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DETERMINATION OF WATER RESOURCE CLASSES AND RESOURCE QUALITY OBJECTIVES FOR THE WATER RESOURCES IN THE MZIMVUBU CATCHMENT

GROUNDWATER REPORT

June 2017

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EXECUTIVE SUMMARY

The Department of Water and Sanitation (DWS) has initiated a study to determine Classes and associated RQOs for the Mzimvubu catchment in Water Management Area (WMA) 7. The main aim of the project defined by the Terms of Reference (ToR) is to undertake the following:

- Coordinate the implementation of the WRCS as required in Regulation 810 in Government Gazette 33541 dated 17 September 2010, by classifying all significant water resources in the Mzimvubu catchment,
- determine RQOs using the DWS's procedures to determine and implement RQOs for the defined classes, and
- review work previously done on Ecological Water Requirements (EWR) and the Basic Human Needs Reserve (BHNR) and assess whether suitable for the purposes of Classification.

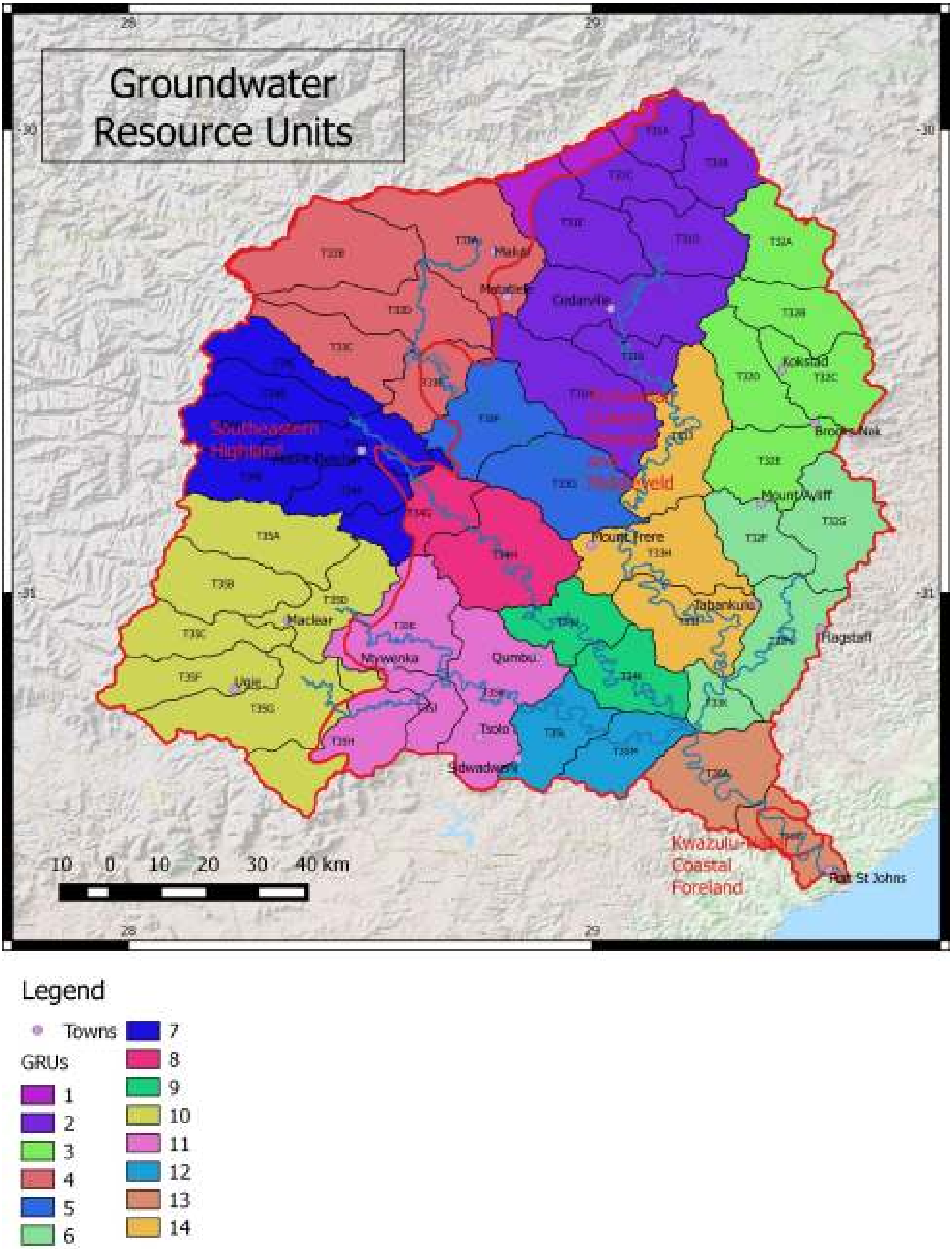
This purpose of this report is to describe and prioritise Groundwater Resource Units (GRUs), quantify the groundwater component of the Reserve, and provide calculations of the groundwater component of the Reserve or EWR at a quaternary level within each GRU.

The catchment was delineated into GRUs as shown in the figure on the following page. Each GRU is described in terms of water quality class distribution, groundwater use and stress index, present state category, groundwater dependency, groundwater EWR and the BHNR, and allocable groundwater. In order to prioritise and select the most important GRUs, the criteria assessed per GRU include: importance of the Resource Unit (RU) to users (degree of groundwater dependence), threat posed to water resource quality for the environment (baseflow), and the degree of use (stress index). Catchments with an A or B status were categorised as low priority. Catchments with a status of C or D, and where groundwater dependence exceeds 50%, were classified as of moderate importance.

Groundwater resources in all tertiary catchments of the Mzimvubu are under-utilised. Total use is only 22 Mm^3/a, from a harvest potential of 317 Mm^3/a, and an aquifer recharge of 492 Mm^3/a. The bulk of groundwater is utilised for domestic water supply, of which 50% is used for regional schemes:

Quat	Area	Recharge	Aquifer recharge	Harvest potential	Groundwater use (Mm^3/a)							Stress index	Present state category
	(km^2)	(Mm^3/a)	(Mm^3/a)	Mm^3/a	Irrigation	Industry	Sched. 1 borehole	Sched.1 spring	Regional schemes	Total use	Domestic use		
T31	3597	371.466	86.214	58.890	3.481	0.000	0.339	0.404	0.208	4.432	0.951	0.047	A
T32	2950	383.186	68.966	40.650	0.841	0.012	0.483	0.829	1.769	3.934	3.081	0.045	A
T33	4452	402.893	96.336	69.220	0.000	0.141	0.743	1.035	5.887	7.807	7.666	0.070	B
T34	3197	720.057	103.052	54.930	0.000	0.016	0.554	0.907	0.868	2.344	2.328	0.014	A
T35	4929	996.339	115.263	83.890	0.000	0.016	0.565	0.460	2.282	3.322	3.306	0.025	A
T36	727	162.291	21.881	9.890	0.000	0.000	0.036	0.116	0.000	0.152	0.152	0.002	A
Total	19852	3036.231	491.711	317.470	4.322	0.185	2.720	3.751	11.013	21.991	17.484	0.037	A

Quat: quaternary catchment



Groundwater Resource Units delineated in the Mzimvubu T3 catchment

Of the 51 quaternary catchments, 42 can be classified as A (stress index < 0.05), 7 as B (stress index < 0.2), and only 2 are classified as C (stress index < 0.4). Only catchments T31F and T33A, near Cedarville and Matatiele respectively, can be considered of moderate priority due to abstraction, however, T33A is less than 50% groundwater dependent. Only 29% of the population is groundwater dependent.

Baseflow across the area is 2 899 Mm^3/a, 87% of which is derived as interflow from springs above the regional groundwater level. The EWR from groundwater is 573.56 Mm^3/a and the BHNR is 6.2 Mm^3/a, resulting in a groundwater component of the Reserve of 580 Mm^3/a, which is only 2.9% of recharge. 387 Mm^3/a of groundwater can still be allocated, of a recharge of 3 036 Mm^3/a.

Quaternary catchment	%	Mm^3/a	%	Mm^3/a		Mm^3/a	% of recharge	Mm3/a
T31	32.06	349.209	81.01	0.453	96.490	96.943	2.70	63.663
T32	22.89	363.246	85.85	1.234	86.050	87.284	2.96	52.760
T33	35.78	382.652	80.36	1.812	133.560	135.372	3.04	61.912
T34	32.21	687.449	89.04	1.197	91.150	92.347	2.89	90.854
T35	25.46	967.810	90.97	1.096	159.310	160.406	3.25	97.391
T36	6.87	148.793	94.96	0.452	7.000	7.452	1.03	21.054
Total	28.78	2899.159	87.48	6.244	573.560	579.804	2.92	387.635

Groundwater is generally of good quality, with 85% of samples being Class 0, 8% of Class 1, and 2% of Class 2. The samples of poor water quality in terms of high electrical conductivity are found in a linear belt from Qumbu to Mount Ayliff across various lithologies.

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LIST OF ACRONYMS

BHN	Basic Human Needs
BHNR	Basic Human Needs Reserve
CGS	Council for GeoScience
DWA	Department Water and Sanitation (Name change applicable after April 2009)
DWAF	Department Water and Sanitation and Forestry
DWS	Department of Water and Sanitation (Name change applicable after March 2014)
EWR	Ecological Water Requirements
GGP	Gross Geographic Product
GRA II	Groundwater Resource Assessment Phase II
GRDM	Groundwater Resource Directed Measures
GRIP	Groundwater Resources Information Project
GRU	Groundwater Resource Unit
GW	Groundwater
HF	Hydraulic fracturing
IUA	Integrated Units of Analysis
l/c/d	Litres per capita per day
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
mbgl	metres below ground level
mm/a	Millimetres per annum
NGDB	National Groundwater Database
NFEPA	National Freshwater Ecosystem Priority Area
NGA	National Groundwater Archive
NWA	National Water Act
quat	Quaternary catchment
RDM	Resource Directed Measures
RQO	Resource Quality Objective
RU	Resource Unit
SFR	Streamflow Reduction
SQ	Sub-quaternary
TDS	Total Dissolved Solids
ToR	Terms of Reference
WARMS	Water Authorisation and Management System
WRCS	Water Resource Classification System
WMA	Water Management Area
WR2012	Water Resources of South Africa, 2012 Study
WRSM2000	Water Resources Simulation Model 2000
ZQM	National Groundwater Quality Monitoring Network database

GLOSSARY

Aquifer hydraulic properties	The properties of permeability and specific yield, or transmissivity and storativity that determine the rate at which an aquifer transmits water, and the volume of water it releases from storage.
Baseflow	The contribution of subsurface water to surface water channels to maintain dry season flows.
Blow Yield	The maximum rate at which water is blown from a borehole by an air compressor after drilling. Commonly assumed to be the maximum inflow rate into that borehole.
Groundwater baseflow	The contribution to baseflow from the regional aquifer.
Interflow	The contribution of subsurface water to surface water courses as baseflow before entering the regional aquifer.
Harvest Potential	The maximum volume of ground water that may be abstracted per area without depleting the aquifers. It is based on estimated mean annual recharge and a rainfall reliability factor, which gives an indication of the possible drought length.
Permeability	The rate at which a permeable material transmits a fluid, expressed as a length per unit time.
Recharge	Rate of ingress or replenishment of water into an aquifer expressed as a volume or depth per unit of time.

1 INTRODUCTION

1.1 BACKGROUND

The Mzimvubu catchment has been prioritised for implementation of the Water Resource Classification System (WRCS) in order to determine appropriate Water Resource Classes and Resource Quality Objectives (RQOs) in order to facilitate the sustainable use of water resources without impacting negatively on their ecological integrity. These activities will guide the management of the T3 Mzimvubu primary catchment toward meeting the departmental objectives of maintaining, and if possible, improving the present state of the Mzimvubu River and its four main tributaries, namely the Tsitsa, Thina, Kinira and Mzintlava. This project is driven by threatened ecosystem services in the Mzimvubu catchment, due to the variety of inappropriate land uses and alien plant infestation that result in extensive erosion and degradation. Degradation can be observed in soil erosion, damage to infrastructure, water supply shortages and loss of grazing.

A previous groundwater assessment was undertaken for the Mzimvubu Development Project in 2009 (DWAF, 2009).

1.2 STUDY AIMS AND OBJECTIVES

The Department of Water and Sanitation (DWS) has initiated a study to determine Classes and associated RQOs for the Mzimvubu T3 catchment in Water Management Area (WMA) 7. The main aim of the project defined by the ToR is to undertake the following:

- Coordinate the implementation of the WRCS as required in Regulation 810 in Government Gazette 33541 dated 17 September 2010, by classifying all significant water resources in the Mzimvubu catchment,
- determine RQOs using the DWS's procedures to determine and implement RQOs for the defined classes, and
- review work previously done on Ecological Water Requirements (EWR) and the Basic Human Needs Reserve (BHNR) and assess whether suitable for the purposes of Classification.

The main objectives of the study are to:

- Delineate the study area into sub-quaternary (SQ) reaches, Resource Units (RUs), Integrated Units of Assessment (IUAs) and select biophysical nodes.
- Determine the status quo of the study areas and identify ecological hotspots (areas requiring detailed information).
- Review the available Reserve information and supplement existing Reserve information in order to provide sufficient Reserve information that covers the study area at the appropriate level, if necessary.
- Identify and model operational scenarios (other than present) and determine the socio-economic and ecological consequences of these scenarios.
- Classify the IUAs into proposed Water Resource Classes.
- Determine the proposed Resource Quality Objectives (RQOs) for proposed classes to allow for monitoring and compliance.
- Provide implementation (including monitoring) guidelines that will ensure compliance of the classes and RQOs.
- Finalise the study with preparation of final deliverable such as the main and close-out reports.
- Compile the legal notice for the Water Resource Classes and RQOs to be published in the Government Gazette for public consultation.

- Assist DWS to address comments and concerns raised during the public consultation and improve the notice for the Water Resource Classes and RQOs where necessary.

1.3 SCOPE OF WORK

The Inception Report (DWS, 2016) for the study outlined a set of tasks (as defined in the ToR) that had to be completed. Tasks relating to the Groundwater Resources Directed Measures (GRDM) process are outlined below. Note that the groundwater contribution to the BHNR is calculated elsewhere, although discussed in this report as a step of the Mzimvubu Project Plan.

1.3.1 Task: Delineation of GRUs

(Completed in Report WE/WMA7/00/CON/CLA/0316, i.e. DWS (2017a))
A map of significant groundwater resource units (GRUs) will be compiled. The following criteria will be utilised:

- Geological conditions that impact on borehole yields and water quality.
- The role of groundwater in baseflow to rivers from the regional aquifer or via interflow from high-lying springs.
- Topography.
- A summary of existing data on harvest potential, groundwater use as per Water Authorisation and Management System (WARMS) data, and baseflows will be compiled and presented at the appropriate scale.

1.3.2 Task: Quantify Ecological Water Requirements - Groundwater

Baseflow contribution to rivers can be identified utilising data from WR2012. These catchments will require more detailed rainfall runoff and rainfall baseflow simulations.

The assessment of groundwater components of relevance to the Reserve will consist of the following for each GRU:

- *Recharge:* Since recharge is the primary source driving the groundwater contribution to EWR, recharge will be obtained from existing sources like Groundwater Resource Assessment Phase II (GRA II) (DWAF, 2006), existing reports and maps. In addition, where gauged catchments with baseflow data exist, these will be used to derive monthly time series of recharge and estimates of threshold monthly precipitation when recharge occurs using WRSM2000. This relationship will be used to estimate recharge in ungauged catchments.
- *Baseflow:* Baseflow will be simulated using the Water Resources Simulation Model 2000 (WRSM2000) (Pitman et al., 2006), and calibrated against gauging weirs. Where no gauging weirs exist, parameters will be transferred from gauged catchments of similar conditions.
- *Groundwater use:* Existing groundwater use affects the groundwater stress index and allocable groundwater. Groundwater use for water supply will be quantified using WARMS data and data from other studies. Figures for irrigation using groundwater will be identified from WARMS and quantities verified by comparing registered use with irrigation area using Google Earth
- *Allocable groundwater*: Volumes of groundwater that are available will be calculated based on recharge, the portion of baseflow required for EWR, the BHNR and current estimated groundwater use.
- *Groundwater quality*: The variations in potable groundwater can be identified from the National Groundwater Quality Monitoring Network *(*ZQM*)* database. Water quality will need to be investigated by lithology and rain zones. Catchments and lithologies with good water quality will be identified.

1.4 GROUNDWATER QUALITY

During the Reserve process, groundwater quality issues are not specifically addressed and as a result, no method is provided to address the groundwater quality component of the Reserve. However, groundwater quality aspects are generally addressed as part of the description of the study area and in the identification of priority areas.

Groundwater quality for each quaternary catchment is expressed as:

- 10th percentile
- 50th percentile (median)
- 95th percentile
- Groundwater quality Reserve (Median +10%) that allows for reasonable contamination.

1.5 SOURCES OF DATA

The following literature sources and databases were accessed for groundwater information (**Table 1.1**):

Table 1.1 Literature sources and databases accessed during this study

Type of data	Data	Source
Catchment delineation	Quaternary catchment boundaries	WR2012
Groundwater discharge zones	Wetland location	National Freshwater Ecosystem Priority Area (NFEPA) Atlas 2011
Population	Population and water source	Statistics SA (referred to as Stats SA)
Climatic data	Rainfall	WR2012
Geology	Lithology and structures	Council for GeoScience (CGS) geological maps
Soils	Soil maps	WR2012
Hydrology	Flow data Baseflow	WR2012 GRA II (DWAF, 2006)
Geohydrology	Harvest potential Exploitation potential Recharge Hydrochemistry Water levels Borehole yields	GRA II (DWAF, 2006) GRA II (DWAF, 2006) GRA II (DWAF, 2006) ZQM database, National Groundwater Archive (NGA) NGA NGA
Groundwater use	Licenced groundwater use Municipal water use Schedule 1 water use Livestock water use	WARMS Stats SA GRA II (DWAF, 2006)
Methodology		GRDM Manual 2012 (Dennis et al. 2013)

1.6 PURPOSE OF THIS TASK

This report documents Steps 2 and 3 of the GRDM process, i.e. to describe and prioritise Groundwater Resource Units (GRUs), and quantify the groundwater component of the Reserve.

1.7 PURPOSE OF THIS REPORT

The purpose of this report is to:

- Quantitatively describe the Mzimvubu River GRUs.
- Prioritise the GRUs.
- Provide calculations of the groundwater component of the Reserve at a quaternary level within each GRU.
- Quantify the groundwater component of the EWR.

1.8 OUTLINE OF THIS REPORT

The report outline is provided below.

Chapter 1: Introduction
This chapter provides general background to the project, study area and purpose of the report.

Chapter 2: GRDM approach
The GRDM approach is outlined and discussed.

Chapter 3: Catchment description
This chapter provides a physical description of the catchment including climate, soils, land cover, population, groundwater use and geology.

Chapter 4: Hydrogeology
This chapter describes the hydrogeology, aquifer classification, and surface groundwater interactions of the catchment.

Chapter 5: Description of GRUs (including the quantification of the groundwater component of the Reserve)
This chapter describes the delineation process and factors considered in the delineation of GRUs and their prioritisation. It also describes each quaternary within each GRU in terms of groundwater use, water quality, recharge, baseflow, groundwater stress, groundwater dependency, the groundwater Reserve, its priority, and the allocable groundwater available.

Chapter 6: Summary and conclusions
This chapter provides a summary of the catchment.

Chapter 7: References

Appendix A: Comments report
Comments from the client are provided.

2 GRDM APPROACH

The GRDM is embedded within the Project Plan for the Mzimvubu Classification and RQO study as provided in **Figure 2.1**.

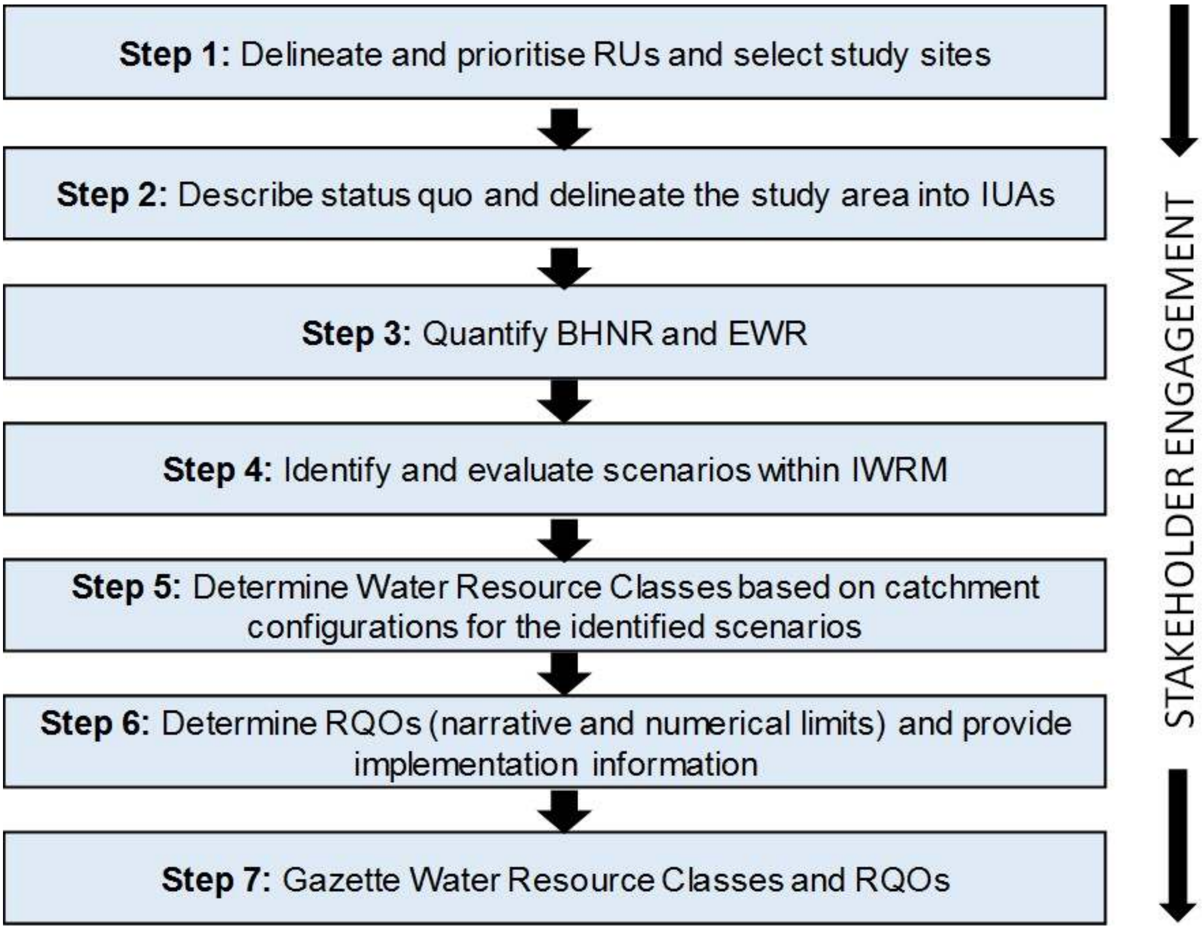

Figure 2.1 Project Plan for the Mzimvubu Classification and RQOs

2.1 STEP 2: DESCRIBE STATUS QUO

Objective: The objective of this sub-step is to define and describe Groundwater Resources for the purpose of GRU delineation.

Quaternary catchments form the basic unit of delineation. These can be grouped into similar geohydrological properties by aquifer type, or be further subdivided if significant geohydrological features cut through catchments. Areas of similar character are grouped and mapped into distinct units, termed GRUs. Criteria that can be utilised to group or disaggregate catchments to form GRUs include:

- Interaction with other components of the hydrological cycle such as wetlands and rivers.
- Nature of the aquifers (primary, secondary dolomitic, alluvial etc.).
- Groundwater depth.
- Lithology when it affects borehole yields and groundwater quality.
- Topography.
- Groundwater dependence and use.
- Groundwater quality.
- Recharge and available groundwater resources.

For the status quo description, additional data requirements and shortcomings should be identified and stressed regions highlighted. The level of uncertainty associated with the data should be presented. The data should be presented in a manner suitable for GRU and IUA delineation.

The bullets below describe the actions required.

- **Describe water resource infrastructure**

This involves identifying hydrogeological units of significance and their boundaries.

- **Identify water users and sources**

This involves identifying and describing the main water users and groundwater dependent communities. The process should include towns, industrial, mining and major irrigation users as well as deriving an estimate of Schedule 1 and livestock water users. WARMS data and the All Towns Strategy studies are potential sources, but do not include Schedule 1 and smaller users. Census data, verification and validation studies etc. must also be considered. The stress on a GRU should define the level of detail and effort expended in quantifying groundwater use. Stream Flow Reduction (SFR) activities also need to be quantified due to their role in baseflow reductions.

- **Identify water quality problem areas**

Problematic water quality areas, both in terms of natural constituents that hinder some uses and contamination must be identified. This can be done by listing the percentage or number of samples falling into various water quality categories.

- **Define the area of significant resources**

Areas of significant resources that need to be identified include:

- Areas where groundwater is the sole source of supply.
- Areas where groundwater contributes a significant component of baseflow and the catchment Mean Annual Runoff (MAR), and where abstraction could reduce these volumes.
- Areas where large volumes of groundwater exist (based on recharge and the harvest potential) and where the existing stress index is low.
- Areas where groundwater is of good quality.

- **Define surface groundwater interaction areas**

Catchments where surface-groundwater interactions exist can be identified from the Groundwater Resource Assessment Phase II (GRA II). The degree of interaction can be obtained from the Water Resources Simulation Model 2000 (WRSM2000 – the Pitman Model with the Sami or Hughes Model Groundwater interactions), amongst other models, if it is calibrated so that simulated recharge approximates recharge estimates from other methods and baseflows fit observed baseflows. The outcomes required for the above are:

- Obtaining a groundwater balance of rainfall recharge and transmission losses from rivers to discharge as baseflow, abstraction, and evapotranspiration under natural and present conditions.
- Quantifying the volumetric contribution of baseflow to rivers.
- Quantifying the degree to which SFR and abstraction have reduced baseflow, and to which abstraction impacts on baseflow.
- Observed gauging weir data to calibrate baseflow volumes and cumulative frequency or flow duration curves.

- **Describe the groundwater quantity and quality status quo**

The information obtained is utilised to define GRUs and describe the existing status quo of each identified GRU.

2.2 STEP 2: DELINEATE AND PRIORITISE INTEGRATED UNITS OF ANALYSIS

Objective: The objective of this step is to identify high priority areas. More detailed work for the rest of the steps would focus on these areas. These high priority areas are selected based on ecological, socio-cultural and water resource use importance and are often areas of high ecological importance where water resources are stressed or may be stressed in future.

The bullets below describe the actions required.

- **Delineate groundwater RUs**

Delineate, categorise or classify GRUs based on stresses on baseflow from (SFRs and abstraction), and stresses on groundwater levels and groundwater use, such as water levels and groundwater quality, borehole yields, aquifer type, hydraulic boundaries, topography, recharge, aquifer vulnerability, or any factors that warrant differing aquifer management practices.

- **Prioritise RUs for groundwater by SFR, stress-index, water level and quality**

Based on Step 1, identify and prioritise GRUs based on stresses. In some areas groundwater stresses that may occur, such as new mines, or groundwater schemes, may not exist yet, and may create future high priority areas.

The concept of stressed water resources is addressed by the National Water Act (NWA), but is not defined quantitatively. The groundwater stress index is used to reflect water availability versus groundwater used. The stress index for an assessment area is defined as follows:

Stress Index = Groundwater use/Recharge

In calculating the stress index, the variability of annual recharge is taken into account in the sense that not more than 65% of average annual recharge should be allocated on a catchment scale without caution and monitoring.

After calculating the stress index, the guide presented in **Table 2.1** is used to set the present status category of each groundwater unit. Firstly, the stress index is used to check the category assigned using the sustainability indicators i.e. whether an 'E' or 'F' category is appropriate. The lowest permissible category should be a D, since it is the lowest limit of sustainability.

Table 2.1 Classification of groundwater by stress

Present class	Description	Present status category	Stress index
I	Minimally used	A	≤ 0.05
		B	0.05 – 0.2
II	Moderately used	C	0.2 – 0.4
		D	0.4 – 0.65
III	Heavily used	E	0.65 – 0.95
		F	> 0.95

2.3 STEP 3: CLASSIFY BHNR

The Basic Human Needs component of the Reserve (BHNR) is set by the Water Services Act (Act No. 108 of 1997) at 25 l/p/d (although this study also determined volumes at 60 l/p/d (DWS, 2017b)). The definition of the Reserve refers to people who are now or who will – in the reasonably near future – be reliant on a resource for water. The BHN component of the Reserve is readily calculated by multiplying the number of people living within the confines of a resource unit AND WITHOUT A CURRENT FORMAL SOURCE OF WATER SUPPLY by 25 l/d.

Where a large proportion of the population already has access to a formal regional water system, setting aside a BHN for this portion and adding it to existing lawful groundwater use would result in a double accounting of water allocations. Hence this study took the approach of only calculating a BHN for the population without access to a formal regional water supply. However, since the bulk of users included in the Reserve are Schedule 1 users, a per capita consumption of 200 l/c/d was utilised.

For the groundwater component of the Reserve, the objective is to define, in a quantitative manner, the groundwater contribution to baseflow, which is required to calculate the groundwater component of the Reserve, and its contribution to the EWR.

The bullets below describe the actions required.

- **Calculate natural baseflow**

This step is necessary to determine the impact of current land use and abstraction in Step 2.

- **Generate present day base flow contribution base flow reduction, stress-index**

Present day and natural baseflow are required, based on a model calibrated against a baseflow time series and recharge, to quantify stress. This allows the quantification of SFRs and groundwater abstraction on baseflow and the importance of groundwater to the EWRs.

- **Align with EWR (base flow) to calculate groundwater component of the Reserve (and derive allocable groundwater)**

Present baseflows compared to the EWR provide a measure of how much further abstraction can be sustained before baseflows reach the EWR at various points in the study area. In some cases, the EWR may preclude the abstraction of available groundwater resources. It then follows that this action depends on the EWR determination and therefore EWR and groundwater actions are linked.

To quantify the groundwater component of the Reserve for each groundwater resource unit, the groundwater volume that is required to sustain the BHN and aquatic ecosystems (or EWR) is required. Only once the groundwater component of the Reserve has been established, can further groundwater allocations be implemented.

The groundwater component of the Reserve for each GRU is calculated by:

Reserve = (EWRgw + BHNgw)

Where:
BHNgw = basic human needs derived from groundwater
EWRgw = groundwater contribution to EWR

Groundwater contributions for the EWR include:

- Baseflow to rivers and springs, including high lying springs fed by interflow.
- Seepage to wetlands and groundwater dependent ecosystems.

The allocable groundwater is the difference between recharge and the Reserve. The groundwater allocation also has to take into account international obligations, existing Schedule 1 usage, General Authorizations and Existing Lawful Users before new license applications can be considered due to the variability of recharge in arid and semi-arid areas, allocable groundwater should not exceed 65% of recharge.

3 CATCHMENT DESCRIPTION

3.1 STUDY AREA

The Mzimvubu River catchment, located in the north-eastern region of the Eastern Cape Province and portions of Kwazulu-Natal Province, has been referred to as one of the poorest parts of South Africa and therefore in dire need for development. Unemployment in the area is amongst the highest in the country, there is little primary economic activity, and a large proportion of the households are dependent on the income of family members who work elsewhere as migrant workers.

The main primary sectors in which potential for economic development may exist have been identified as agriculture, and in particular irrigation (commercial and small scale); forestry; hydropower and tourism. Potential may also exist for mining of heavy metals in some of the dune sands along the coast. Other needs are for improved water supply and sanitation services as well as the possible transfer of water from the Mzimvubu River to other catchments where it could be beneficially utilised. In all of the above, the availability of water is a crucial factor and in many cases the key determinant.

The study area (**Figure 3.1**) consists of the main Mzimvubu River, the Tsitsa, Thina, Kinira and Mzintlava main tributary rivers, and the estuary at Port St Johns. The river flows generally in a south-easterly direction, towards its estuary mouth on the Indian Ocean, through the Gates of St John Gorge at Port St Johns. The river reaches sizeable proportions after the confluence of these four tributaries in the Lower Mzimvubu area, approximately 120 km from its source, where the impressive Tsitsa Falls can be found near Shawbury Mission.

The Mzimvubu catchment and river system lies along the northern boundary of the Eastern Cape and extends for over 200 km from its source in the Maloti-Drakensberg watershed on the Lesotho escarpment to the estuary at Port St Johns.

The catchment is in Primary Drainage Region T, and consists of the T31–36 tertiary catchments. It lies between the Mzimkulu catchment on the north-eastern side, and the Mbashe and Mthatha river catchments in the south. The Mzimvubu River catchment is part of WMA7, i.e. the Mzimvubu to Tsitsikamma WMA. The catchment covers more than two million hectares in the Eastern Cape and is comprised of almost 70% communal land.

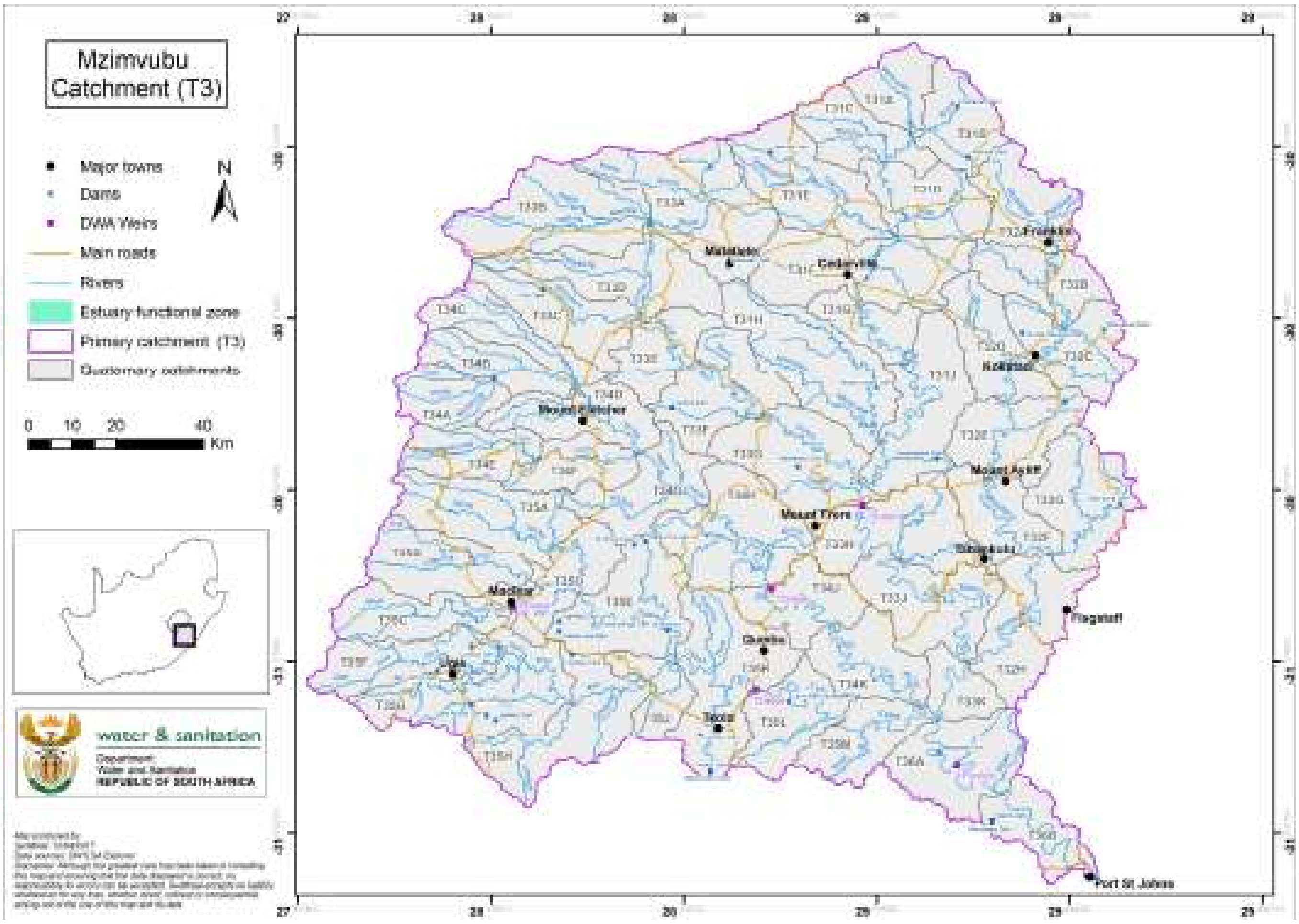

Figure 3.1 Mzimvubu catchment

3.2 MUNICIPALITIES

The Mzimvubu River catchment boundary falls within the following four district municipalities: Alfred Nzo, Ukhahlamba, Sisonke and OR Tambo. The largest urban settlement in the basin is the town of Kokstad, with numerous smaller towns scattered throughout, serving as growth points and governmental service centres. The majority of the population reside in small rural villages scattered throughout the catchment. The catchment contains the following local municipalities (**Figure 3.2**):

Eastern Cape Province

- Matatiele
- Umzimvubu
- Ntabankulu
- Mbizana
- Ngquza Hill
- Port St Johns
- Nyandeni
- Mhlonto
- Elundini

KwaZulu-Natal province

- Greater Kokstad

.

Figure 3.2 Local municipalities in the Mzimvubu WMA

3.3 PHYSIOGRAPHY

The WMA can be divided into three sub areas (**Figure 3.3**):

- The South-eastern Highlands
- The Transkeian Coastal Foreland and Middelveld
- The KwaZulu-Natal Coastal Foreland

The Mzimvubu River and its four main tributaries, the Tsitsa, Thina, Kinira and Mzintlava all have their headwaters in the Drakensberg Mountains. After descending through the South-eastern Highlands, the main stream and these tributaries flow through deep river valleys incised into the Transkeian Coastal Foreland and Middelveld, before discharging into the Indian Ocean at Port St Johns.

The elevation descends rapidly from 2500 mamsl at the catchment divide to 1000 mamsl in the Highlands, before gradually dropping to sea level.

The topography of the Mzimvubu River basin varies from predominantly hilly around the coast and escarpment with numerous rivers draining deep valleys, to a less mountainous undulating central area.

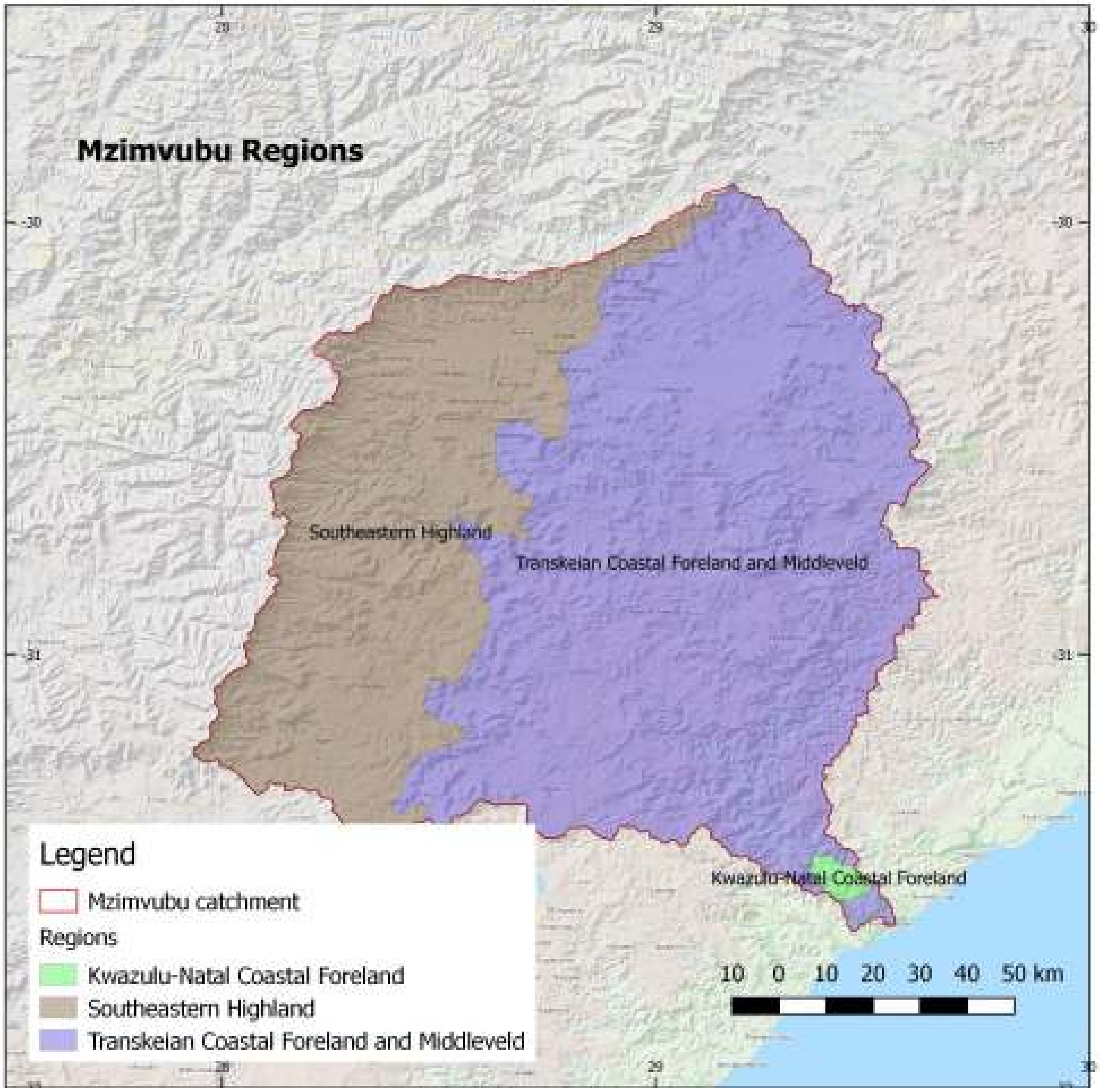

Figure 3.3 Physiographic regions of the Mzimvubu WMA

3.4 SURFACE WATER AND DRAINAGE

The Mzimvubu WMA encompasses a total catchment area of 19 852 km^2. The WMA is characterised by several south to south-east flowing rivers oriented towards the lower Mzimvubu. The primary and secondary river network of the WMA is shown in **Figure 3.4**.

The study area encompasses tertiary drainage regions T31–T36 (**Figure 3.4**). T31 is the catchment of the upper Mzimvubu and Mvenyane rivers. T32 contains the Mzintlava River. T33 is the catchment of the Kinira and middle Mzimvubu rivers. T34 is the catchment of the Thina River. T35 drains the Mooi, iTsitsa, Inxu and Wildebees rivers. T36 is the lower Mzimvubu River.

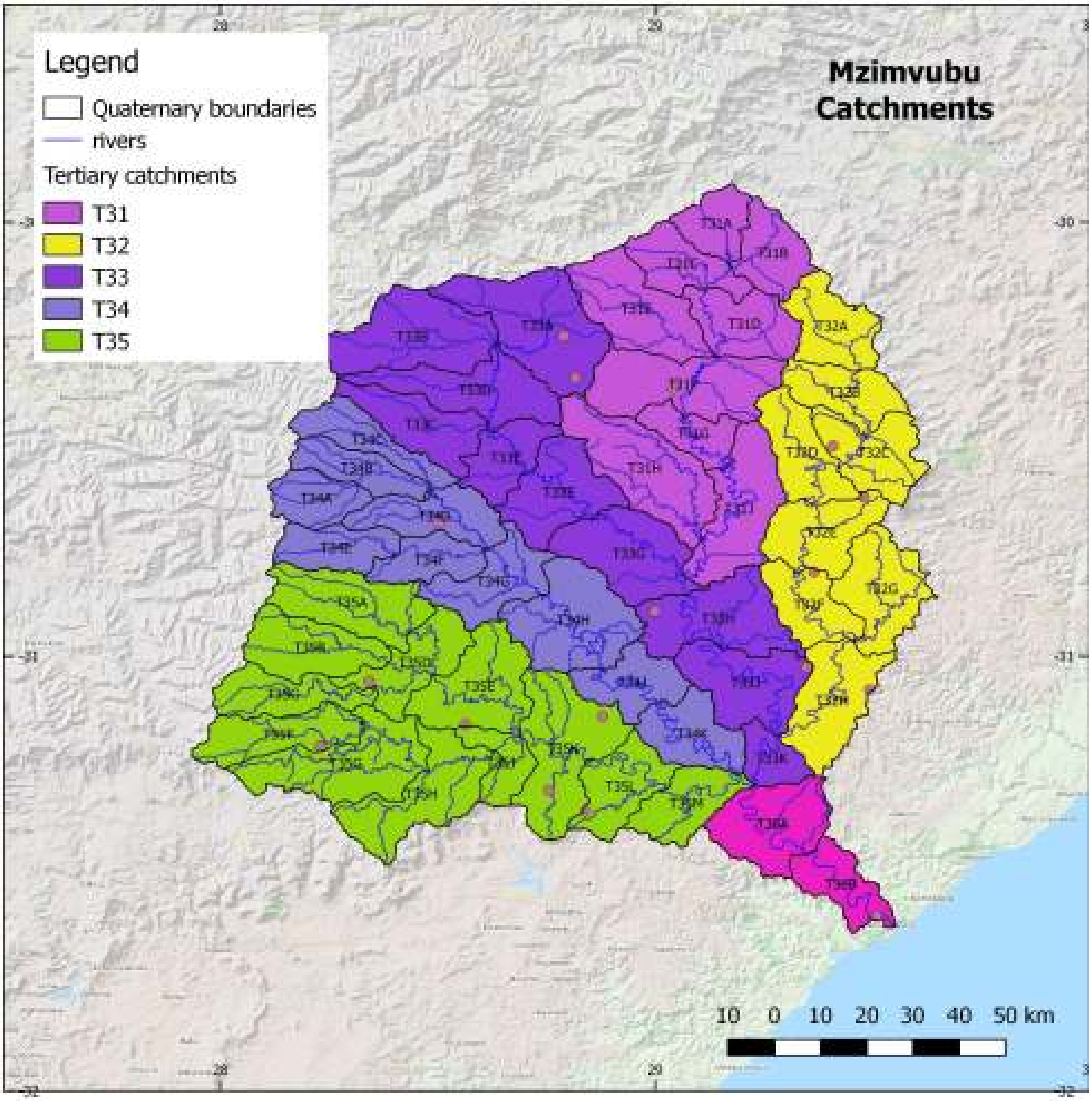

Figure 3.4 Drainage network of the Mzimvubu

3.5 CLIMATE

3.5.1 Climate type

The climate is classified as Temperate (C) under the Koeppen-Geiger classification. It is subdivided further as (**Figure 3.5**):

- Cwa: Subtropical highland climate or temperate oceanic climate with dry winters; coldest month averaging above 0 °C (32 °F), all months with average temperatures below 22 °C (71.6 °F), and at least four months averaging above 10 °C (50 °F). At least ten times as much rain in the wettest month of summer as in the driest month of winter (an alternative definition is 70% or more of average annual precipitation received in the warmest six months).
- *Cfa* = Humid subtropical climate; coldest month averaging above 0 °C (32 °F) and at least one month's average temperature above 22 °C (71.6 °F) and at least four months averaging above

10 °C (50 °F). No significant precipitation difference between seasons (neither abovementioned set of conditions fulfilled). No dry months in the summer.

- *Cfb* = Temperate oceanic climate; coldest month averaging above 0 °C (32 °F), all months with average temperatures below 22 °C (71.6 °F), and at least four months averaging above 10 °C (50 °F). No significant precipitation difference between seasons (neither abovementioned set of conditions fulfilled).

Figure 3.5 Koeppen – Geiger Climatic classification of the Mzimvubu catchment

3.6 RAINFALL

Gridded rainfall shows that rainfall ranges from a high of over 1300 millimetres per annum (mm/a) in parts of central T32 and T35, to less than 700 mm/a in the flat areas of the central interior (**Figure 3.6**).

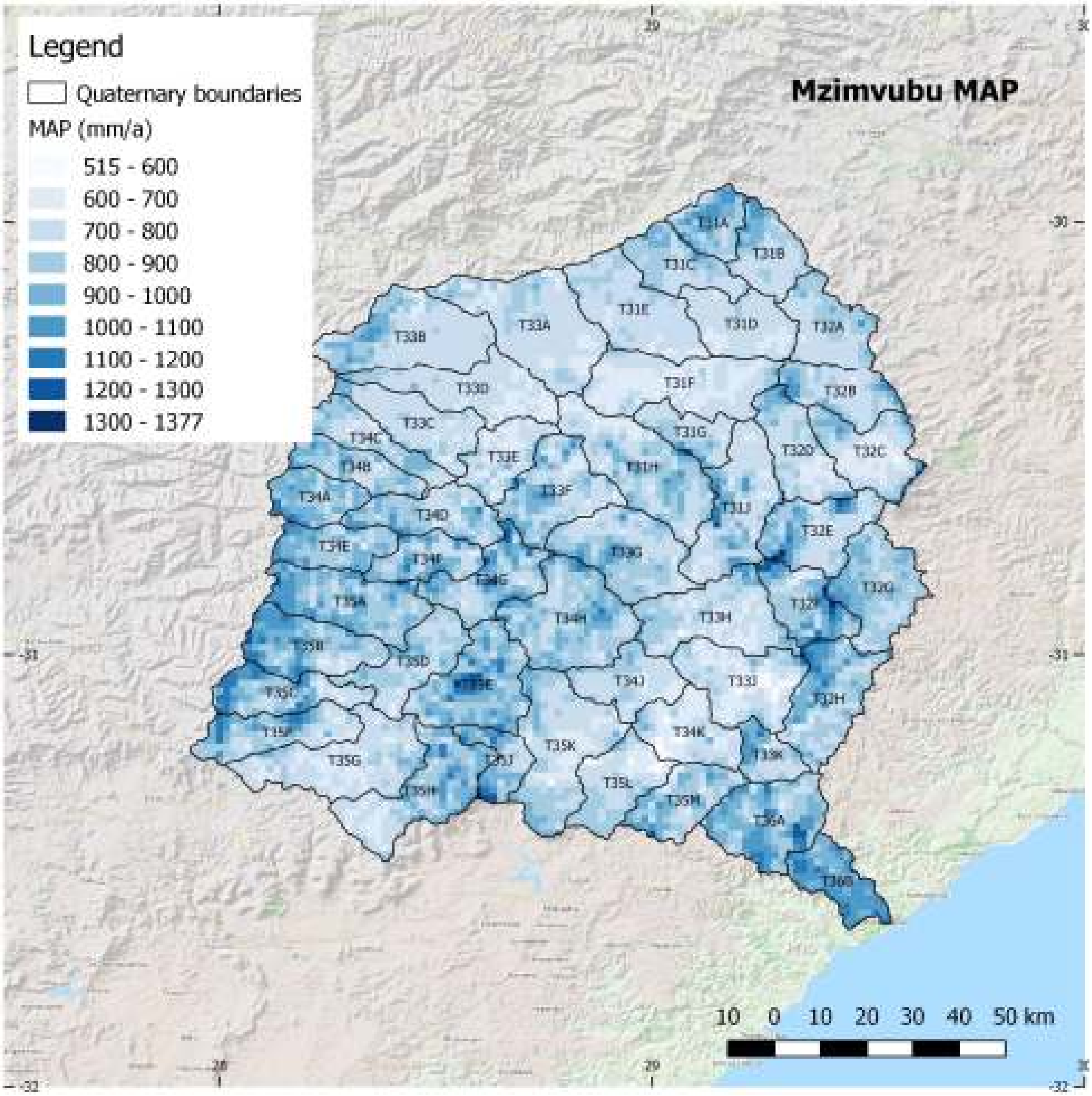

Figure 3.6 Gridded rainfall for the Mzimvubu catchment

Figure 3.7 shows the Mean Annual Precipitation (MAP) distribution by catchment. Catchment MAP varies from less than 750 mm/a in the central region to over 1000 mm/a on the coast and the highlands of T35.

The western part of the catchment is significantly wetter than the eastern part.

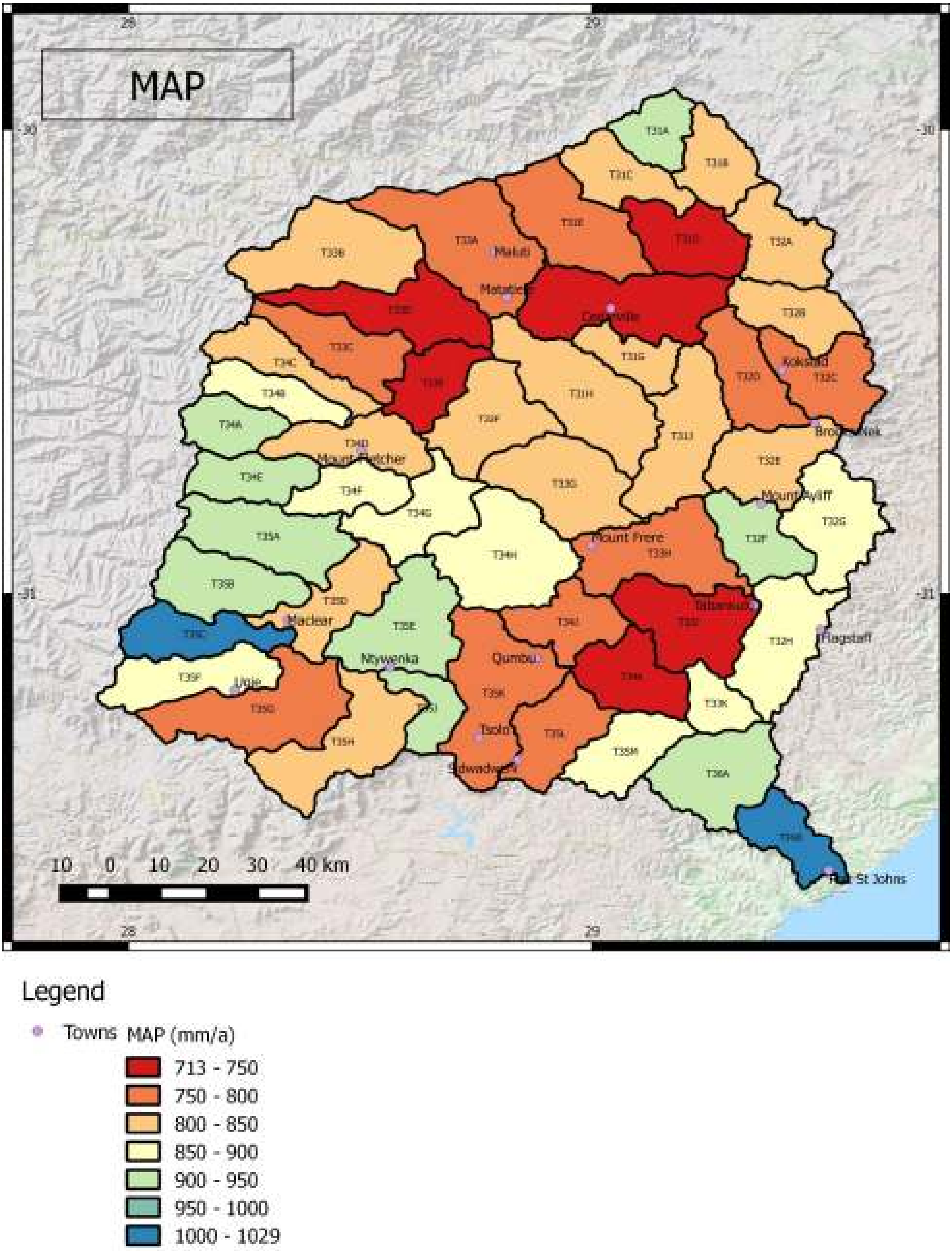

Figure 3.7 MAP of quaternary catchments in the Mzimvubu study area

3.7 EVAPORATION

S-pan evaporation increases from less than 1400 mm/a in the highlands to over 1600 mm/a in the low-lying areas of the interior (**Figure 3.8**).

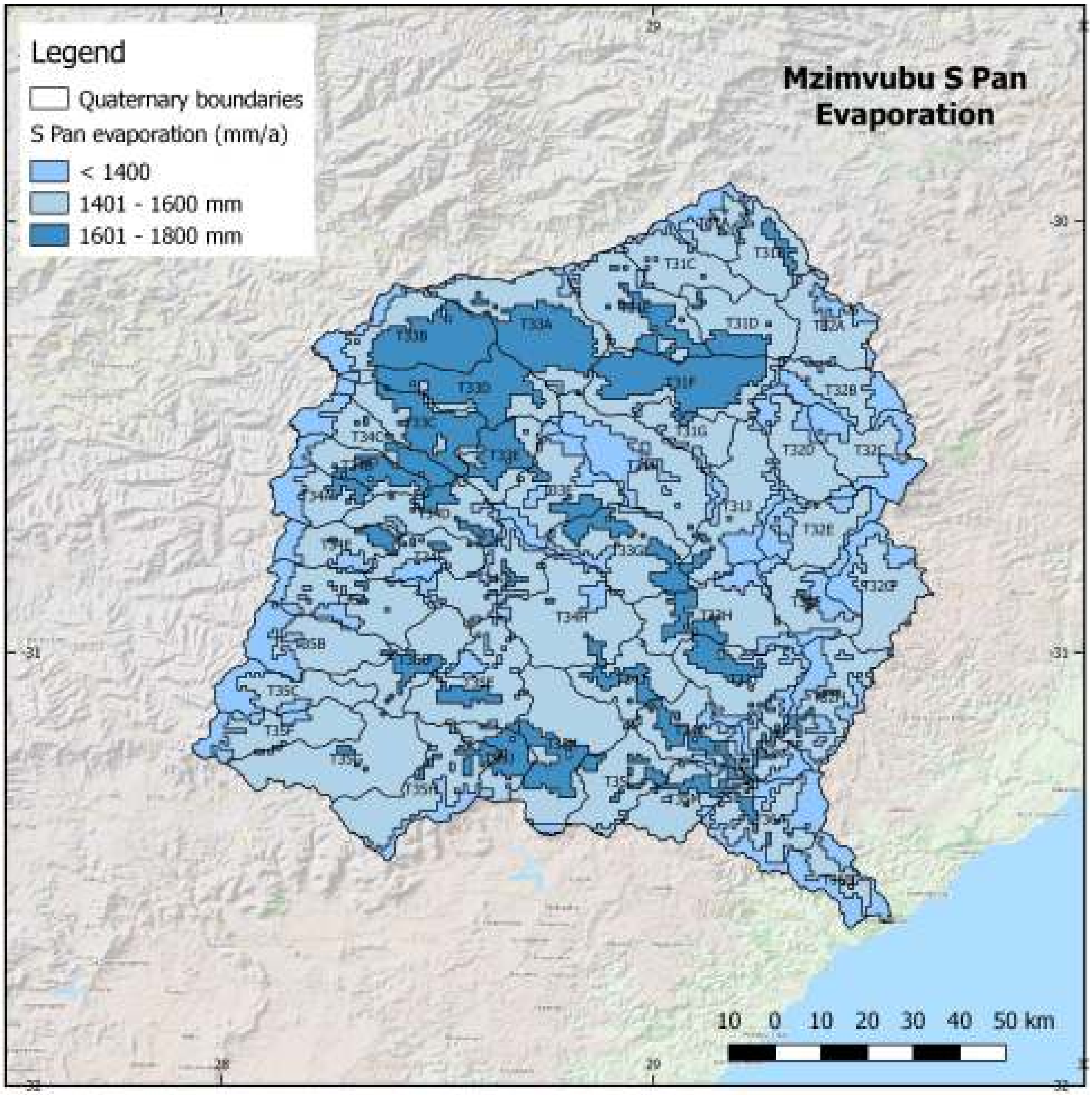

Figure 3.8 S Pan evaporation in the Mzimvubu study area

3.8 VEGETATION

The Mzimvubu catchment is characterised by various veld types. The natural veld varies between lush coastal tropical forest types near the coast and along watersheds, false grassland and karroid types in the deeper river valleys, with temperate and transitional forest and scrub type further away from the coast, and areas of pure grassland. The vegetation zonation is depicted in **Figure 3.9**. The main vegetation types found in the catchment are a series of grasslands in the highlands, grading into savannah bushveld towards the coast.

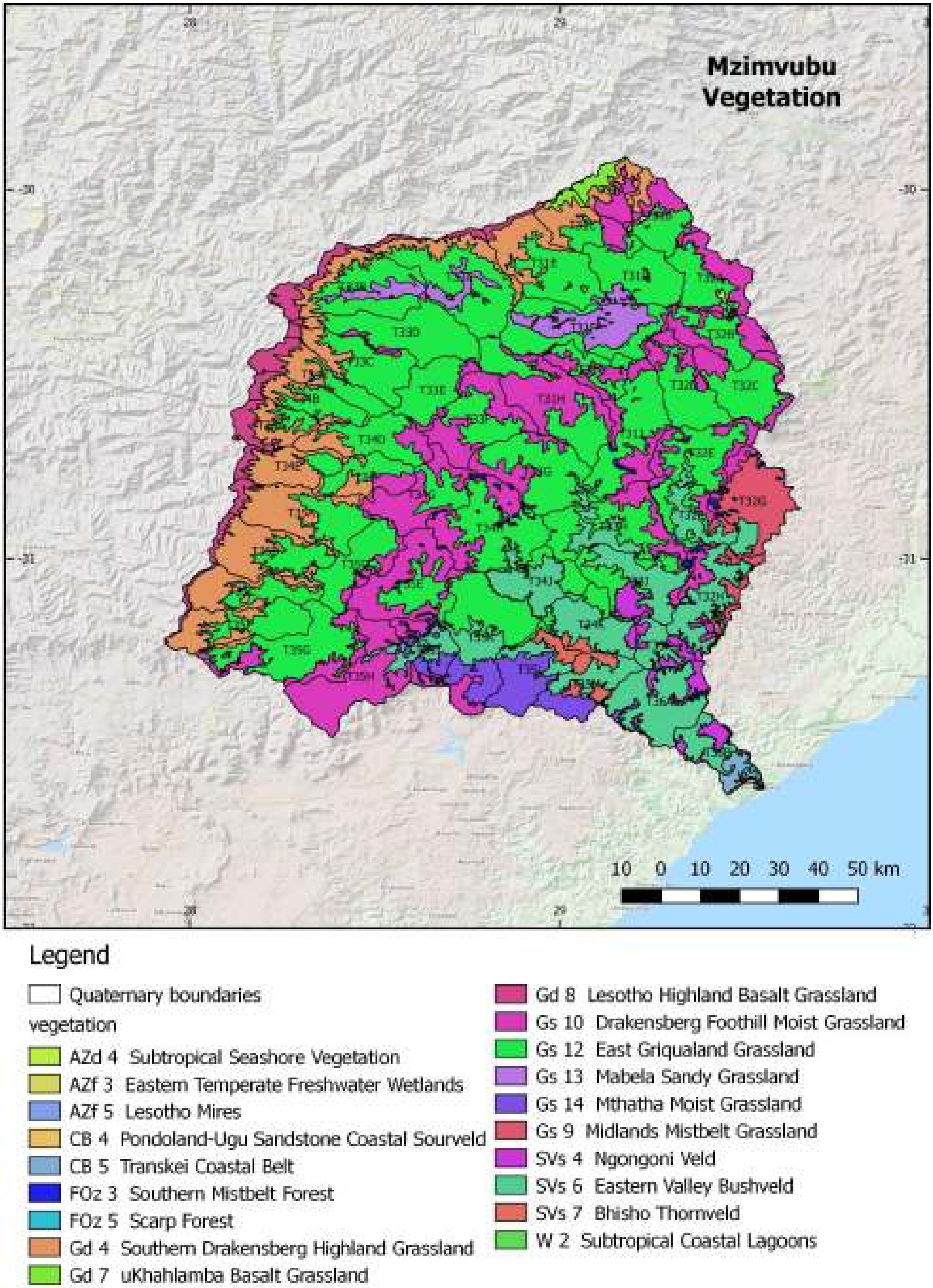

Figure 3.9 Vegetation types of the Mzimvubu study area

3.9 SOILS

Soil cover is an important consideration for groundwater recharge and aquifer vulnerability to contamination. The majority of the catchment is covered by soils with minimal development, which are usually shallow and established on hard rock. These consist of (**Figure 3.10**):

- Leptosols: Soils which are either limited in depth by continuous hard rock within 25 cm from the soil surface, or overly material with a calcium carbonate equivalent of more than 40% within 25 cm from the soil surface, or contain less than 10% (by weight) fine earth (mineral soil material with a diameter of 2 mm or less) to a depth of 75 cm from the soil surface.
- Regosols: Soils where soil has been eroded to the extent that the underlying unconsolidated material comes near to the surface, or where soil formation has not played an important role, e.g. in desert regions.
- Calcisols: Soils where carbonate-rich groundwater comes near the surface resulting in soils having a calcic horizon from the accumulation of secondary calcium carbonates.
- Durisols: Soils develop where a source of silica is present and having a hardpan horizon from the accumulation of secondary silica within 100 cm from the soil surface.

3.10 LAND COVER

Land use is diverse across the catchment but in general the area is largely underdeveloped with minimal large income-generating developments.

The Mzimvubu catchment consists largely of grassland. Extensive tracts of bare ground exist due to overgrazing. A substantial portion of the basin can be classified as degraded, mainly because of overgrazing that has caused severe soil erosion.

Pockets of dryland cultivation also exist (**Figure 3.11**). A prominent feature is the extent of dryland cultivation and the large number of scattered rural villages. These villages are concentrated in the former Transkei area and occupy about 2% of the land area of the basin. The majority of the land is communal and most of the agricultural activity in the former Transkei is based on subsistence dry farming cultivation and rearing of livestock. There are no major irrigation schemes within the region.

Commercial farming mostly occurs outside the former Transkei in areas such as Kokstad, Maclear, Matatiele and Ugie, where irrigated pasture for dairy farming is common practice.

Commercial forestry contributes significantly to the Gross Geographic Product (GGP) of the basin and occurs predominantly in the south-west.

Mineral wealth is considered lacking and to date there is no major mining activity in the basin except for a single quarry.

The invasive alien plants, other than forestry, have been estimated to occupy an equivalent area of 22 600 ha in the basin.

A significant number of wetlands occur in the basin, mostly in the northern portion in KwaZulu-Natal. These wetlands are important to the ecology and in the hydrological cycle.

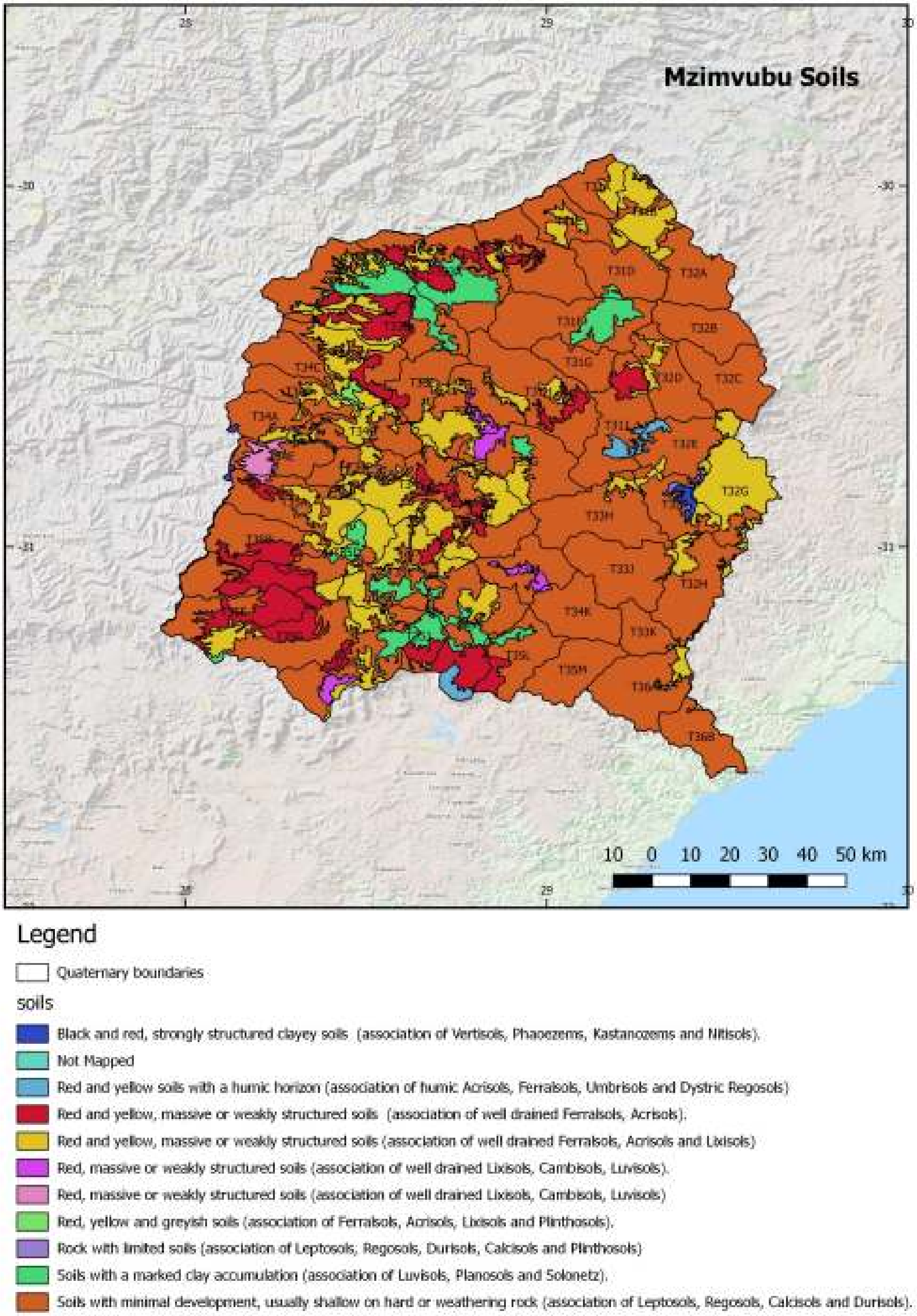

Figure 3.10 Soil types of the Mzimvubu study area

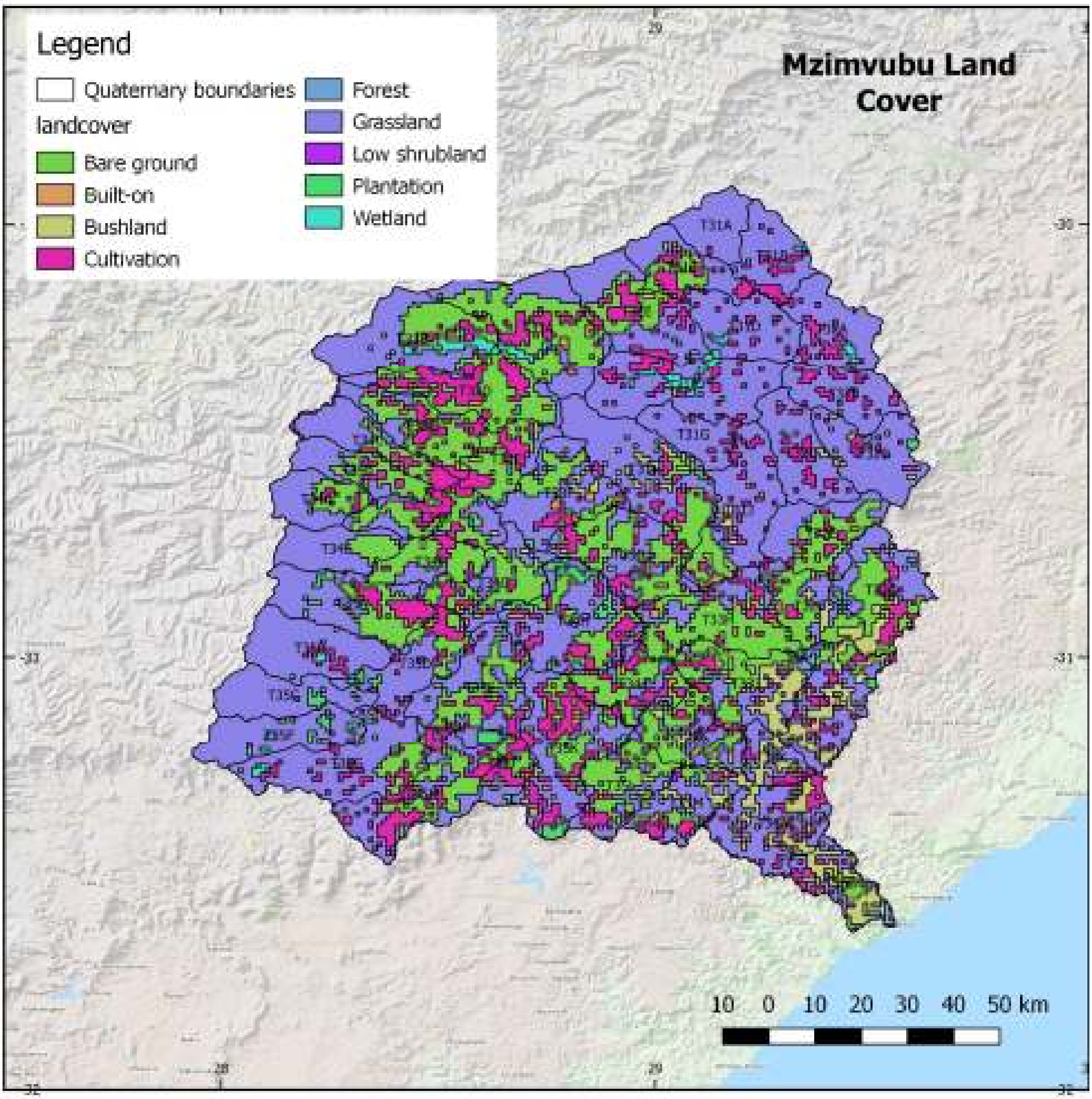

Figure 3.11 Land cover of the Mzimvubu study area

3.11 POPULATION

According to the 2011 Census, 1 045 215 people inhabit the catchment. The bulk of the population live in the lower catchment area, with population densities on a quaternary scale ranging from 0.05–180 people per km^2 (**Figure 3.12**).

A tenth of the total population is urbanised with most of the remaining people living in a large number of small scattered rural villages throughout the river basin. The two largest urban centres are Kokstad and Mount Frere, which account for about 41% of the urban population.

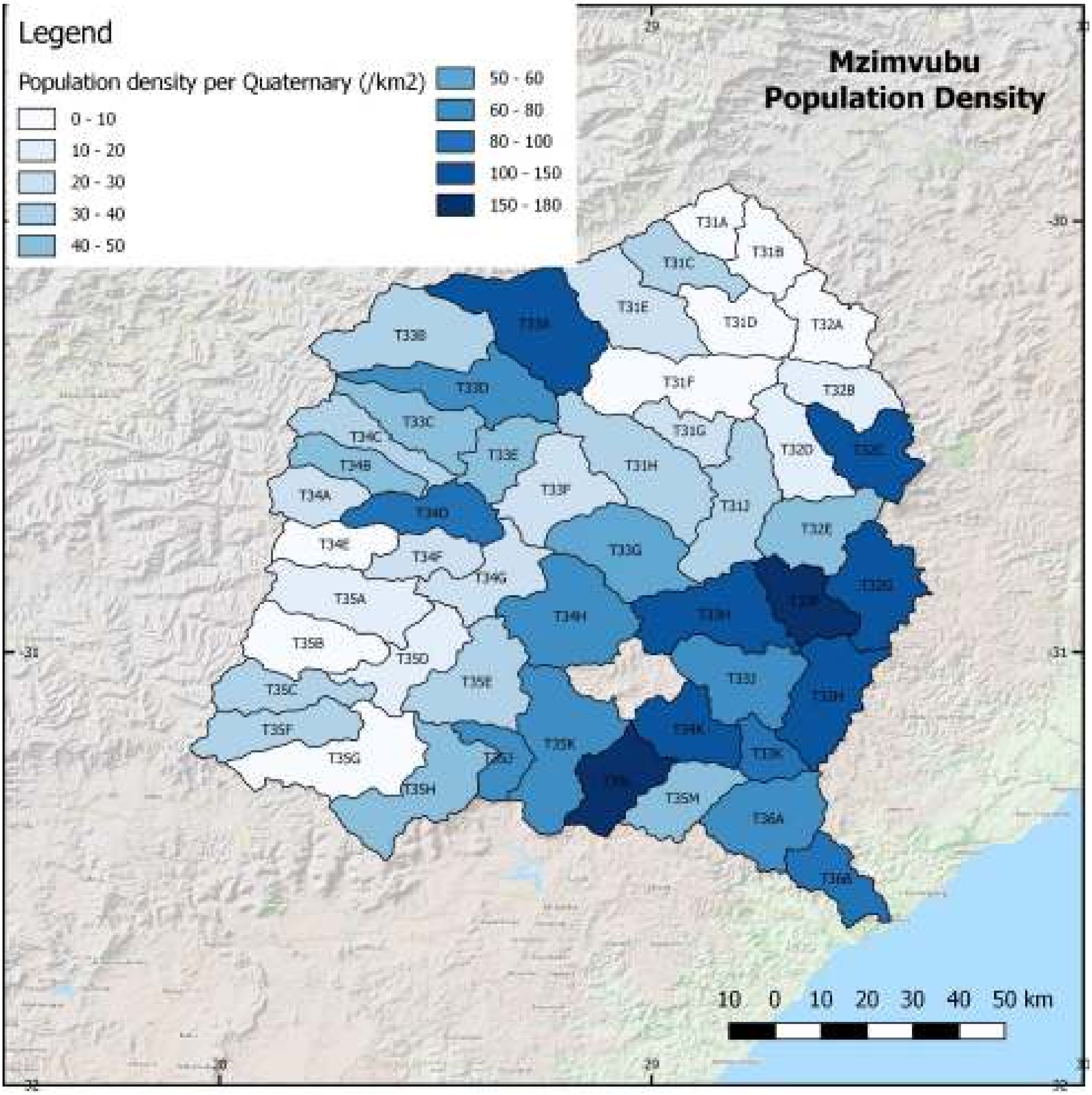

Figure 3.12 Population density of the Mzimvubu study area

3.12 GROUNDWATER USE

3.12.1 Domestic use

Data on groundwater use was collected from WARMS and the 2011 Census. Many communities within the catchment are dependent on groundwater for water supply (**Table 3.1**).

The registered groundwater use in WARMS for formal water schemes is shown in **Figure 3.13**. The registered volume of groundwater population within the catchment supplied by formal groundwater schemes is 12.72 Mm^3/a (**Table 3.2**).

Groundwater use was also estimated based on the number of households on a local formal groundwater scheme as indicated in the 2011 census, and based on a per capita use of 250 litres. (**Table 3.3**). In addition to formal groundwater supply schemes, a large segment of the population is dependent on boreholes and springs. These users were considered Schedule 1 domestic groundwater users. The Schedule 1 use was calculated by taking the number of households stating they obtain water from boreholes or springs, but are not on a regional water scheme, and multiplying by 100 litres per capita per day (l/c/d) (**Table 3.3**).

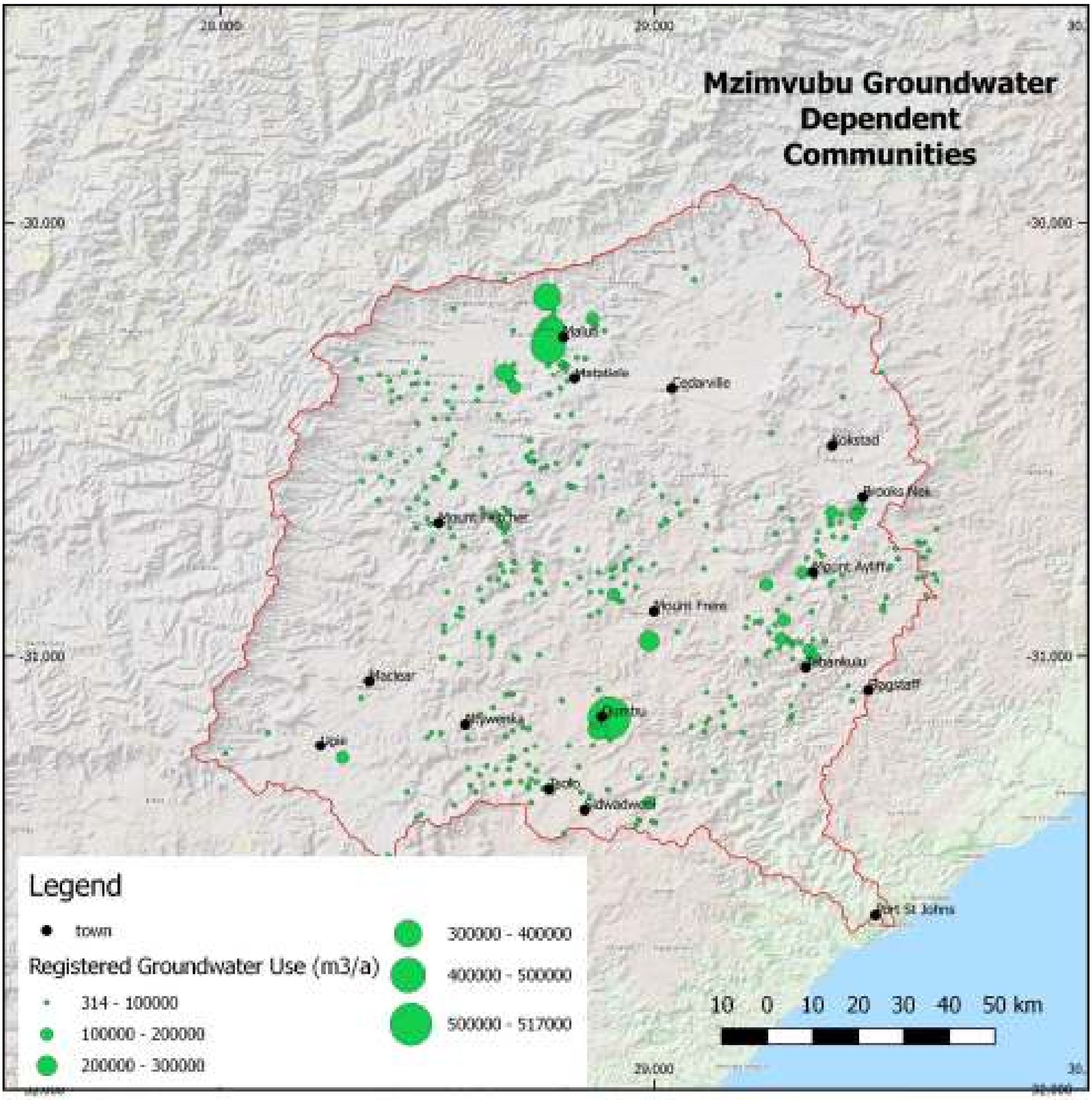

Figure 3.13 Groundwater-dependent communities and registered water use in the Mzimvubu study area

Table 3.1 Towns in T3 utilising groundwater

Town	Municipality	Quaternary
Matatiele	Matatiele	T33A
Mt Frere	Umzimvubu	T33H
Cedarville	Matatiele	T31F
Mt Ayliff	Umzimvubu	T32F
Tsolo	Mhlanto	T35K

Town	Municipality	Quaternary
Qumbu	Mhlanto	T35K
Tabankulu	Ntabamkulu	T33J
Mt Fletcher	Elundi	T34D
Rode	Senqu	T32F
Gugweni	Umzimvubu	T32E
Lubaleko	Umzimvubu	T32G
Kokstad	Greater Kokstad	T32C

Table 3.2 Registered groundwater water use for local water schemes in T3

Quat	Registered water use Mm^3/a	Quat	Registered water use Mm^3/a
T31B	0.01714	T33K	0.06765
T31C	0.009	T34B	0.02336
T31H	0.128898	T34C	0.100914
T31J	0.069086	T34D	0.223614
T32A	0.114128	T34F	0.015602
T32B	0.00036	T34G	0.213293
T32D	0.006	T34H	0.299757
T32E	1.142964	T34J	0.068688
T32F	0.535176	T34K	0.069515
T32G	0.256279	T35C	0.006
T32H	0.409316	T35D	0.020617
T33A	3.054367	T35E	0.093657
T33B	0.003285	T35F	0.010128
T33C	0.12221	T35G	0.170843
T33D	1.237619	T35H	0.229826
T33E	0.172092	T35J	0.371911
T33F	0.477549	T35K	1.484656
T33G	0.20903	T35L	0.146175
T33H	0.922448	T35M	0.122225
T33J	0.099315		
Grand total		12.72469	

Table 3.3 Estimated Schedule 1 groundwater use from boreholes and springs in T3

Quat	Regional schemes	Boreholes (Mm^3/a)	Springs (Mm^3/a)
T31A	0.000	0.015	0.005
T31B	0.002	0.018	0.007
T31C	0.008	0.048	0.098
T31D	0.000	0.027	0.010
T31E	0.000	0.088	0.047
T31F	0.000	0.007	0.003
T31G	0.000	0.018	0.007
T31H	0.129	0.082	0.150
T31J	0.069	0.035	0.077
T32A	0.003	0.020	0.007
T32B	0.000	0.035	0.012

Quat	Regional schemes	Boreholes (Mm^3/a)	Springs (Mm^3/a)
T32C	0.000	0.042	0.040
T32D	0.006	0.046	0.027
T32E	0.559	0.091	0.076
T32F	0.535	0.143	0.284
T32G	0.256	0.022	0.295
T32H	0.409	0.085	0.088
T33A	3.054	0.146	0.089
T33B	0.003	0.043	0.114
T33C	0.122	0.103	0.175
T33D	1.014	0.083	0.246
T33E	0.172	0.048	0.079
T33F	0.223	0.023	0.048
T33G	0.209	0.087	0.054
T33H	0.922	0.149	0.151
T33J	0.099	0.053	0.070
T33K	0.068	0.007	0.011
T34A	0.000	0.019	0.077
T34B	0.023	0.070	0.062
T34C	0.101	0.051	0.060
T34D	0.224	0.123	0.085
T34E	0.000	0.002	0.003
T34F	0.003	0.064	0.058
T34G	0.148	0.110	0.024
T34H	0.300	0.060	0.256
T34K	0.070	0.054	0.282
T35A	0.000	0.104	0.075
T35B	0.000	0.003	0.005
T35C	0.006	0.005	0.010
T35D	0.019	0.051	0.016
T35E	0.094	0.071	0.053
T35F	0.010	0.003	0.007
T35G	0.079	0.022	0.014
T35H	0.230	0.147	0.043
T35J	0.116	0.028	0.102
T35K	1.460	0.052	0.085
T35L	0.146	0.065	0.041
T35M	0.122	0.013	0.011
T36A	0.000	0.023	0.086
T36B	0.000	0.013	0.031
Grand total	11.013	2.720	3.751

The total domestic groundwater use is estimated at 17.484 Mm^3/a.

The percentage of households dependent on groundwater, either from a formal scheme or as Schedule 1 use, are shown in **Figure 3.14** and **Table 3.4**.

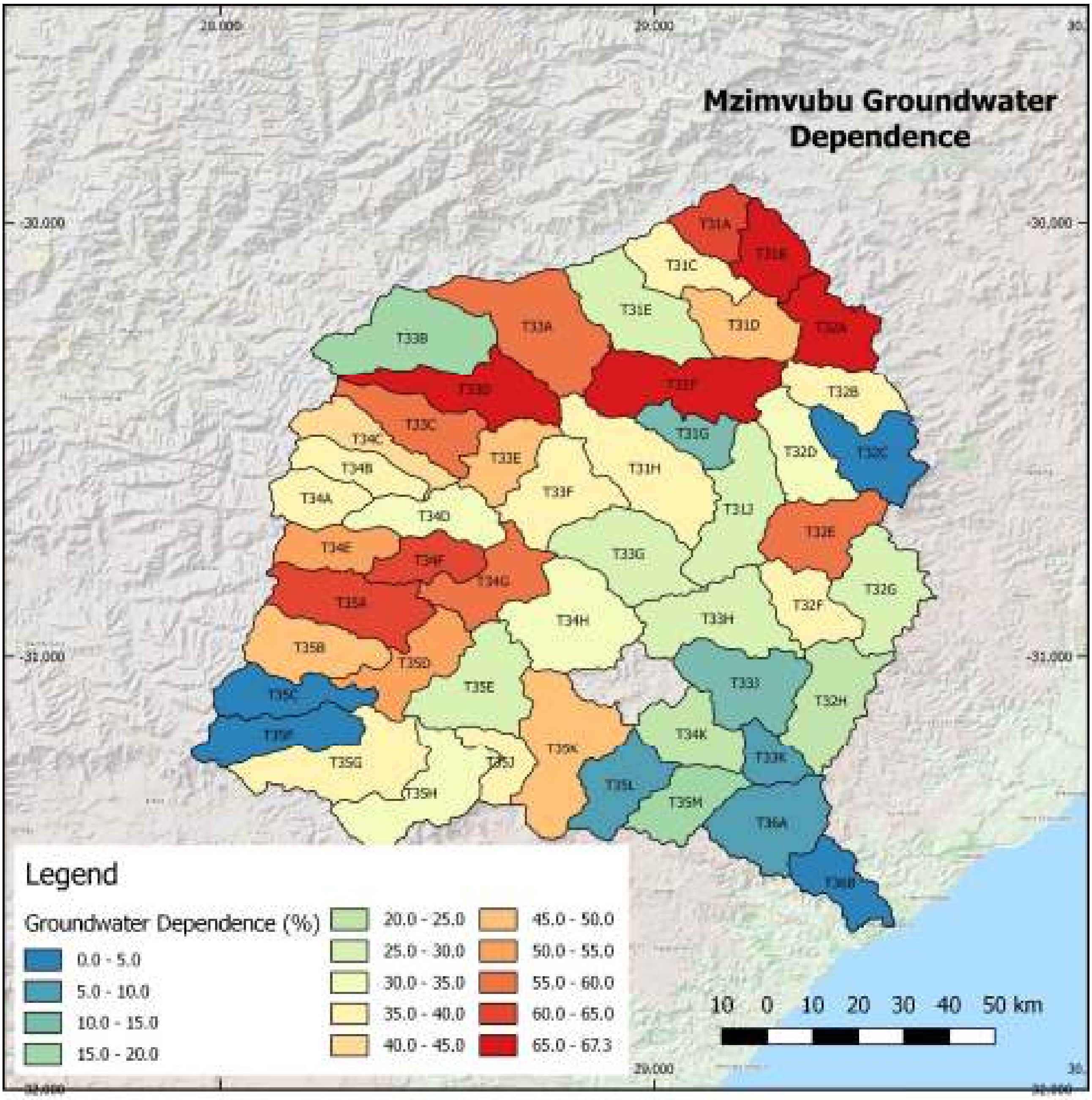

Figure 3. 14 Groundwater dependency in the Mzimvubu catchment

Table 3.4 Source of water by household for the Mzimvubu study area

Quat	Regional water scheme		Schedule 1		Basic Human Needs – No adequate source						Total households	Population
	Groundwater	Surface water	Borehole	Spring	Rainwater tank	Dam or pool	River or stream	Water vendor	Water tanker	Other		
T31A	0	7	127	46	13	29	20	2	20	2	267	858
T31B	8	0	154	57	16	35	25	3	24	3	326	1045
T31C	21	0	330	667	66	706	724	12	85	108	2718	10923
T31D	0	15	205	76	25	94	133	3	55	9	613	2239
T31E	0	1052	582	311	36	426	919	29	31	44	3431	14161
T31F	0	4	52	19	3	8	9	0	8	2	106	411
T31G	0	1081	133	53	21	16	30	6	19	20	1380	5241
T31H	441	1329	562	1025	85	89	1485	71	65	49	5198	20794
T31J	227	1190	229	509	82	217	1049	75	118	46	3741	15566
T32A	9	0	170	62	17	39	27	3	27	3	358	1149
T32B	1	254	230	77	19	75	64	17	35	8	781	3286
T32C	0	13667	334	323	183	61	124	40	77	219	15029	51557
T32D	22	987	335	196	23	50	51	6	43	101	1812	6831
T32E	1198	0	485	407	36	235	724	16	269	131	3500	17894
T32F	1626	2718	868	1723	333	448	2840	170	782	217	11726	52882
T32G	708	819	119	1629	317	522	5053	57	117	106	9448	46846
T32H	1107	257	461	478	357	184	5825	72	279	210	9231	46766
T33A	9825	4229	942	574	299	1441	750	100	868	648	19678	83800
T33B	10	2593	274	722	142	165	633	82	126	377	5125	22196
T33C	437	910	737	1251	63	310	236	9	33	292	4278	16382
T33D	2857	0	583	1730	369	353	841	67	421	546	7766	30204
T33E	593	214	334	542	111	561	511	9	243	71	3187	12660
T33F	647	0	170	345	94	210	1546	23	165	110	3310	12502
T33G	766	343	638	397	468	334	3812	83	138	48	7028	26255
T33H	2922	4114	943	954	958	713	5127	133	717	419	16998	73503
T33J	242	0	276	368	243	253	5115	144	224	96	6960	36418
T33K	122	47	25	38	31	37	1600	10	11	32	1954	14852
T34A	0	151	132	545	81	11	737	8	26	3	1699	6568

Quat	Regional water scheme		Schedule 1		Basic Human Needs – No adequate source						Total households	Population
	Groundwater	Surface water	Borehole	Spring	Rainwater tank	Dam or pool	River or stream	Water vendor	Water tanker	Other		
T34B	61	397	371	325	34	338	295	18	15	68	1922	10005
T34C	258	0	305	361	285	176	416	86	164	22	2073	9512
T34D	904	350	994	689	343	541	1435	288	2298	269	8109	27488
T34E	0	6	15	21	5	4	16	0	3	1	71	259
T34F	8	0	482	435	15	42	371	62	22	45	1480	5364
T34G	446	0	832	180	113	92	748	13	81	13	2519	9154
T34H	1058	953	427	1809	840	471	4271	163	550	207	10750	41728
T34K	207	1199	324	1678	791	240	5000	43	215	185	9882	45450
T35A	0	123	756	543	27	179	414	20	50	41	2153	8144
T35B	0	10	25	35	9	8	24	2	6	3	121	439
T35C	23	2590	35	72	19	7	137	4	11	111	3012	10923
T35D	63	0	425	133	119	83	285	14	24	16	1163	3824
T35E	335	1016	507	378	256	288	1527	117	253	13	4689	17959
T35F	46	4114	31	64	16	20	35	3	8	12	4354	13123
T35G	248	0	176	107	93	213	413	67	27	46	1393	4855
T35H	759	45	973	283	301	577	2559	174	158	84	5913	24532
T35J	265	0	161	581	97	164	1178	7	146	41	2641	12655
T35K	3618	0	320	525	579	378	3358	70	303	157	9310	41169
T35L	466	6370	414	262	1369	175	2327	112	354	236	12086	51932
T35M	362	789	75	63	297	92	1389	15	60	27	3168	14667
T36A	0	54	112	413	152	107	4708	36	70	56	5710	32404
T36B	0	1876	77	188	163	162	3171	23	67	56	5782	25834
Grand total	**32917**	**55872**	**18267**	**24269**	**10414**	**11979**	**74087**	**2587**	**9911**	**5629**	**245949**	**1045209**

3.12.2 Livestock water use

No data is available for livestock water use from WARMS or GRA II. Given the abundance of surface water, it is unlikely groundwater use for livestock is significant.

3.12.3 Irrigation water use

Irrigation from groundwater is 4.32 Mm^3/a according to WARMS and occurs largely in the region between Matatiele and Kokstad in the northeast of the catchment (**Figure 3.15**).

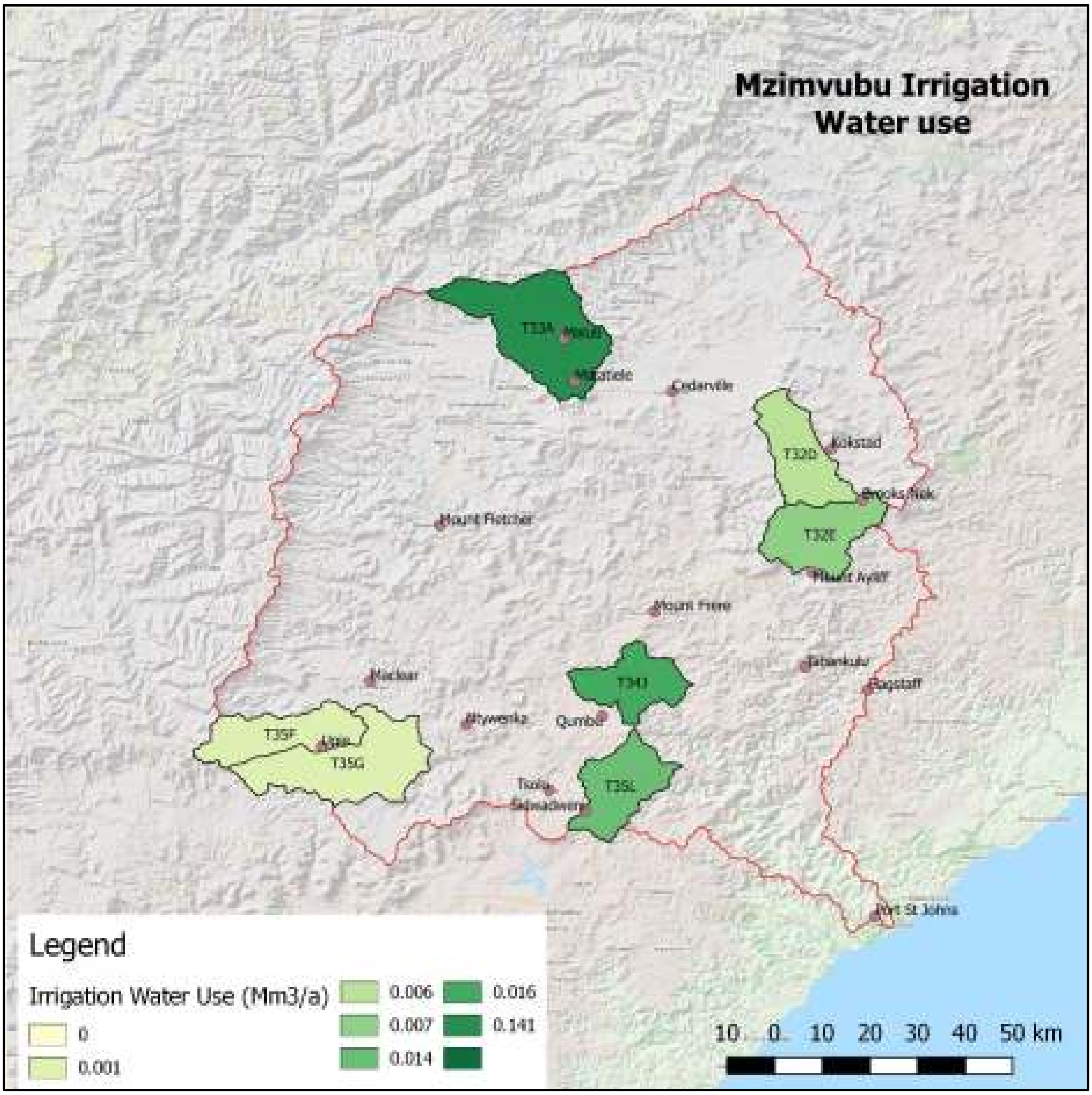

Figure 3.15 Irrigation water use in the Mzimvubu study area

3.12.4 Industrial water use

Registered Industrial water use is 0.184 Mm^3/a and its distribution is shown in **Figure 3.16**.

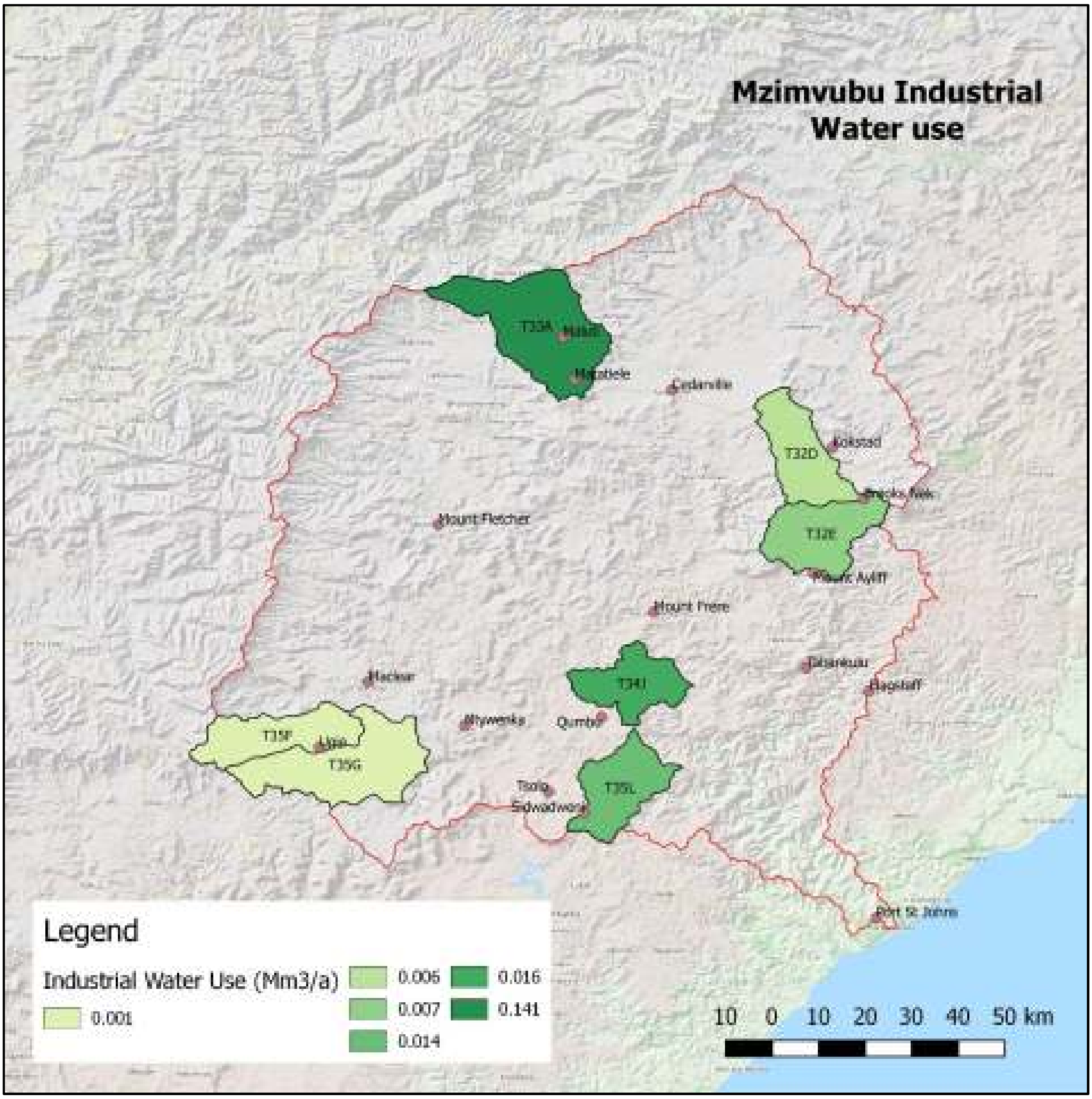

Figure 3.16 Industrial water use

3.12.5 Groundwater use summary

Total groundwater use is 21.988 Mm^3/a, of which 80% is for water supply and 20% for irrigation (**Figure 3.17**).

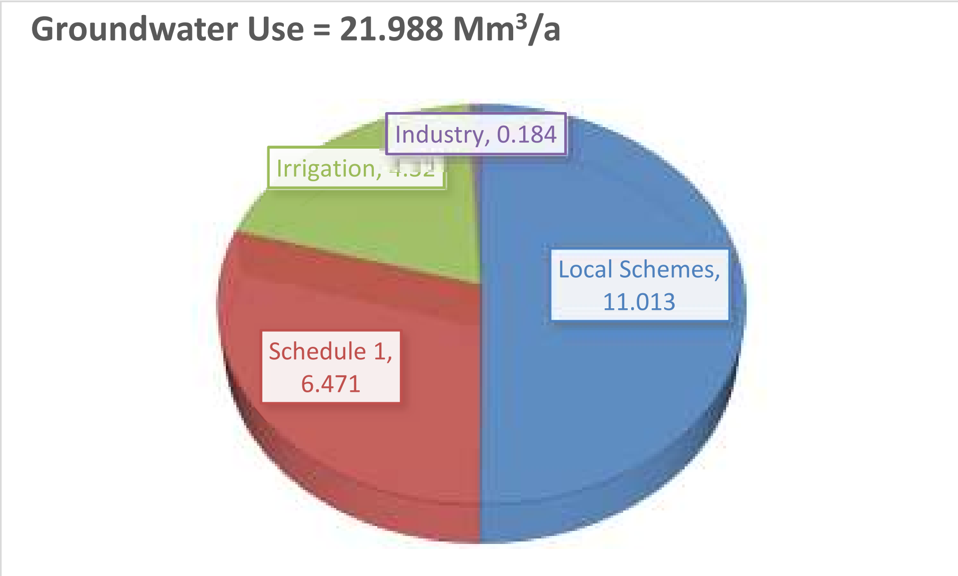

Figure 3.17 Groundwater use summary for the Mzimvubu T3 catchment

3.13 GEOLOGY

3.13.1 Stratigraphy

The geology of the study area represents a layered stratigraphical sequence consisting of Palaeozoic to Jurassic age rocks of the Cape Supergroup and Karoo Supergroups. The lithologies consist of sedimentary rocks and intrusive dolerites.

Karoo Supergroup formations from the Lesotho highlands in the northwest, to Port St Johns in the southeast along the coast at the Mzimvubu River mouth. The geologic units present are described in **Table 3.5** and their distribution is shown in **Figure 3.18**.

Alluvium associated with the tributaries of the Mzimvubu River occurs in small quantities along valleys with the exception of a large accumulation of alluvium found to the north and north west of Cedarville in quaternary catchments T31F and T31D as well as alluvium associated with the Mabele River in quaternary catchments T33A and T33B.

Along the north, northwest and western Mzimvubu River secondary catchment boundary, deposition of basaltic lava with subordinate tuff and conglomerate is found originating from extensive magma intrusion and lava flows that occurred during the early stages of the break-up of Gondwanaland in the Mid-Jurassic period. The basaltic lava constitutes the uppermost part of the Karoo stratigraphical sequence in the study area.

The following geological units are identified:

- Msikaba Formation: These rocks of the Cape Supergroup outcrop are only near the coast near Port St Johns and are of Devonian age. They consist of quartzitic sandstone with grit and conglomerate layers deposited in a shallow marine environment.
- Dwyka Group: Late Carboniferous to early Permian diamictites unconformably overlie the Msikaba Formation northwest of Port St Johns.
- Ecca Group: Permian Ecca Group rocks overlie the Dwyka Group and consist largely of shales. They outcrop on the southeast margin of the WMA.
- Adelaide Subgroup: These rocks of the Beaufort Group consist of late Permian continental mudstones that are generally massive and show blocky weathering. The Adelaide Subgroup

consist of upward fining cycles of sandstone grading into mudstones, with some lenticular sandstone bodies.

- Tarkastad Subgroup: These rocks of the Beaufort Group consist of early Triassic mudstones and sandstones. The Tarkastad Subgroup has a higher abundance of sandstone with a higher quartz fraction than the underlying Adelaide Subgroup.
- Molteno Formation: These late Triassic rocks consist of alternating sandstone and mudrocks, in roughly equal proportions.
- Elliot Formation: These late Triassic rocks consist of alternating mudrocks and subordinate sandstone.
- Clarens Formation: These late Triassic to early Jurassic rocks represent the final phase of Karoo sedimentation and consist of fine-grained aeolian sand, forming siltstone and fine-grained sandstone, with sandstones greatly dominating the Formation.
- Drakensberg Group: These Mesozoic rocks consist of stacked basaltic lavas.
- Karoo Dolerite: These intrusions represent the feeder systems of the basaltic eruptions and form dykes, sills and saucer-like basins which are widespread, particularly in the Beaufort Group.
- Quaternary deposits: These consist of mainly alluvial and aeolian sands. Alluvial slope (sheet-wash) and valley (channel-transported) deposits vary in thickness from a thin veneer to a few metres thick.

Table 3.5 Stratigraphy of the Mzimvubu catchment

Age	Supergroup	Group	Subgroup	Formation/Suite	Lithology
Jurassic	Karoo			Karoo dolerite	Dolerite
Mesozoic		Drakensberg			Basalt
Triassic		Stormberg		Clarens	Sandstone and siltstone
				Elliot	Mudstones and sandstone
				Molteno	Sandstone and mudstone
		Beaufort	Tarkastad	Katberg Burgersdorp	Mudstones and sandstones
Permian			Adelaide	Balfour Middleton Koonap	Mudstones and sandstones
		Ecca			Shales
Carboniferous		Dwyka			Diamictities
Devonian	Cape			Msikaba	Sandstones

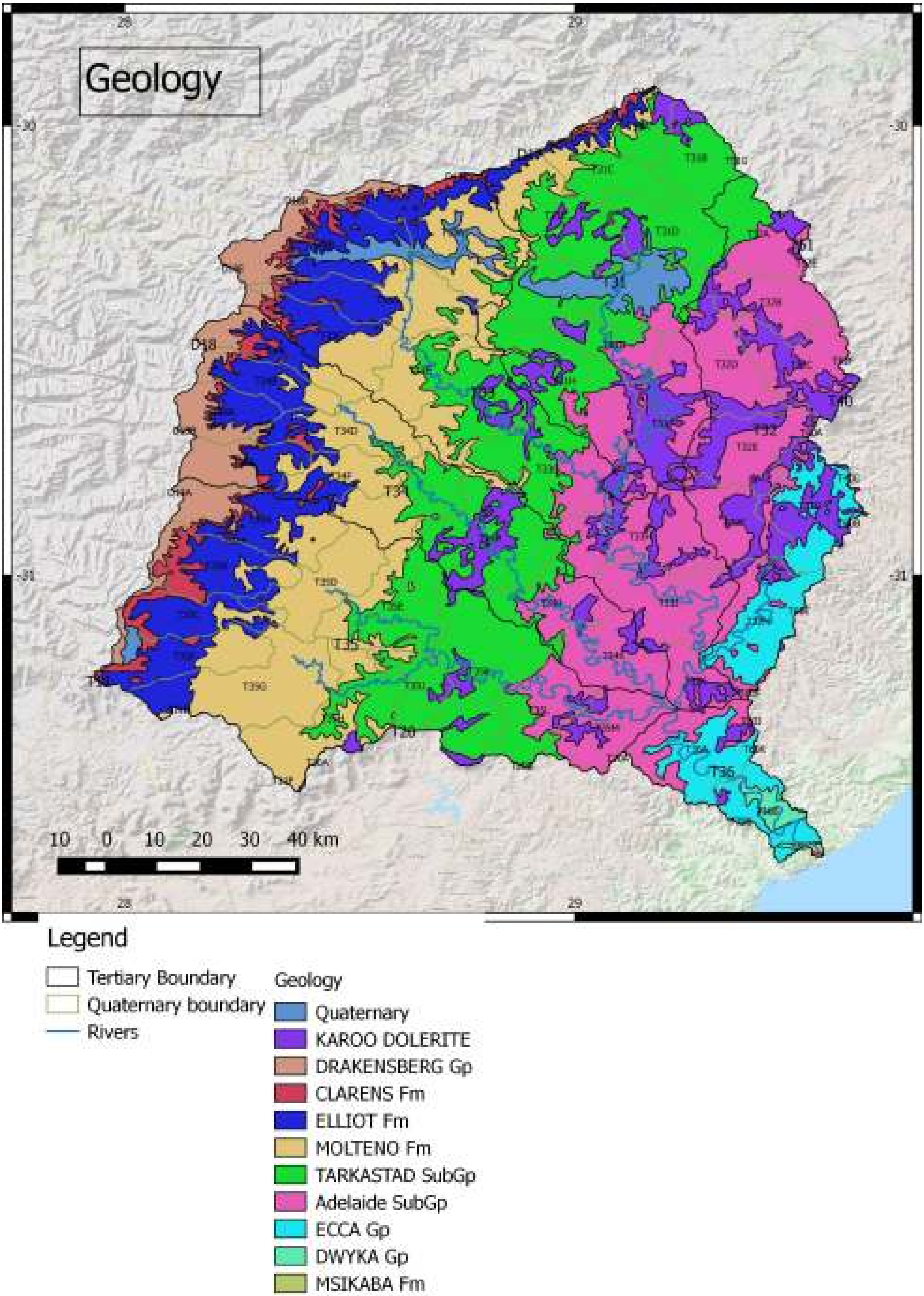

Figure 3.18 Geology of the Mzimvubu catchment

3.13.2 Dolerite intrusions

Throughout the project area, hypabyssal dolerite intruded into the host Karoo sedimentary rock during Jurassic time periods, creating dykes (vertical structures), sills (horizontal structures) and large inclined sheets. The dolerite in the project area is associated with the same volcanic event that formed the Basaltic lava of the Drakensberg Formation in the northeast boundary of the Mzimvubu River catchment.

Dolerite dykes usually range between 1 and 10 m wide and can be tens of kilometres long. Their orientations vary, but with a WNW strike direction being more prominent over much of the area. ENE as well as NS trending dykes are also common.

Sills and sheets are usually between a few metres and 100 m thick, but can be well in excess of this in some instances.

In the Beaufort Group, dolerite intrusions in the form of conical sub-vertical sheets have resulted in numerous dolerite intrusions that can be observed as circular intrusions popularly referred to as ring-structures. These structures are most prominent around the towns of Qumbu and Tsolo, and to the north in the vicinity of Matatiele and Cedarville.

The following types of intrusion are found in the different formations in the study area:

- Adelaide Subgroup – Dykes and sills
- Katberg Formation – Dykes and sheets
- Burgersdorp Formation – Dykes, ring sheets and sheets
- Molteno Formation – Mainly dykes

The baking and metamorphosing of the host rocks were not the only effects that the intrusion of dolerites had on the Karoo sediments. Other effects, particularly mechanical deformation, may also have influenced the geohydrological properties of the rocks.

The weathering of these dykes has, to a considerable extent, controlled the orientation of erosion and water courses.

4 HYDROGEOLOGY

4.1 GROUNDWATER REGIONS

The Vegter groundwater regions (Vegter, 2001) are shown in **Figure 4.1**. The underlying geology in each region and the quaternary catchments incorporated are described in **Table 4.1**.

The KwaZulu-Natal Coastal Foreland approximates the outcrop area of the Msikaba Formation and Dwyka Group. The Transkeian Coastal Foreland and Middelveld approximates the area of the shales and mudstones of the Ecca and Beaufort Groups. The Southeastern Highland covers the area of the sandstones and mudstones of the upper Karoo.

Table 4-1 Groundwater regions of the Mzimvubu catchment

Groundwater region	Stratigraphy	Quaternary catchment
KwaZulu-Natal Coastal Foreland	Msikaba Formation, Dwyka Group	T36B
Transkeian Coastal Foreland and Middelveld	Ecca Group	T32G, T32H T36A, T36B
	Adelaide Subgroup	T31F, T31G, T31H, T31J T32A, T32B, T32C, T32D, T32E, T32F, T32G, T32H T33G, T33H, T33J, T33K T34J, T34K T35K, T35L, T35M T36A
	Tarkastad Subgroup	T31A, T31B, T31C, T31D, T31E, T31F, T31G, T31H, T32A, T33A, T33E, T33F, T33G, T33H T34D, T34G, T34H, T34J T35E, T35H, T35J, T35K, T35L
Southeastern Highland	Molteno and Elliot Formations	T31A, T31C, T31E T33A, T33B, T33C, T33D, T33E, T33F T34A, T34B, T34C, T34D, T34E, T34F, T34G T35A, T35B, T35C, T35D, T35E, T35G, T35H,
	Clarens Formation	T31A, T31C, T31E T33AT33BT33C, T33D T34A, T34B, T34C, T34D, T34E, T34F T35A, T35B, T35C, T35F
	Drakensberg Group	T31A, T31C T33A, t33B, T33C, T33D T34A, T34B, T34C, T34E T35A, T35C, T3fF

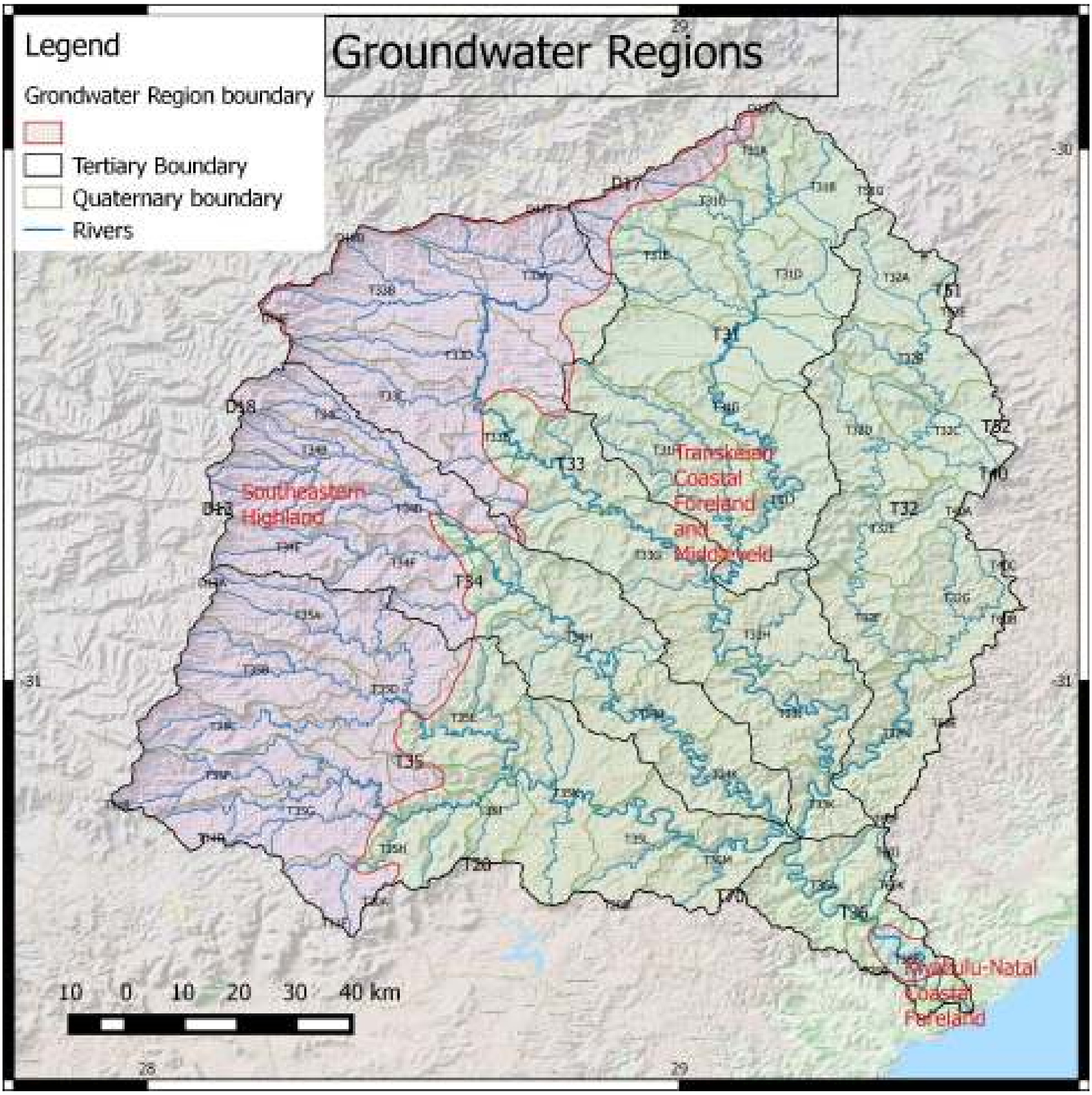

Figure 4.1 Groundwater regions of the Mzimvubu T3 catchment

4.2 AQUIFER TYPES

The aquifer types found in the Mzimvubu catchment are intergranular and fractured (weathered and fractured), and fractured for the Dwyka Group. The distribution of aquifer types is shown in **Figure 4.2**.

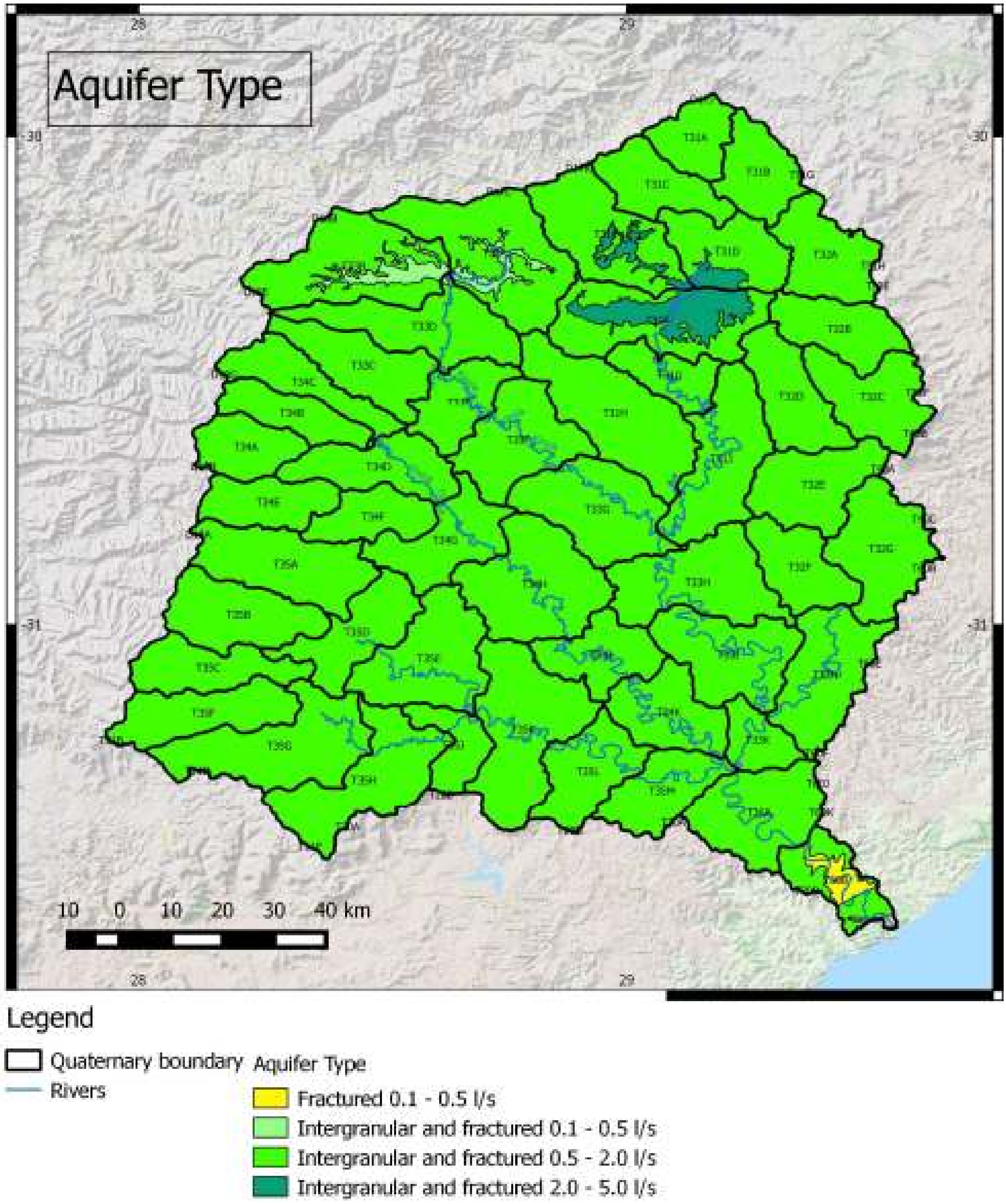

Figure 4.2 Aquifer types in the Mzimvubu catchment

4.2.1 Intergranular and fractured aquifers

Secondary fractured and weathered aquifers are found throughout the study area. Weathering gives rise to low to moderately yielding aquifers where groundwater is stored in the interstices in the weathered saturated zone and in joints and fractures of competent rocks. Borehole yields range from 0.5-2.0 l/s, except where quaternary cover occurs in the upper reaches of the Mzimvubu in T31D-F.

For the bulk of the study area groundwater occurs in dual porosity aquifers, comprising large, but infrequent principle transmissive fractures with relatively low storage capacity, and secondary but numerous micro fissures with high storativity but lower transmissivity. The micro fissures are usually concentrated towards the upper weathered zone (usually first 30 mbgl) and results in a higher storage capacity than deeper lying rocks. The upper and lower zones are hydraulically linked. The deeper fractures often have a high transmissivity but lower storativity than the shallow zone fractures.

The main variations in the Karoo Supergroup hydrogeology occur due to variations in degree of fracturing and weathering, variations in mudstone or shale percentages, the distribution and nature of dolerite intrusions, and the presence of quaternary deposits.

Groundwater potential assessments and aquifer types occurring in the study area must be viewed in the light of the type of dolerite intrusion, as well as the geological formation present. For example, it is expected that drilling of boreholes associated with dolerite intrusions in predominantly mudstone formations will be lower yielding than boreholes drilled in more sandstone rich formations.

Dyke contact zones are the obvious and prevalent target for boreholes, however, drilling yields vary significantly. Although yields may be high, the groundwater flow along dykes is low due to the narrow nature of the associated fracture zone. Consequently, in terms of sustainability, the country rock adjacent to the dyke is important in terms of its ability to supply water to the dyke contact zone. This implies that the proportion of more permeable and higher porosity sandstone is of relevance when determining sustainable groundwater resources.

Dolerite sills are present in the Ecca and Beaufort Group, but their occurrence decreases up the Karoo Supergroup, becoming less prominent in the Molteno, and less so in the Elliot and Clarens Formations. These sills are generally thin and less than 40 m thick. They are flat flying in the Ecca and Adelaide rocks, whereas in the Tarkastad rocks they are thicker and there is a transition to large ring structures instead of flat sills.

Dolerite sills are generally associated with lower yields than dykes, especially away from the edges of the sill and the contact with sediments beneath the sill has poor hydrogeological properties.

Dolerite ring structures dominate in the Molteno and Elliot Formations, where dolerites tend to be present as both inclined sheets and small rings, which can be very thick (> 80 m).

4.2.2 Fractured aquifers

Purely fractured aquifers are found only in the Dwyka Group in T36B. These rocks are low-yielding and boreholes yields are below 0.5 l/s.

Median borehole yields in Quaternary alluvium deposits in the Cedarville and Matatiele region, is known to be between 2 l/s and 5 l/s.

4.3 GROUNDWATER RECHARGE

The estimation of recharge is one the most important components within the GRDM process since it is used to calculate both the stress index and the available groundwater volume for allocation per unit. This allocable volume ultimately determines whether or not additional licence applications for groundwater can be approved.

Based on GRA II, recharge varies from 30–115 mm/a (**Figure 4.3**).

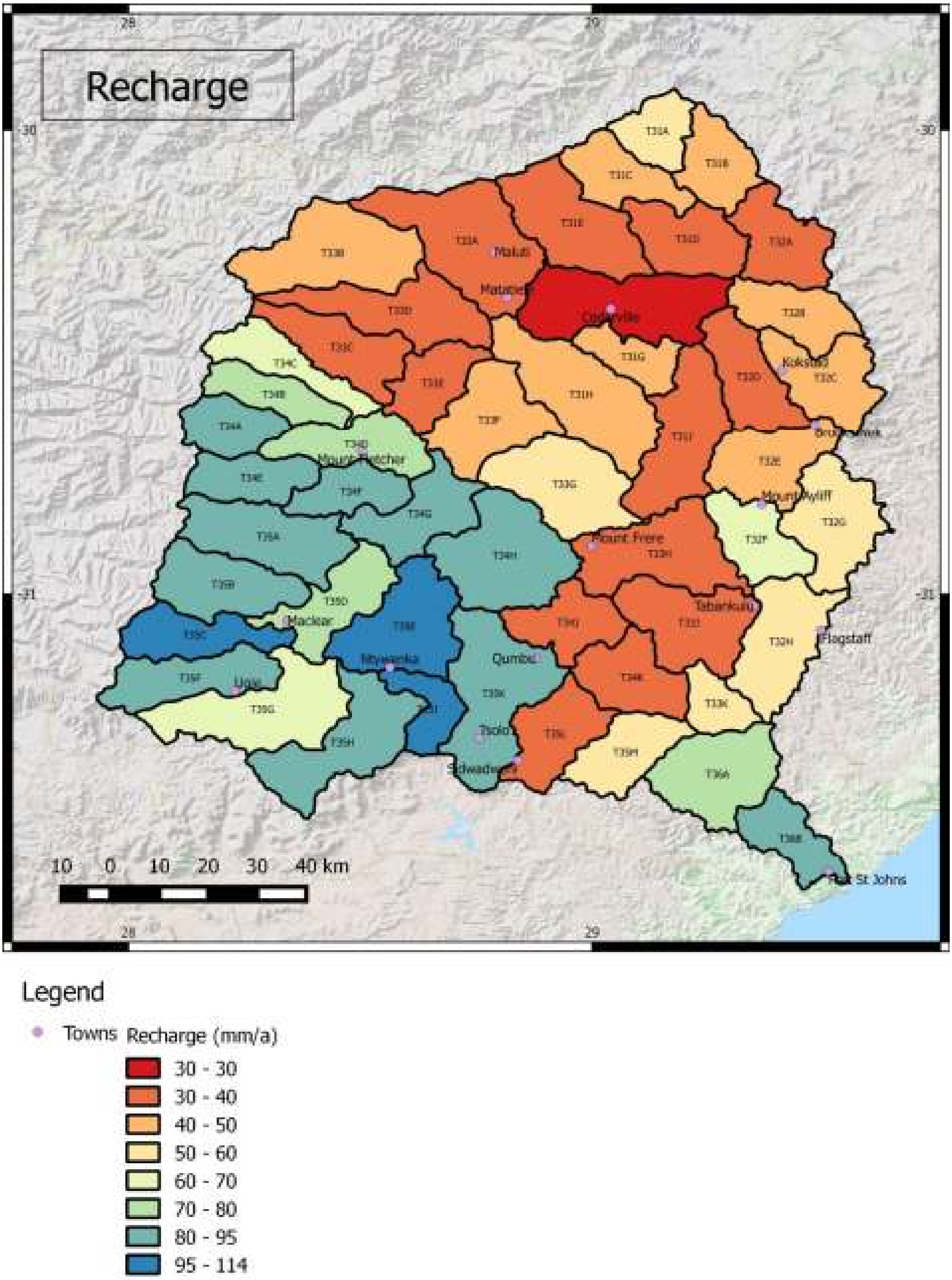

Figure 4.3 Recharge in the Mzimvubu catchment

Significantly higher recharge occurs in the southwest, in the T34 and T35 catchments compared to the T31–T33 catchments.

Because of the occurrence of high-lying springs which occur due to the presence of dolerite sheets or low permeability layers, much of the recharge re-emerges in high-lying areas is lost as interflow before reaching the regional aquifer. Hence total recharge in a catchment is not a good indicator of the groundwater resources. Consequently, the estimate of aquifer recharge (recharge that reaches the aquifer after the subtraction of interflow) in GRA II should be utilised for deriving aquifer resources and stresses. However, total recharge should be used to estimate baseflow and the groundwater component of the Reserve.

4.4 BOREHOLE YIELDS

Borehole yields as listed in the NGA were grouped per quaternary catchment to derive the geometric median borehole yield (**Figure 4.4**). Median yields are above 4 l/s near Maclear and Ugie and decrease to < 0.5 l/s in the upper Tsitsa, Pot and Mooi catchments (T35A–C).

Except in the headwater regions, a significant number of boreholes yield more than 2 l/s, making groundwater a viable source for local water supply (**Figure 4.5**).

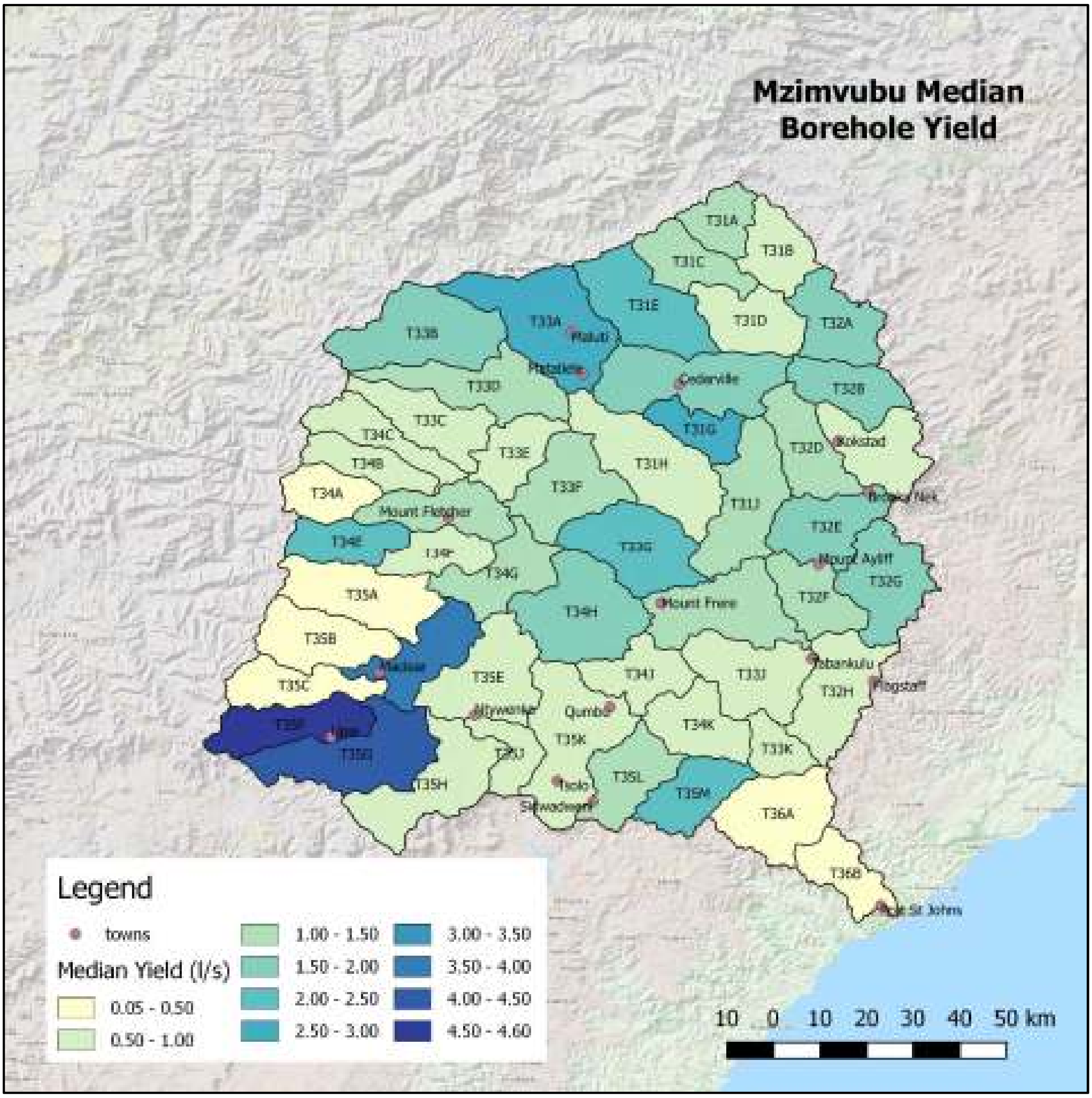

Figure 4.4 Geometric mean borehole yield per quaternary in the Mzimvubu study area

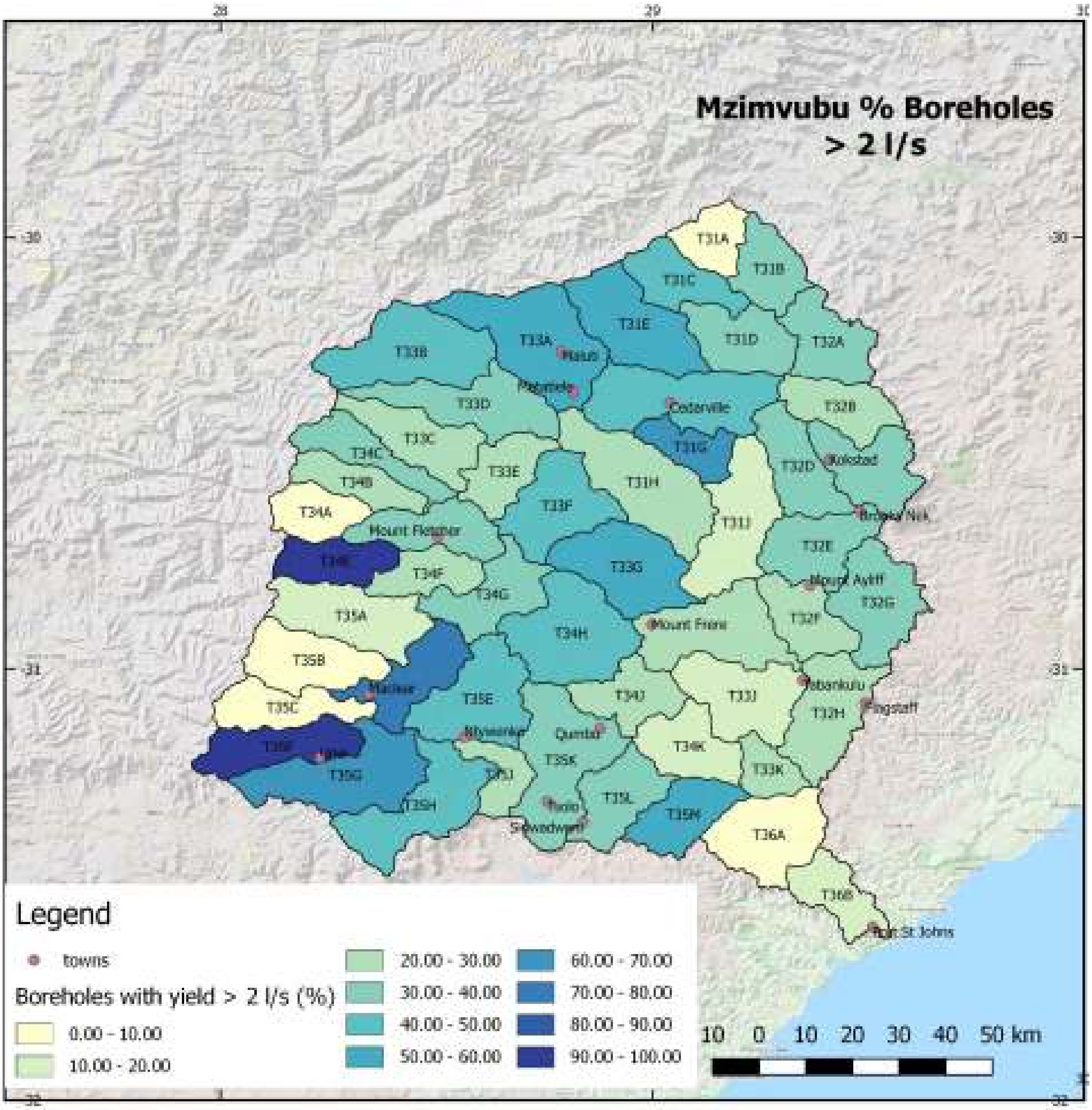

Figure 4.5 Percent of boreholes yielding more than 2 l/s in the Mzimvubu catchments

4.5 GROUNDWATER QUALITY

4.5.1 Electrical conductivity

Groundwater quality was obtained from field measurements in the NGA since few monitoring sites exist in the ZQM database. For boreholes with a time series of analyses, the most recent water quality was used to avoid weighting analyses based on one borehole site. Data from 1183 springs and boreholes are available and provide a good distribution across the catchment (**Figure 4.6**).

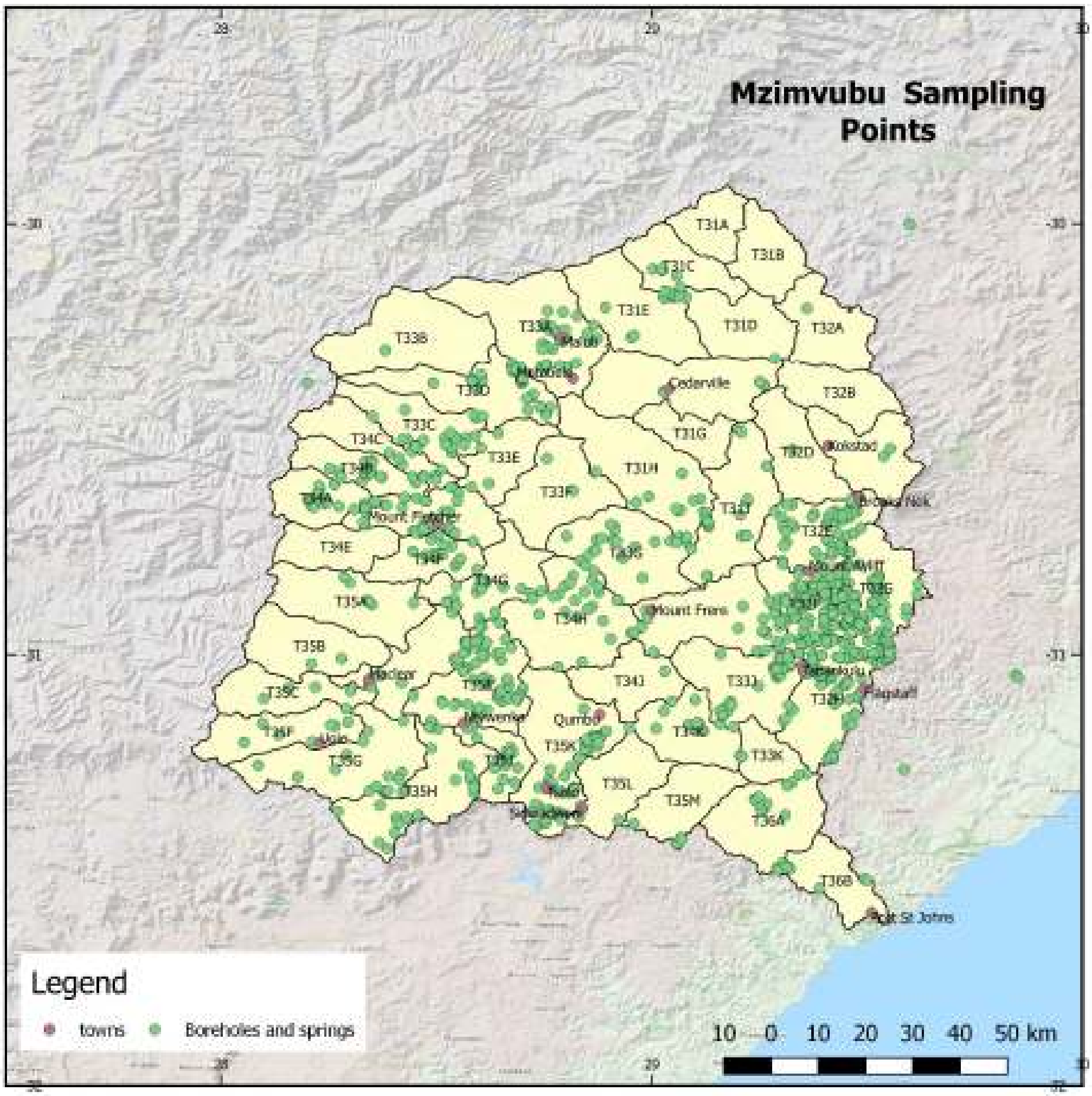

Figure 4.6 Location of groundwater quality sampling points in the Mzimvubu study area

All hydrochemical data were collated and were assessed for potable use by using the Guidelines for Domestic Water Quality (DWAF, 1998) (**Table 4.2**), however, only electrical conductivity is available in the NGA.

Table 4.2 DWS Guidelines for Domestic Water Quality (DWAF, 1998)

Analyses	Unit	Classification				
		Class 0 IDEAL	Class I GOOD	Class II MARGINAL	Class III POOR	Class IV UNACCEPTABLE
pH		5.5 – 9.5	4.5 – 5.5 and 9.5– 10	4 – 4.5 and 10 –10.5	3 – 4 and 10.5 – 11	< 3 or > 11
Conductivity	mS/m	< 70	70 – 150	150 – 270	270 – 450	> 450
TDS	mg/l	< 450	450 – 1000	1000 – 2400	2400 – 3400	> 3400

Analyses	Unit	Classification				
		Class 0 IDEAL	Class I GOOD	Class II MARGINAL	Class III POOR	Class IV UNACCEPTABLE
Total hardness	$CaCO_3$	< 200	200 – 300	300 – 600	> 600	
Calcium	mg/l	< 80	80 – 150	150 – 300	> 300	
Copper	mg/l	< 1	1 – 1.3	1.3 – 2	2 – 15	> 15
Iron	mg/l	< 0.5	0.5 – 1	1 – 5	5 – 10	> 10
Magnesium	mg/l	< 70	70 – 100	100 – 200	200 – 400	> 400
Manganese	mg/l	< 0.1	0.1 – 0.4	0.4 – 4	4 – 10	> 10
Potassium	mg/l	< 25	25 – 50	50 – 100	100 – 500	> 500
Sodium	mg/l	< 100	100 – 200	200 – 400	400 – 1000	> 1000
Chloride	mg/l	< 100	100 – 200	200 – 600	600 – 1200	> 1200
Fluoride	mg/l	< 0.7	0.7 – 1	1 – 1.5	1.5 – 3.5	> 3.5
Nitrate NO_3 – N	mg/l	< 6	6 – 10	10 – 20	20 – 40	> 40
Nitrite NO_2 – N	mg/l	< 6	6 – 10	10 – 20	20 – 40	> 40
Orthophosphate (PO_4 as P)	mg/l	< 0.1	0.1 – 0.25	0.25 – 1	> 1	
Sulphate (SO_4)	mg/l	< 200	200 – 400	400 – 600	600 – 1000	> 1000
MPN *E. coli*	/100ml	0	0 – 1	1 – 10	10 – 100	> 100

The data indicates that electrical conductivity varies between 0.1–1300 mS/m (**Figure 4.7**), and that electrical eonductivity is highly variable, with boreholes of Class 0 located in close proximity to boreholes of Class 3 or 4. This is indicative of localised contamination. Groundwater is generally of Class 0 (Ideal).

The distribution of Groundwater by water quality class in each quaternary catchment is shown in **Table 4.3**.

The fraction of boreholes which are Ideal and Good for potable water (Class 0 and 1), and Marginal water quality for emergency or short-term potable use (Class 2) in each quaternary is shown in **Figure 4.8**. The fraction of boreholes that are potable (potability index) exceeds 85%, except in T35K and T33H.

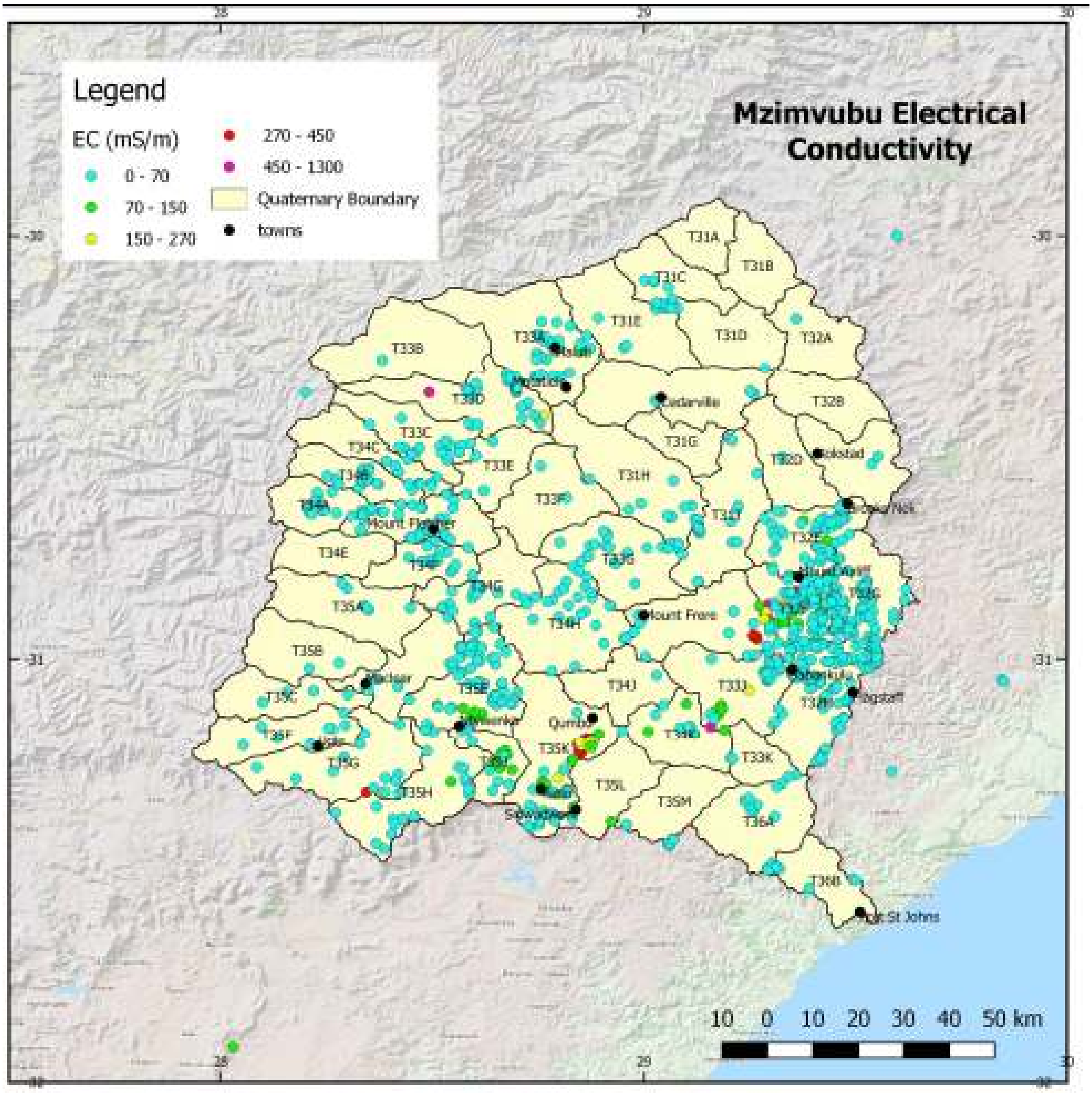

Figure 4.7 Electrical conductivity in boreholes and springs in the Mzimvubu study area

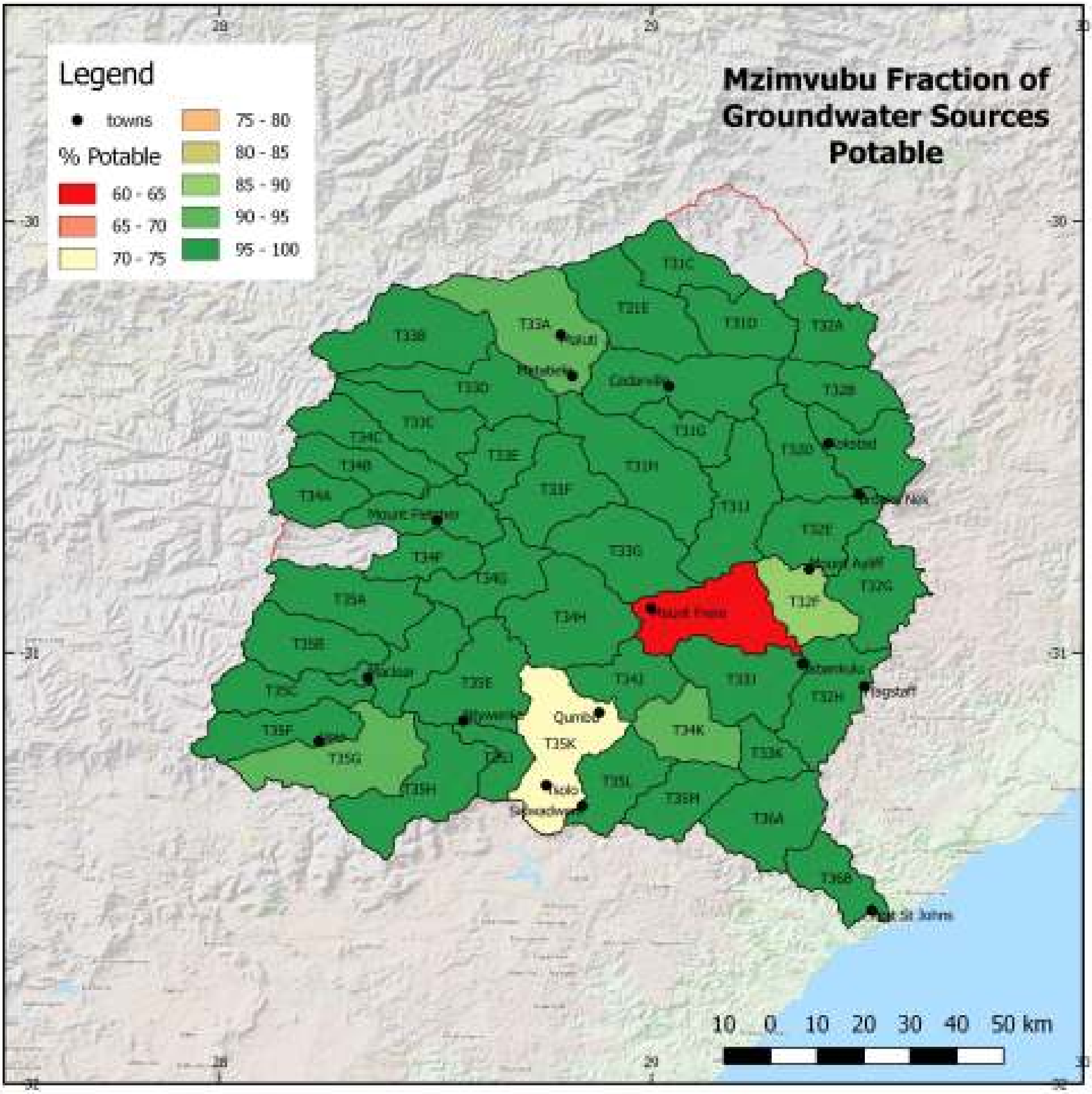

Figure 4.8 Fraction of potable boreholes by electrical conductivity in the Mzimvubu catchment

Table 4.3 Electrical conductivity water quality distribution in mS/m by quaternary catchment in Mzimvubu T3

Quat	N	% Potable	Percentile			Quat	N	% Potable	Percentile		
			10	50	95				10	50	95
T31C	16	100.00	0.20	0.40	32.03	T33K	2	100.00	11.20	20.00	29.90
T31D	1	100.00	15.70	15.70	15.70	T34A	15	100.00	0.10	0.20	29.69
T31E	2	100.00	24.89	36.05	48.61	T34B	22	100.00	0.21	32.50	50.60
T31F	5	100.00	3.52	28.80	65.24	T34C	10	100.00	28.10	44.00	53.16
T31G	1	100.00	4.30	4.30	4.30	T34D	33	100.00	0.10	27.00	46.84
T31H	15	100.00	4.30	13.10	36.10	T34F	13	100.00	0.20	19.80	36.20
T31J	22	100.00	0.54	14.90	55.95	T34G	18	100.00	9.30	21.70	40.69
T32A	1	100.00	15.00	15.00	15.00	T34H	22	100.00	6.00	13.50	48.99
T32B	1	100.00	69.00	69.00	69.00	T34J	4	100.00	8.77	33.50	43.95
T32C	2	100.00	33.50	35.50	37.75	T34K	11	90.91	6.00	42.00	380.00
T32D	1	100.00	30.00	30.00	30.00	T35A	5	100.00	20.40	25.00	29.40
T32E	66	95.45	0.20	13.00	113.50	T35B	3	100.00	20.60	27.00	58.50
T32F	155	85.81	0.70	21.10	509.00	T35C	4	100.00	7.20	11.00	23.05
T32G	127	99.21	4.30	12.50	100.00	T35D	13	100.00	2.30	6.70	26.20
T32H	106	100.00	4.05	18.45	68.45	T35E	64	100.00	2.73	15.45	81.80
T33A	40	95.00	0.40	34.50	265.45	T35F	8	100.00	5.00	16.00	34.30
T33B	1	100.00	18.00	18.00	18.00	T35G	15	93.33	9.20	20.00	260.00
T33C	25	100.00	12.60	34.00	50.80	T35H	28	100.00	19.76	30.65	80.89
T33D	44	97.73	0.10	0.40	177.95	T35J	17	100.00	19.72	75.00	153.20
T33E	6	100.00	0.15	15.65	49.50	T35K	71	71.83	13.30	107.30	680.00
T33F	2	100.00	41.53	53.25	66.44	T35L	2	100.00	53.85	61.25	69.58
T33G	18	100.00	17.82	46.40	59.75	T35M	8	100.00	0.10	0.30	67.50
T33H	13	61.54	5.72	60.00	716.00	T36A	16	100.00	0.10	0.25	10.90
T33J	45	100.00	13.38	33.00	109.16	T36B	6	100.00	0.10	0.15	0.20

N=number

4.5.2 Nitrates

Data on nitrates is limited to where data is available from the Groundwater Resources Information Project GRIP (**Figure 4.9**). Groundwater is generally of class 0 for nitrates, except where localised contamination occurs.

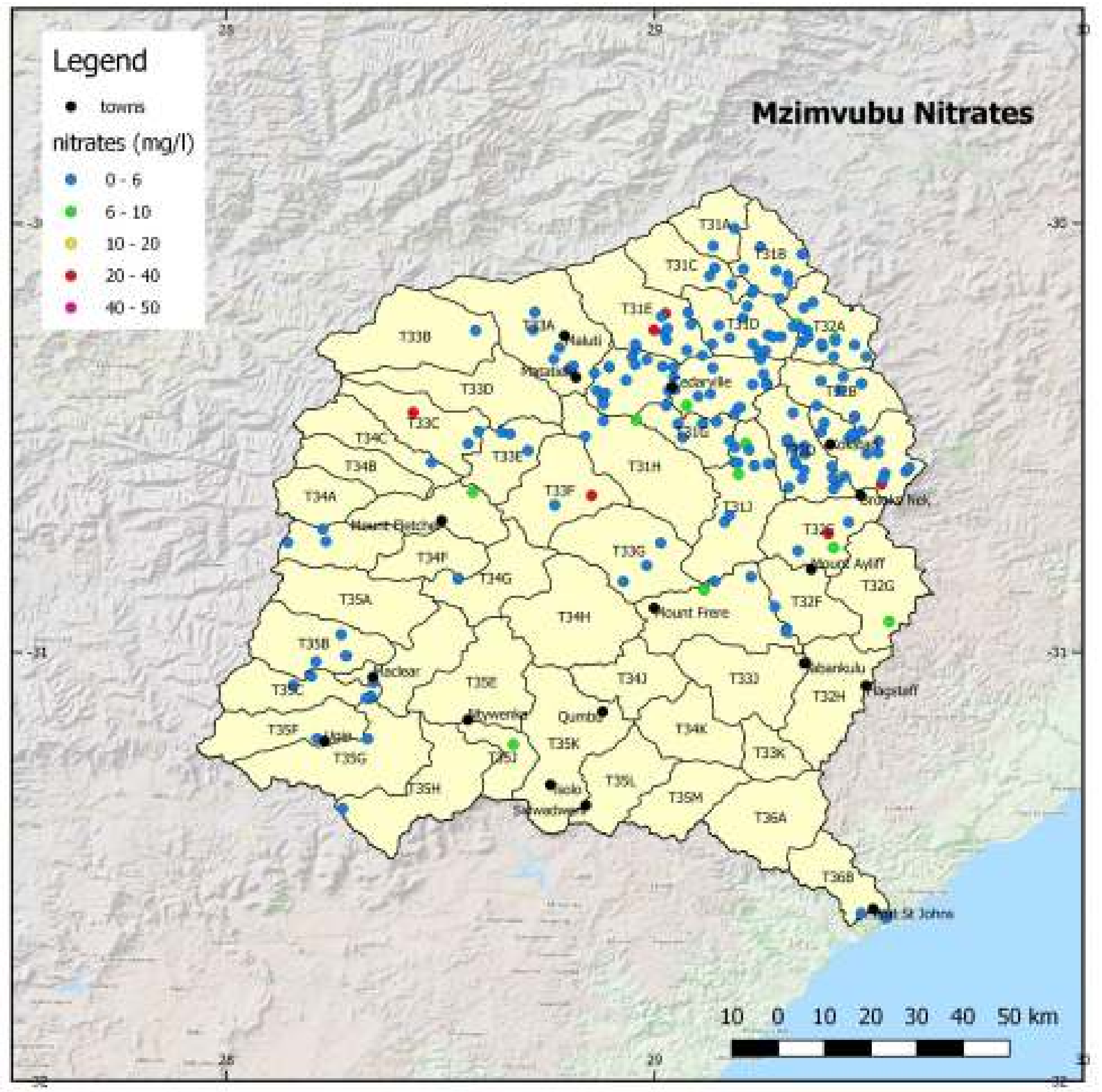

Figure 4.9 Nitrates in boreholes and springs of the Mzimvubu T3 catchment

4.5.3 Fluorides

Data on fluorides is only available from GRIP sampling. Samples are largely of Class 0, but range up to Cass 4 (**Figure 4.10**). The occurrence of fluoride is related to pervasive intrusions of dolerite.

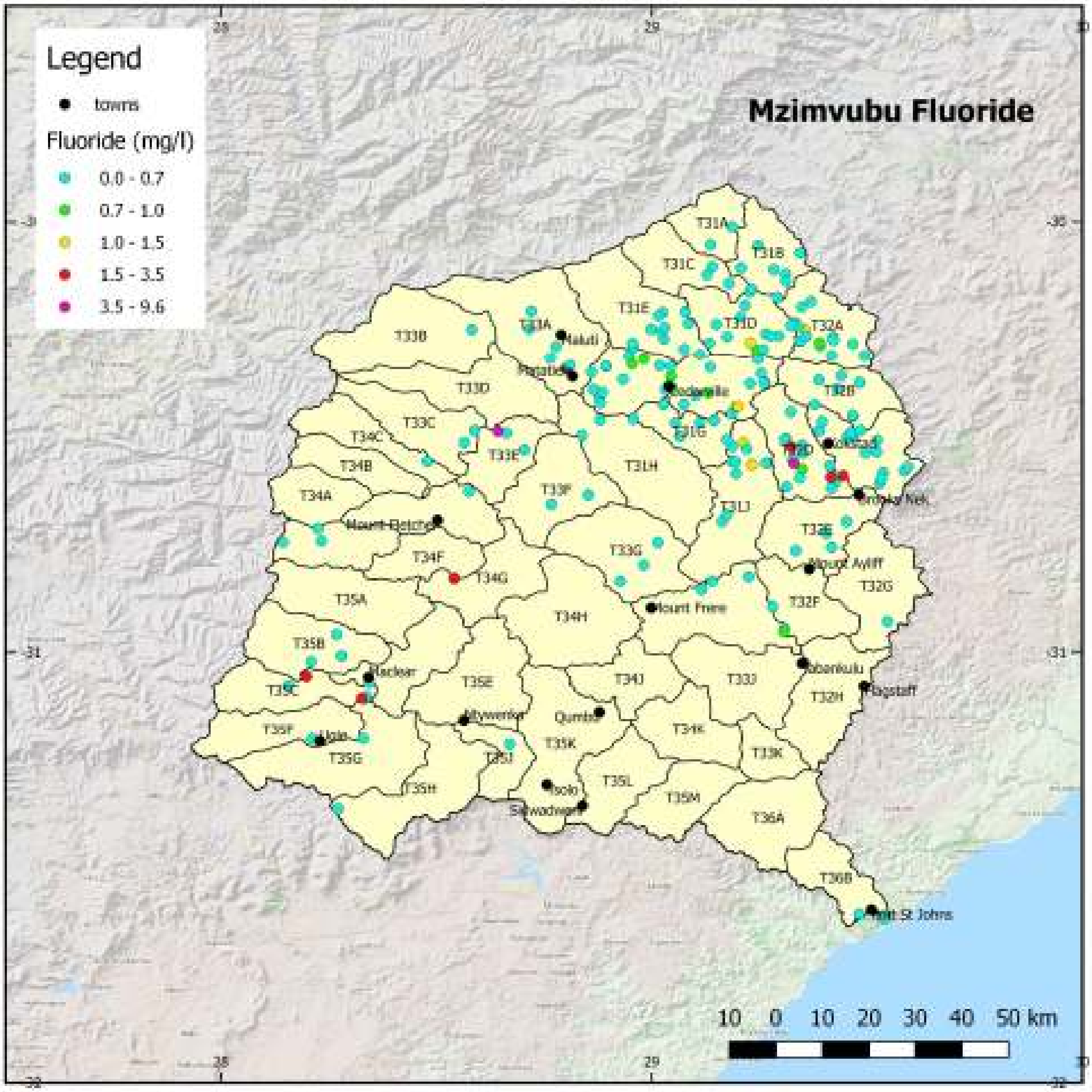

Figure 4.10 Fluorides in boreholes and springs of the Mzimvubu T3 catchment

4.6 SURFACE GROUNDWATER INTERACTION

The interaction of groundwater with surface water depends on the physiography, geology and climate setting of the region. The factors of importance include topography, aquifer type, groundwater levels, rainfall and recharge, and permeability.

Interactions can be expressed as rivers (or pans) gaining baseflow from groundwater, rivers losing water to groundwater, or riverine vegetation evapotranspirating groundwater in shallow groundwater regions.

Hydrographs indicate where baseflow exists. Hydrographs can consist of three components: direct surface runoff, interflow from temporary perched or high lying springs that respond rapidly to rainfall but are above the regional water level, and groundwater baseflow from the saturated zone. The term baseflow is the delayed flow component from the latter two sources.

For the Mzimvubu, GRA II (DWAF, 2006) indicates that all catchments generate significant baseflow (**Figure 4.11**).

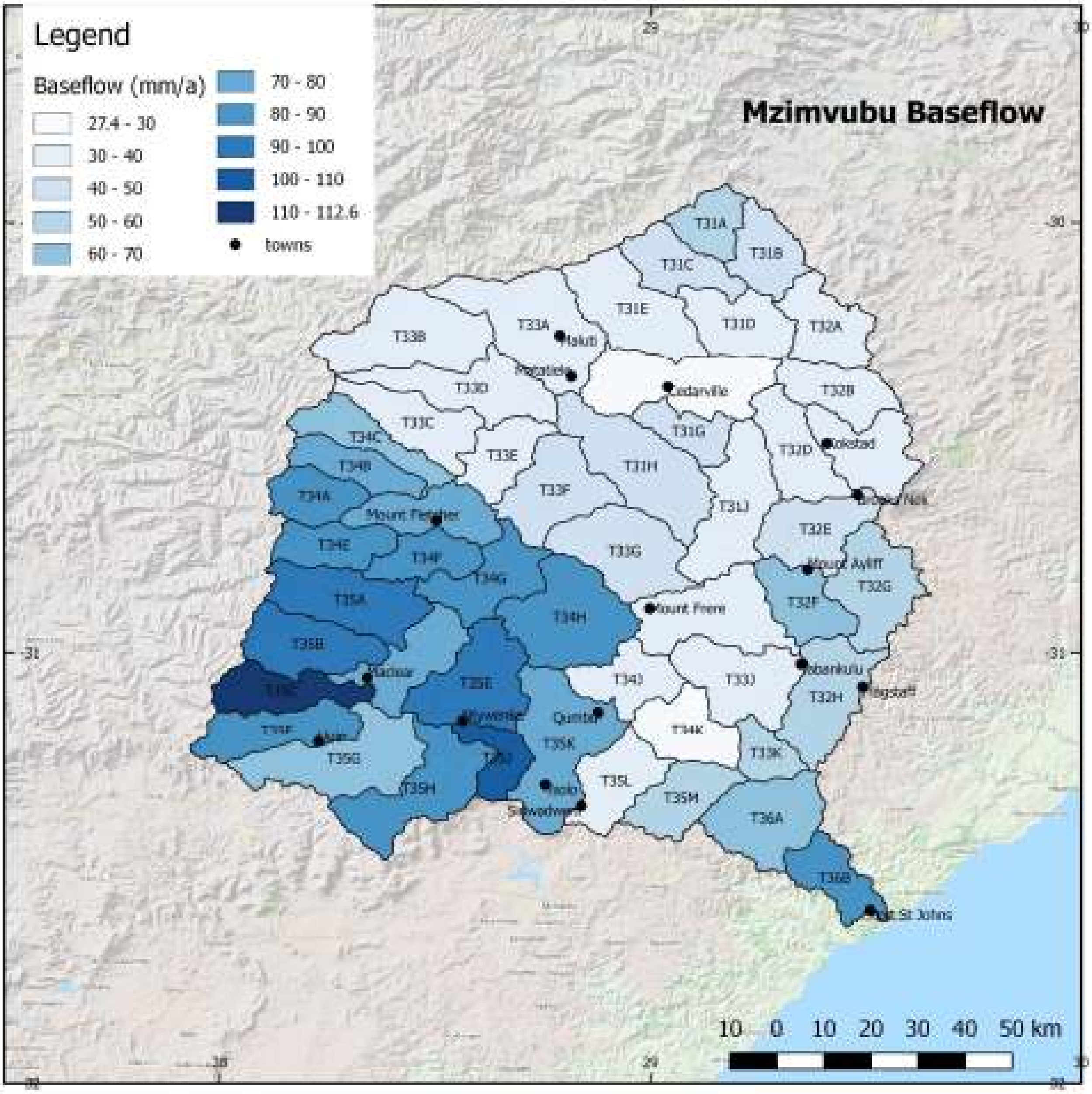

Figure 4.11 Baseflow in the Mzimvubu T3 catchment

Springs play a vital role in the groundwater resources of the region and for providing baseflow. Springs also provide important habitat for wildlife and vegetation, and can result in wetlands.

Springs can occur at the margins of dolerite ring structures, emerging at various places along the dolerite rings where the side slopes consisting of dolerite prevent deeper infiltration. These springs can form the origin of first order streams, where they are associated with wetlands. These springs usually occur on the lower slopes and the inner side of the ring, due to water flowing through shallow dipping fractures parallel to the walls of the intrusion. This type of spring implies a perched water table (interflow) that also feed the wetlands and marshy areas in the fractured dolerite.

Some springs occur below the outer sill, in the sedimentary rocks. They result from water seeping through the vertical cooling cracks of the sill, through the sediment. They emerge at a more impermeable sedimentary layer (mudstone) (**Figure 4.12**).

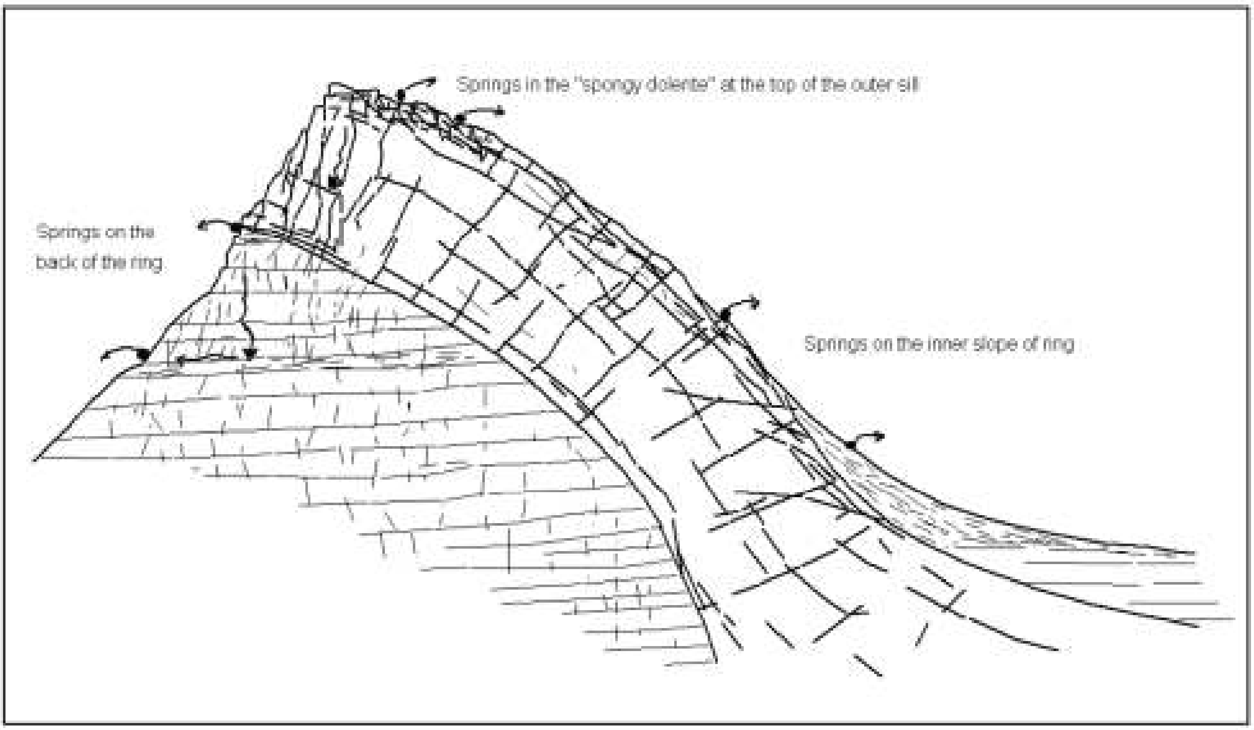

Figure 4.12 The different types of spring occurrences associated with dolerite sill and ring complexes (after Chevallier et al., 2004)

Dolerite sills also generate discharge as high-lying springs since the recharge areas at the top of a sill is trapped between the top of the sill and the overlying sediment, forming thin perched aquifers. This results in interflow at high elevation as elevated springs or seeps feeding the drainage system.

The transition between sandstone-rich formations and low permeability mudstone-rich layers, like the contact between the Molteno and Burgersdorp Formations, can also result in springs, where groundwater percolating through sandstone emerges above low permeability mudstone, resulting in interflow if of sufficient volume.

Some springs are also located alongside dykes, indicating compartmentalisation.

The distribution of springs, when compared with the presence of dolerite sills and rings, indicated that the dolerite sills in the area belong to the tectonic domain defined between 500 and 900 mamsl. This is where flat sills and large shallow ring-type structures start developing instead of dykes.

Interflow is generally not affected by groundwater abstraction since it occurs in high lying areas separated from the regional aquifer by impermeable layers. In the Mzimvubu catchment the bulk of baseflow originates as interflow from springs (**Figure 4.13**).

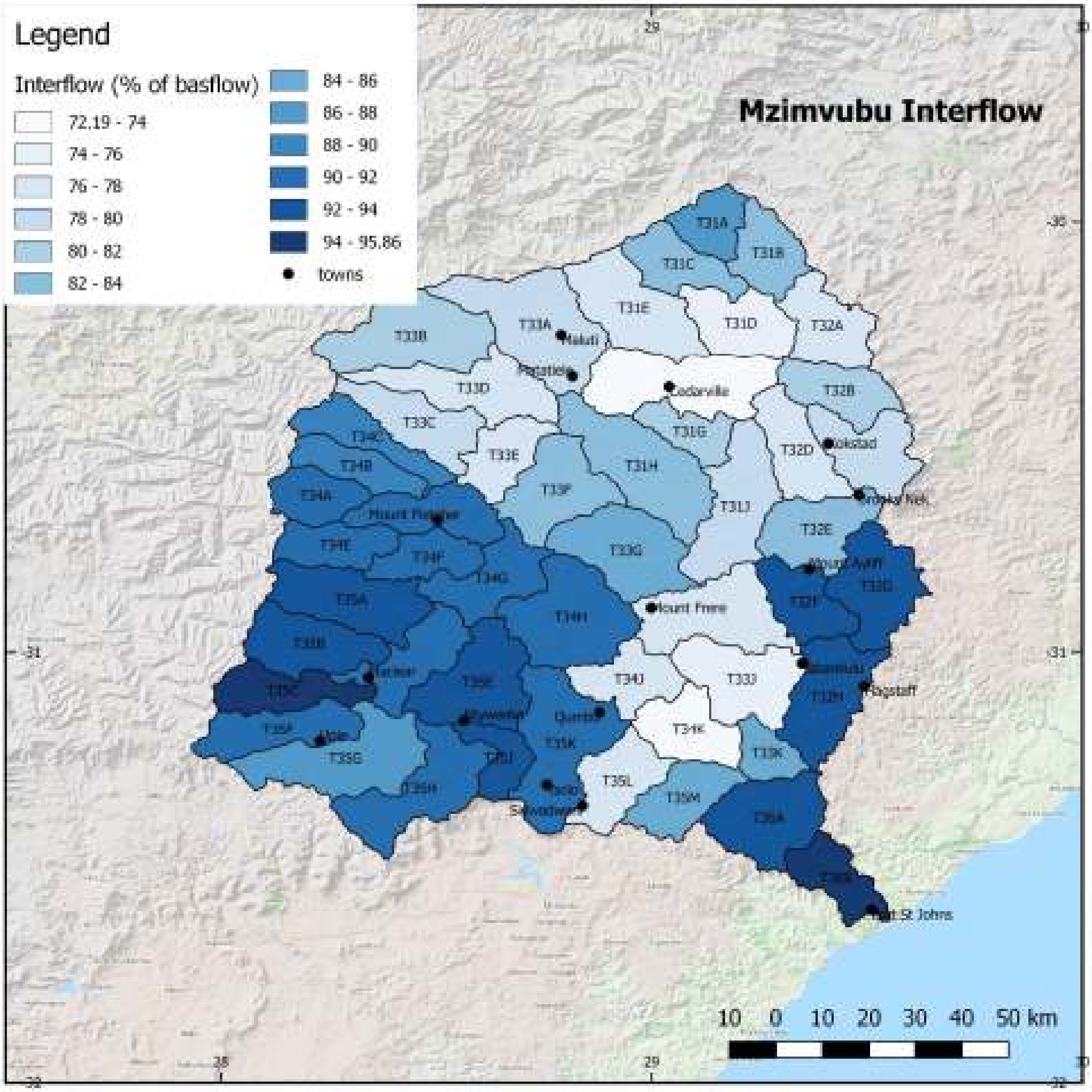

Figure 4.13 Interflow as a percent of baseflow for the Mzimvubu T3 catchment

4.7 HARVEST POTENTIAL

Harvest potential is defined as the maximum volume of groundwater that may be abstracted per area without depleting the aquifers. It is based on estimated mean annual recharge and a rainfall reliability factor, which gives an indication of the possible drought length. The harvest potential represents a synthesis of the amount of groundwater in storage in an aquifer system, the recharge and the time span between these recharge events.

The harvest potential of the Mzimvubu T3 catchment is only moderate, due to the large fraction of recharge lost as interflow. Yields are largely between 13 500–18 000 $m^3/a/km^2$. The harvest potential is highest in the west, in the headwaters of T34 and T35 where it exceeds 25 000 $m^3/a/km^2$ (**Figure 4.14**).

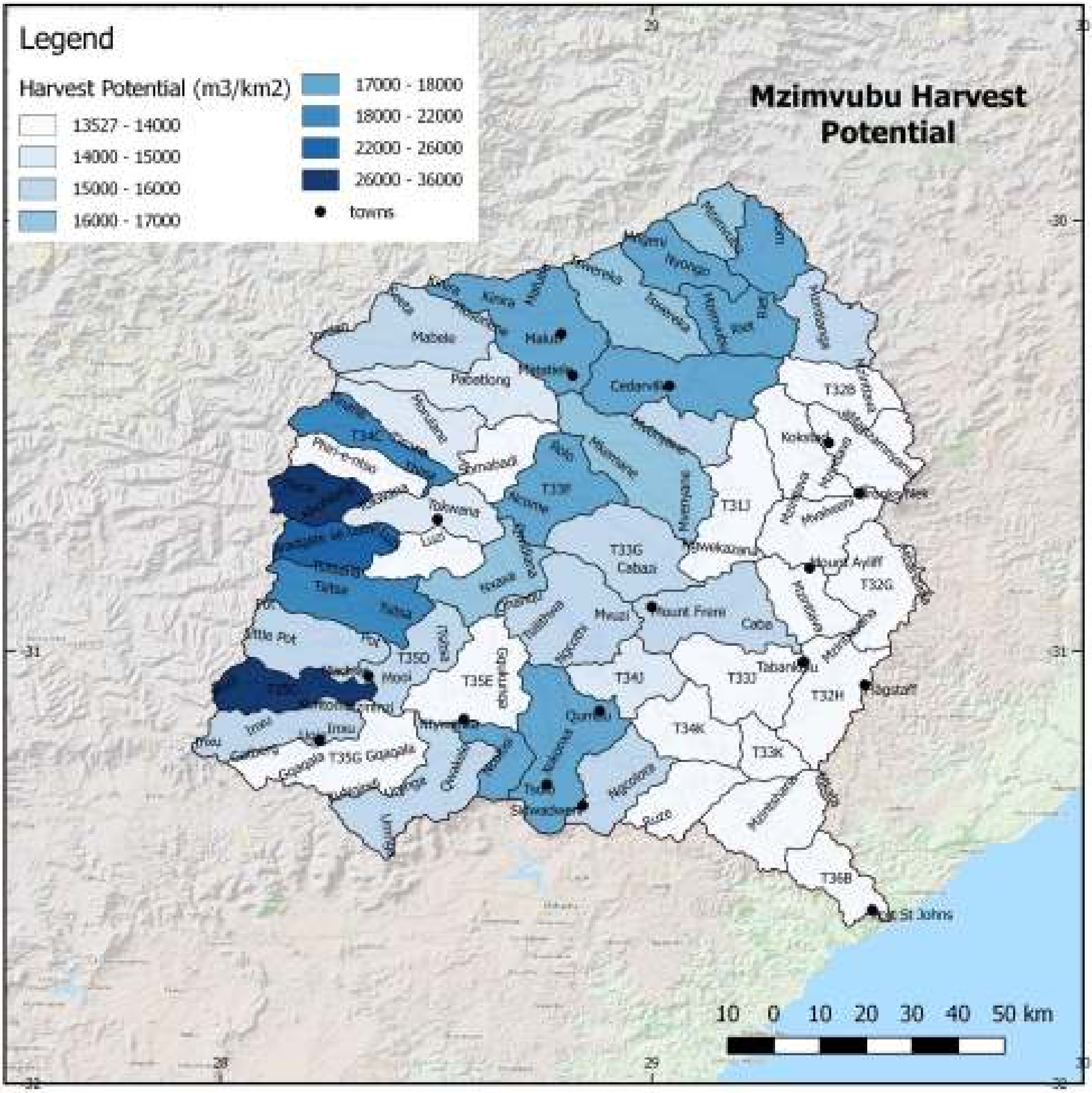

Figure 4.14 Harvest potential of the Mzimvubu T3 catchment

4.8 AQUIFER CLASSIFICATION

According to Parsons and Wentzel (2007), groundwater resources can be classified by the significance of the aquifer:

- Sole-source aquifer: An aquifer used to supply > 50% or more of water for a given area and for which there are no reasonably available alternative sources of water.
- Major aquifer: A high-yield aquifer system of good quality water with a harvest potential greater than 50 000 $m^3/km^2/a$ or average borehole yield greater than 2 l/s.
- Minor aquifer: A moderate-yield aquifer system of variable water quality with a harvest potential between 10 000 and 50 000 $m^3/km^2/a$ or average borehole yield between 1 and 2 l/s.
- Poor aquifer: A low- to negligible-yield aquifer system of moderate to poor water quality with a harvest potential less than 10 000 $m^3/km^2/a$ or average borehole yield less than 1 l/s.

The aquifer classification of the Mzimvubu is shown in **Figure 4.15**. The bulk of the region is a minor aquifer, except where groundwater dependence is >50%.

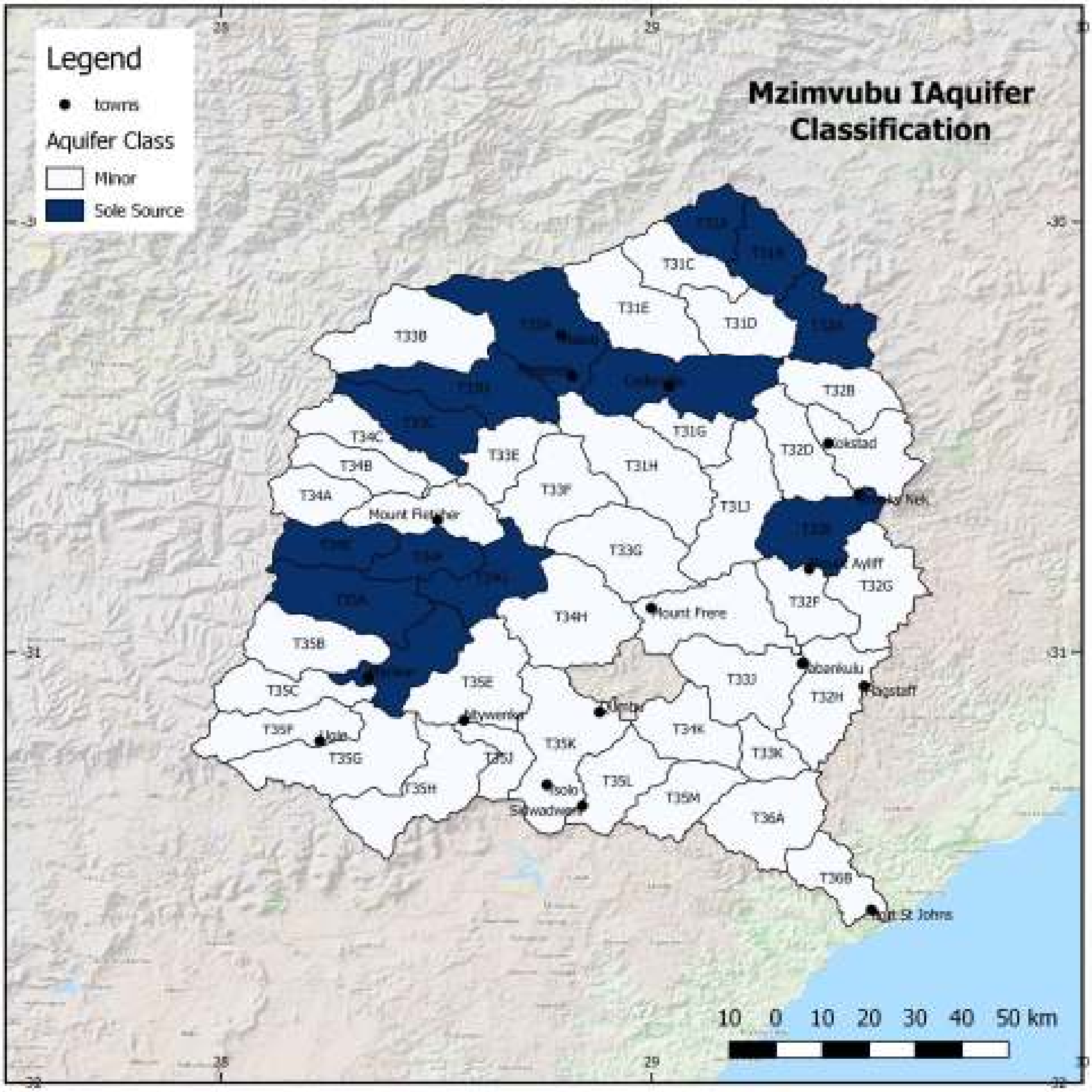

Figure 4.15 Aquifer classification of the Mzimvubu T3 catchment

5 GRU DESCRIPTION AND PRIORITISATION

5.1 DELINEATION OF GROUNDWATER RESOURCE UNITS

The process of delineation of GRUs was described DWS (2017a). The final GRU delineation is shown in **Figure 5.1**.

A summary of the GRUs is given in this chapter and **Table 5.1**. GRUs are described in terms of:

- Water quality Class distribution.
- Groundwater use and stress index (stress index calculated by total groundwater use/ aquifer recharge).
- Present status category relative to the stress index.
- Groundwater dependency.
- Groundwater EWR and the Basic Human Need Reserve which includes Schedule 1 users.
- Allocable groundwater.

Table 5.1 GRUs in the Mzimvubu catchment

GRU	Quaternaries	Catchment	Geology	Baseflow (mm/a)	Description
1	T31A, T31C, T31E	Upper Mzimvubu	Clarens, Elliot, Molteno	33-54, increasing to the NE	Southeastern Highlands with valley bottom wetlands. Baseflow is largely interflow driven.
2	T31A, T31BT31C, T31D, T31E, T31F, T31G, T31H	Upper Mzimvubu	Tarkastad, Dolerite, Quaternary	27-54	Transkeian Coastal Foreland and Middelveld with valley bottom wetlands and seeps. Baseflow is interflow driven with a component from the regional aquifer.
3	T32A, T32B, T32C, T32D, T2E	Mzintlava	Adelaide, Dolerite	30-50	Transkeian Coastal Foreland and Middelveld with valley bottom wetlands and seeps. Baseflow is interflow driven with a component from the regional aquifer.
4	T33A, T33B, T33C, T33D, T33E	Upper Kinira	Drakensberg, Clarens, Elliot, Molteno, Quaternary	30-40	Southeastern Highlands in the upper Kinira catchment with flood plain wetlands and valley head seeps. Baseflow is interflow driven with a component from the regional aquifer.

GRU	Quaternaries	Catchment	Geology	Baseflow (mm/a)	Description
5	T33F, T33G	Lower Kinira	Molteno, Tarkastad, Adelaide, Dolerite	40-50	Transkeian Coastal Foreland and Middelveld of the lower Kinira with valley bottom wetlands. Baseflow is interflow driven with a component from the regional aquifer.
6	T32F, T32G, T32H, T33K	Lower Mzintlava, Middle Mzimvubu, Mzintlavana	Adelaide, Ecca, Dolerite	50-70	Transkeian Coastal Foreland and Middelveld with valley bottom wetlands. Baseflow is interflow driven with minor groundwater baseflow from the regional aquifer.
7	T34A, T34B, T34C, T34D, T34E, T34F	Upper Thina	Drakensberg, Clarens, Elliot, Molteno	60-90	Southeastern Highlands with few wetlands. Baseflow is interflow driven with a component from the regional aquifer.
8	T34G, T34H	Middlle Thina	Tarkastad, Dolerite	80-90	Transkeian Coastal Foreland and Middelveld with valley bottom wetlands. Baseflow is interflow driven with a component from the regional aquifer
9	T34J, T34K	Lower Thina	Adelaide	27-40	Transkeian Coastal Foreland and Middelveld with valley bottom wetlands. Baseflow is interflow driven with a component from the regional aquifer.
10	T35A, T35B, T35C, T35D, T35F, T35G, T35H	Upper Tsitsa and Inxu	Drakensberg, Clarens, Elliot, Molteno	60-112	Southeastern Highlands with valley bottom wetlands, seeps. Baseflow is interflow driven with a component from the regional aquifer.
11	T35E, T35H, T35J, T35K	Middle Tsitsa and lower Inxu	Molteno, Tarkastad, Dolerite	70-110	Transkeian Coastal Foreland and Middelveld with valley bottom wetlands. Baseflow

GRU	Quaternaries	Catchment	Geology	Baseflow (mm/a)	Description
					is interflow driven with a component from the regional aquifer.
12	T35L, T35M	Lower Tsitsa	Tarkastad, Adelaide, Dolerite	30-60	Transkeian Coastal Foreland and Middelveld with valley bottom seeps. Baseflow is interflow driven with a component from the regional aquifer.
13	T36A, T36B	Lower Mzimvubu	Ecca, Dwyka,	60-90	Coastal belt with no significant wetlands. Baseflow is dominated by interflow.
14	T31J, T33H, T33J	Middle and lower Mzimvubu	Adelaide, Dolerite	30-40	Transkeian Coastal Foreland and Middelveld with Baseflow is interflow driven with a component from the regional aquifer valley bottom wetlands.

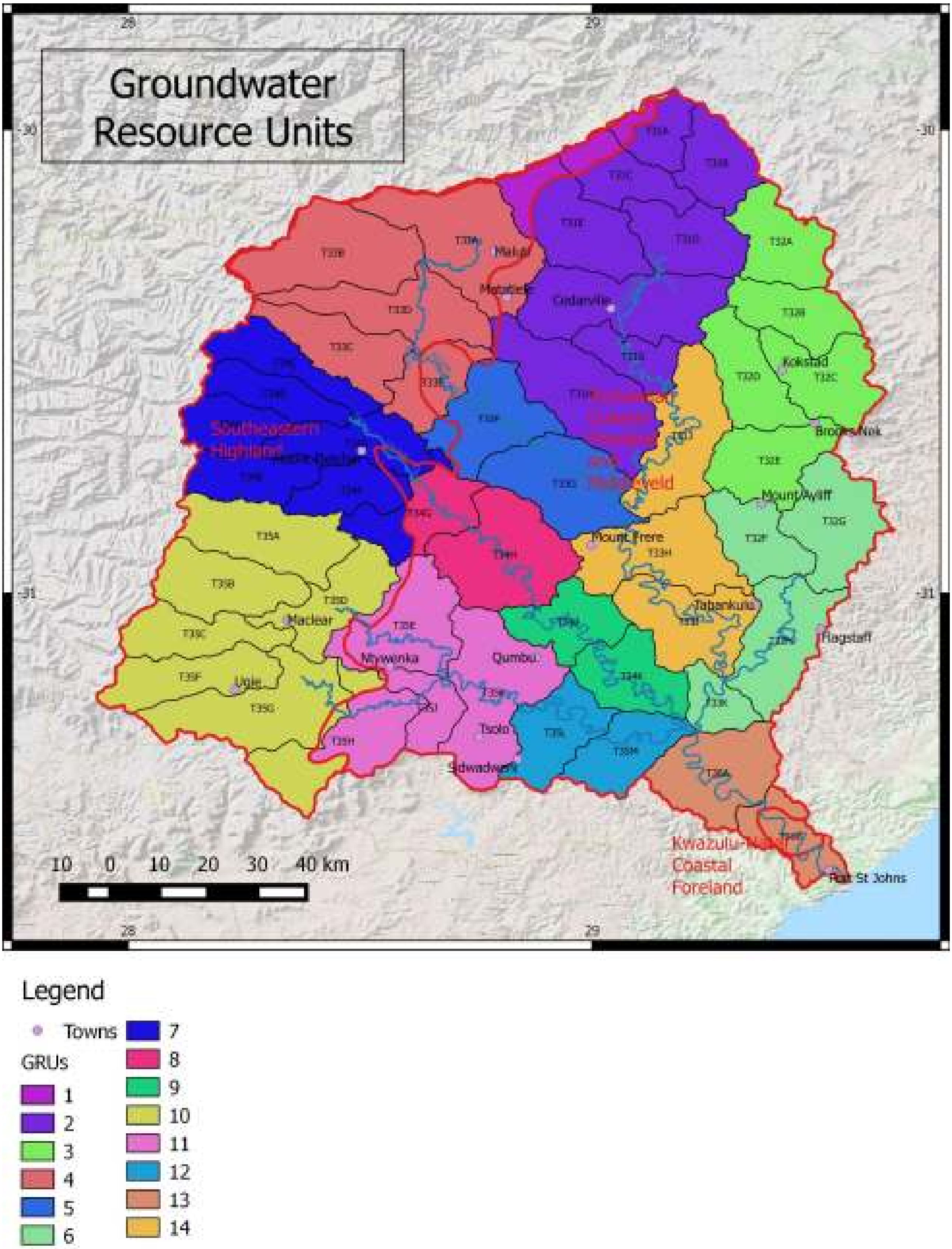

Figure 5.1 Delineation of GRUs for the Mzimvubu T3 catchments

5.2 CRITERIA FOR CHARACTERISATION AND PRIORITISATION OF GRUS

5.2.1 Stress index

In order to calculate the stress index of the regional aquifer, total use from groundwater was utilised, less spring water use, as this is considered as originating from interflow and does not induce a stress on the regional aquifer. Stress index was based on this groundwater use divided by the aquifer recharge, not the total recharge, since much of the recharge is lost as interflow and is not available to boreholes in the regional aquifer.

5.2.2 Groundwater EWR and Reserve

The groundwater EWR was taken from the river desktop EWR and modelling report (DWS, 2017c). The EWR component was added to the BHN, which was based on 25 l/c/d for people without access to a regional scheme. The BHN also includes Schedule 1 users currently on springs or boreholes.

5.2.3 Allocable groundwater

The volume of allocable groundwater was calculated by:

Allocable groundwater = Recharge – (irrigation+ industrial + regional scheme use) - BHN – (baseflow – interflow * EWR)

This water balance equation assumes that the same fraction of groundwater recharge is required to meet the EWR as the natural fraction of groundwater baseflow.

5.2.4 Prioritisation of catchments

In order to prioritise and select the most important GRUs, the criteria assessed per RU include:
- Importance of the RU to users (degree of groundwater dependence).
- Threat posed to water resource quality for the environment (baseflow).
- Degree of use (stress index).

Catchments classified as having a status of A or B were classified as low priority. Catchments with a present use status of C or D, and where groundwater dependence exceeds 50% were classified as of moderate importance.

5.3 DESCRIPTION OF GROUNDWATER RESOURCE UNITS

5.3.1 Upper Mzimvubu

This area forms GRUs 1 and 2, which are distinguished by the rugged escarpment zone of the Southeastern Highlands. They contain catchments T31A (Mzimvubu), T31C (Mingeni and Nyongo), and T31E (Tswereka). T31B, (Krom, A, T31D (Riet and Mzimkulu), T31H (Myenyane), and T31F and T31G (Mzimkulu). T31F contains the town of Cedarville.

The GRUs consists of rural areas, with dryland irrigation and some irrigated lands in the lower reaches of T31E, T31D, F and G. Some afforestation exists in the upper reaches of T31A and B. T31A, B and F are heavily dependent on groundwater (> 65%).

Rocks of the Clarens, Elliot and Molteno Formations underlie the Escarpment watershed of GRU 1, and rocks of the Tarkastad Subgroup underlies GRU 2, along with extensive quaternary cover in the flat lands between Matatiele, Cedarville and Swartberg (**Figure 5.2**).

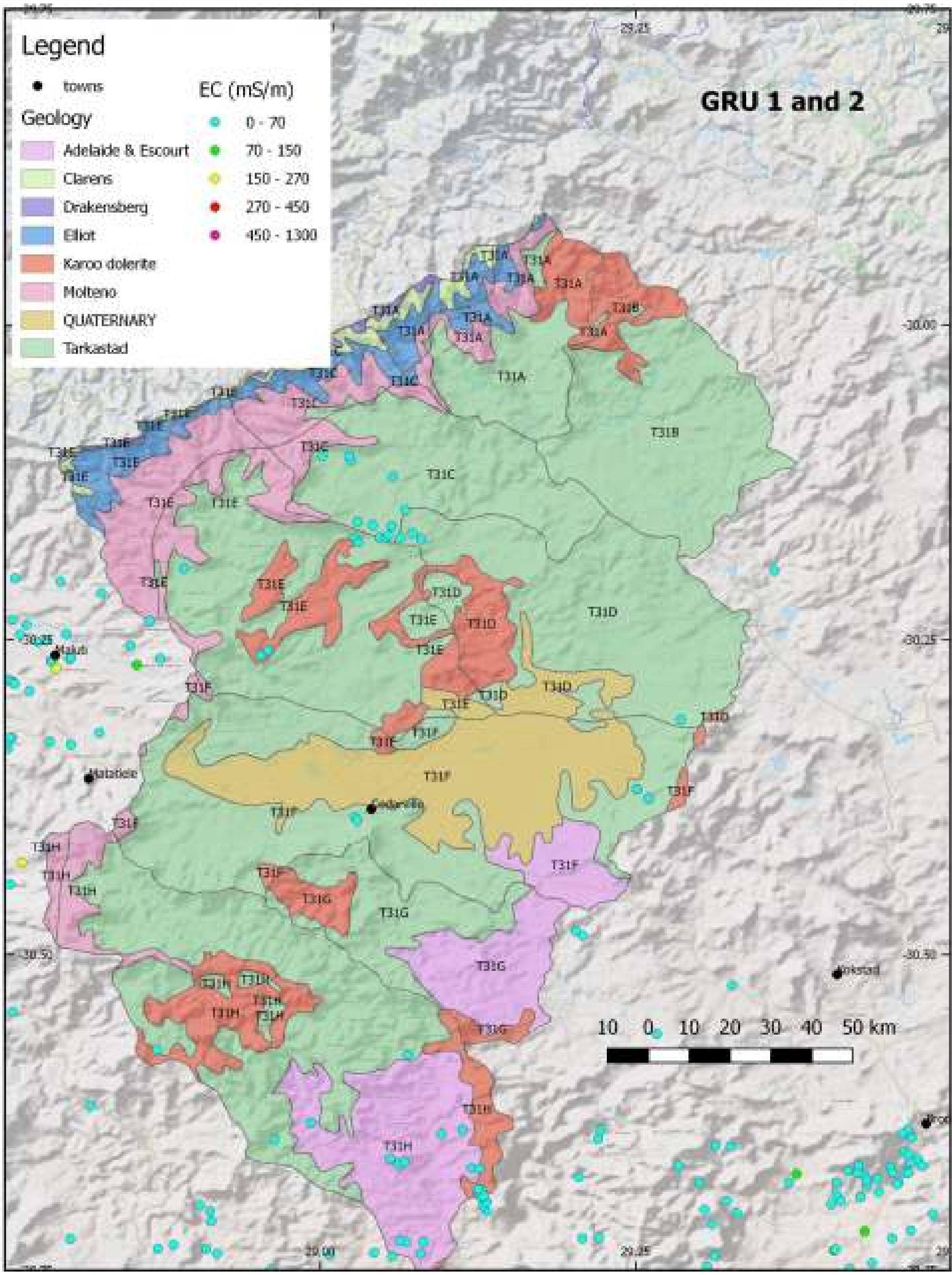

Figure 5.2 Upper Mzimvubu GRUs

One hundred percent of boreholes are of Class 0 (**Table 5.2**) based on electrical conductivity. Pockets of Class 2 and 3 water related to elevated nitrates exist in the central part of GRU 2 in T31E.

Groundwater use is very low (stress index < 0.05 of aquifer recharge), except in T31F in the vicinity of Cedarville, due to irrigation (**Table 5.3**). Groundwater dependency is high in T31A, B and F. Based on the high level of groundwater dependence, and a moderate stress index, T31F is considered a moderate priority catchment in this GRU (**Table 5.4**).

Table 5.2 Upper Mzimvubu: Water quality distribution

Electrical conductivity													
Quat	**Number of boreholes per Class**					**% of boreholes per Class**					**Percentiles below (mS/m)**		
	0	1	2	3	4	0	1	2	3	4	10	50	95
T31C	16	0	0	0	0	100	0	0	0	0	0.20	0.40	32.03
T31D	1	0	0	0	0	100	0	0	0	0	15.70	15.70	15.70
T31E	2	0	0	0	0	100	0	0	0	0	24.89	36.05	48.61
T31F	5	0	0	0	0	100	0	0	0	0	3.52	28.80	65.24
T31G	1	0	0	0	0	100	0	0	0	0	4.30	4.30	4.30
T31H	15	0	0	0	0	100	0	0	0	0	4.30	13.10	36.10
Nitrates													
T31A	2	0	0	0	0	100	0	0	0	0			
T31B	8	0	0	0	0	100	0	0	0	0			
T31C	3	0	0	0	0	100	0	0	0	0			
T31D	14	1	0	0	0	93	7	0	0	0			
T31E	10	0	0	2	0	83	0	0	17	0			
T31F	28	1	0	0	0	97	3	0	0	0			
T31G	7	1	0	0	0	88	13	0	0	0			
T31H	2	0	0	0	0	100	0	0	0	0			
Fluorides													
T31A	2	0	0	0	0	100	0	0	0	0			
T31B	8	0	0	0	0	100	0	0	0	0			
T31C	3	0	0	0	0	100	0	0	0	0			
T31D	13	1	1	0	0	87	7	7	0	0			
T31E	12	0	0	0	0	100	0	0	0	0			
T31F	22	6	1	0	0	76	21	3	0	0			
T31G	8	0	0	0	0	100	0	0	0	0			
T31H	2	0	0	0	0	100	0	0	0	0			

Table 5.3 Upper Mzimvubu: Groundwater use and stress index

Quat	MAP (mm/a)	Area	Recharge	Aquifer recharge	Harvest potential	Groundwater use (Mm^3/a)							Stress index	Present status category
		(km^2)	(Mm^3/a)	(Mm^3/a)	Mm^3/a	Irrigation	Industry	Schedule 1 borehole	Schedule 1 spring	Regional schemes	Total use	Domestic use		
T31A	907	222	56.02	7.858	3.62			0.015	0.005	0.000	0.020	0.020	0.002	A
T31B	833	284	44.82	9.678	5.03			0.018	0.007	0.002	0.027	0.027	0.002	A
T31C	830	291	45.32	9.731	5.08			0.048	0.098	0.008	0.154	0.154	0.006	A
T31D	736	353	32.83	9.282	6.22	0.175		0.027	0.010	0.000	0.213	0.037	0.022	A
T31E	756	509	36.50	10.339	8.47			0.088	0.047	0.000	0.135	0.135	0.008	A
T31F	713	605	29.66	9.490	10.41	3.232		0.007	0.003	0.000	3.243	0.010	0.341	C
T31G	801	209	43.55	9.939	3.26	0.074		0.018	0.007	0.000	0.099	0.026	0.009	A
T31H	808	617	44.45	9.622	9.9			0.082	0.150	0.129	0.361	0.361	0.022	A
		3090	333.16	75.94	51.99	3.481	0.000	0.304	0.327	0.139	4.251	0.770		

Table 5.4 Upper Mzimvubu: Groundwater Reserve and allocable groundwater

Quat	GW dependence	Baseflow	Interflow	BHN	EWR	GW component of the Reserve		Allocable GW	Priority
	%	Mm^3/a	% of baseflow	Mm^3/a		Mm^3/a	% of recharge	Mm^3/a	
T31A	64.79	54.52	87.17	0.01	7.67	7.68	13.70	6.866	Low
T31B	67.18	41.94	83.01	0.01	7.41	7.42	2.61	8.406	Low
T31C	37.45	42.81	83.29	0.10	10.93	11.03	3.79	7.782	Low
T31D	45.84	30.40	75.48	0.02	5.58	5.60	1.59	7.714	Low
T31E	26.03	33.02	77.63	0.09	11.99	12.08	2.37	7.547	Low
T31F	66.98	27.36	72.19	0.00	3.75	3.75	0.62	5.210	Moderate
T31G	13.48	40.90	81.94	0.01	15.87	15.88	7.60	6.988	Low
T31H	37.32	42.04	82.48	0.13	12.03	12.16	1.97	7.238	Low

5.3.2 Upper Mzintlava

This area forms GRU 3, the upper Mzintlava from the catchment watershed to Mount Ayliff. It contains catchments T32A and B (Mzintlava), T32C (Manzamnyama and Mzintlava), T32D (Droewig and Mzintlava), and T32E (Mvalweni and Mzintlava). T32C contains the town of Kokstad.

The GRUs consist of rural areas, with dryland irrigation and some irrigated lands in T32A–C in the vicinity of Franklin, Swartberg and Kruisfontein, downstream to Kokstad. Some afforestation exists in T32C. T32A is heavily dependent on groundwater (> 65%).

Rocks of the Tarkastad Subgroup underlie the upper reaches of T32A, otherwise the GRU is underlain by mudstones and sandstones of the Adelaide Subgroup. Extensive outcrop of dolerite sheets occur across the GRU (**Figure 5.3**).

One hundred percent of boreholes are of Class 0 (**Table 5.5**) based on electrical conductivity, except in the vicinity of Mount Ayliff in T32E. Pockets of Class 2 and 3 water related to elevated nitrates and fluorides exist in the lower part of the GRU in T32C–E.

Groundwater use is low (stress index < 0.15 of aquifer recharge) (**Table 5.6**). Groundwater dependency is high in T32A. Based on the low level of groundwater dependence, none of the catchments are considered priority (**Table 5.7**).

Table 5.5 Upper Mzintlava: Water quality distribution

Electrical conductivity													
Quat	**Number of boreholes per Class**					**% of boreholes per Class**					**Percentiles below (mS/m)**		
	0	1	2	3	4	0	1	2	3	4	10	50	95
T32A	1	0	0	0	0	100	0	0	0	0	15.00	15.00	15.00
T32B	1	0	0	0	0	100	0	0	0	0	69.00	69.00	69.00
T32C	2	0	0	0	0	100	0	0	0	0	33.50	35.50	37.75
T32D	1	0	0	0	0	100	0	0	0	0	30.00	30.00	30.00
T32E	57	6	0	0	3	86	9	0	0	5	0.20	13.00	113.50
Nitrates													
T32A	13	1	0	0	0	93	7	0	0	0			
T32B	8	0	0	0	0	100	0	0	0	0			
T32C	14	0	0	1	0	93	0	0	7	0			
T32D	15	0	1	0	0	94	0	6	0	0			
T32E	2	1	0	1	0	50	25	0	25	0			
Fluorides													
T32A	12	1	1	0	0	86	7	7	0	0			
T32B	8	0	0	0	0	100	0	0	0	0			
T32C	14	0	0	1	0	93	0	0	7	0			
T32D	12	1	0	2	1	75	6	0	13	6			
T32E	4	0	0	0	0	100	0	0	0	0			

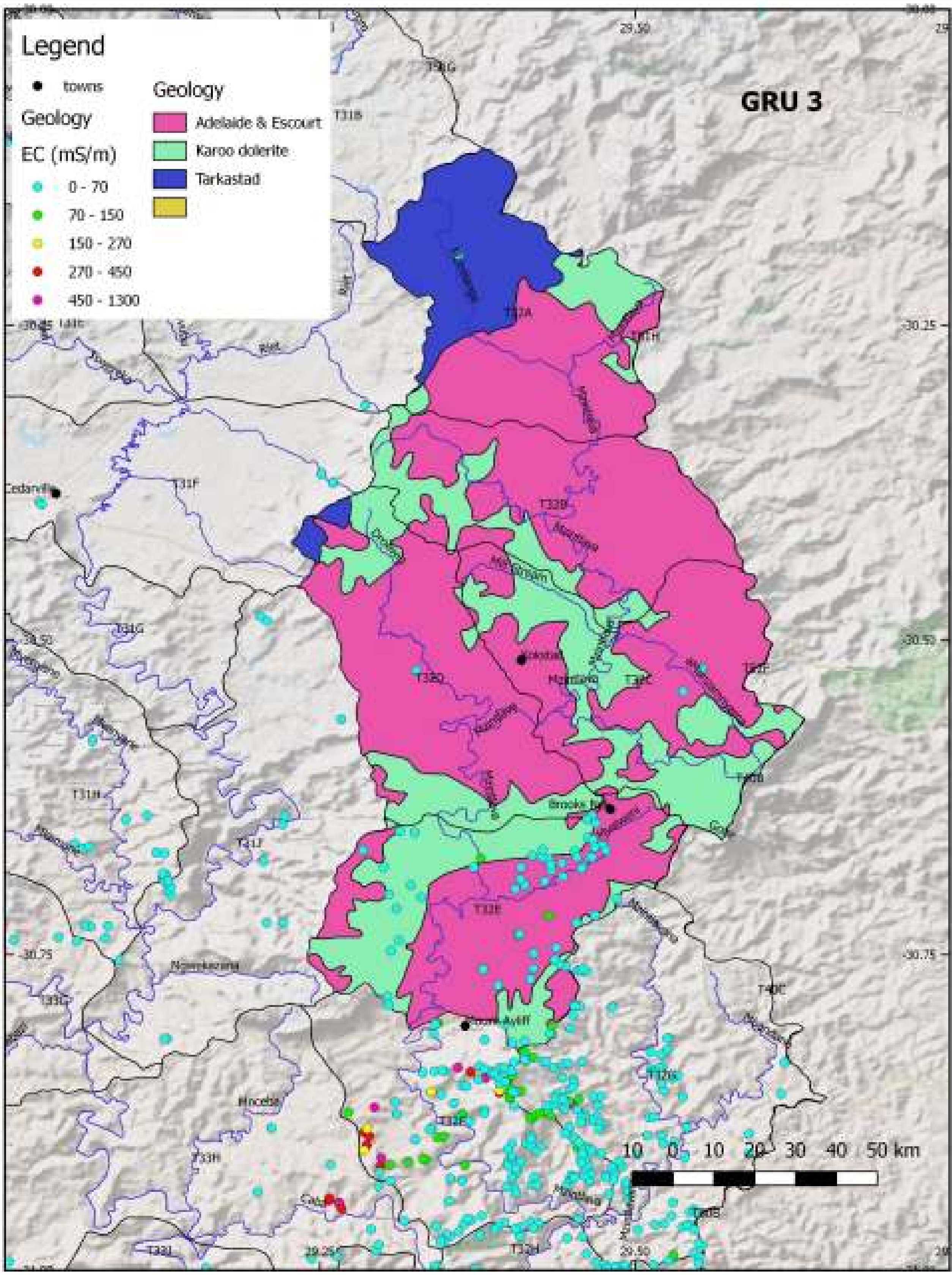

Figure 5.3 Upper Mzintlava GRU

Table 5.6 Upper Mzintlava: Groundwater use and stress index

Quat	MAP (mm/a)	Area	Recharge	Aquifer recharge	Harvest potential	Groundwater use (Mm³/a)							Stress index	Present status category
		(km²)	(Mm³/a)	(Mm³/a)	Mm³/a	Irrigation	Industry	Schedule 1 borehole	Schedule 1 spring	Regional schemes	Total use	Domestic use		
T32A	804	348	38.59	10.488	5.26	0.770		0.020	0.007	0.003	0.800	0.030	0.076	B
T32B	814	307	42.92	10.128	4.18		0.000	0.035	0.012	0.000	0.048	0.048	0.004	A
T32C	781	373	40.20	10.086	5.07	0.041		0.042	0.040	0.000	0.123	0.082	0.008	A
T32D	789	351	39.70	12.525	4.77	0.030	0.006	0.046	0.027	0.006	0.115	0.079	0.007	A
T32E	844	383	49.33	9.736	5.21	0.001	0.007	0.091	0.076	0.559	0.732	0.725	0.067	B
Total		1762	210.74	52.96	24.49	0.841	0.012	0.234	0.162	0.568	1.817	0.964		

Table 5.7 Upper Mzintlava: Groundwater Reserve and allocable groundwater

Quat	GW dependence	Baseflow	Interflow	BHN	EWR	GW component of the Reserve		Allocable GW	Priority
	%	Mm³/a	% of baseflow	Mm³/a		Mm³/a	% of recharge	Mm³/a	
T32A	67.32	35.36	77.36	0.01	2.66	2.67	0.77	9.101	Low
T32B	39.43	40.00	80.23	0.02	3.95	3.97	1.29	9.323	Low
T32C	4.37	37.83	78.92	0.04	5.93	5.97	1.60	8.744	Low
T32D	30.27	35.61	77.71	0.03	8.8	8.83	2.52	10.488	Low
T32E	59.71	47.37	83.21	0.11	15.69	15.80	4.12	6.410	Low

5.3.3 Upper Kinira

This area forms GRU 4, the upper Kinira, from the catchment watershed to T33E. It contains catchments T33A (upper Kinira and its tributaries), T33B (Mabele and tributaries), T33C (Monulane), T32D (Pabatlong and Kinira), and T32E (Kinira and Somabadi). T33A contains the towns of Maluti and Matatiele.

The GRUs consists of rural areas, with dryland irrigation. T33D is heavily dependent on groundwater (> 65%).

Rocks of the Drakensberg, Clarens and Elliot Formations underlie the Escarpment watershed in the west, while the underlying Molteno Formation and Tarkastad Subgroup are exposed in the east. Quaternary cover underlies the Mabele in T33A and B (**Figure 5.4**).

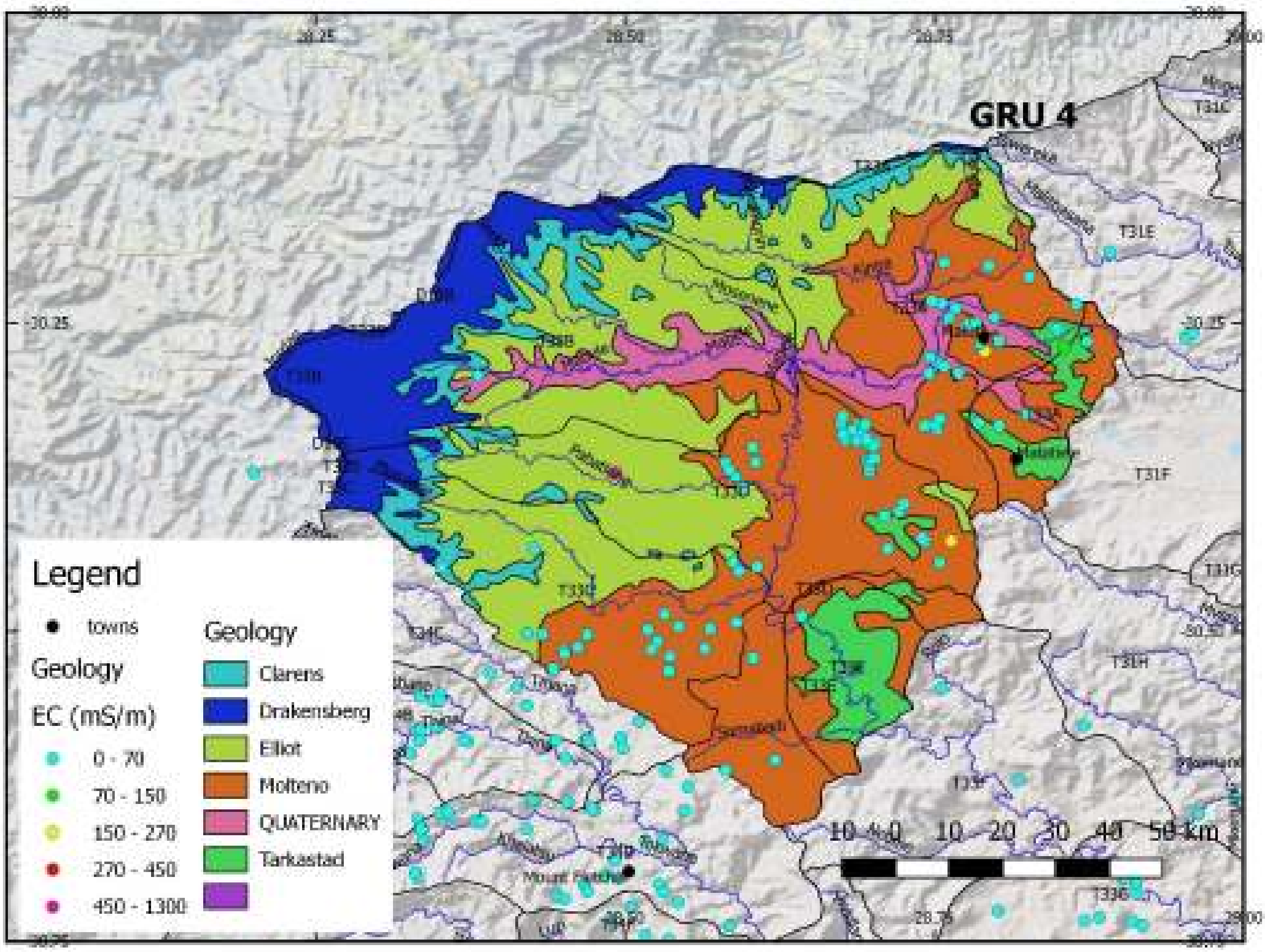

Figure 5.4 Upper Kinira GRU

One hundred percent of boreholes are of Class 0 (**Table 5.8**) based on electrical conductivity, except in n T33D. Pockets of Class 3 and 4 water related to elevated nitrates and fluorides exist throughout the GRU.

Groundwater use is low (stress index < 0.15 of aquifer recharge), except in T33A due to water supply to Matatiele (**Table 5.9**). Groundwater dependency is high in T33D. Based on the moderate level of groundwater dependence and the stress index, catchment T33A is considered of moderate priority (**Table 5.10**).

Table 5.8 Upper Kinira: Water quality distribution

Electrical conductivity													
Quat	Number of boreholes per Class					% of boreholes per Class					Percentiles below (mS/m)		
	0	1	2	3	4	0	1	2	3	4	10	50	95
T33A	35	1	2	2	0	88	3	0	5	0	0.40	34.50	265.45
T33B	1	0	0	0	0	100	0	0	0	0	18.00	18.00	18.00
T33C	25	0	0	0	0	100	0	0	0	0	12.60	34.00	50.80
T33D	41	0	2	0	1	93	0	0	0	2	0.10	0.40	177.95
T33E	6	0	0	0	0	100	0	0	0	0	0.15	15.65	49.50
Nitrates													
T33A	7	0	0	0	0	100	0	0	0	0			
T33B	1	0	0	0	0	100	0	0	0	0			
T33C	2	0	0	1	0	67	0	0	33	0			
T33E	3	0	0	0	0	100	0	0	0	0			
Fluorides													
T33A	6	0	0	1	0	86	0	0	14	0			
T33B	1	0	0	0	0	100	0	0	0	0			
T33C	2	0	0	0	0	100	0	0	0	0			
T33E	2	0	0	0	1	67	0	0	0	33			

Table 5.9 Upper Kinira: Groundwater use and stress index

Quat	MAP (mm/a)	Area	Recharge	Aquifer recharge	Harvest potential	Groundwater use (Mm^3/a)							Stress index	Present status category
		(km^2)	(Mm^3/a)	(Mm^3/a)	Mm^3/a	Irrigation	Industry	Schedule 1 borehole	Schedule 1 spring	Regional schemes	Total use	Domestic use		
T33A	757	672	36.00	9.012	11.64		0.141	0.146	0.089	3.054	3.431	3.290	0.371	C
T33B	801	602	41.86	10.189	9.57			0.043	0.114	0.003	0.161	0.161	0.005	A
T33C	768	367	35.00	9.211	5.43			0.103	0.175	0.122	0.400	0.400	0.024	A
T33D	736	461	33.64	9.237	6.85			0.083	0.246	1.014	1.342	1.342	0.119	B
T33E	748	267	35.59	10.602	3.63			0.048	0.079	0.172	0.299	0.299	0.021	A
Total		2369	182.09	48.25	37.12	0.000	0.141	0.424	0.702	4.366	5.633	5.492		

Table 5.10 Upper Kinira: Groundwater Reserve and allocable groundwater

Quat	GW dependence	Baseflow	Interflow	BHN	EWR	GW component of the Reserve		Allocable GW	Priority
	%	Mm^3/a	% of baseflow	Mm^3/a		Mm^3/a	% of recharge	Mm^3/a	
T33A	47.65	34.65	79.03	0.22	19.96	20.18	3.00	1.366	Moderat e
T33B	19.60	38.33	81.30	0.10	18.83	18.93	3.14	6.547	Low
T33C	54.65	33.60	78.49	0.10	17.865	17.97	4.90	5.121	Low
T33D	66.57	31.76	77.01	0.17	17.865	18.04	3.91	3.901	Low
T33E	42.38	32.44	76.92	0.09	9.91	10.00	3.74	8.036	Low

5.3.4 Lower Kinira

This area forms GRU 5, the lower Kinira between GRU 4 and the confluence with the Mzimvubu. It contains catchments T33F and G of the lower Kinira.

The GRUs consists of rural areas, with dryland irrigation. Some afforestation exists. The GRU is not very dependent on groundwater.

Rocks of the Tarkastad and Adelaide Subgroups underlie most of the GRU (**Figure 5.5**).

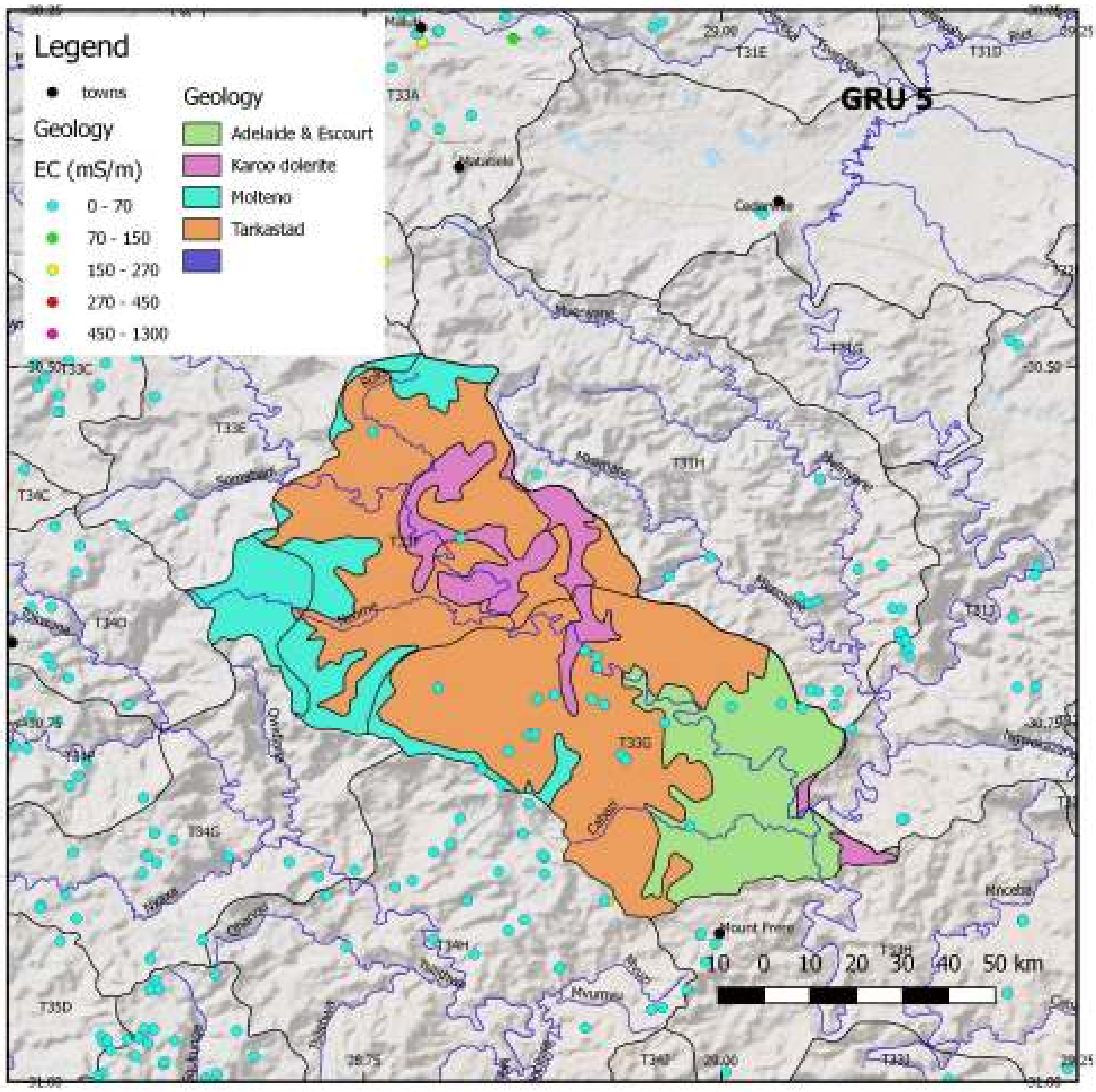

Figure 5.5 Lower Kinira GRU

One hundred percent of boreholes are of Class 0 (**Table 5.11**) based on electrical conductivity, nitrates and fluorides.

Groundwater use is very low (stress index < 0.05 of aquifer recharge) (**Table 5.12**). Groundwater dependency is low. Based on the low level of stress and groundwater dependence, both catchments are considered to be of low priority (**Table 5.13**).

Table 5.11 Lower Kinira: Water quality distribution

Electrical conductivity													
Quat	**Number of boreholes per Class**					**% of boreholes per Class**					**Percentiles below (mS/m)**		
	0	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	**10**	**50**	**95**
T33F	2	0	0	0	0	100	0	0	0	0	41.53	53.25	66.44
T33G	18	0	0	0	0	100	0	0	0	0	17.82	46.40	59.75
Nitrates													
T33F	2	0	0	0	0	100	0	0	0	0			
T33G	18	0	0	0	0	100	0	0	0	0			
Fluorides													
T33F	2	0	0	0	0	100	0	0	0	0			
T33G	3	0	0	0	0	100	0	0	0	0			

Table 5.12 Lower Kinira: Groundwater use and stress index

Quat	MAP (mm/a)	Area	Recharge	Aquifer recharge	Harvest potential	Groundwater use (Mm^3/a)							Stress index	Present status category
		(km^2)	(Mm^3/a)	(Mm^3/a)	Mm^3/a	Irrigation	Industry	Schedule 1 borehole	Schedule 1 spring	Regional schemes	Total use	Domestic use		
T33F	829	437	46.62	9.867	7.5			0.023	0.048	0.223	0.294	0.294	0.025	A
T33G	835	503	50.31	9.451	7.99			0.087	0.054	0.209	0.350	0.350	0.031	A

Table 5.13 Lower Kinira: Groundwater Reserve and allocable groundwater

Quat	GW dependence	Baseflow	Interflow	BHN	EWR	GW component of the Reserve		Allocable GW	Priority
	%	Mm^3/a	% of baseflow	Mm^3/a		Mm^3/a	% of recharge	Mm^3/a	
T33F	35.11	44.14	83.52	0.09	10.54	10.63	2.43	7.800	Low
T33G	23.45	48.74	85.16	0.20	11.4	11.60	2.31	7.319	Low

5.3.5 Lower Mzintlava

This area forms GRU 6, the lower Mzintlava from Mount Ayliff to below the confluence with the Mzimvubu. It contains catchments T32F (Mzintlava), T32G (Mzintlavana), T32H (Mzintlava), and T33K (Mzimvubu). T32F contains the town of Mount Ayliff and T32H contains Flagstaff.

The GRUs consists of rural areas with some minor irrigated areas. Afforestation exists in T32F and G, but not in T33K. The GRU is not very dependent on groundwater (8–33%).

Rocks of the Ecca Group and Adelaide Subgroup underlie the GRU, with extensive outcrop of dolerite sills (**Figure 5.6**).

Water quality is variable, being largely of Class 0 with some boreholes exhibiting high salinities based on electrical conductivity and being of Class 3 or 4, especially around Mount Ayliff (**Table 5.14).** Insufficient data exists on nitrates and fluorides.

Groundwater use is low (stress index < 0.15 of aquifer recharge), with water supply to Mount Ayliff being the largest water use (**Table 5.15**). Based on the low level of groundwater dependence, all the catchments are of low priority (**Table 5.16**).

Table 5.14 Lower Mzintlava: Water quality distribution

Electrical conductivity													
Quat	**Number of boreholes per Class**					**% of boreholes per Class**					**Percentiles below (mS/m)**		
	0	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	**10**	**50**	**95**
T32F	112	17	4	11	10	73	11	0	7	6	0.70	21.10	509.00
T32G	110	16	0	0	1	87	13	0	0	1	4.30	12.50	100.00
T32H	101	5	0	0	0	95	5	0	0	0	4.05	18.45	68.45
T33K	2	0	0	0	0	100	0	0	0	0	11.20	20.00	29.90
Nitrates													
T32G	0	1	0	0	0	0	100	0	0	0			
Fluorides													
T32G	1	0	0	0	0	100	0	0	0	0			

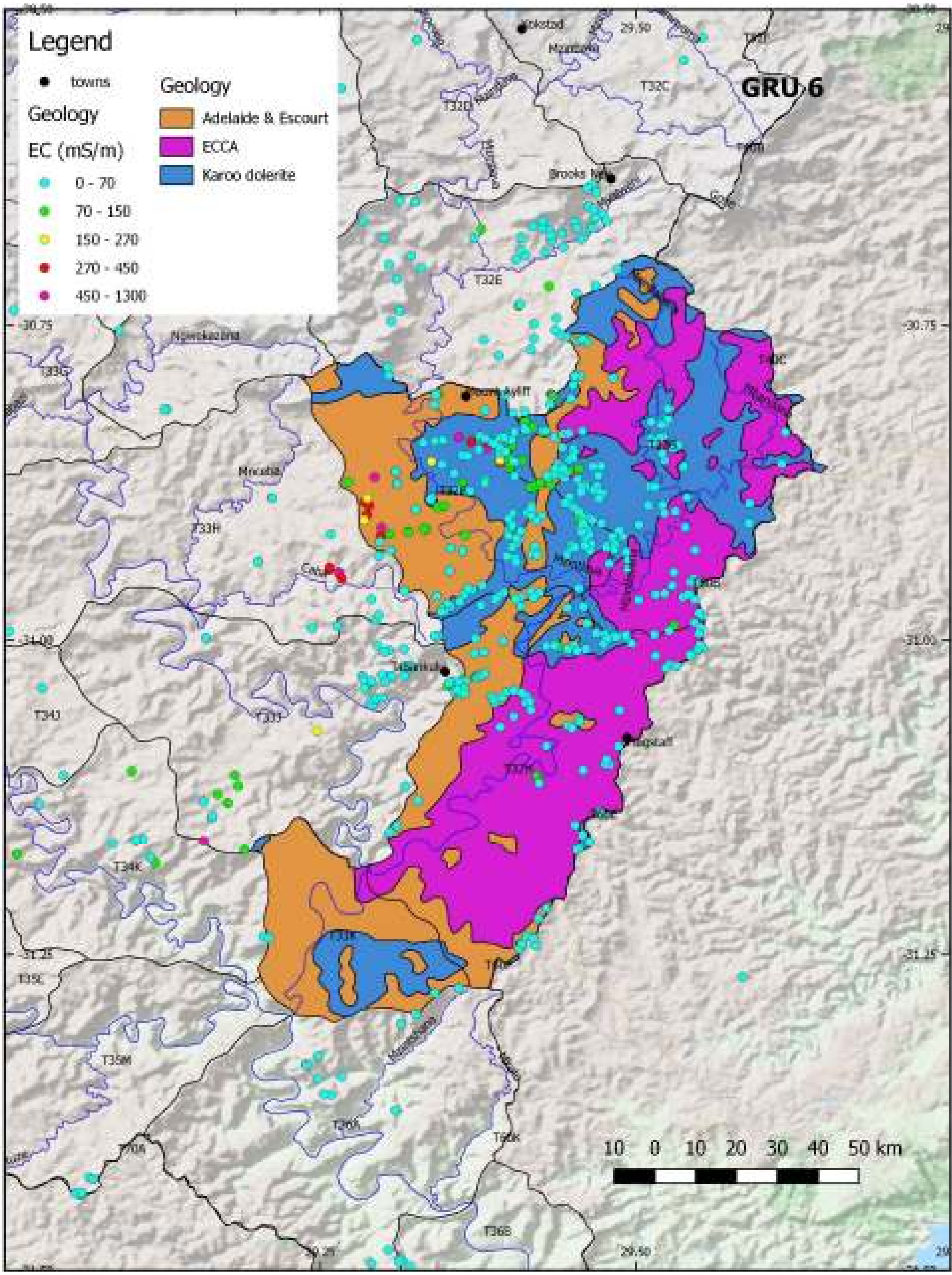

Figure 5.6 Lower Mzintlava GRU

Table 5.15 Lower Mzintlava: Groundwater use and stress index

Quat	MAP (mm/a)	Area	Recharge	Aquifer recharge	Harvest potential	Groundwater use (Mm^3/a)							Stress index	Present status category
		(km^2)	(Mm^3/a)	(Mm^3/a)	Mm^3/a	Irrigation	Industry	Schedule 1 borehole	Schedule 1 spring	Regional schemes	Total use	Domestic use		
T32F	924	297	63.37	5.504	4.04			0.143	0.284	0.535	0.962	0.962	0.123	B
T32G	862	438	52.56	5.799	5.96			0.022	0.295	0.256	0.573	0.573	0.048	A
T32H	892	453	56.52	4.700	6.16			0.085	0.088	0.409	0.583	0.583	0.105	B
T33K	856	169	51.48	8.748	2.3			0.007	0.011	0.068	0.085	0.085	0.009	A
Total		1357	223.93	24.75	18.46	0.000	0.000	0.257	0.677	1.268	2.202	2.202		

Table 5.16 Lower Mzintlava: Groundwater Reserve and allocable groundwater

Quat	GW dependence	Baseflow	Interflow	BHN	EWR	GW component of the Reserve		Allocable GW	Priority
	%	Mm^3/a	% of baseflow	Mm^3/a		Mm^3/a	% of recharge	Mm^3/a	
T32F	33.19	61.34	93.83	0.30	15.69	15.99	5.39	3.678	Low
T32G	24.50	50.31	92.14	0.36	13.11	13.47	3.07	4.126	Low
T32H	19.76	55.42	93.00	0.36	20.22	20.58	4.54	2.487	Low
T33K	8.22	50.40	84.57	0.12	12	12.12	7.17	6.686	Low

5.3.6 Upper Thina

GRU 7 consists of the rugged escarpment zone of the South-eastern Highlands. It contains catchments T34A (Thina), T34B (Phiri e ritso, Nxotshana and Thina), T34C (Tinana and Phipari), T34D (Tokwana and Thina), T34E (Bradgate se Loop and Luzi), and T34F (Luzi). T34D contains the town of Mount Fletcher.

The GRUs consists of rural areas, with some afforestation in T34B, D and E. Settlements are found in the upper reaches of T31A and B. The area is moderately dependent on groundwater (30–60%).

Rocks of the Drakensberg, Clarens, Elliot and Molteno Formations underlie the GRU (**Figure 5.7**).

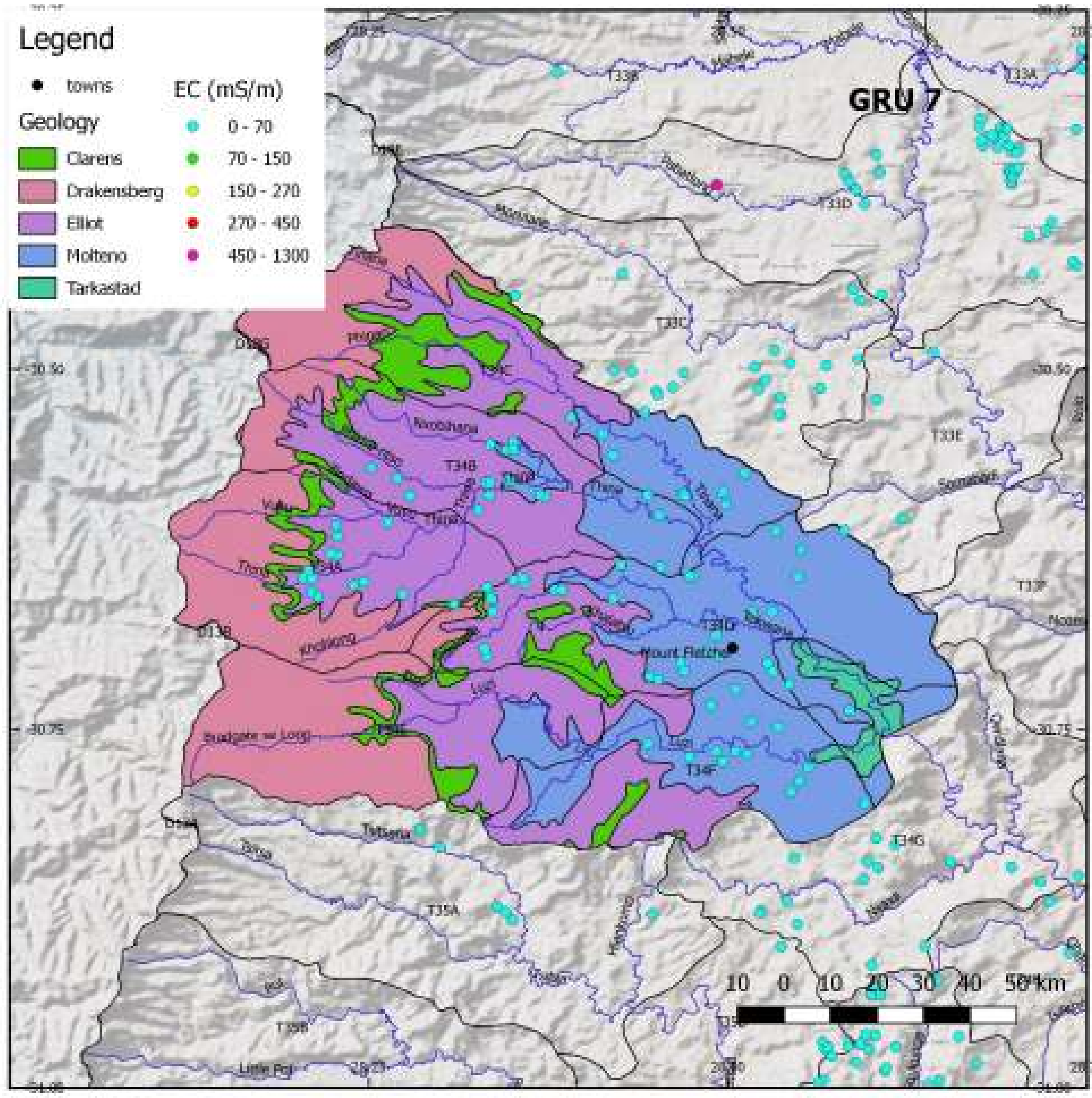

Figure 5.7 Upper Thina GRU

One hundred percent of boreholes are of Class 0 (**Table 5.17**) based on electrical conductivity. Very little data exists on nitrates and fluorides.

Groundwater use is very low (stress index < 0.05 of aquifer recharge) (**Table 5.18**), however, groundwater dependency is moderate to high in T34F (**Table 5.19**). Based on the low stress index and only moderate groundwater dependence, all the catchments are considered to be of low priority in this GRU (**Table 5.19**).

Table 5.17 Upper Thina: Water quality distribution

Electrical conductivity													
Quat	**Number of boreholes per Class**					**% of boreholes per Class**					**Percentiles below (mS/m)**		
	0	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	**10**	**50**	**95**
T34A	15	0	0	0	0	100	0	0	0	0	0.10	0.20	29.69
T34B	22	0	0	0	0	100	0	0	0	0	0.21	32.50	50.60
T34C	10	0	0	0	0	100	0	0	0	0	28.10	44.00	53.16
T34D	33	0	0	0	0	100	0	0	0	0	0.10	27.00	46.84
T34F	13	0	0	0	0	100	0	0	0	0	0.20	19.80	36.20
Nitrates													
T34C	1	0	0	0	0	100	0	0	0	0			
T34D	0	1	0	0	0	0	100	0	0	0			
T34E	3	0	0	0	0	100	0	0	0	0			
Fluorides													
T34C	1	0	0	0	0	100	0	0	0	0			
T34D	1	0	0	0	0	100	0	0	0	0			
T34E	3	0	0	0	0	100	0	0	0	0			

Table 5.18 Upper Thina: Groundwater use and stress index

Quat	MAP (mm/a)	Area	Recharge	Aquifer recharge	Harvest potential	Groundwater use (Mm^3/a)							Stress index	Present status category
		(km^2)	(Mm^3/a)	(Mm^3/a)	Mm^3/a	Irrigation	Industry	Schedule 1 borehole	Schedule 1 spring	Regional schemes	Total use	Domestic use		
T34A	905	242	85.55	9.982	6.81			0.019	0.077	0.000	0.096	0.096	0.002	A
T34B	860	246	77.15	10.458	3.33			0.070	0.062	0.023	0.156	0.156	0.009	A
T34C	807	282	67.53	11.000	5.77			0.051	0.060	0.101	0.212	0.212	0.014	A
T34D	850	342	79.37	10.132	4.93			0.123	0.085	0.224	0.432	0.432	0.034	A
T34E	901	268	84.76	9.989	6.83			0.002	0.003	0.000	0.005	0.005	0.000	A
T34F	875	238	83.98	10.039	3.29			0.064	0.058	0.003	0.124	0.124	0.007	A
		1618	478.34	61.60	30.96	0.000	0.000	0.329	0.345	0.351	1.024	1.024		

Table 5.19 Upper Thina: Groundwater Reserve and allocable groundwater

Quat	GW dependence	Baseflow	Interflow	BHN	EWR	GW component of the Reserve		Allocable GW	Priority
	%	Mm^3/a	% of baseflow	Mm^3/a		Mm^3/a	% of recharge	Mm^3/a	
T34A	39.85	82.34	91.26	0.05	17.6	17.65	7.30	8.384	Low
T34B	38.77	73.62	89.98	0.07	14.98	15.05	6.12	8.857	Low
T34C	43.75	63.86	88.07	0.08	8.92	9.00	3.19	9.750	Low
T34D	29.67	75.81	90.29	0.21	10	10.21	2.99	8.705	Low
T34E	50.70	81.52	91.15	0.00	11.98	11.98	4.47	8.926	Low
T34F	62.50	80.59	91.00	0.05	7.67	7.72	3.24	9.293	Low

5.3.7 Middle Thina

This area forms GRU 8, the Middle Thina from the confluence with the Luzi to T34H. It contains catchments T34G and T34H.

The GRUs consists of rural areas, with dryland irrigation. Significant afforestation exists, especially in T34H, which has resulted in significant baseflow depletion (17%) (DWS, 2017). T34G is moderately dependent on groundwater.

Rocks of the Tarkastad Subgroup underlie most of the GRU, with the Molteno Formation underlying the high lying areas. and Adelaide Subgroup underlie most of the GRU (**Figure 5.8**).

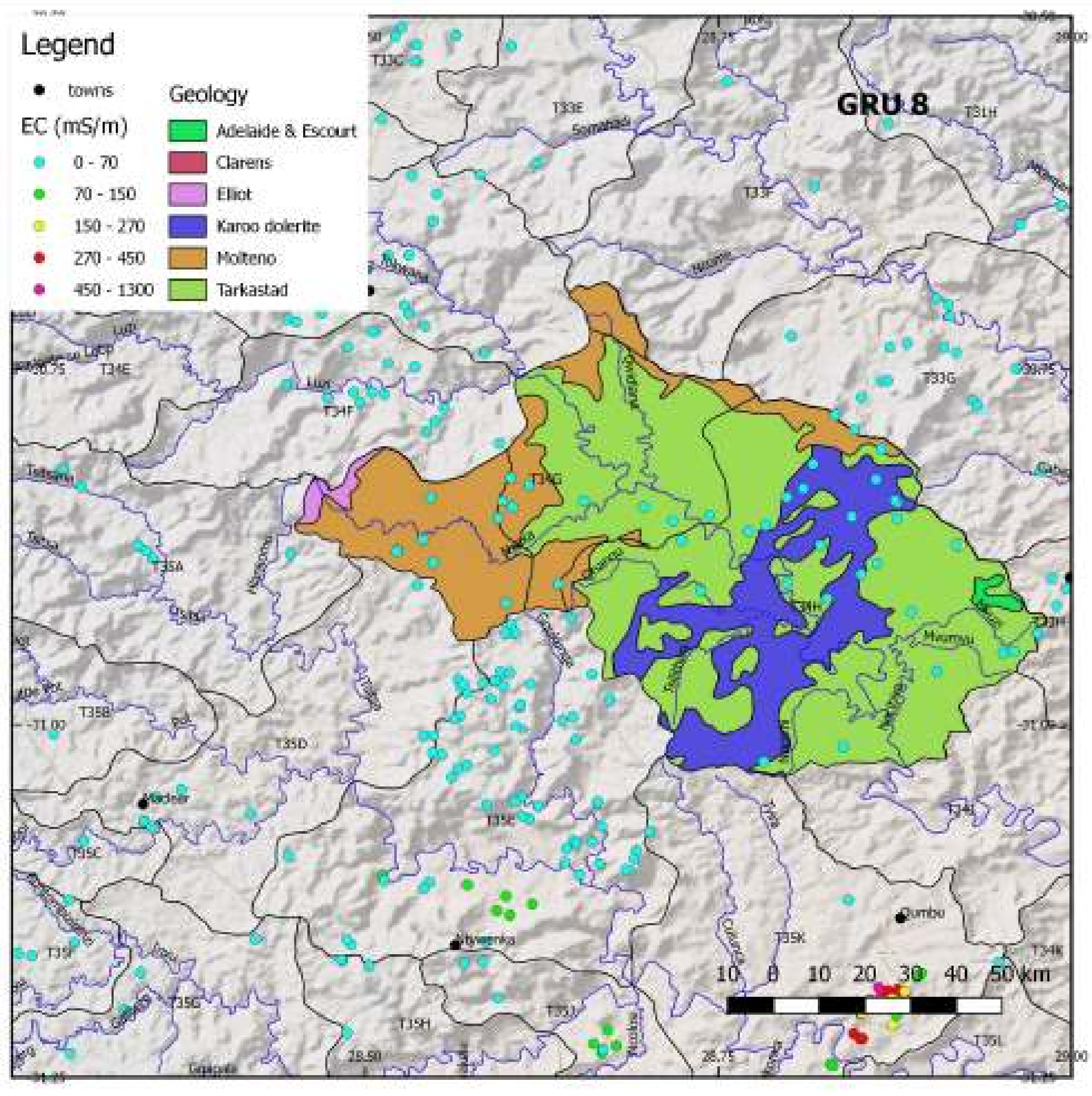

Figure 5.8 Middle Thina GRU

Almost 100% of boreholes are of Class 0 (**Table 5.20**) based on electrical conductivity. Insufficient data exists on nitrates and fluorides.

Groundwater use is very low (stress index < 0.05 of aquifer recharge) (**Table 5.21**). Groundwater dependency is moderate. Based on the low level of groundwater use, both catchments are considered to be of low priority (**Table 5.22**).

Table 5.20 Middle Thina: Water quality distribution

Electrical conductivity													
Quat	**Number of boreholes per Class**					**% of boreholes per Class**					**Percentiles below (mS/m)**		
	0	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	**10**	**50**	**95**
T34G	18	0	0	0	0	100	0	0	0	0	9.30	21.70	40.69
T34H	21	0	1	0	0	95	0	0	0	0	6.00	13.50	48.99
Nitrates													
T34G	1	0	0	0	0	100	0	0	0	0			
Fluorides													
T34G	1	0	0	0	0	100	0	0	0	0			

Table 5.21 Middle Thina: Groundwater use and stress index

Quat	MAP (mm/a)	Area	Recharge	Aquifer recharge	Harvest potential	Groundwater use (Mm^3/a)							Stress index	Present status category
		(km^2)	(Mm^3/a)	(Mm^3/a)	Mm^3/a	Irrigation	Industry	Schedule 1 borehole	Schedule 1 spring	Regional schemes	Total use	Domestic use		
T34G	894	358	86.38	9.979	5.74			0.110	0.024	0.148	0.282	0.282	0.026	A
T34H	863	591	84.79	9.866	9.35			0.060	0.256	0.300	0.617	0.617	0.037	A

Table 5.22 Middle Thina: Groundwater Reserve and allocable groundwater

Quat	GW dependence	Baseflow	Interflow	BHN	EWR	GW component of the Reserve		Allocable GW	Priority
	%	Mm^3/a	% of baseflow	Mm^3/a		Mm^3/a	% of recharge	Mm^3/a	
T34G	57.88	83.76	91.02	0.07	8	8.07	2.25	9.037	Low
T34H	28.67	82.03	90.75	0.31	7	7.31	1.24	8.581	Low

5.3.8 Lower Thina

This area forms GRU 9, the Lower Thina from GRU 8 to the confluence with the Tsitsa. It contains catchments T34J and T34K.

The GRUs consists of rural areas. Some afforestation exists in T34J. Dependency on groundwater is low.

Rocks of the Adelaide Subgroup Formation underlie most of the GRU, with the Tarkastad Formation underlying the upper reaches of T34J (**Figure 5.9**).

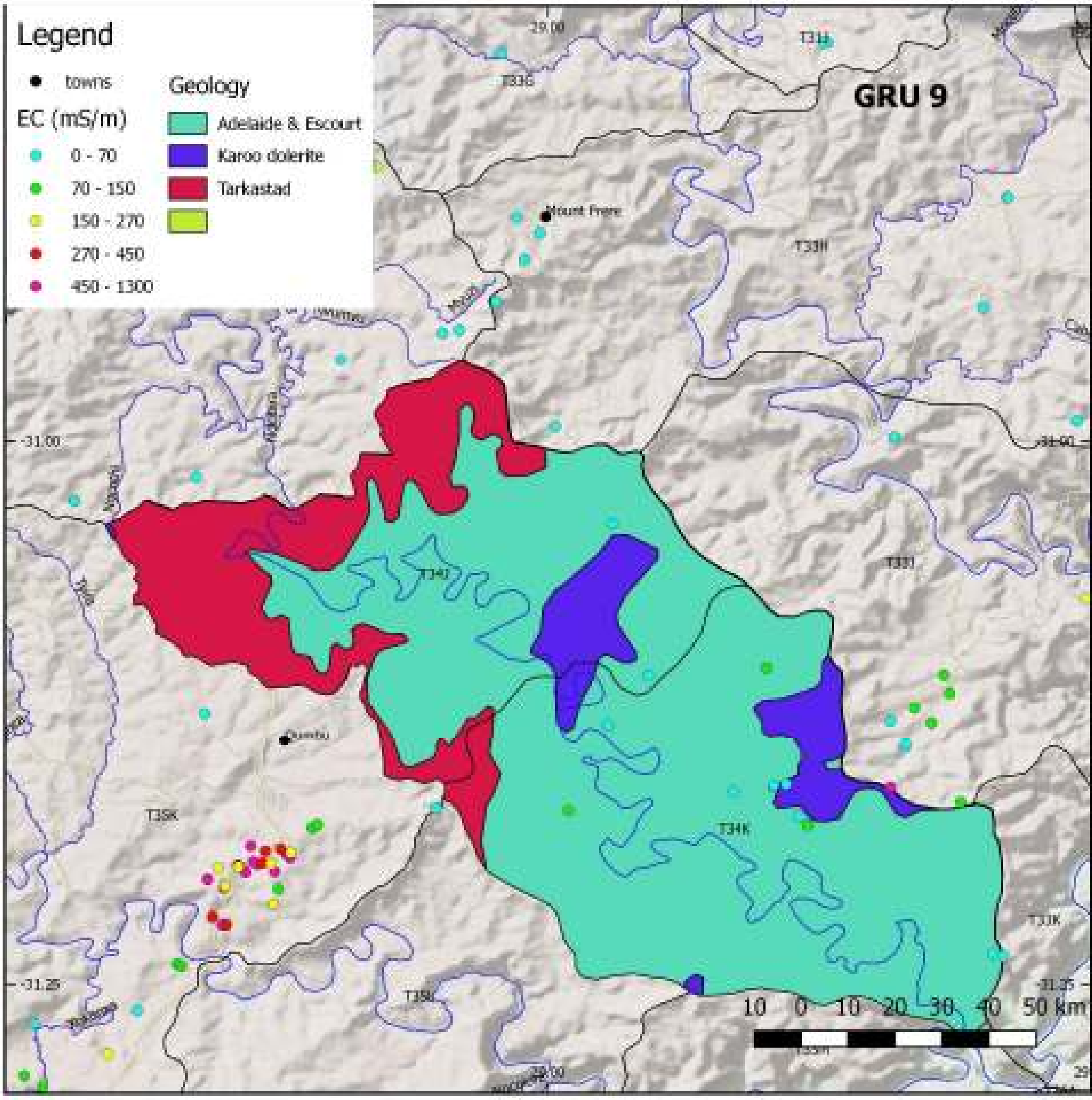

Figure 5.9 Lower Thina GRU

Groundwater quality is variable, and water quality of class 0–4 is found (**Table 5.23**) based on electrical conductivity. Insufficient data exists on nitrates and fluorides.

Groundwater use is very low (stress index < 0.05 of aquifer recharge) (**Table 5.24**). Groundwater dependency is low. Based on the low level of groundwater use, both catchments are considered to be of low priority (**Table 5.25**).

Table 5.23 Lower Thina: Water quality distribution

Electrical conductivity													
Quat	**Number of boreholes per Class**					**% of boreholes per Class**					**Percentiles below (mS/m)**		
	0	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	**10**	**50**	**95**
T34J	4	0	0	0	0	100	0	0	0	0	8.77	33.50	43.95
T34K	7	2	1	0	1	64	18	0	0	9	6.00	42.00	380.00
Nitrates													
Fluorides													

Table 5.24 Lower Thina: Groundwater use and stress index

Quat	MAP (mm/a)	Area	Recharge	Aquifer recharge	Harvest Potential	Groundwater use (Mm3/a)							Stress index	Present status category
		(km^2)	(Mm^3/a)	(Mm^3/a)	Mm^3/a	Irrigation	Industry	Schedule 1 borehole	Schedule 1 spring	Regional schemes	Total use	Domestic use		
T34J	771	297	37.07	10.690	4.35		0.016				0.016	0.000	0.001	A
T34K	715	333	33.48	10.917	4.53			0.054	0.282	0.070	0.406	0.406	0.011	A

Table 5.25 Lower Thina: Groundwater Reserve and allocable groundwater

Quat	GW dependence	Baseflow	Interflow	BHN	EWR	GW component of the Reserve		Allocable GW	Priority
	%	Mm^3/a	% of baseflow	Mm^3/a		Mm^3/a	% of recharge	Mm^3/a	
T34J		33.97	76.41		3	3.00	1.01	9.966	Low
T34K	21.94	29.94	72.76	0.36	2	2.36	0.71	9.850	Low

5.3.9 Upper Tsitsa

GRU 10 consists of the rugged escarpment zone of the Southeastern Highlands of the upper Tsitsa. It contains catchments T35A (Tsitsa and Tsitsana), T35B (Pot and Little Pot), T35C (Mooi), T35D (Tsitsa, Pot and Mooi), T35F (Inxu), and T35G (Gatberg and Gqaqala). T35D contains the town of Maclear and T35F contains the town of Ugie.

The GRUs consists of rangeland, rural areas, with irrigated lands concentrated mostly in T5G. Significant afforestation exists, which has resulted in interflow depletion, especially in the Gat and Inxu. The area is variably dependent on groundwater, with T35A, B, D and G being moderately dependent on groundwater (40–60%), and T35C and F being not dependent (3–4%).

Rocks of the Drakensberg, Clarens, Elliot and Molteno Formations underlie the GRU (**Figure 5.10**).

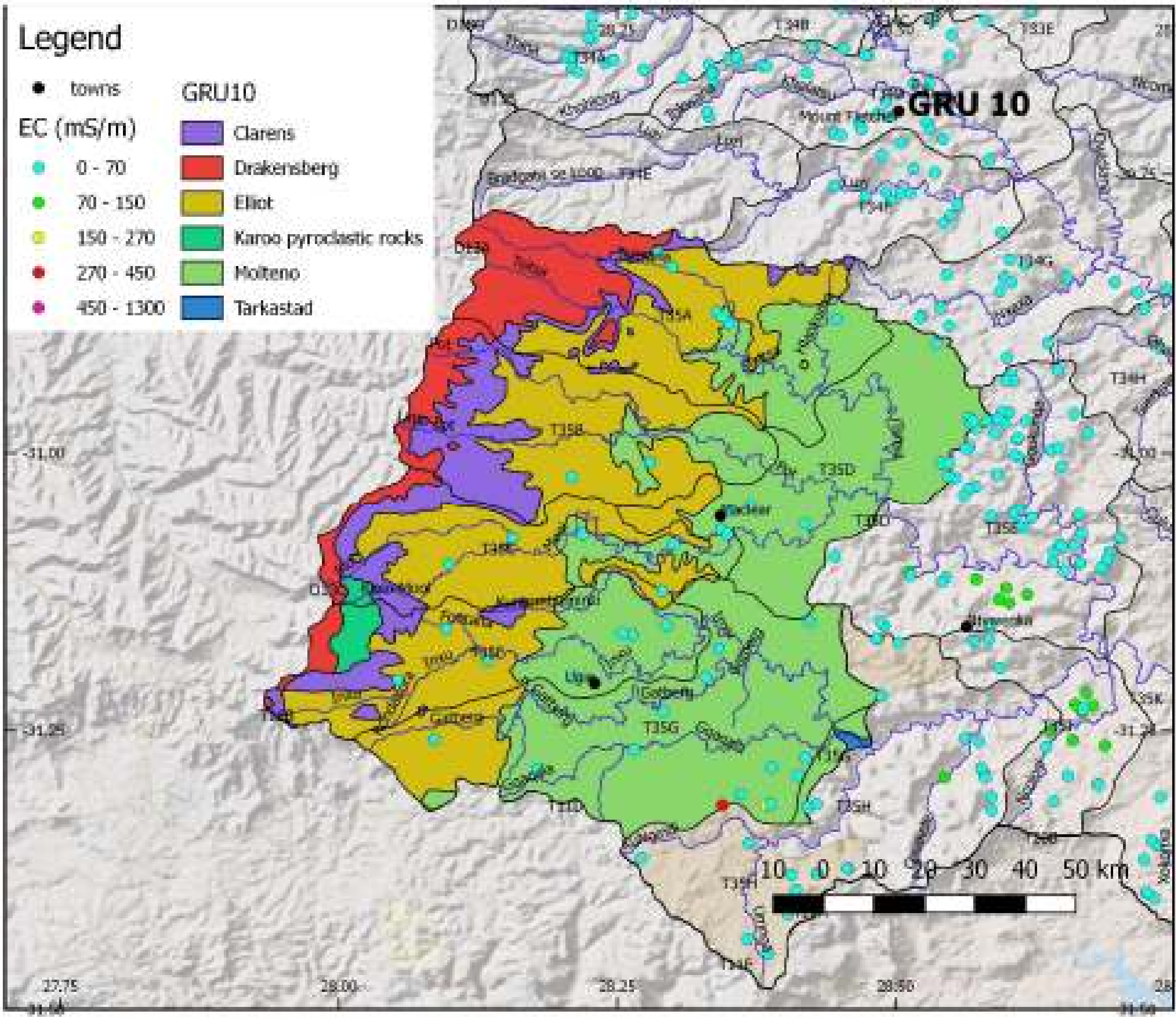

Figure 5.10 Upper Tsitsa GRU

One hundred percent of boreholes are of Class 0 (**Table 5.26**) based on electrical conductivity, except in T35G where some Class 2 and 3 boreholes exist in the Gqaqala catchment. Very little data exists on nitrates and fluorides; however, nitrates are all of Class 0.

Groundwater use is very low (stress index < 0.05 of aquifer recharge) (**Table 5.27**), however, groundwater dependency is moderate in some catchments (40–60%) (**Table 5.28**). Based on the low stress index and only moderate groundwater dependence, all the catchments are considered to be of low priority in this GRU (**Table 5.28**).

Table 5.26 Upper Tsitsa: Water quality distribution

Electrical conductivity													
Quat	**Number of boreholes per Class**					**% of boreholes per Class**					**Percentiles below (mS/m)**		
	0	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	**10**	**50**	**95**
T35A	5	0	0	0	0	100	0	0	0	0	20.40	25.00	29.40
T35B	3	0	0	0	0	100	0	0	0	0	20.60	27.00	58.50
T35C	4	0	0	0	0	100	0	0	0	0	7.20	11.00	23.05
T35D	13	0	0	0	0	100	0	0	0	0	2.30	6.70	26.20
T35F	8	0	0	0	0	100	0	0	0	0	5.00	16.00	34.30
T35G	13	0	1	1	0	87	0	0	7	0	9.20	20.00	260.00
Nitrates													
T35B	4	0	0	0	0	100	0	0	0	0			
T35C	6	0	0	0	0	100	0	0	0	0			
T35D	1	0	0	0	0	100	0	0	0	0			
T35F	1	0	0	0	0	100	0	0	0	0			
T35G	1	0	0	0	0	100	0	0	0	0			
Fluorides													
T35B	4	0	0	0	0	100	0	0	0	0			
T35C	4	0	0	2	0	67	0	0	33	0			
T35D	1	0	0	0	0	100	0	0	0	0			
T35F	1	0	0	0	0	100	0	0	0	0			
T35G	1	0	0	0	0	100	0	0	0	0			

Table 5.27 Upper Tsitsa: Groundwater use and stress index

Quat	MAP (mm/a)	Area	Recharge	Aquifer recharge	Harvest potential	Groundwater use (Mm^3/a)							Stress index	Present status category
		(km^2)	(Mm^3/a)	(Mm^3/a)	Mm^3/a	Irrigation	Industry	Schedule 1 borehole	Schedule 1 spring	Regional schemes	Total use	Domestic use		
T35A	912	475	92.37	9.143	9.34			0.104	0.075	0.000	0.179	0.179	0.011	A
T35B	915	396	93.13	9.152	6.04			0.003	0.005	0.000	0.008	0.008	0.000	A
T35C	1008	306	114.27	8.253	11.02			0.005	0.010	0.006	0.020	0.020	0.001	A
T35D	818	348	77.79	9.974	5.5			0.051	0.016	0.019	0.086	0.086	0.007	A
T35F	860	359	85.63	9.897	5.57		0.001	0.003	0.007	0.010	0.021	0.021	0.001	A
T35G	759	575	67.62	11.076	7.9		0.001	0.022	0.014	0.079	0.116	0.115	0.009	A
		2459	530.81	57.50	45.37	0.000	0.002	0.189	0.126	0.114	0.430	0.429		

Table 5.28 Upper Tsitsa: Groundwater Reserve and allocable groundwater

Quat	GW dependence	Baseflow	Interflow	BHN	EWR	GW component of the Reserve		Allocable GW	Priority
	%	Mm^3/a	% of baseflow	Mm^3/a		Mm^3/a	% of recharge	Mm^3/a	
T35A	60.33	90.86	92.21	0.07	28.25	28.32	5.96	6.868	Low
T35B	49.59	91.51	92.32	0.00	22.17	22.17	5.60	7.445	Low
T35C	4.15	112.65	94.07	0.01	25.89	25.90	8.47	6.698	Low
T35D	53.40	75.67	90.28	0.03	14	14.03	4.03	8.558	Low
T35F	3.03	82.56	91.30	0.01	12	12.01	3.34	8.836	Low
T35G	38.12	63.60	87.98	0.04	8	8.04	1.40	9.995	Low

5.3.10 Middle Tsitsa

GRU 11 consists of the middle Tsitsa from GRU 10 to below Qumbu. It contains catchments T35E (Tsitsa), T35H (Umanga and Qwakele), T35J (Mooi), T35D (Qwakele and Ncolisi), and T35K (Tsitsa). T35E contains the town of Ntywenka, and T35K contains the towns of Qumbu and Tsolo.

The GRUs consists of rural areas, with significant afforestation in T35J and K. The area is moderately dependent on groundwater (25–50%).

Rocks of the Molteno Formation and Tarkastad Subgroup underlie the GRU (**Figure 5.11**).

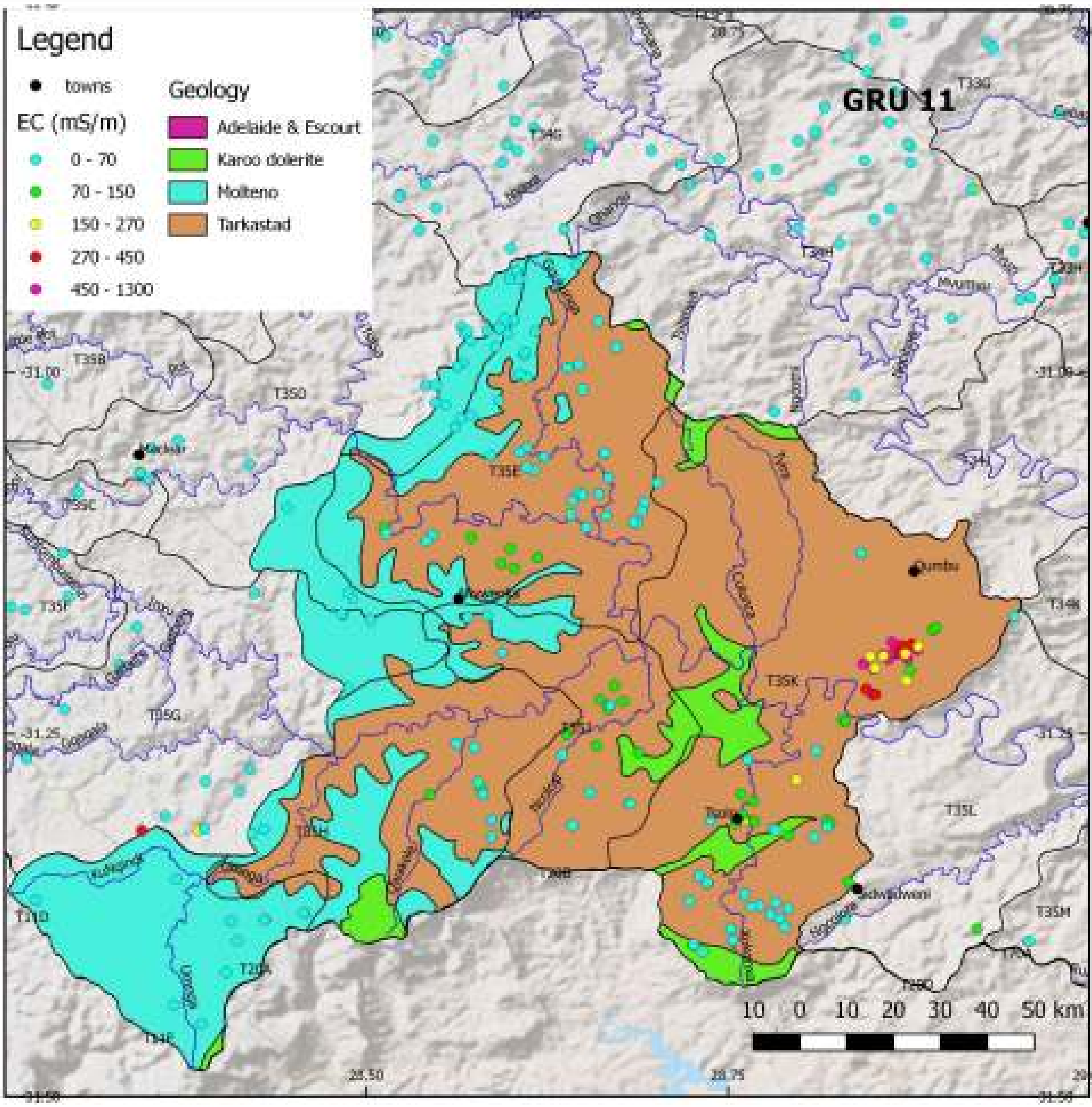

Figure 5.11 Middle Tsitsa GRU

Groundwater quality is of Class 0 and 1 (**Table 5.29**) based on electrical conductivity, except in T35K where water quality is variable between Class 0–4. Very little data exists on nitrates and fluorides.

Groundwater use is very low (stress index < 0.05 of aquifer recharge), except in T35K where it is low (< 0.15) (**Table 5.30**). Groundwater dependence is moderate (25–50%) (**Table 5.31**). Based on the low stress index and only moderate groundwater dependence, all the catchments are considered to be of low priority in this GRU (**Table 5.31**).

Table 5.29 Middle Tsitsa: Water quality distribution

Electrical conductivity													
Quat	**Number of boreholes per Class**					**% of boreholes per Class**					**Percentiles below (mS/m)**		
	0	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	**10**	**50**	**95**
T35E	58	6	0	0	0	91	9	0	0	0	2.73	15.45	81.80
T35H	25	3	0	0	0	89	11	0	0	0	19.76	30.65	80.89
T35J	8	8	1	0	0	47	47	0	0	0	19.72	75.00	153.20
T35K	26	17	8	10	10	37	24	0	14	14	13.30	107.30	680.00
Nitrates													
T35H	1	0	0	0	0	100	0	0	0	0			
T35J	0	1	0	0	0	0	100	0	0	0			
Fluorides													
T35H	1	0	0	0	0	100	0	0	0	0			
T35J	1	0	0	0	0	100	0	0	0	0			

Table 5.30 Middle Tsitsa: Groundwater use and stress index

Quat	MAP (mm/a)	Area	Recharge	Aquifer recharge	Harvest potential	Groundwater use (Mm^3/a)							Stress index	Present status category
		(km^2)	(Mm^3/a)	(Mm^3/a)	Mm^3/a	Irrigation	Industry	Schedule 1 borehole	Schedule 1 spring	Regional schemes	Total use	Domestic use		
T35E	918	492	97.94	8.738	6.69			0.071	0.053	0.094	0.217	0.217	0.019	A
T35H	845	520	86.44	9.645	8.23			0.147	0.043	0.230	0.420	0.420	0.039	A
T35J	924	188	107.80	8.893	3.31			0.028	0.102	0.116	0.246	0.246	0.016	A
T35K	783	625	80.88	10.147	10.99			0.052	0.085	1.460	1.596	1.596	0.149	B
		1825	373.06	37.42	29.22	0.000	0.000	0.298	0.282	1.899	2.479	2.479		

Table 5.31 Middle Tsitsa: Groundwater Reserve and allocable groundwater

Quat	GW dependence	Baseflow	Interflow	BHN	EWR	GW component of the Reserve		Allocable GW	Priority
	%	Mm^3/a	% of baseflow	Mm^3/a		Mm^3/a	% of recharge	Mm^3/a	
T35E	24.59	96.56	92.80	0.12	15	15.12	3.07	7.439	Low
T35H	31.51	83.34	91.38	0.19	10	10.19	1.96	8.343	Low
T35J	38.13	105.71	93.62	0.10	10	10.10	5.37	8.029	Low
T35K	47.94	77.67	90.31	0.23	7	7.23	1.16	7.757	Low

5.3.11 Lower Tsitsa

This area forms GRU 12, the Lower Tsitsa from GRU 8 to the confluence with the Thina. It contains catchments T35L and T35M.

The GRUs consists of rural areas. Some afforestation exists in T35L. Dependency on groundwater is low.

Rocks of the Adelaide Subgroup Formation underlie most of the GRU, with the Tarkastad Subgroup underlying the upper reaches of T35L (**Figure 5.12**).

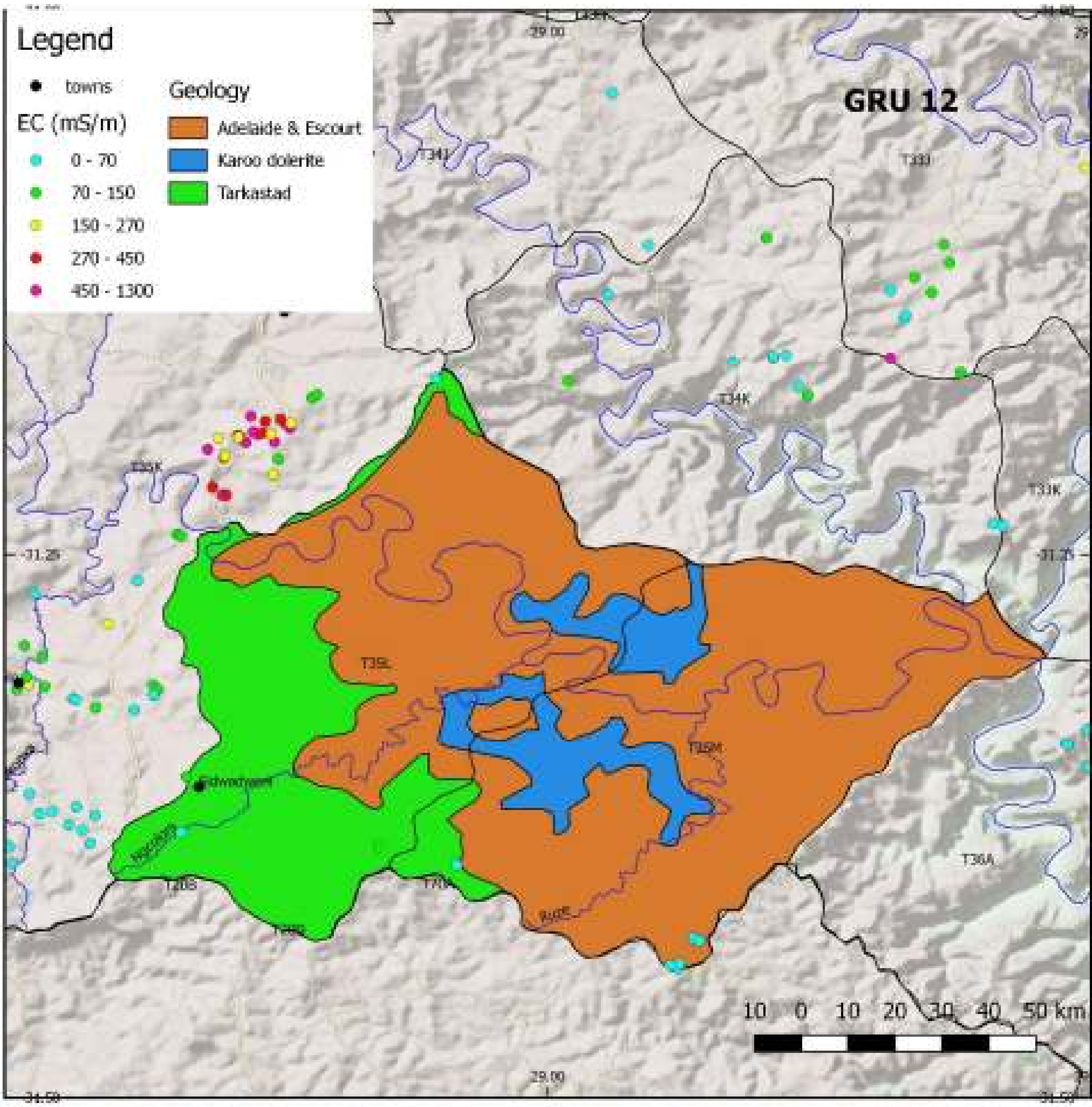

Figure 5.12 Lower Tsitsa GRU

Little data is available on groundwater quality, however, water quality of Class 0 and 1 (**Table 5.32**) based on electrical conductivity. Insufficient data exists on nitrates and fluorides.

Groundwater use is very low (stress index < 0.05 of aquifer recharge) (**Table 5.33**). Groundwater dependency is low (< 15%). Based on the low level of groundwater use, both catchments are considered to be of low priority (**Table 5.34**).

Table 5.32 Lower Tsitsa: Water quality distribution

Electrical conductivity													
Quat	**Number of boreholes per Class**					**% of boreholes per Class**					**Percentiles below (mS/m)**		
	0	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	**10**	**50**	**95**
T35L	1	1	0	0	0	50	50	0	0	0	53.85	61.25	69.58
T35M	7	1	0	0	0	88	13	0	0	0	0.10	0.30	67.50
Nitrates													
Fluorides													

Table 5.33 Lower Tsitsa: Groundwater use and stress index

Quat	MAP (mm/a)	Area	Recharge	Aquifer recharge	Harvest potential	Groundwater use (Mm^3/a)							Stress index	Present status category
		(km^2)	(Mm^3/a)	(Mm^3/a)	Mm^3/a	Irrigation	Industry	Schedule 1 borehole	Schedule 1 spring	Regional schemes	Total use	Domestic use		
T35L	764	340	38.08	10.799	5.13		0.014	0.065	0.041	0.146	0.266	0.252	0.021	A
T35M	861	305	54.38	9.545	4.17			0.013	0.011	0.122	0.146	0.146	0.014	A

Table 5.34 Lower Tsitsa: Groundwater Reserve and allocable groundwater

Quat	GW dependence	Baseflow	Interflow	BHN	EWR	GW component of the Reserve		Allocable GW	Priority
	%	Mm^3/a	% of baseflow	Mm^3/a		Mm^3/a	% of recharge	Mm^3/a	
T35L	8.68	34.72	76.29	0.21	3	3.21	0.94	9.672	Low
T35M	13.49	52.98	85.38	0.09	4	4.09	1.34	8.740	Low

5.3.12 Lower Mzimvubu

This area forms GRU 13, the Lower Mzimvubu from the confluence with the Thina and Tsitsa to the sea. It contains catchments T36A and T36B. It contains the town of Port St Johns at the coast.

The GRUs consists of rural areas. Some irrigation occurs in both catchments. Dependency on groundwater is low.

Rocks of the Adelaide Subgroup and Ecca Group underlie most of the GRU, with the Dwyka Group outcropping in T36B (**Figure 5.13**).

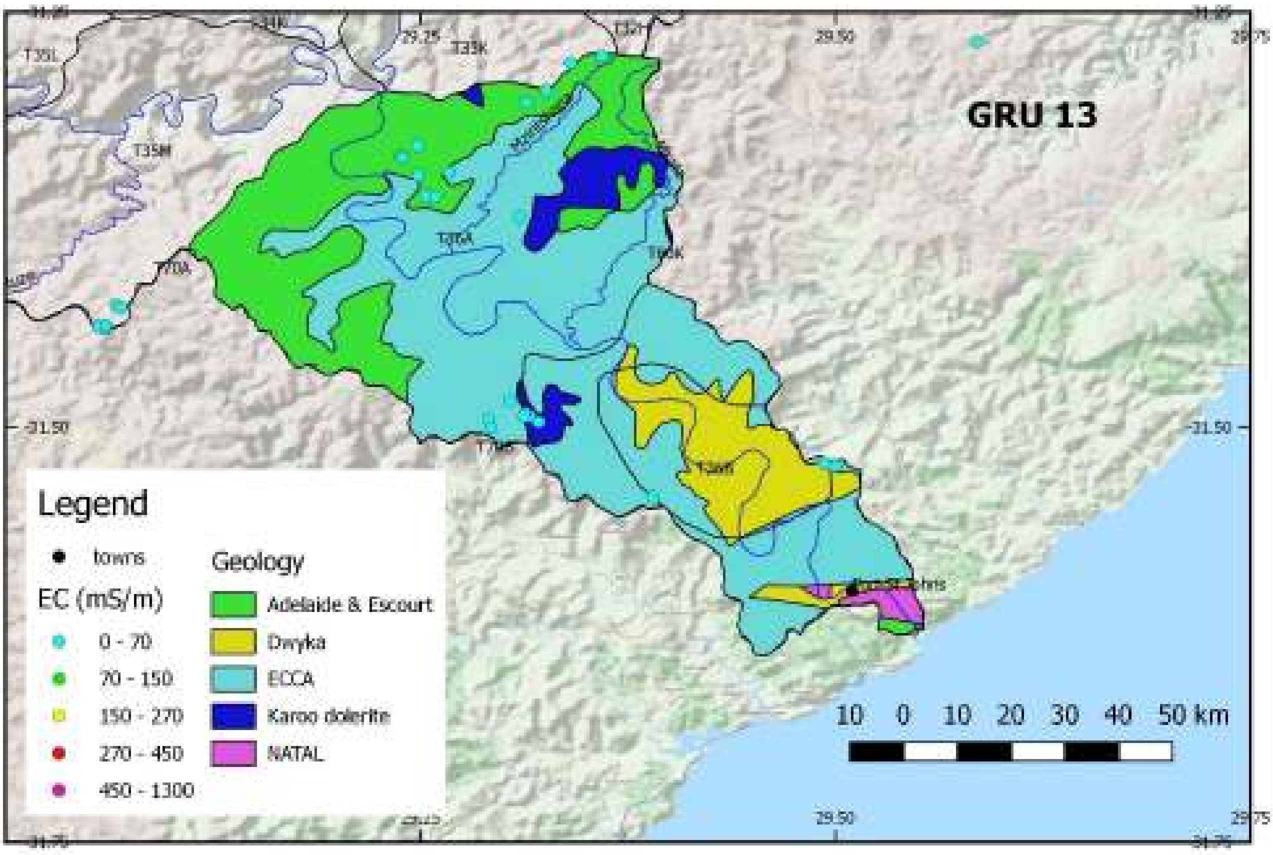

Figure 5.13 Lower Mzimvubu GRU

Groundwater quality is of Class 0 (**Table 5.35**) based on electrical conductivity. Insufficient data exists on nitrates and fluorides.

Groundwater use is very low (stress index < 0.05 of aquifer recharge) (**Table 5.36**). Groundwater dependency is low (< 10%). Based on the low level of groundwater use, both catchments are considered to be of low priority (**Table 5.37**).

Table 5.35 Lower Mzimvubu: Water quality distribution

Electrical conductivity													
Quat	**Number of boreholes per Class**					**% of boreholes per Class**					**Percentiles below (mS/m)**		
	0	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	**10**	**50**	**95**
T36A	16	0	0	0	0	100	0	0	0	0	0.10	0.25	10.90
T36B	6	0	0	0	0	100	0	0	0	0	0.10	0.15	0.20
Nitrates													
T36B	3	0	0	0	0	100	0	0	0	0			
Fluorides													
T36B	3	0	0	0	0	100	0	0	0	0			

Table 5.36 Lower Mzimvubu: Groundwater use and stress index

Quat	MAP (mm/a)	Area	Recharge	Aquifer recharge	Harvest potential	Groundwater use (Mm³/a)							Stress index	Present status category
		(km²)	(Mm³/a)	(Mm³/a)	Mm³/a	Irrigation	Industry	Schedule 1 borehole	Schedule 1 spring	Regional schemes	Total use	Domestic use		
T36A	930	462	70.17	12.693	6.28			0.023	0.086	0.000	0.109	0.109	0.002	A
T36B	1029	265	92.12	9.188	3.61			0.013	0.031	0.000	0.043	0.043	0.001	A

Table 5.37 Lower Mzimvubu: Groundwater Reserve and allocable groundwater

Quat	GW dependence	Baseflow	Interflow	BHN	EWR	GW component of the Reserve		Allocable GW	Priority
	%	Mm³/a	% of baseflow	Mm³/a		Mm³/a	% of recharge	Mm³/a	
T36A	9.19	61.54	93.69	0.29	4	4.29	0.93	12.129	Low
T36B	4.58	87.25	95.86	0.16	3	3.16	1.19	8.898	Low

5.3.13 Middle Mzimvubu

GRU 14 consists of the middle Mzimvubu from T31J to the confluence with the Mzintlava. It contains catchments T31J, T33H and T33J. T33H contains the town of Mount Frere, and T33J contains the towns of Tabankulu.

The GRUs consists of rural areas and dryland farming, with significant irrigation in T31J. Some afforestation exists in T33H and J. The area is not very dependent on groundwater (<25%).

Nickel deposits in T33H pose a moderate threat to groundwater if mining occurs.

Rocks of the Adelaide Subgroup underlie most of the GRU, with significant outcrop of dolerite sheets (**Figure 5.14**).

Groundwater quality is of Class 0 in T31J, but highly variable from Class 0–4 in T33 H and J (**Table 5.38**). Very little data exists on nitrates and fluorides; however, boreholes seem to be of Class 0 and 1.

Groundwater use is very low (stress index < 0.05 of aquifer recharge), except in T33H where it is low (0.10) due to water supply to Mount Frere (**Table 5.39**). Groundwater dependence is low (< 25%) (**Table 5.40**). Based on the low stress index and groundwater dependence, all the catchments are considered to be of low priority in this GRU (**Table 5.40**).

Table 5.38 Middle Mzimvubu: Water quality distribution

Electrical conductivity													
Quat	**Number of boreholes per Class**					**% of boreholes per Class**					**Percentiles below (mS/m)**		
	0	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	**10**	**50**	**95**
T31J	22	0	0	0	0	100	0	0	0	0	0.54	14.90	55.95
T33H	8	0	0	2	2	67	0	0	17	17	T33H	8	0
T33J	35	9	1	0	0	78	20	0	0	0	T33J	35	9
Nitrates													
T33H	5	1	0	0	0	83	17	0	0	0			
T33H	5	1	0	0	0	83	17	0	0	0			
Fluorides													
T31J	10	0	2	0	0	83	0	17	0	0			
T33H	5	1	0	0	0	83	17	0	0	0			

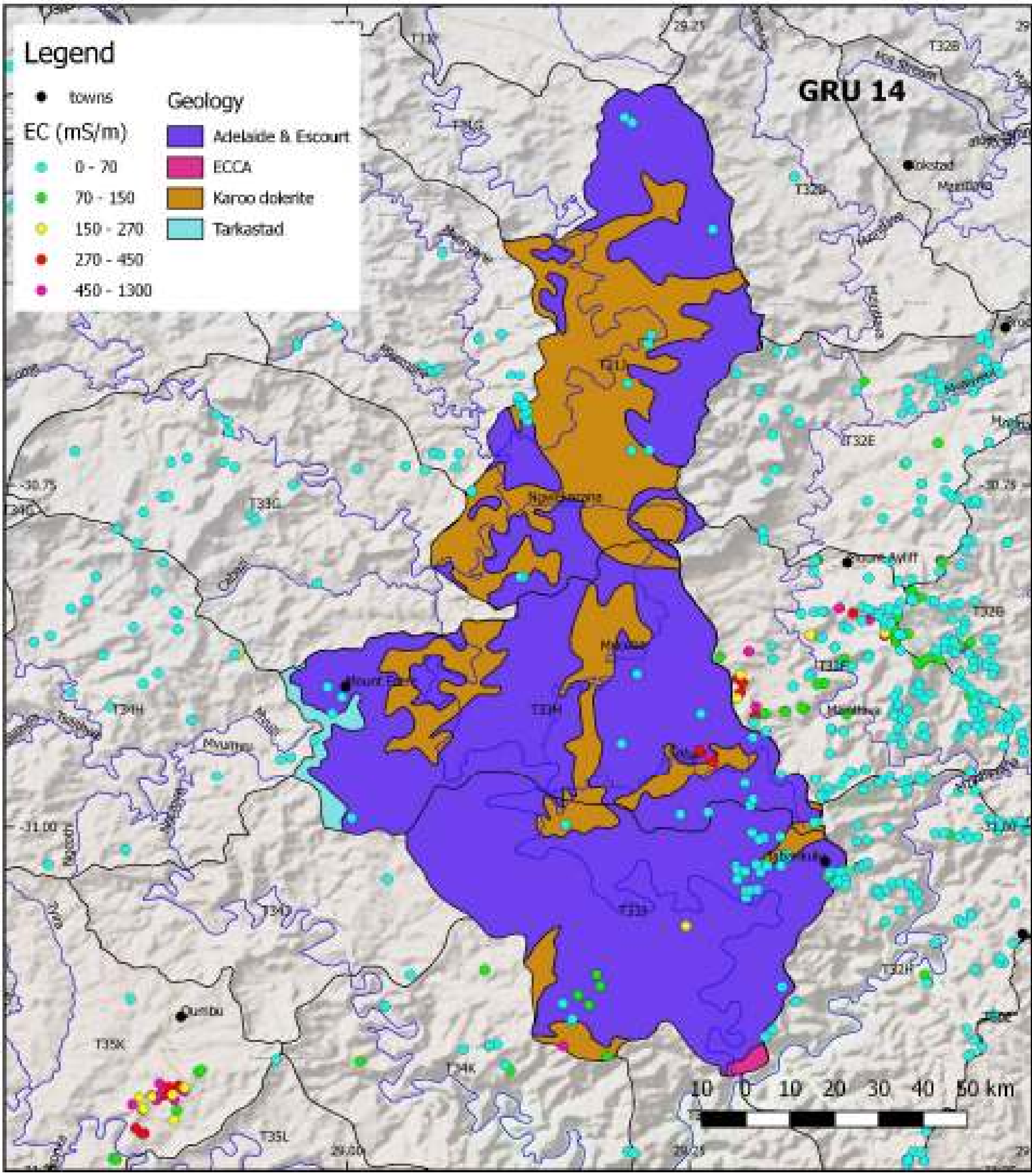

Figure 5.14 Middle Mzimvubu GRU

Table 5.39 Middle Mzimvubu: Groundwater use and stress index

Quat	MAP (mm/a)	Area	Recharge	Aquifer recharge	Harvest potential	Groundwater use (Mm^3/a)							Stress index	Present status category
		(km^2)	(Mm^3/a)	(Mm^3/a)	Mm^3/a	Irrigation	Industry	Schedule 1 borehole	Schedule 1 spring	Regional schemes	Total use	Domestic use		
T31J	807	507	38.30	10.275	6.9			0.035	0.077	0.069	0.181	0.181	0.010	A
T33H	780	517	39.24	10.636	8.09			0.149	0.151	0.922	1.222	1.222	0.101	B
T33J	730	457	33.15	9.383	6.22			0.053	0.070	0.099	0.222	0.222	0.016	A

Table 5.40 Middle Mzimvubu: Groundwater Reserve and allocable groundwater

Quat	GW dependence	Baseflow	Interflow	BHN	EWR	GW component of the Reserve		Allocable GW	Priority
	%	Mm^3/a	% of baseflow	Mm^3/a		Mm^3/a	% of recharge	Mm^3/a	
T31J	24.59	36.22	78.35	0.09	21.26	21.35	4.21	5.496	Low
T33H	24.91	36.07	77.41	0.39	7.19	7.58	1.47	7.607	Low
T33J	12.24	32.54	74.60	0.32	8	8.32	1.82	6.850	Low

6 SUMMARY AND CONCLUSIONS

Groundwater resources in all tertiary catchments of the Mzimvubu T3 catchment are underutilised. Total use is only 22 Mm^3/a, from an available harvest potential of 317 Mm^3/a and an aquifer recharge of 492 Mm^3/a. The bulk of groundwater is utilised for domestic water supply, of which 50% is for regional schemes (**Table 6.1**).

Of the 51 quaternary catchments, 42 can be classified as having a present status category of A (stress index < 0.05), 7 as B (stress index < 0.2), and only 2 are classified as C (stress index < 0.4). Only catchments T31F and T33A, near Cedarville and Matatiele respectively, can be considered of moderate priority due to abstraction, however, T33A is less than 50% groundwater dependent.

Only 29% of the population is groundwater dependent (**Table 6.2**).

Baseflow is 2899 Mm^3/a, 87% of which is derived as interflow from springs above the regional groundwater level. The EWR from groundwater is 573.56 Mm^3/a and the BHNR is 6.2 Mm^3/a, resulting in a groundwater component of the Reserve of 580 Mm^3/a, which is only 2.9% of recharge. This means that 387 Mm^3/a of groundwater can still be allocated, of a recharge of 3036 Mm^3/a.

Groundwater is generally of good quality, with 85% of samples being of Class 0, 8% of Class 1, and 2% of Class 2. The samples of poor water quality in terms of high electrical conductivity are found in a linear belt from Qumbu to Mount Ayliff across various lithologies.

Table 6.1 Summary of groundwater resources and water use

Quat	Area	Recharge	Aquifer recharge	Harvest potential	Groundwater use (Mm^3/a)							Stress index	Present status category
	(km^2)	(Mm^3/a)	(Mm^3/a)	Mm^3/a	Irrigation	Industry	Sched. 1 borehole	Sched.1 spring	Regional schemes	Total use	Domestic use		
T31	3597	371.466	86.214	58.890	3.481	0.000	0.339	0.404	0.208	4.432	0.951	0.047	A
T32	2950	383.186	68.966	40.650	0.841	0.012	0.483	0.829	1.769	3.934	3.081	0.045	A
T33	4452	402.893	96.336	69.220	0.000	0.141	0.743	1.035	5.887	7.807	7.666	0.070	B
T34	3197	720.057	103.052	54.930	0.000	0.016	0.554	0.907	0.868	2.344	2.328	0.014	A
T35	4929	996.339	115.263	83.890	0.000	0.016	0.565	0.460	2.282	3.322	3.306	0.025	A
T36	727	162.291	21.881	9.890	0.000	0.000	0.036	0.116	0.000	0.152	0.152	0.002	A
Total	19852	3036.231	491.711	317.470	4.322	0.185	2.720	3.751	11.013	21.991	17.484	0.037	A

Table 6.2 Summary of the groundwater Reserve and allocable groundwater

Quat	GW dependence	Baseflow	Interflow%	BHN	EWR	GW component of the Reserve		Allocable GW
	%	Mm^3/a	%	Mm^3/a		Mm^3/a	% of recharge	Mm^3/a
T31	32.06	349.209	81.01	0.453	96.490	96.943	2.70	63.663
T32	22.89	363.246	85.85	1.234	86.050	87.284	2.96	52.760
T33	35.78	382.652	80.36	1.812	133.560	135.372	3.04	61.912
T34	32.21	687.449	89.04	1.197	91.150	92.347	2.89	90.854
T35	25.46	967.810	90.97	1.096	159.310	160.406	3.25	97.391
T36	6.87	148.793	94.96	0.452	7.000	7.452	1.03	21.054
Total	28.78	2899.159	87.48	6.244	573.560	579.804	2.92	387.635

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APPENDIX A: COMMENTS REPORT