| Groundwater Reserve | Data/information to verify the current, i.e. 2019 status of the groundwater Reserve presents a key constraint. | Three (3) attributes of the groundwater component of the Reserve's algorithm might be "outdated" for the 2019 timeline – they are:<br>(i) 2019 water use figures;<br>(ii) groundwater recharge due to lower rainfall depths; and | A limited search for local scale hydrogeological assessment will be conducted to augment the current data/ information base as far as possible |

| Aspect | Gap Identified | Potential Consequence to outputs | Proposed Intervention |
|---|---|---|---|
| | | (iii) Actual BHN requirements. | |
| | Many of the reports/ documents referenced in the 2009 Groundwater Reserve Determination Study may be out of date in terms of the attributes required for this assessment. | | A limited search for local hydrogeological assessment will be conducted to augment the current data/ information base as far as possible |
| Groundwater data | Groundwater contribution to the baseflow – changed due to extraordinary climate variation impact (significant drop in regional groundwater level elevations). | Groundwater resource classifications and RQO numerical values. | Will be based on the long-term aquifer saturation level trends – groundwater contribution to baseflow may not change significantly if these saturation levels remain stable (DWAF, 2009). |

The relevant RDM attributes assessed and subsequently calculated during the DWAF 2009 High-Level Assessment of the Groundwater Reserve Determination forms a sound baseline for addressing only specific time-related variables for this study. It is, therefore, foreseen that in certain cases, "hotspot" RUs or parts thereof identified in 2009, might have changed significantly and these will need to be re-assessed. As per the 2009 study only eight (8) quaternary catchments representing two (2) RUs need to be re-assessed. It is expected that the surpluses identified in the remaining 80 quaternary catchments during the 2009 Reserve study will still be classified as being in an unstressed condition. However, desktop screening of the remaining quaternary catchments will be conducted using the latest WARMS dataset.

In terms of the groundwater component, the information produced for the 2009 Reserve Determination study requires limited updates to bridge the information gap between 2009 and 2019. Assuming that the WARMS information is accurately updated, and information from local groundwater sites, *i.e*. water use license audits, specific [recent] groundwater resources studies and long-term regional monitoring data, are available, this "time-lapse" can be successfully addressed and a 2019 version of the required RDM attributes produced.

## 3.7 Socio-Economics

### 3.7.1 Information assessment

This section reports on the data required to do the socio-economic assessment and proposes alternative sources should the recommended data not be available. This section reports in line with requirements to fulfil each task in the socio-economic component of the project.

#### *3.7.1.1 Task 1: Determination of Catchment Status-quo & Determination of IUAs*

The data required to determine the status quo of the catchment and contribute to determining IUAs is summarised in Table 18. The data required for this task is predominantly spatial in nature and Stats SA census data. Stats SA census data which is on a ward level was last done in 2011. To calculate recent population in the catchment, the census data will be manipulated using municipal non-financial census and General Household Surveys (GHS) which are reported on a municipal level annually.

Land tenure data is available on a high level, and the project team will contact the Department of Rural Development and Land Reform to get more detailed data, should it be available.

Water resources data is dated 2011 and more recent data will be requested from relevant stakeholders.

**Table 18: Recommended data requirements for describing the socio-economic status, key drivers and general spatial features across a catchment**

| Data Required | Possible Source | Data/ Information Availability | Suitability (confidence) | Other Sources |
|---|---|---|---|---|
| Latest Population densities | National Census data (Stats SA) | Yes (2011) | Low (data only available for 2011) | Municipal Non-Financial census; Household surveys |
| Latest Land Use/Cover | DEA (egis.environment.gov.za) | Yes (2018) | High | SANBI provides additional cover for the years 2000 and 2013/14 |
| Economic contributors | Stats SA/ GDP Publication | Yes (2019) | High | |
| Catchment boundaries | Department of Water and Sanitation (DWS) | Yes (2016) | Medium | |
| Water resources | South African National Biodiversity Institute (SANBI) | Yes (2011) | Low | |
| Towns and cities | DEA (egis.environment.gov.za) | Yes | High | |
| Infrastructure | DEA (egis.environment.gov.za) | Yes | High | |
| Satellite Imagery | Google Earth™ | Yes | High | |

| Data Required | Possible Source | Data/ Information Availability | Suitability (confidence) | Other Sources |
|---|---|---|---|---|
| Latest Land Tenure | Department of Rural Development and Land Reform (DRDLR) | Yes (2015) | Medium | |
| Latest Aquatic resources (Wetlands and waterways) | South African National Biodiversity Institute (SANBI) | Yes (2011) | Low | |
| Latest Protected areas | DEA (www.egis.environment.gov.za) | Yes (2018) | High | |

#### *3.7.1.2 Task 2: Describe communities and their well-being*

Indicators such as employment status, household income, access to water services, education level describes the social well-being of communities. This data is mainly sourced from Stats SA census. Data required to undertake this task is reported in Table 19. The data is outdated and can lead to underestimation of the social index score. The data will therefore be manipulated using Stats SA household surveys and Municipal Non-financial census. The data will be further manipulated as the data is reported on municipal/ward boundaries, which does not match catchment boundaries. Transfer methods will be used should data not be available. Transfer methods assume that you can report data from other catchment that has similar living condition.

Human Health diseases is not available and will be investigated through literature review and consultation with Department of Health.

**Table 19: Recommended indicators for describing social wellbeing of IUAs**

| Data Required | Possible Source | Data/Information Availability | Suitability (confidence) | Other Sources/ Mitigation of Gap |
|---|---|---|---|---|
| Household Income | Stats SA (census) | Yes (2011) | Low | Municipal Non-financial census; General Household surveys and Transfer methods |
| Access to water services | | | | |
| Education level | | | | |
| Source of water per household | | | | |
| Household Income | | | | |

| Data Required | Possible Source | Data/Information Availability | Suitability (confidence) | Other Sources/ Mitigation of Gap |
|---|---|---|---|---|
| Employment Status | | | | |
| Human health diseases | Stats SA/ Department of health | No | High | Consult Department of Health and conduct literature review |

#### *3.7.1.3 Task 3: Describe the Use and Value of Water*

Development of physical and monetary accounts helps to assess the use and value of water in the catchment. The data required to develop monetary accounts is municipal financial census which is water sales by the municipality from different sectors (Table 20). The data are available from Stats SA. The data will be manipulated to fit in catchment boundaries, as the data is reported on a municipal level. Data required to develop the physical account is typically sourced through documents such as reconciliation strategies. The reconciliation strategy for Thukela Catchment has never been done (Table 21). A solution is that monetary accounts will be used together with inputs from the greater classification process (i.e. hydrological and groundwater studies), to develop the physical account. The general approach is that the volume of water utilised will be determined by calculating monetary values with water tariff per sector in the catchment.

**Table 20: Data required to develop Monetary water account**

| Data Required | Type of Data |
|---|---|
| GHS | Qualitative information on service delivery |
| Census of Agriculture | Crop water use data at Magisterial District level |
| LSS – Electricity, gas and water supply | Water volumes used water purchases |
| LSS – Manufacturing | Water purchases |
| Supply and Use Tables | Monetary transitions for water use sectors defined in the supply use tables |
| Survey of Actual Capital Expenditure of Municipalities | No direct relevant information |
| Survey of Actual Capital Expenditure of National Government, Provincial Government and Extra-budgetary and Funds | No direct relevant information |
| Financial Census of Municipalities | Water purchases by municipalities<br>Water sales by municipalities |
| Non-Financial Census of Municipalities | Number of consumer units served |

**Table 21: Data required to develop the physical water account**

| Data Required | Possible source |
|---|---|
| Source of water and water use | DWS Catchment and All Town reconciliation strategies |
| Volume of groundwater extracted and used | Inputs from groundwater study |
| Volume of water used in the electricity industry | Stats SA Electricity Large Sample Survey (LSS) |
| Water supply by water boards in the country | Water boards annual reports |
| Total mean annual runoff, flows between catchments and other countries | Inputs from our hydrological study |
| System input volume per municipality | DWS no drop system |

#### *3.7.1.4 Task 4: Develop an Inventory of Aquatic Ecosystem Services*

Following on from task 1, the purpose of this step is to identify the ecosystem services (ES) within the catchment at an IUA level and determine a broad idea of the demand of these services by communities and the economic sectors that utilize them.

**Table 22: Indicators required to develop aquatic ecosystem services**

| Data Required | Possible Source | Data/ Information availability | Significance/ confidence |
|---|---|---|---|
| Ecosystem Service Flow Data | Millennium Ecosystem Assessment: Ecosystems and Human Well-Being<br>The Economics of Ecosystems and Biodiversity for Water and Wetlands<br>Existing ESA studies within South Africa | Based on preliminary literature investigations there are recent studies in the Upper Thukela Catchment.<br>Alternatively, benefit transfer methods will be utilised (i.e. The use of secondary data from other catchments such as uMgeni catchment). | High confidence in existing data |

#### *3.7.1.5 Task 5: Evaluate Scenarios*

Key to this step is input from all relevant parallel workstreams. The data inputs to this point are required for the evaluation of scenarios and therefore all gaps identified above will be relevant for this step.

### 3.7.2 Gap identification

The gaps in data required to complete the socio-economic component are summarised in Table 23.

**Table 23: Gaps analysis of the Socio-Economic component based on the information assessment**

| Aspect | Gap Identified | Potential Consequence to outputs | Proposed Intervention |
|---|---|---|---|
| Socio Economic Zone Delineation | Current Population Data Extrapolated from 2011 Census Data | Underestimate population density in the catchment | Use Stats SA municipal non-financial and household surveys to better manipulate the census data |
| | High level information on current land tenure | Distorted land tenure data reported | Consultation with Department of Rural Development and Land Reform to get access to detailed database |
| | Substantial gaps in information/data related to Economic Status, EGSA Status, Macro-Economic Classification Data for the Thukela Catchment | | The data required in this task is high level. Current spatial data will be able to determine ecosystem service hotspots. |
| Communities and their well-being | Limited health data by municipality for the catchment | The data is not a prerequisite for the study and therefore consequences of no data are not significant. | Consult with Department of Health to get any available. Literature review to find any studies done in the catchment. |
| | Outdated Employment, education level, household income level, access to water | Under/overestimation of the social well-being and vulnerability scores | Latest Stats SA municipal non-financial census and household surveys to better manipulate the census data |
| Use and Value of Water | Limited water quality data for the catchment | This will depend on the greater approach to the study (i.e. studies conducted by parallel workstreams) | Receive Inputs from the greater classification process |
| | Lack of Physical water account for the sub-catchments (water use data *i.e.* Volume of water used by sectors, municipal water use, | No reporting on the use of water in the catchment which will negatively affect scenario evaluations | Develop monetary water account, then develop physical water account from monetary water account. With inputs from DWS (e.g. No drop data) data and inputs (i.e. groundwater and |

| Aspect | Gap Identified | Potential Consequence to outputs | Proposed Intervention |
|---|---|---|---|
| | transfers data, groundwater extractions, waste-water volumes) | | hydrological studies) greater classification process. |
| Water transfers | There are current uncertainties surrounding data availability for receiving catchments | This will significantly affect the ability to assess the impact to scenarios | Literature review and potential expert consultation on receiving catchments |

# 4 SUMMARY OF KEY GAPS

Based on the assessment of information and review of data availability a summary of the key gaps that would need to addressed in order to ensure the process of determining water resource classes and RQOs in the Thukela Catchment is technically sound are listed below in Table 24.

**Table 24: Summary of Key Gaps**

| Task description | Gap | Intervention/Mitigation |
|---|---|---|
| Evaluation of scenarios within IWRM | No current combined model available of the entire catchment linked to a single strategy. Currently available complete WRPM or WRYM configurations are dated, or not focused on the whole catchment. | Certain sub-catchments are well studied with updated hydrology and models. An updated complete single model will have to be built. |
| | No planning scenarios for the whole Thukela Catchment. A reconciliation strategy with reconciliation options is not available for the Thukela Catchment in its entirety. | Development of long term planning options and future development scenarios will have to be confirmed to determine possible changes in water resources supply and demands. This process is underway.<br>The following data will need to be acquired:<br>• Future water requirements with transfer volumes out of the catchment; and<br>• Time series of transfer volumes from Thukela for each of the main transfers |
| Provision of natural and present-day hydrology data | Confirming and determining hydrology to be used | Various sets of hydrology are available for the different catchments in the Thukela system. The most recent set of data available for the entire catchment is the WR2012 data (1920-2009) – No drought information for the last few years is included.<br>To confirm the best hydrology to use, it is recommended that a comparison be conducted to test the difference in record length. This will be done by comparing flow duration curves (FDCs) for select catchments to establish if there are |

| Task description | Gap | Intervention/Mitigation |
|---|---|---|
| | | differences in FDC for different record periods. |
| Socio-economic assessment | No socio-economic classification of catchment area has been undertaken - Economic Status, EGSA Status, Macro-Economic Classification | Various resources will provide inputs into the WRC process. Financial municipal data from Stats SA, municipal integrated plan will be used as an input to understand economic conditions of the catchment. |
| | Physical water account data for the Thukela Catchment is very limited. | Monetary water account together with inputs from greater classification process, physical water account will also be developed. |
| EWR Quantification | Hydraulics - Unavailability of data and modelling results from previous 2003 Reserve Study. | Existing 2003 data is being sourced from previous Reserve study team. Should the data not be usable, the department will be engaged on a way forward. Re-survey of sites will be required.<br>Selection of only key EWR sites based on priorities in terms of IUA and hydronode selection to reduce the number of sites required for re-survey. |
| | No EWR sites and preliminary Reserve for sub-catchments within the Thukela Catchment *i.e.* Upper Buffalo, upper Mooi River | Rapid assessments are proposed to be undertaken at additional sites to address potential EWR gaps. |
| RQO determination | Limited or lack of water quality data for prioritised Resource Units | PES will be used as a guide to set water quality RQOs |
| Groundwater Assessment | Groundwater use: WARMS dataset is not thoroughly updated, not verified. | This would need to be opened up for verification per quaternary catchments |
| | Gaps in generating a concerned status, or hotspot condition. | Limited information on areas (*viz*. quaternary catchments) where groundwater yield and/or quality may be stressed. |

| Task description | Gap | Intervention/Mitigation |
|---|---|---|
| | | GIS dataset on land use activities would be required – verified with field inspections. |
| | Demarcation of surface water-groundwater interaction. Absent, especially in the primary aquifer systems present in the middle reaches of the major river channel. | Probably it may be necessary to qualify these areas as “potential hotspots” and propose management protocols (narratives with specific numerical limits). |
| | Groundwater contribution to the baseflow – changed due to extraordinary climate variation impact (significant drop in regional groundwater level elevations). | Will be based on the long-term aquifer saturation level trends – groundwater contribution to baseflow may not change significantly if these saturation levels remain stable (DWAF, 2009).<br>Updated baseflow values and mapping/ calculation of baseflow reduction (where expected) only required if a significant change in the regional water level elevation is confirmed. |
| Wetland Assessment | It is reiterated that inherent in a wetland study of this nature are the limitations/risks related to the lack of field verified information, not only of the wetlands in general, but also of the Priority Wetlands.<br>As there is limited to no field verification of the ecological categorisation of most the wetland systems, the derived ecological categories may thus not be an accurate representation of what is actually on the ground. Similarly, the constraints related to desktop mapping do not always enable the identification of all the Hydrogeomorphic (HGM) units applicable to a particular wetland or wetland system. Nor do they always provide an accurate delineation of the | A -day field visit will be undertaken.<br>Additional data will be sourced from relevant stakeholders in the catchment who are busy with studies, or who have undertaken studies in respect of the wetlands’ component. |

| Task description | Gap | Intervention/Mitigation |
|---|---|---|
| | boundaries of the wetland systems. Also, the grouping of wetland HGM units necessary for the desktop derived ecological categorisation may over-simplify the ecological state of a particular wetland complex. | |
| Stakeholder Engagement | Lack of buy in of the Ingonyama Trust in the process. Lack of timeous engagement and consultation with the Trust could influence the technical process. | A meeting with the Ingonyama Trust is being arranged by the DWS. |

# 5 CONCLUSION

Based on the information review and analysis that has been undertaken on understanding the availability, accessibility and usefulness of the information and data sources applicable to Thukela catchments, it is clear that gaps do exist. There have been very few studies undertaken in the Thukela catchment in the last ten years, and those that have been done have not been to the extent needed to support all aspects of the classification and RQO setting process.

However, based on the specialists' knowledge of the system, both in the project team and within the networks of the project team, and potential for other additional data/ information to be made available from external sources, the gaps can be addressed adequately. Best available and reasonable data and information sources will be used to meet the objectives of the study. Guidance from the DWS will be sought where specific direction is needed.

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# APPENDIX 1: WMS - WATER QUALITY MONITORING SITE INFORMATION

## Table A1:Water Quality Monitoring Points within the Thukela Catchment – Data Availability

| Monitoring Point ID | Monitoring Point Name | Latitude | Longitude | Drainage Region | Number of Samples | First Sample Date | Last Sample Date |
|---|---|---|---|---|---|---|---|
| **Upper Tugela** | | | | | | | |
| 102713 | V1H033Q01 TUGELA RIVER AT WAN HOOP/CLIFFORD CHAMBERS | -28.6528 | 29.0444 | V11A | 189 | 7/4/1978 | 12/17/2013 |
| 188282 | WAN HOOP D/S OF HLALANATHI STW ON TUGELA | -28.6558 | 29.0422 | V11A | 73 | 6/7/2005 | 7/12/2011 |
| 188283 | TRILBY D/S MOUNT AUX SOURCES HOTEL U/S HLALANATHI STW ON TUGELA | -28.6686 | 29.0219 | V11A | 109 | 1/12/2005 | 2/28/2017 |
| 188292 | UPSTREAM OF ROYAL NATIONAL PARK STW ON GOLIDE | -28.6861 | 28.9533 | V11A | 109 | 1/12/2005 | 2/28/2017 |
| 188293 | AT ROAD BRIDGE D/S ROYAL NATIONAL PARK STW & U/S MOUNT AUX SOUR RCES HOTEL STW ON TUGELA | -28.6825 | 28.9767 | V11A | 107 | 1/12/2005 | 2/28/2017 |
| 103323 | KILBURN DAM: NEAR DAM WALL | -28.5914 | 29.1009 | V11C | 601 | 1/4/2003 | 12/2/2014 |
| 102712 | V1H032Q01 PUTTERILL SPRUIT AT WAN HOOP | -28.6411 | 29.0333 | V11C | 184 | 7/11/1978 | 2/14/1983 |
| 102714 | V1H034Q01 KOMBE RIVER AT GROOT GELUK | -28.6731 | 29.0858 | V11C | 190 | 7/11/1978 | 11/14/2016 |
| 102722 | V1H048Q01 TUGELA RIVER AT WAN HOOP/UP STREAM WOODSTOCK DAM | -28.6397 | 29.0672 | V11C | 164 | 10/14/1985 | 2/28/2017 |
| 188305 | KRUISFONTEIN BERGVILLE HARRISMITH ROAD BRIDGE U/S WOODSTOCK DAM ON MAJANE ENI | -28.6272 | 29.1214 | V11C | 64 | 9/14/2005 | 2/28/2017 |
| 188306 | GRANSMOOR BERGVILLE HARRISMITH ROAD BRIDGE U/S OF WOODSTOCK DAM ON MPA ANDWENI | -28.6431 | 29.1644 | V11D | 64 | 9/14/2005 | 2/28/2017 |
| 102732 | V1R003Q01 UPPER TUGELA 4794 WOODSTOCK 2189 - WOODSTOCK DAM ON TUGELA RIVER: NEAR DAM WALL | -28.7608 | 29.2444 | V11E | 292 | 11/11/1985 | 4/17/2018 |
| 102733 | V1R003Q02 WOODSTOCK DAM ON TUGELA RIVER: POINT IN DAM | -28.7608 | 29.2444 | V11E | 732 | 5/5/1986 | 12/2/2014 |
| 102734 | V1R003Q03 WOODSTOCK DAM ON TUGELA RIVER: POINT IN DAM | -28.7608 | 29.2444 | V11E | 23 | 8/11/1986 | 3/28/1988 |
| 103355 | V1R003K01 WOODSTOCK DAM ON TUGELA RIVER: RIVER OUTLET | -28.7608 | 29.2444 | V11E | 76 | 2/24/1986 | 5/16/1988 |
| 102717 | V1H037Q01 MNWENI RIVER AT ISANDLWANA/DOWN STREAM POLICE STA | -28.8050 | 29.1783 | V11E | 123 | 12/2/1985 | 2/4/1992 |
| 102711 | V1H031Q01 AT KLEINE WATERVAL BERGVILLE ON SANDSPRUIT | -28.7225 | 29.3514 | V11F | 436 | 7/19/1977 | 4/17/2018 |
| 102697 | V1H003Q01 NDUMENI TRIBUTARY 2 AT CATHEDRAL PEAK | -28.9897 | 29.2267 | V11G | 120 | 3/8/1984 | 1/24/2018 |
| 102699 | V1H005Q01 MASONGWANE TRIBUTARY 4 AT CATHEDRAL PEAK | -28.9906 | 29.2439 | V11G | 225 | 11/19/1981 | 10/5/1990 |
| 102700 | V1H006Q01 MASONGWANE TRIBUTARY 1 AT CATHEDRAL PEAK | -28.9797 | 29.2375 | V11G | 3 | 9/22/1981 | 3/1/1993 |
| 102701 | V1H007Q01 MASONGWANE TRIBUTARY 3 AT CATHEDRAL PEAK | -28.9897 | 29.2383 | V11G | 225 | 11/12/1981 | 12/12/2016 |
| 102705 | V1H021Q01 MASONGWANE TRIBUTARY 7 AT CATHEDRAL PEAK | -28.9869 | 29.2536 | V11G | 222 | 11/26/1981 | 6/6/1990 |
| 102706 | V1H022Q01 MASONGWANE TRIBUTARY 6 AT CATHEDRAL PEAK | -28.9875 | 29.2519 | V11G | 221 | 11/19/1981 | 6/6/1990 |

| Monitoring Point ID | Monitoring Point Name | Latitude | Longitude | Drainage Region | Number of Samples | First Sample Date | Last Sample Date |
|---|---|---|---|---|---|---|---|
| 102707 | V1H023Q01 MHLWAZINI TRIBUTARY 9 AT CATHEDRAL PEAK | -28.9914 | 29.2736 | V11G | 222 | 11/19/1981 | 2/17/1993 |
| 188844 | HOPETON UPSTREAM OF CATHEDRAL PEAK HOTEL STW FINAL EFFLUENT DISCHARG GE ON MLAMBONJA | -28.9459 | 29.2100 | V11G | 84 | 3/31/2005 | 3/15/2017 |
| 188861 | HOPETON DOWNSTREAM OF CATHEDRAL PEAK HOTEL STW FINAL EFFLUENT DISCHA ARGE ON MLAMBONJA | -28.9459 | 29.2101 | V11G | 84 | 3/31/2005 | 3/15/2017 |
| 102721 | V1H041Q01 MLAMBONJA RIVER AT KLEINERIVIER | -28.8117 | 29.3119 | V11H | 608 | 4/6/1977 | 4/17/2018 |
| 102731 | V1R002Q01 DRIEL BARRAGE ON TUGELA RIVER: NEAR BARRAGE WALL | -28.7633 | 29.2908 | V11J | 846 | 6/11/1980 | 4/17/2018 |
| 102696 | V1H002Q01 TUGELA RIVER AT BERGVILLE | -28.7375 | 29.3525 | V11J | 5 | 2/18/1966 | 9/23/1998 |
| 102708 | V1H026Q01 TUGELA RIVER @ KLEINE WATERVAL | -28.7219 | 29.3757 | V11J | 1096 | 1/27/1970 | 4/17/2018 |
| 102723 | V1H049Q01 TUGELA RIVER AT KLEINE WATERVAL/UP STREAM SPIOENK | -28.7369 | 29.3625 | V11J | 105 | 10/7/1985 | 5/23/1988 |
| 102727 | V1H058Q01 DRIEL BARRAGE ON TUGELA RIVER: DOWN STREAM WEIR | -28.7622 | 29.2925 | V11J | 370 | 3/14/1989 | 4/17/2018 |
| 188298 | BERGVILLE U/S OF BERGVILLE STW FINAL EFFLUENT DISCHARGE ON SANDSPRUIT | -28.7289 | 29.3572 | V11J | 108 | 1/13/2005 | 2/27/2017 |
| 188299 | BERGVILLE D/S OF BERGVILLE STW FINAL EFFLUENT DISCHARGE ON SANDSPRUIT | -28.7278 | 29.3592 | V11J | 112 | 1/13/2005 | 2/27/2017 |
| 102709 | V1H029Q01 AT SCHOONSPRUIT ON GELUKSBURGSPRUIT | -28.5078 | 29.3483 | V11K | 241 | 1/14/1977 | 6/29/1992 |
| 102710 | V1H030Q01 NJONGOLA RIVER AT STRYDHOEK | -28.5139 | 29.3369 | V11K | 220 | 1/14/1977 | 10/12/1992 |
| 102728 | V1R001Q01 RHENOSTER FONTEIN 1051 - SPIOENKOP DAM ON TUGELA RIVER: NEAR DAM WALL | -28.6815 | 29.5161 | V11L | 320 | 3/20/1975 | 8/8/2017 |
| 102730 | V1R001Q03 SPIOENKOP DAM ON TUGELA RIVER: POINT IN DAM | -28.6811 | 29.5167 | V11L | 889 | 1/12/1987 | 8/21/2018 |
| 102724 | V1H050Q01 VENTER SPRUIT AT KLIPPLAATSFONTEIN/ACTOIN VALLEY | -28.6208 | 29.4122 | V11L | 172 | 10/14/1985 | 7/4/1995 |
| 102726 | V1H057Q01 SPIOENKOP DAM ON TUGELA RIVER: DOWN STREAM WEIR | -28.6787 | 29.5201 | V11M | 781 | 5/2/1983 | 4/16/2018 |
| 102718 | V1H038Q01 KLIP RIVER AT LADYSMITH TOWNLANDS/ARMY CAMP | -28.5617 | 29.7525 | V12F | 702 | 7/19/1977 | 8/25/2018 |
| 188288 | LADYSMITH WAGON BRIDGE UPSTREAM OF STW FINAL EFFLUENT DISCHARGE ON KLI IP RIVER | -28.5678 | 29.7711 | V12G | 106 | 6/9/2005 | 3/16/2017 |
| 188289 | LADYSMITH DOWNSTREAM OF STW DISCHARRGE ON KLIP REVER | -28.5794 | 29.8014 | V12G | 108 | 6/9/2005 | 6/5/2018 |
| 100001155 | KLIPRIVER U/S EZAKHENI SEWAGE TREATMENT WORKS FINAL EFFLUENT | -28.6356 | 29.9217 | V12G | 90 | 10/22/2004 | 6/5/2018 |
| 100001156 | KLIPRIVER D/S EZAKHENI SEWAGE TREATMENT WORKS FINAL EFFLUENT | -28.6419 | 29.9306 | V12G | 57 | 10/22/2004 | 11/29/2011 |
| 102704 | V1H010Q01 LITTLE TUGELA RIVER AT WINTERTON | -28.8181 | 29.5450 | V13C | 599 | 2/18/1966 | 4/16/2018 |
| 102719 | V1H039Q01 LITTLE TUGELA RIVER AT DRAKENSBERG 2 | -29.0581 | 29.5289 | V13C | 227 | 7/19/1977 | 9/29/1998 |
| 189136 | WINTERTON D/S OF WINTERTON STW FINAL DISCHARGE ON LITTLE TUGELA | -28.8095 | 29.5353 | V13D | 67 | 7/26/2006 | 3/14/2017 |
| 189140 | WINTERTON U/S OF WINTERTON STW FINAL DISCHARGE ON LITTLE TUGELA | -28.8112 | 29.5343 | V13D | 65 | 7/26/2006 | 3/14/2017 |

| Monitoring Point ID | Monitoring Point Name | Latitude | Longitude | Drainage Region | Number of Samples | First Sample Date | Last Sample Date |
|---|---|---|---|---|---|---|---|
| 188302 | COLENSO BULWER BRIDGE U/S OF COLENSO FINAL EFFLUENT DISCHARGE ON TUG GELA | -28.7364 | 29.8208 | V14A | 104 | 6/9/2005 | 3/16/2017 |
| 102695 | V1H001Q01 TUGELA RIVER AT TUGELA DRIFT/COLENSO | -28.7356 | 29.8206 | V14B | 3491 | 10/19/1952 | 3/14/2018 |
| 188303 | COLENSO D/S OF COLENSO FINAL EFFLUENT DISCHARGE ON TUGELA | -28.7344 | 29.8406 | V14B | 105 | 6/9/2005 | 3/16/2017 |
| 102703 | V1H009Q01 BLOUKRANS RIVER AT FRERE | -28.8914 | 29.7706 | V14D | 588 | 2/18/1966 | 4/16/2018 |
| 102783 | V6H004 KLEIN FONTEIN 1262 GT ON SUNDAYS RIVER | -28.4044 | 30.0131 | V60B | 537 | 2/19/1966 | 3/20/2018 |
| 102784 | V6H006Q01 SUNDAYS RIVER AT WATERFALL | -28.2397 | 29.7544 | V60B | 454 | 9/21/1976 | 4/17/2018 |
| 187716 | #2 PLAT BERG NATAL STEAM COAL DECANT | -28.3538 | 30.0177 | V60B | 100 | 11/25/2003 | 12/12/2017 |
| 187722 | #3 PLAT BERG DOWN STREAM OF NATAL STEAM COAL DECANT | -28.3539 | 30.0174 | V60B | 99 | 11/25/2003 | 12/12/2017 |
| 187726 | #1 PLAT BERG AT R602 ROAD BRIDGE ON SUNDAYS | -28.3609 | 30.0112 | V60B | 100 | 11/25/2003 | 12/12/2017 |
| 188372 | WATERKLOOF D/S FORT MISTAKE AND PIGGARY ON NKUNZI | -28.2067 | 29.9586 | V60B | 65 | 7/21/2005 | 10/21/2014 |
| 188772 | QUAGGAS KIRK UPSTREAM OF PIGGERY ON NKUNZI | -28.1794 | 29.9564 | V60B | 67 | 7/21/2005 | 10/21/2014 |
| 188773 | GARTMORE AT N11 BRIDGE ON NKUNZI | -28.2351 | 29.9671 | V60B | 66 | 7/21/2005 | 10/21/2014 |
| 188843 | ROODE POORT AT R23 BRIDGE ON SUNDAYS | -28.3481 | 29.9681 | V60B | 62 | 7/21/2005 | 10/21/2014 |
| 102786 | V6H009Q01 WASBANK RIVER AT BURNSIDE ESTATE | -28.1789 | 30.0761 | V60D | 213 | 12/14/1995 | 7/23/2013 |
| 102787 | V6H010Q01 MANZIMNYAMA AT BURNSIDE ESTATE - U/S WASBANK CONF | -28.1731 | 30.0914 | V60D | 146 | 12/14/1995 | 7/23/2013 |
| 102788 | V6H011Q01 WASBANK RIV AT UITHOEK - U/S UITHOEK SPRUIT D/S M | -28.2125 | 30.1242 | V60D | 224 | 12/14/1995 | 7/23/2013 |
| 102789 | V6H012Q01 UITHOEK SPRUIT AT UITHOEK - U/S WASBANK CONFLUENC | -28.2044 | 30.1322 | V60D | 212 | 12/14/1995 | 7/23/2013 |
| 102790 | V6H013Q01 WASBANK RIV AT WASBANK - D/S BUSANA & DNDEE ROAD | -28.2914 | 30.1222 | V60D | 222 | 12/14/1995 | 7/23/2013 |
| 102791 | V6H014Q01 @ KWEEKVLEI DE KROON U/S OF WASBANK ON BIGGARSGAT | -28.3000 | 30.1556 | V60D | 241 | 12/14/1995 | 12/13/2017 |
| 187700 | #6 BIGGARSGAT UPSTREAM OF INDUMENI DECANT | -28.2539 | 30.1925 | V60D | 37 | 11/25/2003 | 3/10/2009 |
| 187701 | #11 BURNSIDE DECANT | -28.1782 | 30.0907 | V60D | 80 | 11/25/2003 | 11/14/2017 |
| 187702 | #10 BURNSIDE UPSTREAM DECANT | -28.1781 | 30.0904 | V60D | 54 | 11/25/2003 | 2/9/2016 |
| 187705 | #12 BURNSIDE DOWNSTREAM DECANT | -28.1909 | 30.0970 | V60D | 88 | 11/25/2003 | 11/14/2017 |
| 187709 | #5 BIGGARSGAT INDUMENI POP DECANT | -28.2546 | 30.1918 | V60D | 93 | 11/25/2003 | 12/13/2017 |
| 189041 | VLEI POORT DOWNSTREAM OF NORTHFIELD PRISON ON MANZIMNYAMA | -28.1629 | 30.1071 | V60D | 44 | 5/22/2006 | 12/4/2014 |
| 189043 | VALKENBURG U/S OF NORTHFIELD PRISON ON TRIBUTARY OF MANZIMNYAMA | -28.1435 | 30.1238 | V60D | 39 | 5/22/2006 | 12/4/2014 |
| 102782 | V6H003Q01 WASBANK RIVER AT KUICK VLEI | -28.3094 | 30.1481 | V60E | 734 | 7/21/1977 | 3/20/2018 |

| Monitoring Point ID | Monitoring Point Name | Latitude | Longitude | Drainage Region | Number of Samples | First Sample Date | Last Sample Date |
|---|---|---|---|---|---|---|---|
| 102792 | V6H016Q01 MKOMAZANA RIV AT WASBANK - U/S WB CONFL D/S WB VI | -28.3172 | 30.1278 | V60E | 164 | 12/14/1995 | 7/23/2013 |
| 102793 | V6H017Q01 BLINKWATER RIVER AT LYNWOOD - U/S WASBANK CONFLUE | -28.3333 | 30.1733 | V60E | 182 | 12/14/1995 | 7/23/2013 |
| 102794 | V6H018Q01 THOLENI RIVER AT VAALKOP - U/S WASBANK CONFLUENCE | -28.4528 | 30.1742 | V60E | 161 | 12/14/1995 | 7/23/2013 |
| 102795 | V6H019Q01 WASBANK RIVER AT VAALKOP - D/S THOLENI CONFLUENCE | -28.4586 | 30.1792 | V60E | 221 | 12/14/1995 | 2/2/2017 |
| 102785 | V6H007Q01 TUGELA RIVER AT IMPAFANA | -28.7458 | 30.3789 | V60H | 22 | 1/20/1983 | 11/25/1998 |
| 102781 | V6H002Q01 AT TUGELA FERRY ON TUGELA | -28.7500 | 30.4428 | V60J | 1023 | 7/21/1977 | 4/19/2018 |
| **Mooi catchment** | | | | | | | |
| 188045 | GAME PASS E 5596 KAMBERG NATURE RESERVE ON MOOI RIVER | -29.3756 | 29.6396 | V20A | 89 | 3/7/2006 | 12/13/2017 |
| 102738 | V2H006Q01 LITTLE MOOI RIVER AT DARTINGTON | -29.2653 | 29.8680 | V20B | 694 | 9/21/1976 | 3/22/2018 |
| 102739 | V2H007Q01 HLATIKULU RIVER AT BROADMOOR | -29.2386 | 29.7883 | V20C | 699 | 9/21/1976 | 3/22/2018 |
| 195009 | MEARNS DAM- MEARNS MAIN BASIN INTEGRATED | -29.2471 | 29.9701 | V20D | 554 | 1/8/2013 | 3/28/2017 |
| 195010 | SPRING GROVE DAM- SPRING GROVE MAIN BASIN INTEGRATED | -29.3201 | 29.9648 | V20D | 581 | 6/28/2013 | 3/31/2017 |
| 177645 | V2H009Q01 MEARNS | -29.2458 | 29.9706 | V20D | 4 | 5/30/2012 | 9/26/2014 |
| 195005 | MOOI AT SPRING GROVE (OUTFLOW)- DOWNSTREAM OF DAM WALL | -29.3179 | 29.9670 | V20D | 132 | 1/8/2013 | 3/17/2017 |
| 195006 | LITTLE MOOI AT CONNINGTON ROAD BRIDGE (UPSTREAM OF MEARNS) | -29.2320 | 29.9253 | V20D | 119 | 7/9/2013 | 3/28/2017 |
| 195007 | MOOI AT ROSETTA BRIDGE- AT BRIDGE | -29.3010 | 29.9636 | V20D | 120 | 1/8/2013 | 3/7/2017 |
| 195008 | MOOI 0.7KM D/S OF MEARNS- AT LOW LEVEL BRIDGE | -29.2379 | 29.9828 | V20D | 89 | 1/8/2013 | 3/7/2017 |
| 102735 | V2H002Q01 @ MOOIRIVIER ON MOOIRIVIER | -29.2194 | 29.9936 | V20E | 1249 | 1/28/1970 | 4/19/2018 |
| 102736 | V2H004Q01 MOOI RIVER AT DOORNKLOOF | -29.0708 | 30.2458 | V20E | 629 | 7/21/1977 | 4/19/2018 |
| 189112 | MOOIRIVIER DOWNSTREAM OF N3 ROAD BRIDGE & STW ON MOOIRIVIER | -29.2097 | 30.0034 | V20E | 112 | 2/17/2005 | 10/27/2016 |
| 102745 | V2R001Q01 RIETVLEI 3281 - CRAIGIE BURN DAM ON MNYAMVUBU RIVER: NEAR DAM WALL | -29.1635 | 30.2866 | V20F | 447 | 5/21/1968 | 10/24/2017 |
| 102748 | V2R001Q04 CRAIGIE BURN DAM ON MNYAMVUBU RIVER: POINT IN DAM | -29.1631 | 30.2868 | V20F | 771 | 6/25/1986 | 9/4/2018 |
| 102741 | V2H010Q01 MNYAMVUBU RIVER AT RIETVLEI/CRAIGIE BURN DAM INFL | -29.1825 | 30.2667 | V20F | 121 | 10/2/1985 | 11/26/1992 |
| 102742 | V2H011Q01 MPATENI SPRUIT AT RIETVLEI/CRAIGIE BURN DAM INFLO | -29.1814 | 30.2894 | V20F | 118 | 10/2/1985 | 5/25/1988 |
| 102743 | V2H012Q01 RIETVLEI SPRUIT AT BALMORAL/UP STREAM MNYAMVUBU C | -29.1864 | 30.2800 | V20F | 22 | 10/2/1985 | 2/3/1987 |
| 102744 | V2H016Q01 CRAIGIE BURN DAM ON MNYAMVUBU RIVER: DOWN STREAM | -29.1631 | 30.2881 | V20F | 720 | 7/30/1984 | 10/11/2017 |
| 102740 | V2H008Q01 MOOI RIVER AT KEATE S DRIFT | -28.8594 | 30.5000 | V20H | 312 | 4/29/1982 | 4/19/2018 |

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|---|---|---|---|---|---|---|---|
| **Buffalo Catchment** | | | | | | | |
| 102778 | V3R003Q01 ZAAIHOEK 377 - ZAAIHOEK DAM ON SLANG RIVER: NEAR DAM WALL | -27.4397 | 30.0599 | V31B | 1054 | 3/8/1989 | 4/18/2018 |
| 102752 | V3H005Q01 SLANG RIVER AT VLAKDRIFT | -27.4356 | 29.9761 | V31B | 341 | 7/20/1977 | 3/31/1993 |
| 102771 | V3H028Q01 ZAAIHOEK DAM: DOWN STREAM WEIR | -27.4375 | 30.0611 | V31B | 256 | 4/6/1989 | 4/18/2018 |
| 189704 | SCHUILKLIP 109 @ ROAD BRIDGE 1911 ON BUFFELSRIVIER | -27.5782 | 29.9204 | V31B | 44 | 6/11/2007 | 2/8/2017 |
| 102750 | V3H002Q01 AT SCHURVEPOORT ON BUFFELS RIVER | -27.6022 | 29.9428 | V31C | 1205 | 2/19/1966 | 6/26/2018 |
| 189701 | WHITE HOUSE 14178 @ MAIN ROAD 186 BRIDGE UPSTREAM OF INGOGO ON HARTS RIVIER | -27.5814 | 29.8733 | V31C | 49 | 6/11/2007 | 2/8/2017 |
| 189702 | WHITE HOUSE 14178 @ MAIN ROAD 186 BRIDGE UPSTREAM OF HARTS ON NGOGO | -27.5824 | 29.8751 | V31C | 47 | 6/11/2007 | 2/8/2017 |
| 189703 | DUMBANY 15101 @ NEWCASTLE VOLKSRUST ROAD BRIDGE ON NGOGO | -27.5918 | 29.9249 | V31C | 43 | 6/11/2007 | 2/8/2017 |
| 102766 | V3H022Q01 AT VAALSPRUIT/NGAGANE RIVER CONFLUENCE ON BUFFELSRIVIER | -27.7194 | 30.0778 | V31D | 80 | 4/2/1987 | 6/13/1990 |
| 102772 | V3R001Q01 NTSHINGWAYO (CHELMSFORD) DAM ON NGAGANE: NEAR WALL | -27.9531 | 29.9481 | V31E | 1114 | 3/28/1968 | 8/22/2018 |
| 102773 | V3R001Q02 NTSHINGWAYO (CHELMSFORD) DAM ON NGAGANE RIVER: POINT IN DAM | -27.9526 | 29.9479 | V31E | 9 | 4/8/1986 | 3/10/1987 |
| 102774 | V3R001Q03 NTSHINGWAYO (CHELMSFORD) DAM ON NGAGANE RIVER: POINT IN DAM | -27.9528 | 29.9477 | V31E | 3 | 5/6/1986 | 4/28/1987 |
| 102775 | V3R001Q04 NTSHINGWAYO (CHELMSFORD) DAM ON NGAGANE RIVER: POINT IN DAM | -27.9531 | 29.9476 | V31E | 3 | 6/24/1986 | 5/5/1987 |
| 102776 | V3R001Q05 NTSHINGWAYO (CHELMSFORD) DAM ON NGAGANE RIVER: POINT IN DAM | -27.9532 | 29.9479 | V31E | 19 | 9/2/1986 | 4/7/1987 |
| 102757 | V3H012Q01 AT SLEUTELPOORT CFR 5 ON FOURIESPRUIT | -28.0711 | 29.8667 | V31E | 70 | 10/15/1985 | 1/30/1991 |
| 102758 | V3H013Q01 MAHLOMYANE RIVER AT DOORNPOORT (CFR 4) | -28.0644 | 29.8428 | V31E | 69 | 10/15/1985 | 5/3/1989 |
| 102759 | V3H014Q01 AT BIDFORD NOOITGEDACHT (CFR1) ON NGAGANE | -28.0681 | 29.7981 | V31E | 68 | 10/15/1985 | 5/3/1989 |
| 102761 | V3H016Q01 KLIP SPRUIT AT B OF BRADFORD/NORMANDIEN (KLIP) | -27.9869 | 29.7789 | V31E | 71 | 10/15/1985 | 11/17/2016 |
| 102762 | V3H017Q01 SPECTACLE SPRUIT AT SPECTACLE SPRUIT NTSINGWAYO (CHELMSFORD) ) DAM | -27.9625 | 29.8933 | V31E | 68 | 10/15/1985 | 5/3/1989 |
| 102764 | V3H019Q01 MANZAMNYAMA RIVER AT LILYDALE (CFR 2) | -28.0769 | 29.9317 | V31E | 72 | 10/15/1985 | 5/4/2017 |
| 102765 | V3H020Q01 KALBAS RIVER AT LILYDALE/KALBASKOP (CFR 3) | -28.0611 | 29.9556 | V31E | 75 | 10/15/1985 | 5/3/1989 |
| 102770 | V3H027Q01 NTSHINGWAYO (CHELMSFORD) DAM ON NGAGANE RIVER: DOWN STREAM W WEIR | -27.9536 | 29.9489 | V31E | 321 | 6/16/1982 | 5/18/2018 |
| 1000011639 | KALBAL RIVER ON THE NOMANDEEN ROAD BRIDGE | -28.0569 | 29.9553 | V31E | 71 | 7/19/2005 | 2/7/2017 |
| 1000011641 | MAZAMYAMA RIVER ON THE NOMANDEEN ROAD BRIDGE | -28.0778 | 29.9314 | V31E | 72 | 7/19/2005 | 2/7/2017 |
| 1000011643 | MHLONYANA RIVER ON THE NOMANDEEN ROAD BRIDGE | -28.0636 | 29.8433 | V31E | 74 | 7/19/2005 | 2/7/2017 |

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|---|---|---|---|---|---|---|---|
| 1000011645 | KLIP RIVER ON THE OLD NEWCASTLE ROAD BRIDGE | -27.9875 | 29.7783 | V31E | 71 | 7/19/2005 | 2/7/2017 |
| 1000011646 | NGAGANE RIVER ON THE OLD NEWCASTLE ROAD BRIDGE | -28.0408 | 29.7867 | V31E | 75 | 7/19/2005 | 2/7/2017 |
| 102754 | V3H009Q01 HORN RIVER AT BALLENGEICH | -27.8958 | 29.9514 | V31F | 1207 | 2/18/1966 | 4/20/2018 |
| 187707 | #24 HORN RIVER DOWN STREAM OF NATAL COAL EXPLORATION | -27.8957 | 29.8806 | V31F | 92 | 11/25/2003 | 11/9/2017 |
| 187708 | #22 HORN RIVER UP STREAM OF NATAL COAL EXPLORATION | -27.8986 | 29.8709 | V31F | 96 | 11/25/2003 | 11/9/2017 |
| 187717 | #23 HORN RIVER KNOWESLEY NATAL COAL EXPLORATION SEEPAGE | -27.8970 | 29.8785 | V31F | 26 | 1/20/2005 | 1/22/2013 |
| 102751 | V3H003Q01 AT BALLENGEICH ON NGAGANE | -27.9228 | 29.9494 | V31G | 52 | 2/9/1957 | 12/5/1957 |
| 102763 | V3H018Q01 AT NTSINGWAYO (CHELMSFORD) DAM DOWN STREAM OF DAM ON NGAGANE E | -27.9383 | 29.9433 | V31G | 40 | 11/26/1985 | 12/1/1988 |
| 188866 | KILBARCHAN D/S OF HORN AND NGAGANE CONFLUENCE U/S OF KILBARCHAN ON INGA AGANE | -27.8843 | 29.9753 | V31G | 62 | 3/22/2006 | 1/23/2017 |
| 188867 | BALLENGEICH 3299 - U/S SILTECH @ BRIDGE TO NTSHINGWAYO DAM ON INGAGANE | -27.9235 | 29.9681 | V31G | 61 | 5/15/2006 | 1/23/2017 |
| 188868 | BALLENGEICH 3299 - D/S SILTECH & U/S OF HORN @ RAILWAY BRIDGE ON INGAGANE | -27.8900 | 29.9781 | V31G | 75 | 5/15/2006 | 1/23/2017 |
| 188872 | BALLENGEICH @ WEIR U/S OF NGAGANE ON HORN | -27.8851 | 29.9742 | V31G | 63 | 3/22/2006 | 1/23/2017 |
| 102753 | V3H007Q01 NCANDU RIVER AT RUST | -27.8494 | 29.8408 | V31H | 571 | 2/19/1966 | 4/19/2018 |
| 102777 | V3R002Q01 AMCOR DAM ON NCANDU RIVER: NEAR DAM WALL | -27.7364 | 29.9864 | V31J | 352 | 1/1/1980 | 4/17/2018 |
| 189028 | BOSCH HOEK LENNOXTON D/S OF WEIR & U/S OF TAXI RANK ON NCANDU | -27.7854 | 29.8971 | V31J | 42 | 9/28/2006 | 9/26/2016 |
| 189029 | NEWCASTLE RIVERSIDE U/S OF AMCOR DAM ON NCANDU | -27.7446 | 29.9686 | V31J | 42 | 9/28/2006 | 11/24/2015 |
| 189030 | NEWCASTLE DOWNSTREAM OF TAXI RANK AND ALLEN STREET BRIDGE ON NCANDU | -27.7498 | 29.9319 | V31J | 43 | 9/28/2006 | 9/26/2016 |
| 102768 | V3H024Q01 AT PARKLANDS DOWN STREAM OF BRIDGE ON NGAGANE | -27.7267 | 30.0550 | V31K | 39 | 8/26/1987 | 6/29/2016 |
| 188917 | NEWCASTLE TOWNSHIP - AT WEIR ON NGAGANE | -27.7698 | 30.0171 | V31K | 57 | 4/11/2006 | 12/23/2010 |
| 188918 | ROY POINT @ UTHUKELA ABSTRACTION POINT ON INGAGANE | -27.7986 | 29.9884 | V31K | 56 | 4/11/2006 | 10/27/2015 |
| 189366 | SHAKESPEARE D/S OF NEWCASTLE STW EFFLUENT & MITTAL STEEL WORKS & U/S MIT TTAL STEEL EFFLUENT | -27.7219 | 30.0215 | V31K | 37 | 8/22/2006 | 1/26/2017 |
| 1000011731 | MADADENI 15961 HT U/S MITTAL STEEL (ISCOR) EFFLUENT DISCHAR AT WEIR ON NGAGANE | -27.7217 | 30.0208 | V31K | 57 | 7/19/2005 | 1/26/2017 |
| 1000011734 | MADADENI 15961 HT D/S MITTAL STEEL (ISCOR) EFFLUENT DISCHARGE POINT ON NGAGANE | -27.7266 | 30.0546 | V31K | 64 | 7/19/2005 | 1/26/2017 |
| 88805 | ZKIL001 CELL 1 KILBARCHAN COAL DISCARD DUMPS REHABILITATION | -27.8483 | 29.9767 | V31K | 299 | 12/14/1993 | 3/3/2011 |
| 88806 | ZKIL002 CELL 2 KILBARCHAN COAL DISCARD DUMPS REHABILITATION | -27.8483 | 29.9767 | V31K | 312 | 12/14/1993 | 3/23/2004 |
| 88807 | ZKIL003 CELL 3 KILBARCHAN COAL DISCARD DUMPS REHABILITATION | -27.8483 | 29.9767 | V31K | 308 | 12/14/1993 | 3/23/2004 |

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|---|---|---|---|---|---|---|---|
| 88808 | ZKIL004 CELL 4 KILBARCHAN COAL DISCARD DUMPS REHABILITATION | -27.8483 | 29.9767 | V31K | 294 | 12/14/1993 | 3/23/2004 |
| 88809 | ZKIL005 CELL 5 KILBARCHAN COAL DISCARD DUMPS REHABILITATION | -27.8483 | 29.9767 | V31K | 300 | 12/14/1993 | 3/23/2004 |
| 88810 | ZKIL006 CELL 6 KILBARCHAN COAL DISCARD DUMPS REHABILITATION | -27.8483 | 29.9767 | V31K | 305 | 12/14/1993 | 3/23/2004 |
| 88811 | ZKIL007 CELL 7 KILBARCHAN COAL DISCARD DUMPS REHABILITATION | -27.8483 | 29.9767 | V31K | 275 | 12/14/1993 | 3/23/2004 |
| 88812 | ZKIL008 CELL 8 KILBARCHAN COAL DISCARD DUMPS REHABILITATION | -27.8483 | 29.9767 | V31K | 291 | 12/14/1993 | 10/27/2003 |
| 88813 | ZKIL009A CELL 9A KILBARCHAN COAL DISCARD DUMPS REHABILITATIO | -27.8483 | 29.9767 | V31K | 7 | 2/28/1994 | 4/23/2001 |
| 88814 | ZKIL009B CELL 9B KILBARCHAN COAL DISCARD DUMPS REHABILITATIO | -27.8483 | 29.9767 | V31K | 219 | 2/21/1994 | 1/13/2003 |
| 88815 | ZKIL010A CELL 10A KILBARCHAN COAL DISCARD DUMPS REHABILITATI | -27.8483 | 29.9767 | V31K | 11 | 1/18/1994 | 11/26/2001 |
| 88816 | ZKIL010B CELL 10B KILBARCHAN COAL DISCARD DUMPS REHABILITATI | -27.8483 | 29.9767 | V31K | 188 | 12/14/1993 | 10/13/2002 |
| 102767 | V3H023Q01 AT PARKLANDS BUFFALSRIVIER CONFLUENCE ON NGAGANE | -27.7219 | 30.0803 | V32B | 310 | 4/2/1987 | 6/7/1995 |
| 189204 | PARKLANDS BEFORE CONFLUENCE WITH BUFFALO D/S OF FLOOD PANS & IRRIGATIO ON CIRCLES ON INGAGANE | -27.7246 | 30.0804 | V32B | 43 | 8/22/2006 | 1/26/2017 |
| 189205 | UPSTREAM OF MADADENI STW ON BUFFELSRIVIER | -27.7262 | 30.0867 | V32B | 23 | 4/24/2007 | 6/9/2009 |
| 102760 | V3H015Q01 AT VAALBANK RAIL BRIDGE ON BUFFELS RIVER | -27.7375 | 30.2039 | V32C | 190 | 7/27/1982 | 4/18/2018 |
| 188825 | WATERVAL D/S OF OSIZWENI STW & U/S OF WATERVAL STW ON BUFFELSRIVIER | -27.8041 | 30.2482 | V32C | 91 | 6/23/2005 | 3/13/2017 |
| 188835 | WITTEKLIP UPSTREAM OF OSIZWENI STW FINAL EFFLUENT DISCHARGE ON BUFFELS SRIVIER | -27.7400 | 30.2034 | V32C | 92 | 6/23/2005 | 3/13/2017 |
| 188842 | WATERVAL DOWNSTREAM OF WATERVAL STW ON BUFFELSRIVIER | -27.8072 | 30.2594 | V32C | 97 | 6/23/2005 | 3/13/2017 |
| 102755 | V3H010Q01 AT TAYSIDE ON BUFFELS RIVER | -28.0589 | 30.3736 | V32D | 1312 | 5/17/1977 | 4/19/2018 |
| 189163 | DE JAGERSDRIFT NORTH @ R33 DUNDEE VRYHEID BRIDGE ON BUFFELSRIVI IER | -28.0038 | 30.3861 | V32D | 81 | 1/10/2006 | 3/7/2017 |
| 187697 | #9 BANNOCKBURN DOWNSTREAM DECANT | -28.1591 | 30.1835 | V32E | 57 | 11/25/2003 | 4/23/2015 |
| 187698 | #7 BANNOCKBURN UPSTREAM DECANT | -28.1611 | 30.1724 | V32E | 58 | 11/25/2003 | 5/12/2015 |
| 187704 | #16 GLADSTONE SEEPAGE | -28.0796 | 30.2888 | V32E | 8 | 1/22/2004 | 1/20/2005 |
| 187706 | #18 GLADSTONE UPSTREAM OF GLADSTONE SEEPAGE | -28.0714 | 30.2860 | V32E | 47 | 11/25/2003 | 8/12/2014 |
| 187711 | #25 KLIP RAND KLIPRAND DAM ON TRIBUTARY OF MZINYASHANA | -27.9972 | 30.1562 | V32E | 74 | 11/25/2003 | 7/13/2016 |
| 187712 | #26 KLIP RAND KLIPRAND DECANT | -28.0030 | 30.1475 | V32E | 26 | 11/25/2003 | 7/21/2015 |
| 187714 | #13 DALRY DOWN STREAM OF CORBY ROCK | -28.1387 | 30.3807 | V32E | 41 | 11/25/2003 | 6/5/2014 |
| 187715 | #14 CORBY ROCK UPSTREAM OF CORBY ROCK DOWNSTREAM OF DAM | -28.1561 | 30.3833 | V32E | 51 | 11/25/2003 | 6/5/2014 |

| Monitoring Point ID | Monitoring Point Name | Latitude | Longitude | Drainage Region | Number of Samples | First Sample Date | Last Sample Date |
|---|---|---|---|---|---|---|---|
| 187719 | #21 PIETERSDALE OF IGNUSDALE DOWNSTREAM OF NNC2 AND NNC3 | -28.0402 | 30.1713 | V32E | 55 | 11/25/2003 | 12/9/2016 |
| 187721 | #19 SWISS VALLEY UPSTREAM OF NNC2 NNC3 | -28.0641 | 30.1825 | V32E | 46 | 11/25/2003 | 7/21/2015 |
| 187723 | #15 CORBY ROCK SEEPAGE FROM CORBY ROCK | -28.1543 | 30.3832 | V32E | 37 | 11/25/2003 | 6/5/2014 |
| 187724 | #20 SWISS VALLEY SEEPAGE FROM NNC2 | -28.0648 | 30.1681 | V32E | 41 | 11/25/2003 | 7/21/2015 |
| 187725 | #17 COTSWOLD DOWNSTREAM OF GLADSTONE | -28.0963 | 30.3168 | V32E | 84 | 11/25/2003 | 12/11/2017 |
| 187940 | #27 AT SWISS VALLEY D/S OF NNC2 U/S OF OLD BRIGDE ON NGOBIYA | -28.0634 | 30.1716 | V32E | 33 | 3/11/2004 | 9/4/2013 |
| 188884 | CRAIGSIDE U/S DUNDEE STW FINAL EFFLUENT DISCHARGE POINT ON STERKSTROOM | -28.1309 | 30.2353 | V32E | 95 | 1/27/2006 | 2/6/2017 |
| 188888 | CRAIGSIDE D/S DUNDEE STW FINAL EFFLUENT DISCHARGE POINT ON STERKSTROOM | -28.1297 | 30.2364 | V32E | 103 | 1/27/2006 | 2/6/2017 |
| 192150 | STERKSTROOM @U/S AVOCA | -28.1447 | 30.2283 | V32E | 8 | 11/25/2008 | 1/30/2017 |
| 192151 | MZIMYASHANA D/S SOLMAR @ D/S SOLMAR | -28.0467 | 30.2039 | V32E | 8 | 11/25/2008 | 1/30/2017 |
| 192153 | SANDSPRUIT ON NQUTU ROAD BRIDGE | -28.1397 | 30.3317 | V32E | 9 | 11/4/2008 | 1/30/2017 |
| 192154 | SANDSPRUIT/STERKSPRUIT ON VRYHEID ROAD BRIDGE | -28.0963 | 30.3168 | V32E | 8 | 11/4/2008 | 1/30/2017 |
| 192466 | SANDSPRUIT @U/S  CONFLUENCE BUFFALO RIVER | -28.0874 | 30.3907 | V32E | 8 | 11/4/2008 | 1/30/2017 |
| 1000010650 | UBHOBHOJANE RIVER U/S NQUTHU STW | -28.1234 | 30.4047 | V32E | 110 | 8/13/2004 | 8/10/2010 |
| 1000010651 | UBHOBHOJANE RIVER D/S NQUTHU SEWAGE TREATMENT WORKS | -28.1231 | 30.4047 | V32E | 102 | 8/13/2004 | 8/10/2010 |
| 88497 | ZBAN001 BANNOCKBURN COLL. REED BEDS: INFLOW TO UPPER BED | -28.1600 | 30.1783 | V32E | 193 | 1/5/1995 | 11/14/2017 |
| 88498 | ZBAN002 BANNOCKBURN COLL. REED BEDS: OUTFLOW FROM UPPER B | -28.1600 | 30.1783 | V32E | 106 | 1/5/1995 | 4/2/2004 |
| 88499 | ZBAN003 BANNOCKBURN COLL. REED BEDS: FLOW FROM I TO G | -28.1600 | 30.1783 | V32E | 105 | 1/5/1995 | 11/23/2015 |
| 88500 | ZBAN004 BANNOCKBURN COLL. REED BEDS: OUTFLOW TO RIVER | -28.1600 | 30.1783 | V32E | 104 | 1/5/1995 | 4/2/2004 |
| 88501 | ZBAN011 BANNOCKBURN COLL. REED BEDS: FLOW FROM A TO C | -28.1600 | 30.1783 | V32E | 19 | 1/5/1995 | 7/18/1997 |
| 88629 | ZBAN012 BANNOCKBURN COLL. REED BEDS: FLOW FROM B TO C | -28.1600 | 30.1783 | V32E | 19 | 1/5/1995 | 7/18/1997 |
| 88630 | ZBAN013 BANNOCKBURN COLL. REED BEDS: FLOW FROM C TO D | -28.1600 | 30.1783 | V32E | 19 | 1/5/1995 | 7/18/1997 |
| 88631 | ZBAN014 BANNOCKBURN COLL. REED BEDS: FLOW FROM D | -28.1600 | 30.1783 | V32E | 19 | 1/5/1995 | 7/18/1997 |
| 88632 | ZBAN015 BANNOCKBURN COLL. REED BEDS: FLOW FROM E TO G | -28.1600 | 30.1783 | V32E | 19 | 1/5/1995 | 7/18/1997 |
| 88633 | ZBAN016 BANNOCKBURN COLL. REED BEDS: FLOW FROM F TO H | -28.1600 | 30.1783 | V32E | 19 | 1/5/1995 | 7/18/1997 |
| 88634 | ZBAN017 BANNOCKBURN COLL. REED BEDS: FLOW FROM H TO I | -28.1600 | 30.1783 | V32E | 18 | 1/5/1995 | 7/18/1997 |
| 1000010562 | UGOQO RIVER D/S MONDLO S.T.W | -28.0147 | 30.4480 | V32F | 128 | 8/12/2004 | 10/17/2016 |

| Monitoring Point ID | Monitoring Point Name | Latitude | Longitude | Drainage Region | Number of Samples | First Sample Date | Last Sample Date |
|---|---|---|---|---|---|---|---|
| 1000010565 | UGOQO RIVER U/S MONDLO S.T.W | -28.0144 | 30.4477 | V32F | 132 | 8/12/2004 | 12/7/2016 |
| 89015 | Z211000 TSHOBA RIVER U/S CONFLUENCE WITH WHITE UMFOLOZI | -27.7083 | 30.5625 | V32G | 52 | 6/15/1993 | 11/21/1995 |
| 89039 | Z410300 BIVANE U/S CONFLUENCE ZOETMELK | -27.7264 | 30.5792 | V32G | 51 | 6/15/1993 | 11/22/1995 |
| 102756 | V3H011Q01 BLOED RIVER AT RIETVLEI/BEMBASKOP | -27.8978 | 30.5814 | V32G | 451 | 11/18/1965 | 3/26/1992 |
| 188946 | KANDAS PRISON U/S OF NCOME PRISON STW FIN EFF DISCHARGE ON MDLENERU U | -27.9233 | 30.6519 | V32H | 52 | 1/31/2006 | 2/6/2017 |
| 188947 | BEDROG DOWNSTREAM OF NCOME PRISON STW FINAL DISCHARGE ON MDLENERU (NDHLEVENU) | -27.9336 | 30.6145 | V32H | 53 | 1/31/2006 | 2/6/2017 |
| 194844 | VANTS DRIFT - ON BUFFELSRIVIER | -28.2435 | 30.5153 | V32H | 9 | 2/3/2016 | 6/2/2016 |
| 102749 | V3H001Q01 @ VANT S DRIFT ST PETERS MISSION ON BUFFELSRIVIER | -28.2456 | 30.5094 | V33A | 95 | 8/26/1987 | 3/7/2017 |
| 189586 | MCHJEAANE 2254 RORKE S FERRY D/S NQUTU STW ON BUFFELSRIVIER | -28.3457 | 30.5384 | V33A | 78 | 1/10/2006 | 3/7/2017 |
| 195401 | ISANDLWANA - ON NGXOBONGO TRIBUTARY | -28.3564 | 30.6323 | V33B | 9 | 2/3/2016 | 6/2/2016 |
| 102796 | V6H020Q01 WASBANK RIVER AT ASYNKRAAL - U/S SONDAGS CONFLUEN | -28.5311 | 30.7817 | V33C | 163 | 12/14/1995 | 7/23/2013 |
| **Lower Tugela catchment** | | | | | | | |
| 88972 | ZTUGMID01 TUGELA RIVER AT MIDDELDRIFT (TUGELA-MHLATUZE GWS) | -28.8958 | 31.0267 | V40E | 132 | 10/27/1994 | 7/29/1999 |
| 194574 | TH-01 ESTUARY MOUTH @ THUKELA ESTUARY | -29.2235 | 31.5004 | V50D | 80 | 10/7/2015 | 10/16/2018 |
| 194575 | TH-02 ULTIMATUM TREE @THUKELA ESTUARY | -29.2141 | 31.4356 | V50D | 82 | 10/6/2015 | 10/16/2018 |
| 194576 | TH-03 ESTUARY HEAD @THUKELA ESTUARY | -29.1767 | 31.4422 | V50D | 75 | 10/6/2015 | 10/16/2018 |
| 102779 | V5H002Q01 AT MANDINI ON TUGELA RIVER | -29.1406 | 31.3919 | V50D | 1777 | 1/13/1971 | 5/17/2018 |
| 102780 | V5H002Q02 TUGELA RIVER AT MANDINI/JOHN ROSS BRIDGE D/ST SAP | -29.1406 | 31.3919 | V50D | 6 | 3/30/1995 | 10/6/2006 |
| 188472 | SUNDUMBILI U/S OF STW FINAL DISCHARGE ON MANDENI | -29.1310 | 31.4084 | V50D | 28 | 4/7/2015 | 5/17/2018 |
| 188473 | JOHN ROSS BRIDGE D/S OF SAPPI MANDINI FINAL EFFLUENT DISCHARGE ON N TUGELA | -29.1733 | 31.4385 | V50D | 16 | 10/14/2014 | 5/17/2018 |
| 188475 | SUNDUMBILI D/S OF SUNDUMBILI STW ON MANDENI | -29.1371 | 31.4063 | V50D | 28 | 4/7/2015 | 5/17/2018 |