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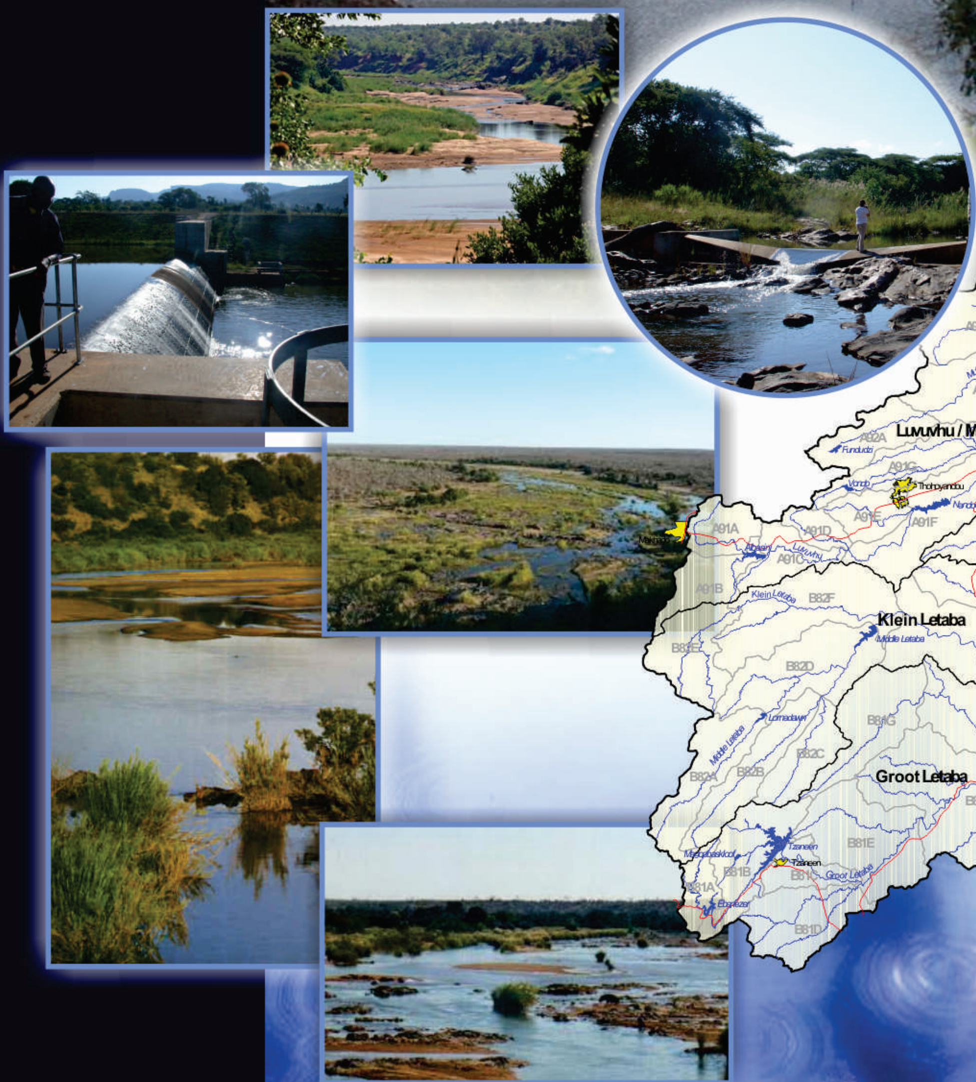
DIRECTORATE: NATIONAL WATER RESOURCE PLANNING

Development of a Reconciliation Strategy for the Luvuvhu and Letaba Water Supply System

GROUNDWATER UTILIZATION SCENARIOS



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DEVELOPMENT OF A RECONCILIATION STRATEGY FOR THE LUVUVHU AND LETABA WATER SUPPLY SYSTEM

GROUNDWATER UTILIZATION SCENARIOS REPORT

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Authors:	*K Sami*
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Directorate: National Water Resource Planning

Approved for DWA by:

....

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Acting Director: National Water Resource Planning

LIST OF REPORTS

The following reports form part of this study:

Report Title	Report number
Inception Report	P WMA 02/B810/00//1412/1
Literature Review Report	P WMA 02/B810/00//1412/2
Water requirements and Return Flow Report	P WMA 02/B810/00//1412/3
Rainfall analysis report	P WMA 02/B810/00//1412/4
Hydrology report (includes IAP)	P WMA 02/B810/00//1412/5
Water Conservation and Water Demand Management Report	P WMA 02/B810/00//1412/6
Water re-use report	P WMA 02/B810/00//1412/7
Water Quality Assessment Report	P WMA 02/B810/00//1412/8
Groundwater utilization scenarios	**P WMA 02/B810/00//1412/9**
Yield Analysis Report (include EWR)	P WMA 02/B810/00//1412/12
Planning Analysis Report	P WMA 02/B810/00//1412/13
Water Supply Schemes, Social and Environmental Aspects	P WMA 02/B810/00//1412/14
Final Reconciliation Strategy Report	P WMA 02/B810/00//1412/15
Executive Summary of Final Reconciliation Strategy	P WMA 02/B810/00//1412/16
Demographic and Economic Development Potential	P WMA 02/B810/00//1412/17

DEVELOPMENT OF A RECONCILIATION STRATEGY FOR THE LUVUVHU AND LETABA WATER SUPPLY SYSTEM

Groundwater Utilization Scenarios

EXECUTIVE SUMMARY

The Department of Water Affairs (DWA) has identified the need for the Reconciliation Study for the Luvuvhu-Letaba WMA. The WMA is almost fully developed and demands from the Letaba River currently exceed the yield capability of the system. Regulation for the Letaba WMA is mainly provided by Middle Letaba, Ebenezer and Tzaneen Dams. In the Luvuvhu WMA the recently completed Nandoni Dam will be used in combination with Albasini, Vondo and Damani dams to be managed as one system. It is expected that the total yield from this combined system will be fully utilized by around 2020, considering only the current planned projected demands. The yield of the Albasini Dam has reduced over the years and as a consequence the dam is over allocated. The Shingwedzi catchment is situated almost entirely in the Kruger National Park and for all practical purposes no sustainable yield is derived from surface flow in the Shingwedzi catchment.

The main objective of the study is to compile a Reconciliation Strategy that will identify and describe water resource management interventions that can be grouped and phased to jointly form a solution to reconcile the water requirements with the available water for the period up to the year 2040 and to develop water availability assessment methodologies and tools applicable to this area that can be used for decision support as part of compulsory licensing to come. The development of the strategy requires reliable information on the water requirements and return flows (wastewater) as well as the available water resources for the current situation and likely future scenarios for a planning horizon of thirty years.

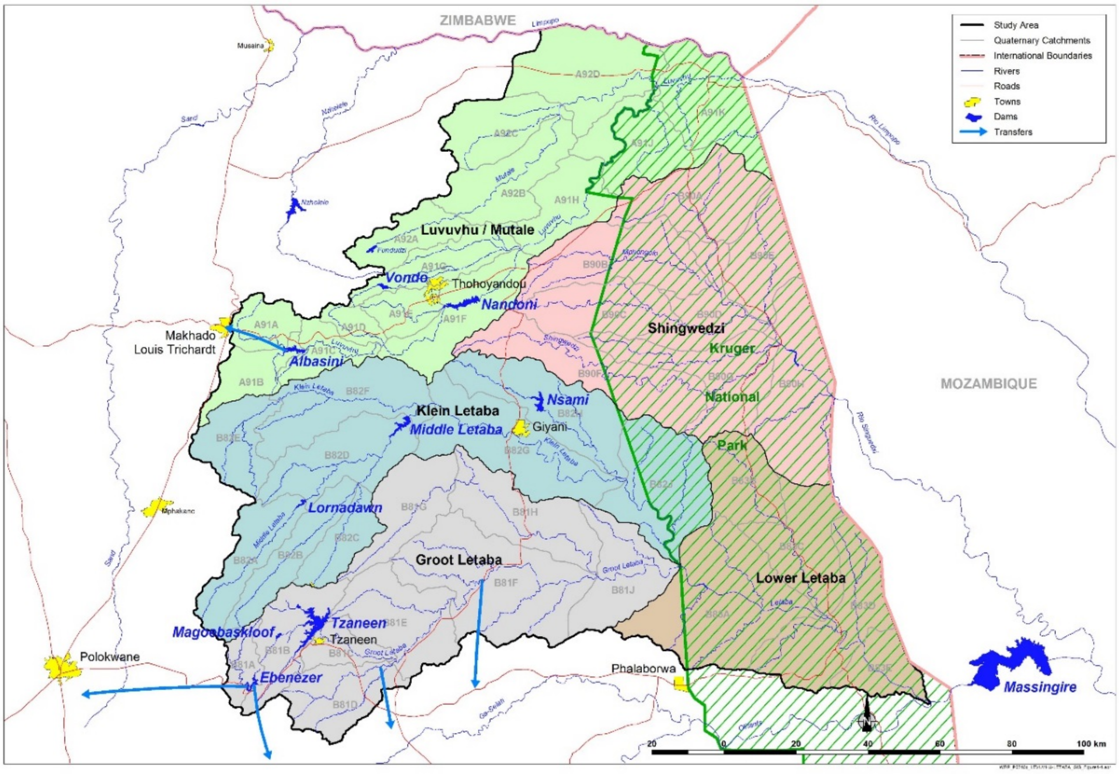
To achieve the above objectives, the following main aspects will be covered in the study:

- *Update the current and future urban and agricultural water requirements and return flows;*
- *Assess the water resources and existing infrastructure;*

- *Configure the system models (WRSM2005, WRYM, WRPM) in the Study Area at a quaternary catchment scale, or finer where required, in a manner that is suitable for allocable water quantification;*
- *To firm up on the approach and methodology, as well as modelling procedures, for decision support to the on-going licensing processes;*
- *To use system models, in the early part of the study, to support allocable water quantifications in the Study Area and, in the latter part of the study, to support ongoing licensing decisions, as well as providing information for the development of the Reconciliation Strategy;*
- *Formulate reconciliation interventions, both structural and administrative/regulatory;*
- *Document the reconciliation process including decision processes that are required by the strategy; and*
- *Conduct stakeholder consultation in the development of the strategy*.

Study Area

The study area comprises of the water resources of the catchment of the Luvuvhu, Mutale, Letaba and Shingwedzi rivers linked to adjacent systems as indicated by the inter-basin transfers (figures below). This area represents the entire WMA 2 and includes tertiary catchments A91, A92, B81, B82, B83 and B90. Adjacent areas supplying water to this WMA or getting water from this WMA are also part of the study area.



Purpose and Objectives

The purpose of this report is to present a compilation of the available data on groundwater resources. The report utilises data from the modelling of the hydrology using WRSM2000 to generate new surface-groundwater interaction data. The hydrological simulation calibrated the time series of recharge and baseflow, utilising time series of afforestation, alien vegetation, growth in dams, and surface and groundwater abstraction, against gauging station and dam level data. The time series was naturalised to derive mean annual values of recharge and baseflow, to quantify groundwater resources, and identify areas of groundwater surplus and shortfall to reconcile groundwater availability with demand.

- *describes the hydrogeological characteristics of identified groundwater regions*
- *summarises the groundwater use and existing capacity of groundwater schemes*
- *presents an analysis of groundwater availability in each Quaternary catchment and within each water supply scheme*
- *reconciles groundwater availability with demand*
- *provides an analysis of potential groundwater development options and limitations*.

Groundwater resources were assessed in terms of:

- *Quaternary catchment*
- *Hydrogeological unit*
- *Water supply scheme*

Data Sources

The investigation was based on existing data collated from the National Groundwater Data Base, the National Groundwater Archive, the GRIP data base, the GRAII data base, the Harvest Potential map and data base of South Africa in WSAM, WARMS, a Water use validation and verification study, the All towns studies, and on additional data on the time series of recharge and baseflow was derived during this study by detailed sub-Quaternary WRSM2000 modelling.

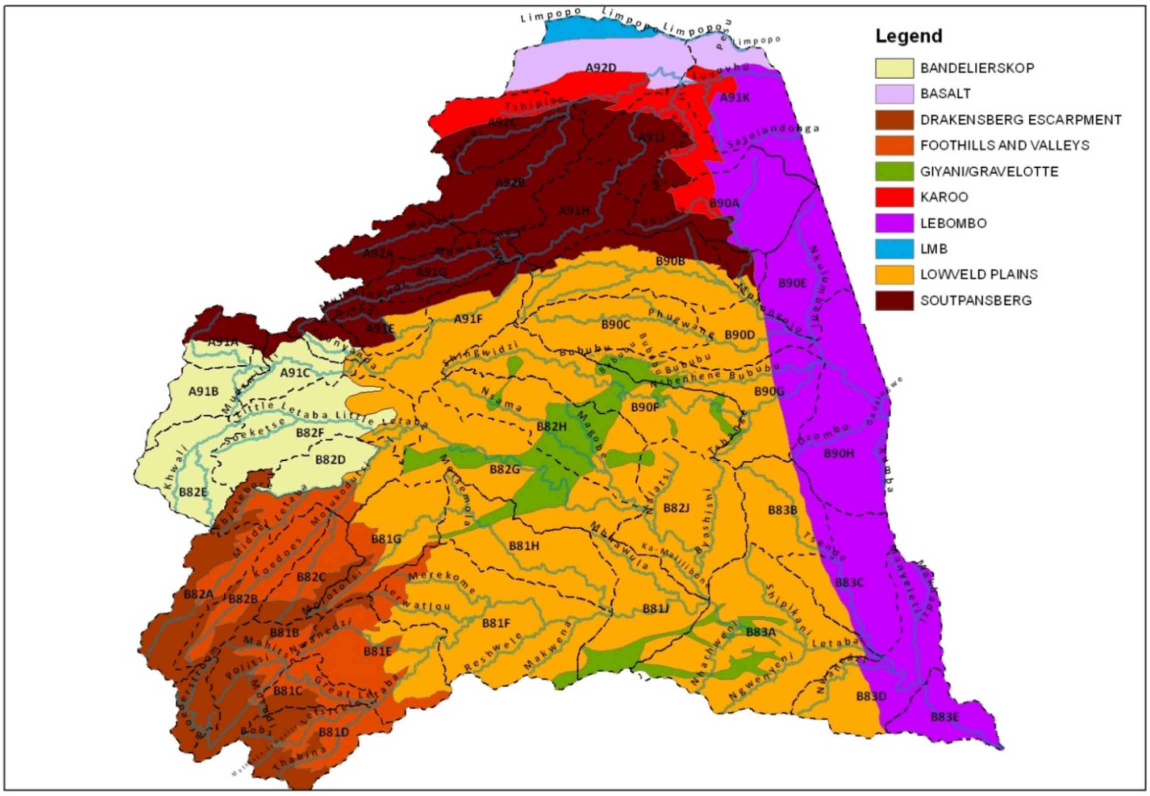
Geology

The study area is underlain by a diverse range of lithologies, spanning the geological time scale, from more than 3 Billion years old, to recent sediments. The lithological units were grouped into hydrogeological units based on lithological and topographical considerations that affect the occurrence of groundwater.

Groundwater Response Units

The study area can be subdivided into several hydrogeological regions based on topography, surface groundwater interactions, and groundwater yield characteristics (figure below. These units are: Drakensberg Escarpment, Drakensberg Foothills and valleys, Soutpansberg, Bandelierskop, Giyani-Gravelotte greenstones, Low veld plains, Lebombo, Karoo, Limpopo Mobile Belt, Limpopo Basalts, Alluvium.

The Drakensburg escarpment forms 6% of the total WMA, and is found in the south-western part of the WMA. Rainfall exceeds 1000 mm/a, except in the upper Koedoes and Middle Letaba valleys where rainfall is 600 mm/a due to the rain shadow effect of the Duiwelskloof mountains. Recharge is rapidly discharged in the forms of springs, which provide rapid baseflow via interflow to the rivers, hence much of the recharge is not stored in the regional aquifer for any length of time. Recharge may exceed 200 mm/a, however, since most generates interflow on the steep slopes, it does not reach the regional aquifers that occur in the valley bottoms, hence is not directly exploitable via boreholes. Interflow has been depleted by commercial afforestation and alien vegetation that is found on the high lying *areas, or by transmission losses downstream where abstraction causes the water level to drop below the river, inducing losses from the river to the aquifer.*



The Drakensberg foothills and valleys form nearly 8% of the WMA. Rainfall is 500-1000 mm and slopes are generally flat to moderate, with slopes generally less than 15%. The aquifers are of a composite type, consisting of fractured zone and overlying weathered zone aquifers. The aquifers are extensively used by rural water supply boreholes. A fair proportion of these boreholes are situated in the granite aquifers. As a result of the lack of sanitation facilities, elevated nitrate concentrations commonly occur in groundwater. Extensive sub-tropical agriculture is practised in the south of the Lowveld plain east of Tzaneen, especially along the Letaba River. Groundwater is also used for supplementary irrigation along the Letaba River. Due to low volumes of groundwater storage, these aquifers are very vulnerable and sensitive to changes in rainfall patterns during droughts. During times of drought, boreholes dry out if not managed properly. Extensive forestry and agricultural activities in and around Tzaneen also impacts on the volumes and quality of groundwater flowing back to the Letaba River as base flow.

The Soutpansberg comprises the eastern part of the east - west trending Soutpansberg Mountains and underlie 13% of the WMA. Rainfall exceeds 1000 mm/a in the upper reaches *of the Luvuvhu and declines to less to 200 mm/a in an ENE direction. The steep topography and resistant nature of the rock generally inhibits deep weathered profiles and aquifers are fractured in nature. Storage in these fractured aquifers is very limited, especially where a deep overlying weathered zone is absent. As a result they may provide high initial yields, which decline rapidly as the larger joints and fractures are dewatered. There is widespread use of groundwater and many of the communities are supplied with conjunctive schemes using surface water together with groundwater as the source. Springs are also an important source of water supply for the rural communities. The Soutpansberg Mountains are an important recharge area and provide significant volumes of baseflow to surface drainage. On the steep slopes that generally exceed 15^o, recharge to these aquifers is rapidly discharged in the forms of springs, which provide interflow to the rivers that may exceed 200 mm/a, however, these resources are not directly exploitable by the regional aquifers that occur in the valley bottoms. As a result, a large fraction of recharge cannot be directly exploited through boreholes.*

The Bandelierskop zone forms the escarpment trending north from Tzaneen towards Thohoyandou. It underlies 7% of the WMA. The regional MAP is 500-1000 mm. The region is hilly and has slopes of 5-15^o. There is heavy dependence on groundwater in Elim (A91B). Conjunctive use schemes supply many of the communities. Large scale irrigation takes place at Levubu (1 to 2 million m^3/a) right through to Louis Trichardt (which falls outside the Letaba catchment).

The Giyani-Gravelotte greenstone belt forms 4% of the WMA. Rainfall varies from 500-600 mm/a and the topography is generally flat, except where steep ridges where quartzite and ironstone formations outcrop. It forms a hilly landscape and are characterised by numerous gold, silver, copper, nickel and zinc deposits and small abandoned mines. Much of the central area around Giyani and the area around Letsitele relies on groundwater for domestic supplies and stock watering. Large-scale groundwater abstraction currently takes place at Giyani for domestic purposes. Elevated NO_3 levels are reported in many of the settlements.

The Lowveld Plains cover 42% of the study area. Rainfall varies from 500-600 mm/a. Much of the Lowveld area comprises communal lands. There is heavy dependence on groundwater in Malemulele (western parts of B90B, C & F), Giyani (B81H & J, B82F, G, H, & J), Sekgosese (B82D) Bolebedu (B81E, F & G), and NW of Phalaborwa (B81F & J). Conjunctive use schemes supply many of the communities, particularly in the Giyani area. In addition to the above, localized groundwater use for domestic and game watering purposes is widespread at the various game farms in the area from Phalaborwa to Hoedspruit.

Groundwater levels are generally below stream level, hence baseflow is unlikely to be generated except in exceptionally wet periods.

The Lebombo region forms 6% of the WMA. The MAP is less than 500 mm. Borehole yields are generally low and the groundwater resources of the fine grained rhyolite are marginal. Basalts forms the wide north south trending central plains and gently rolling countryside of the northern part of the Kruger National Park from Pafuri in the north to Letaba in the south and have a higher yield.

The Limpopo Mobile Belt occupies only 0.5% of the WMA. Drainage is primarily towards the Limpopo River rather than to the Mutale and it is a dry region with less than 300 mm of rain per annum. It lies on a flat plain known as the Malonga flats. Groundwater resources are poor and less than 40% of boreholes are successful. Only 16% have a useable yield of greater than 1 l/s. The groundwater is generally of a poor quality as well due to elevated nitrates, salinity and fluorides. The area is mostly stock and game farming and is sparsely populated. Irrigation is practised along the Limpopo River on the old flood plain.

Karoo rocks occupy 3% of the WMA. Groundwater tends to be saline due to the low rainfall and high proportion of mudstones and shales. The area is agricultural with scattered communal land settlements in A92C and A92D reliant on groundwater for domestic supply and cattle watering. The area is pristine within the KNP. Groundwater quality varies from generally good (Class I) to moderate (Class 2) with conductivities below 300 mS/m, to very saline from south-north and increasing distance from the Soutpansberg.

The basalts of the Soutpansberg Hinterland form a flat lying area known as the Malonga Plain. They cover 2% of the WMA. Very few surface drainage features exist, and are oriented towards the Limpopo. Rainfall is approximately 320 mm/a.

Primary alluvial aquifers, consisting of saturated alluvium, are often present along major river drainage systems and are composed of unconsolidated clayey silts to coarse gravels and boulders. The highest yielding aquifers of this type are present in the south-eastern and eastern regions of the Letaba catchment, mostly in the Kruger Park. In the middle and upper reaches of the Klein Letaba and Molototsi rivers alluvial deposits of up to 150 m wide and 8 m thick are present. The average borehole yield of this aquifer is more than 5 l/s. During the rainy season, up to 20 l/s per borehole can be abstracted. However, the yield diminishes during the dry season if the volume of storage is limited or if there is no recharge from the host rock. Alluvial aquifers form isolated local aquifers along major river courses and are recharged during periods of high streamflow and discharge once again to the river once *stream stage drops. Since they are recharged by surface water rather than conventional direct groundwater recharge, their maintenance depends on ensuring periods of high flow to replenish bank storage, and their use results in significant flow depletion as transmission losses. They exist in delicate equilibrium with surface water and ecosystems present along the river course. In terms of the future exploitation potential of these aquifers, the sensitivity of ecosystems along the Letaba River to a drop in water table resulting from a change in the flow regime need to be evaluated.*

Groundwater Use

Groundwater use per Quaternary catchment was obtained from the Validation and Verification study (DWA 2013b) based on validated irrigation areas. Estimates of domestic water use were undertaken in the All Towns study (DWA 2011). Estimates of water use were made from measured use, capacities of treatment works, and estimates of per capita use. These were subsequently adjusted in this study by water demand modelling by the project team based on existing infrastructure and population.

Groundwater demand is approximately 157.36 Mm^3/a, of which 141.42 Mm^3/a is for irrigation (Table 5-1). The registered water use in the WARMS data base is 101-102 Mm^3/a, of which 91.65 Mm^3/a is for irrigation.

Rural water supply is provided by several water supply schemes, some of which cut across catchment boundaries. A significant portion of the population used to be serviced with groundwater, however, there has been a transition to surface water and regionalisation and many of the larger schemes, like the Middle Letaba, Giyani and the Vondo schemes.

Estimated water use for rural water services (and transfers out of the catchment) is 116.6 Mm^3/a, of which 17.9 Mm^3/a is met from groundwater (table 5.5). 15.9 Mm^3/a is from within the Luvuvhu Letaba.

The GRIP data base was used to evaluate the yield of each borehole located within each water supply scheme. The existing boreholes could yield 66.52 Mm^3/a. These data include many boreholes which were tested but were equipped with hand pumps, or are not equipped, hence this capacity is not fully utilisable given the existing infrastructure. If only boreholes equipped with motorised pumps and with a power source are included, the infrastructure capacity is 32.68 Mm^3/a.

Groundwater Availability

The yield of boreholes drilled in each Quaternary catchment was obtained from the NGDB. Most of the study area has a geometric mean yield of more than 1 l/s, except A91 F and J, on the southern margin of the Soutpansberg region in the lower Luvuvhu, B81A, C and E of the Drakensberg escarpment in the Groot Letaba, B82A and B82B of the upper Middle Letaba in the Drakensberg region. B81D in the Drakensberg foothills underlain by greenstones and the Rooiwater complex has higher yields. In most of the rural water schemes, sufficient boreholes exceed 2 l/s (>20%) to warrant groundwater supply. Low yields are encountered in the Sekgopo groundwater supply scheme in B82A and the Thapane rural water supply scheme in B81E, yet both of these schemes are reliant on groundwater.

Good quality groundwater exists throughout the study area, with the following exceptions: B81B exhibits elevated nitrates and TDS, however the numbers of boreholes sampled is small: B81 F and H in the low veld plains exhibit high levels of nitrate. These catchments are densely settled and elevated nitrate is probably associated with the removal of vegetation. B82D G and H, shows elevated nitrates due to dense settlement. B90B and C F and G show elevated nitrates.

Data on the volumes of groundwater that can be exploited were obtained from:

- *The Harvest Potential database*
- *Groundwater Resources Assessment Phase II (GRAII) database*
- *Modifications to the GRAII data base undertaken by WSM Leshika*
- *Modelling of surface groundwater interactions using the WRSM2000 model*

The Ground Water Harvest Potential provides a basis for the evaluation of the volume of groundwater resources. The Harvest Potential is defined as the maximum volume of groundwater that is available for abstraction without depleting the aquifer systems, and takes into account recharge, storage and drought periods. The Harvest Potential for the study area is 271.09 Mm^3/a (table 6.12). It is however not possible to abstract all the ground water available. The Harvest Potential was reduced by an exploitation factor, determined from borehole yield data, to obtain an exploitation potential, i.e. the portion of the Harvest Potential which can practically be exploited (Table 6.12). The Exploitation Potential for the study area is 183.82 Mm^3/a.

GRAII provided a National data set of the Groundwater Resource Potential, which provides estimates of the maximum volumes of groundwater that are potentially available for abstraction on a sustainable basis. The Exploitation Potential for the study area in GRAII is 607.21 Mm^3/a. The exploitation potential values in GRAII were considered to be too high due to incorrect storage estimates. The data used in the calculation in the original GRAII report was re-examined. The aquifer storage volumes utilised (DWA, 2006) were considered to be too high and were recalculated, and subsequently the Exploitation Potential was recalculated by the same GRAII methodology. This modified Exploitation Potential was calculated as 369.5 Mm^3/a.

GRAII exploitation potential is calculated based on rainfall recharge, which assumes all recharge enters the aquifer. This assumption doesn't consider that some recharge rapidly re-emerges as interflow in high lying areas and is not available to the regional aquifer as a resource, hence the values calculated in terms of recharge to the regional aquifer may be too high, especially in regions like the Drakensberg Escarpment and Foothills, where much of the recharge emerges as springs in high lying areas before reaching the regional aquifer. The surface groundwater interaction component in WRSM2000 was utilised to derive recharge, aquifer recharge and baseflow. Recharge and baseflow were calibrated against gauging stations and dam water levels to ensure a water balance between groundwater recharge and baseflow. The calculated aquifer recharge for the study area is 466 Mm^3/a, whereas the total recharge is 921 Mm^3/a (table 6.14). The aquifer recharge can be considered the upper limit of what can be abstracted, as it is the average rainfall recharge to the regional aquifer. However, abstracting this volume would deplete the source of groundwater baseflow, which provides low flows during the dry season.

The WRSM2000 model was utilised to simulate recharge and baseflow. The WRSM2000 model distinguishes between interflow occurring from the unsaturated zone contributing to hydrograph recession following a large storm event, or discharge from perched water tables via temporary or perennial springs located above low permeability layers, and groundwater baseflow discharged from the regional aquifer to surface water as baseflow to river channels, either to perennial effluent or intermittent streams. WRSM2000 also simulates transmission losses of surface water when river stage is above the groundwater table in phreatic aquifers with a water table in contact with the river, and baseflow reduction and induced recharge caused by pumping of aquifer systems in the vicinity of rivers causing a flow reversal.

Baseflow is 41% of the MAR, of which groundwater baseflow is 7.15% of MAR. The location of baseflow generation is shown in figure 6.7. Of 466 Mm^3/a of aquifer recharge, 95 Mm^3/a, *emerges as groundwater baseflow from the regional aquifer (table 6.15). The remainder of the 549 Mm^3/a of baseflow is generated as interflow in the high lying areas in the west along the Drakensberg, the Drakensberg foothills, and the Soutpansberg. This baseflow represents virgin conditions. Under present day conditions, the interflow component is significantly depleted by afforestation and alien vegetation, while groundwater baseflow is impacted by abstraction. The difference between aquifer recharge and groundwater baseflow is lost as evapotranspiration from groundwater by riverine vegetation and from areas of shallow groundwater.*

The naturalised setup of WRSM2000 was run for the period 1920-2010 under current groundwater abstraction conditions to determine the impact of current abstraction on runoff by a reduction in baseflow and the increased potential for transmission losses. For the Letaba system, a long term groundwater abstraction of 80 Mm^3/a reduces runoff from 753 Mm^3/a to 727 Mm^3/a, with the most heavily impacted region being the Middle Letaba in catchments B82B and B82C, where runoff has been decreased by nearly 40%. In the Luvuvhu system a groundwater abstraction of 52 Mm^3/a has reduces the MAR from 578 Mm^3/a to 538 Mm^3/a, with the upper Luvuvhu, A91A-C being the most heavily impacted with flow reductions of 33-50%. Baseflow depletion is 10% in the Letaba system and 15% in the Luvuvhu.

Reconciliation of demand and groundwater availability

Estimates of groundwater use for water supply are close to 16 Mm^3/a for water supply and 141 Mm^3/a for irrigation. If water use for industry, livestock, and Schedule 1 water use is added from WARMS, total use is 157.94 Mm^3/a. Only 50% of recharge reaches the regional aquifers and is accessible to groundwater users. Consequently, the stress index (use/recharge) of groundwater use was assessed relative to aquifer recharge. Stressed catchments where use is greater than 65% of aquifer recharge include:

- *the upper Luvuvhu in the vicinity of Albisini dam (A91A-C),*
- *the lower Groot Letaba in the vicinity of the proposed Nwamitwa dam (B811E-F),*
- *the Koedoes and Brandboontjies catchments, parts of the Middle Letaba system (B82B-C)*

The stress of groundwater use in each catchment, and the remaining groundwater resources that can be allocated are shown below.

	> 95% of aquifer recharge or recharge
	>65% of aquifer recharge or recharge
	>40% of aquifer recharge or recharge
	>20% of aquifer recharge or recharge
	>5% of aquifer recharge or recharge
	<05% of aquifer recharge or recharge

Catchment	Total Use	Stress index	Catchment classification	Available groundwater Mm^3/a		
	Mm^3/a	%		Harvest Pot	Exploitation Pot	Aquifer recharge
A91A	9.16	81.47	Heavily utilised	0.00	0.00	2.08
A91B	8.22	105.03	Over utilised	0.00	0.00	0.00
A91C&F3	29.21	94.81	Heavily utilised	0.00	0.00	1.60
A91D	6.96	39.21	Heavily utilised	0.00	0.00	10.79
A91E	0.17	1.17	Underutilised	2.76	1.88	14.31
A91F1&F2	0.27	2.56	Underutilised	7.89	4.63	10.29
A91G	0.38	1.01	Underutilised	3.03	2.01	37.07
A91H	0.52	7.22	Underutilised	3.30	2.15	6.68
A91J	0.04	0.66	Underutilised	4.05	2.41	6.04
A91K	0.00	0.00	Underutilised	6.93	4.85	4.31
A92A	0.20	1.54	Underutilised	2.56	1.73	12.77
A92B	0.17	3.86	Underutilised	4.50	3.10	4.23
A92C	0.36	27.28	Underutilised	2.62	1.73	0.96
A92D	0.56	54.78	Underutilised	2.66	1.70	0.46
B81A	0.15	1.45	Underutilised	2.57	1.21	10.19
B81B	2.65	13.04	Underutilised	5.07	2.75	17.67
B81C	5.49	33.75	Heavily utilised	0.00	0.00	10.78
B81D	4.13	32.16	Moderately utilised	3.64	1.31	8.71
B81E	23.01	126.42	Over utilised	0.00	0.00	0.00
B81F	13.20	71.47	Significantly utilised	1.20	0.00	5.27
B81G	5.56	44.20	Significantly utilised	1.22	0.00	7.02
B81H	3.82	43.39	Moderately utilised	4.15	1.76	4.98
B81J	0.12	1.89	Underutilised	6.34	4.40	6.22
B82A	1.67	14.70	Underutilised	5.70	2.75	9.69
B82B	20.69	217.78	Over utilised	0.00	0.00	0.00
B82C	11.01	154.27	Over utilised	0.00	0.00	0.00
B82D	1.80	17.40	Underutilised	8.31	5.28	8.55
B82E	1.71	21.25	Underutilised	4.70	2.78	6.34
B82F	3.16	22.09	Underutilised	8.89	5.28	11.14
B82G	2.28	21.21	Underutilised	8.74	5.44	8.47
B82H	0.62	7.28	Underutilised	7.85	5.31	7.90
B82J	0.13	1.40	Underutilised	6.29	4.36	9.14
B83A	0.00	0.00	Underutilised	12.08	8.46	11.77
B83B	0.00	0.00	Underutilised	3.51	2.46	5.71

B83C	0.00	0.00	Underutilised	4.74	3.32	7.70
B83D	0.00	0.00	Underutilised	6.64	4.65	7.88
B83E	0.00	0.00	Underutilised	2.48	1.49	3.11
B90A	0.00	0.00	Underutilised	5.51	3.31	6.77
B90B	0.06	0.90	Underutilised	7.44	5.19	6.58
B90C	0.07	1.36	Underutilised	5.57	3.88	5.06
B90D	0.00	0.00	Underutilised	3.49	2.44	3.79
B90E	0.00	0.00	Underutilised	3.78	1.89	3.75
B90F	0.36	4.07	Underutilised	8.08	5.55	8.48
B90G	0.03	0.42	Underutilised	5.72	4.00	7.13
B90H	0.00	0.00	Underutilised	6.20	4.34	7.32
TOTAL	157.94			190.20	119.75	328.69

The existing water supply schemes were categorised according to the stress index (current groundwater use/ aquifer recharge).

The schemes that are stressing water resources within the supply area include:

- *Greater Letaba LM farms supply*
- *Masisi RWS*
- *Thabina RWS*
- *Thulamela LM farms supply*
- *Tshikondeni Mine*

To determine level of stress within the catchments occupied by water supply schemes, total use was utilised relative to aquifer recharge (table 7-4). The following schemes are located in stressed catchments:

- *Ba-Phalaborwa*
- *Elim Vleifontein RWS*
- *Giyani system D: southwest*
- *Greater Giyani LM Farms Supply*
- *Greater Letaba LM Farms Supply*
- *Letaba Individual Supply*
- *Ritavi / Letaba RWS*
- *Makhado RWS*
- *Thapane RWS*
- *Valdezia RWS*

An analysis was undertaken to determine which water supply schemes could feasibly be supplied with additional groundwater. This was undertaken by evaluating population (and projected water demand at 100 l/c/d, the area of the scheme to determine aquifer recharge and harvest potential, Existing borehole capacity, the proportion of boreholes with potable water, and the proportion of boreholes yielding > 2 l/s per second as an indicator of the feasibility of drilling boreholes that could be equipped with motorised systems. It was assumed that per capita demands would grow at 2% per annum and that present demand met by surface water sources would remain constant, so that additional demands would be met from groundwater.

The results are shown below.

Note[1]: MAR reduction as a percentage of abstraction

Scheme	**Impact on baseflow[1]**	***Demand relative to***							**Limitations**
	%	Catchment	Harvest Potential (%)	Aquifer Recharge (%)	BH >2 l/s (%)	Existing capacity (%)	TDS % potable	Nitrates % potable	
SILUWANE - NONDWENI EXTENDED RWS	2	Moderately utilised	0	0	41.38	0	98	83	None
BA-PHALABORWA INDIVIDUAL SUPPLY	2	Significantly utilised	4	3			50	100	50% of boreholes have elevated salinity. Catchment significantly utilised
DAMANI RWS	51	Underutilised	10	2	31.82	20	100	100	Abstraction reduces runoff by 50% of abstraction
ELIM/VLEIFONTEIN RWS	70-85	Over utilised	25	9	67.39	16	100	96	Abstraction reduces runoff by 70-85% of abstraction. Catchment over utilised
GIYANI SYSTEM A/B	<2	Underutilised	4	4	47.30	32	96	71	none
GIYANI SYSTEM D: SOUTH WEST	2	Moderately utilised	39	33	42.31	38	97	58	>40% of boreholes have excessive nitrates.
GIYANI SYSTEM F1	0	Underutilised	8	8	36.00	36	80	47	>50% of boreholes have elevated nitrates
GIYANI SYSTEM F2	0	Underutilised	13	13	46.67	28	100	65	35% of boreholes have elevated nitrates
GIYNAI SYSTEM C/D	2	Underutilised	33	32	61.60	37	88	77	none
GREATER GIYANI LM FARMS SUPPLY	2	Significantly utilised	79	61					Catchment significantly utilised
GREATER LETABA LM FARMS SUPPLY	64	Over utilised	127	87					Abstraction reduces runoff by 64% of abstraction. Catchment over utilised
GREATER TZANEEN LM FARMS SUPPLY	52	Underutilised	0	0					Abstraction reduces runoff by 52% of abstraction. Only 11% of boreholes yield > 2/s
LAMBANI RWS	9	Underutilised	0	0	33.33	0	100	100	None. Abstraction reduces runoff by <10% of abstraction
LETABA INDIVIDUAL SUPPLY	64	Over utilised	6	4					Abstraction reduces runoff by 64% of abstraction. Catchment over utilised
LEVUBU CBD	85	Heavily utilised	76	10	100.00				.Abstraction reduces runoff by 85% of abstraction. Catchment heavily utilised
LOWER MOLOTOTSI	2	Moderately utilised	0	0	60.00	0	91	56	Nearly 50% of boreholes have excessive nitrates.
LUPHEPHE/NWANEDZI MAIN RWS	6	Underutilised	23	43	40.00	21	90	94	None
LUPHEPHE/NWANEDZI NORTH	6	Underutilised	51	125	35.00	15	92	50	50% of boreholes have excessive nitrates. Scheme already heavily utilised
MAKHADO RWS	69	Heavily utilised	71	19	48.54	324			Abstraction reduces runoff by69% of abstraction. Catchment heavily utilised. Infrastructure over utilised
MALAMULELE WEST RWS	9	Underutilised	5	4	36.17	17	100	62	None. Abstraction reduces runoff by <10% of abstraction. 38% of boreholes have elevated nitrates
MAPUVE/SYSTEM N RWS	<2	Underutilised	8	8	38.10	31	100	38	>60% of boreholes have excessive nitrates.
MASISI RWS	<1	Underutilised	26	79	55.26	19	87	80	None

MATSHAVHAVE/KUNDA RWS		*Heavily utilised*	*0*	*0*	*33.33*	*0*			
MIDDLE LETABA RWS: BABANGU	*2-53*	*Underutilised*	*9*	*8*	*41.38*	*29*	*100*	*51*	*Nearly 50% of boreholes have elevated nitrates*
MIDDLE LETABA RWS: MAGORO	*53*	*Underutilised*	*19*	*18*	*50.00*	*35*	*100*	*56*	*Nearly 50% of boreholes have elevated nitrates. Abstraction reduces runoff by 53% of abstraction*
MIDDLE LETABA RWS: MAJOSI	*7*	*Underutilised*	*17*	*14*	*34.88*	*24*	*100*	*78*	*None*
MIDDLE LETABA RWS: VYEBOOM MASIA	*7*	*Underutilised*	*28*	*28*	*66.67*	*23*	*90*	*55*	*45% of boreholes have elevated nitrates*
MIDDLE LETABA: BOLOBEDU NW	*3*	*Significantly utilised*	*19*	*16*	*39.02*	*24*	*100*	*88*	*Catchment is significantly utilised*
MIDDLE LETABA RWS: MALAMULELE WEST	*0*	*Underutilised*	*4*	*2*	*41.67*	*18*	*98*	*63*	*None*
MODJADJI RWS	*3*	*Significantly utilised*	*0*	*0*	*28.86*	*0*	*99*	*93*	*Catchment is significantly utilised*
MUTALE LM FARMS SUPPLY	*<1*	*Underutilised*	*49*	*33*					*None*
MUTALE MAIN RWS	*>50*	*Underutilised*	*20*	*10*	*38.89*	*59*	*100*	*100*	*Abstraction reduces runoff by 50% of abstraction*
MUTALE MUKUYA RWS	*9*	*Underutilised*	*8*	*6*	*43.75*	*14*	*100*	*100*	*None. Abstraction reduces runoff by <10% of abstraction*
NORTH MALAMULELE EAST RWS	*<5*	*Underutilised*	*5*	*4*	*44.19*	*11*	*100*	*62*	*Abstraction reduces runoff by <5% of abstraction. 38% of boreholes have elevated nitrates*
NZHELELE RWS		*Underutilised*	*0*	*0*	*42.10*	*0*	*100*	*100*	*None. May impact on inflows to Nzhelele dam*
RITAVI II RWS	*44*	*Moderately utilised*	*28*	*13*	*40.00*	*34*	*100*	*100*	*Abstraction reduces runoff by 44% of abstraction*
RITAVI/LETABA RWS	*2*	*Significantly utilised*	*5*	*3*	*36.36*	*11*	*97*	*67*	*Catchment is significantly utilised*
SEKGOPO LOCAL GWS	*52*	*Underutilised*	*33*	*21*	*11.76*	*20*	*100*	*100*	*Abstraction reduces runoff by 52% of abstraction. Only 11% of boreholes yield > 2/s*
SEKGOSESE INDIVIDUAL GROUNDWATER SCHEME	*53*	*Underutilised*	*12*	*11*	*50.00*	*10*	*100*	*88*	*Abstraction reduces runoff by >50% of abstraction*
SOUTH MALAMULELE EAST RWS	*0*	*Underutilised*	*2*	*2*	*47.37*	*5*	*100*	*53*	*47% of boreholes have elevated nitrates*
THABINA RWS	*44*	*Moderately utilised*	*143*	*86*	*60.34*	*80*			*Abstraction reduces runoff by 44% of abstraction*
THAPANE RWS	*5*	*Over utilised*	*20*	*11*	*15.09*	*72*	*100*	*95*	*Catchment is over utilised*
THULAMELA LM FARMS SUPPLY	*9*	*Underutilised*	*348*	*185*					*None. Abstraction reduces runoff by <10% of abstraction. Scheme heavily utilised due to small area, however catchment is under utilised*
TOURS RWS		*Moderately utilised*	*0*	*0*	*57.41*				
TSHAKUMA RWS	*63-83*	*Heavily utilised*	*24*	*3*	*50.00*	*33*	*100*	*100*	*Abstraction reduces runoff by >60% of abstraction. Catchment heavily utilised*
TSHIFIRE MURUNWA RWS		*Heavily utilised*	*0*	*0*	*100.00*	*0*	*100*	*100*	*None*
TSHIFUDI RWS	*9*	*Underutilised*	*22*	*7*	*44.00*	*52*	*100*	*100*	*None. Abstraction reduces runoff by <10% of abstraction*
TSHIKONDENI MINE	*<1*	*Underutilised*	*125*	*107*					*Scheme heavily utilised however catchment is under utilised*
TSHITALE RWS	*7-8*	*Underutilised*	*9*	*7*	*27.40*	*47*	*100*	*86*	*none*
TZANEEN/HAERNETSBURG INDIVIDUAL SUPPLY	*100*	*Underutilised*	*0*	*0*	*0.00*				*Abstraction reduces runoff by 100% of abstraction*
TZANEEN/MODJADJISKLOOF	*43-49*	*Underutilised*	*0*	*0*	*42.86*	*0*	*100*	*100*	*Abstraction reduces runoff by 43-49% of abstraction*
VALDEZIA RWS	*85*	*Heavily utilised*	*19*	*3*	*20.00*	*25*	*100*	*100*	*Abstraction reduces runoff by 85% of abstraction. Catchment heavily utilised*
VONDO CENTRAL RWS	*51-63*	*Underutilised*			*37.25*		*100*	*95*	*Abstraction reduces runoff by> 50% of abstraction*
VONDO EAST RWS	*9*	*Underutilised*			*36.36*		*100*	*91*	*Abstraction reduces runoff by <10% of abstraction*
VONDO NORTH RURAL RWS	*>50*	*Underutilised*			*40.00*		*100*	*100*	*Abstraction reduces runoff by 50% of abstraction.*
VONDO SOUTH RWS	*9*	*Underutilised*	*2*	*1*	*0.00*	*5*	*100*	*74*	*Abstraction reduces runoff by <10% of abstraction*
WORCESTER/MOTHOBEKI RWS	*3*	*Significantly utilised*	*0*	*0*	*55.56*	*0*	*92*	*57*	*Catchment is significantly utilised*

Note[1]: MAR reduction as a percentage of abstraction

Evaluation of artificial recharge scheme in an alluvial aquifer

A potential scheme for impounding surface water by means of a weir to artificially recharge the underlying alluvial sand aquifer in order to abstract alluvial groundwater in the Molototsi was considered to supply water to Mulele in the Lower Molototsi water supply scheme. The scheme is to be located SW of Giyani. The scheme could provide 0.05-0.055 Mm^3/a without the construction of a weir, or 0.05-0.065 Mm^3/a with a 1.3 m weir, depending on the level of assurance of supply selected.

Development of a Reconciliation Strategy for the Luvuvhu and Letaba Water Supply System
Groundwater Utilization Scenarios

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Acronyms

BID	Background Information Documents
CBO	Community Based Organisation
DA	Drainage Area
DM	District Municipality
DPLG	Department of Provincial and Local Government
DWAF	Department of Water Affairs and Forestry
EFR	Environmental Flow Requirement
EMA	Ecological Management Area
EWR	Ecological Water Requirements
GIS	Geographical Information System
GRAII	Groundwater resource assessment phase II
GRIP	Groundwater Resource Information Project
GRU	Groundwater resource unit
IFR	Instream Flow Requirements
IWRM	Integrated Water Resource Management
LLRS	Development of Water of a Reconciliation Strategy for the Luvuvhu and Letaba Water Supply System
MAP	Mean Annual precipitation
MAR	Mean Annual Runoff
NGDB	National Groundwater Database
NGO	Non-Governmental Organisation
RWQO	River Water Quality Objectives
SAGDT	South African Groundwater Tool
SSC	Study Steering Committee
TDS	Total Dissolved Solids
URV	Unit Reference Value
WARMS	Water Use Authorisation and registration Management System
WC	Water Conservation
WDM	Water Demand Management
WMA	Water Management Area
WRC	Water Research Commission
WRP	WRP Consulting Engineers (Pty) Ltd.
WRSM2000	Water Resources Simulation Model (Pitman model)
WRSS	Water reconciliation Strategy Study
WRPM	Water Resources Planning Model
WRYM	Water Resources Yield Model
WSA	Water Service Authority
WSAs	Water Service Authorities
WSAM	Water Situation Assessment Model
WSP	Water Service Providers

Development of a Reconciliation Strategy for the Luvuvhu and Letaba Water Supply System

Groundwater Utilization Scenarios

1 INTRODUCTION

1.1 BACKGROUND

The Department of Water Affairs (DWA) has identified the need for the Reconciliation Study for the Luvuvhu-Letaba WMA. The WMA is almost fully developed and demands from the Letaba River currently exceed the yield capability of the system. Regulation for the Letaba is mainly provided by Middle Letaba, Ebenezer and Tzaneen Dams. The recently completed Nandoni Dam located in the Luvuvhu basin will be used in combination with Albasini, Vondo and Damani dams to be managed as one system. It is expected that the total yield from this combined system will be fully utilized by around 2020, considering only the current planned projected demands. The yield of the Albasini Dam has reduced over the years and as a consequence the dam is over allocated. The Shingwedzi catchment is situated almost entirely in the Kruger National Park and for all practical purposes, no sustainable yield is derived from surface flow in the Shingwedzi catchment.

The main urban areas in these catchments are Tzaneen and Nkowakowa in the Groot Letaba River catchment, Giyani in the Klein Letaba River catchment and Thohoyandou and Makhado (Louis Trichardt) in the Luvuvhu catchment. An emergency water supply scheme to transfer water from Nandoni Dam is currently under construction to alleviate the deficits of the stressed Middle Letaba sub-system in the Letaba River basin. Other future developments planned to be supplied from Nandoni Dam will already utilize the full yield available from the Nandoni sub-system by 2021, without supporting Giyani. Supporting Giyani from Nandoni will bring this date forward to approximately 2018

Intensive irrigation farming is practised in the upper parts of the Klein Letaba River catchment (upstream and downstream of the Middle Letaba Dam), the Groot Letaba (downstream of the Tzaneen Dam) and Letsitele Rivers, as well as in the upper Luvuvhu River catchment. Vegetables (including the largest tomato production area in the country), citrus and a variety of sub-tropical fruits such as bananas, mangoes, avocados and nuts are grown. Large areas of the upper catchments have been planted with commercial forests in the high rainfall parts of the Drakensberg escarpment and on the Soutpansberg. The area, particularly the Groot Letaba sub-area, is a highly productive agricultural area with mixed farming, including cattle ranching, game farming, dry land crop production and irrigated cropping. Agriculture, with the irrigation sector in particular, is the main base of the economy of the region. Large scale utilization of the groundwater resource occurs mostly downstream of the Albasini Dam in the Luvuvhu catchment, where it is used by irrigators as well as in the vicinity of Thohoyandou where it is used to supply rural communities. The limited mineral resources in the Luvuvhu basin are dominated by deposits of cooking coal in the northeast near Masisi. In addition to irrigation water supply from the dams in the study area, towns, villages and rural settlements are also supplied with potable water.

DWA and other institutions involved in the management of the water resource and supply systems of the Luvuvhu-Letaba catchments, have in the past carried out various studies on intervention measures to improve the water supply situation. The knowledge base that has been created by these studies provides a sound and essential platform from which the Reconciliation Strategy will be developed. In order to harness this information a Literature Review Report (DWA, 2013) was compiled to summarise the available information in one document and also present a synthesis of the information by highlighting the pertinent aspects of Integrated Water Resource Management that will be assessed and incorporated in the Reconciliation Strategy.

1.2 OBJECTIVES OF THE STUDY

The main objective of the study is to compile a Reconciliation Strategy that will identify and describe water resource management interventions that can be grouped and phased to jointly form a solution to reconcile the water requirements with the available water for the period up to the year 2040 and to develop water availability assessment methodologies and tools applicable to this area that can be used for decision support as part of compulsory licensing to come. The development of the strategy requires reliable information on the water requirements and return flows (wastewater) as well as the available water resources for the current situation and likely future scenarios for a planning horizon of thirty years.

To achieve the above objectives, the following main aspects will be covered in the study:

- Update the current and future urban and agricultural water requirements and return flows;
- Assess the water resources and existing infrastructure;
- Configure the system models (WRSM2005, WRYM, WRPM) in the Study Area at a quaternary catchment scale, or finer where required, in a manner that is suitable for allocable water quantification;
- To firm up on the approach and methodology, as well as modelling procedures, for decision support to the on-going licensing processes;
- To use system models, in the early part of the study, to support allocable water quantifications in the Study Area and, in the latter part of the study, to support ongoing licensing decisions, as well as providing information for the development of the

reconciliation strategy;

- Formulate reconciliation interventions, both structural and administrative/regulatory;
- Document the reconciliation process including decision processes that are required by the strategy; and
- Conduct stakeholder consultation in the development of the strategy.

1.3 STUDY AREA

The study area comprises of the water resources of the catchment of the Luvuvhu, Mutale, Letaba and Shingwedzi rivers linked to adjacent systems as indicated by the inter-basin transfers on **Figure 1.1**. This area represents the entire WMA 2 and includes tertiary catchments A91, A92, B81, B82, B83 and B90. Adjacent areas supplying water to this WMA or getting water from this WMA are also part of the study area.

The Luvuvhu-Letaba water management area (WMA) is located in the north-eastern corner of South Africa, where it borders on Zimbabwe in the north and on Mozambique along the eastern side. It falls entirely within the Northern Province, and adjoins the Olifants and Limpopo WMAs to the south and west respectively. The Luvuhu-Letaba WMA forms part of the Limpopo River Basin, an international river shared by South Africa, Botswana, Zimbabwe and Mozambique.

Approximately 35% of the land area of the WMA along the eastern boundary falls within the Kruger National Park. The rivers flowing through the park are of particular importance to the maintenance of ecosystems.

The confluence of the Luvuvhu and Limpopo rivers forms the common point where South Africa borders on both Zimbabwe and Mozambique. The Shingwedzi River first flows into the Rio des Elephantes (Olifants River) in Mozambique, which then joins the Limpopo River.

The two main branches of the Letaba River, the Klein and Groot Letaba, have their confluence on the western boundary of the Kruger National Park. The Letaba River flows into the Olifants River just upstream of the border with Mozambique **(Figure 1.1).**

The topography is marked by the northern extremity of the Drakensberg range and the eastern Soutpansberg, which both extend to the western parts of the water management area, and the characteristic wide expanse of the Lowveld to the east of the escarpment. Climate over the water management area is generally sub-tropical, although mostly semiarid to arid. Rainfall usually occurs in summer and is strongly influenced by the topography.

Along the western escarpment rainfall can be well over 1 000 mm per year, while in the Lowveld region in the eastern parts of the water management area rainfall decreases to less than 300 mm per year and the potential evaporation is well in excess of the rainfall. Grassland and sparse bushveld shrubbery and trees cover most of the terrain, marked by isolated giant Baobab trees.

The geology is varied and complex and consists mainly of sedimentary rocks in the north, and metamorphic and igneous rocks in the south. High quality coal deposits are found near Tshikondeni and in the northern part of the Kruger National Park. The eastern limb of the mineral rich Bushveld Igneous Complex touches on the southern parts of the WMA. With the exception of sandy aquifers in the Limpopo River valley, the formation is of relatively low water bearing capacity. A wide spectrum of soils occurs in the WMA, with sandy soils being most common.

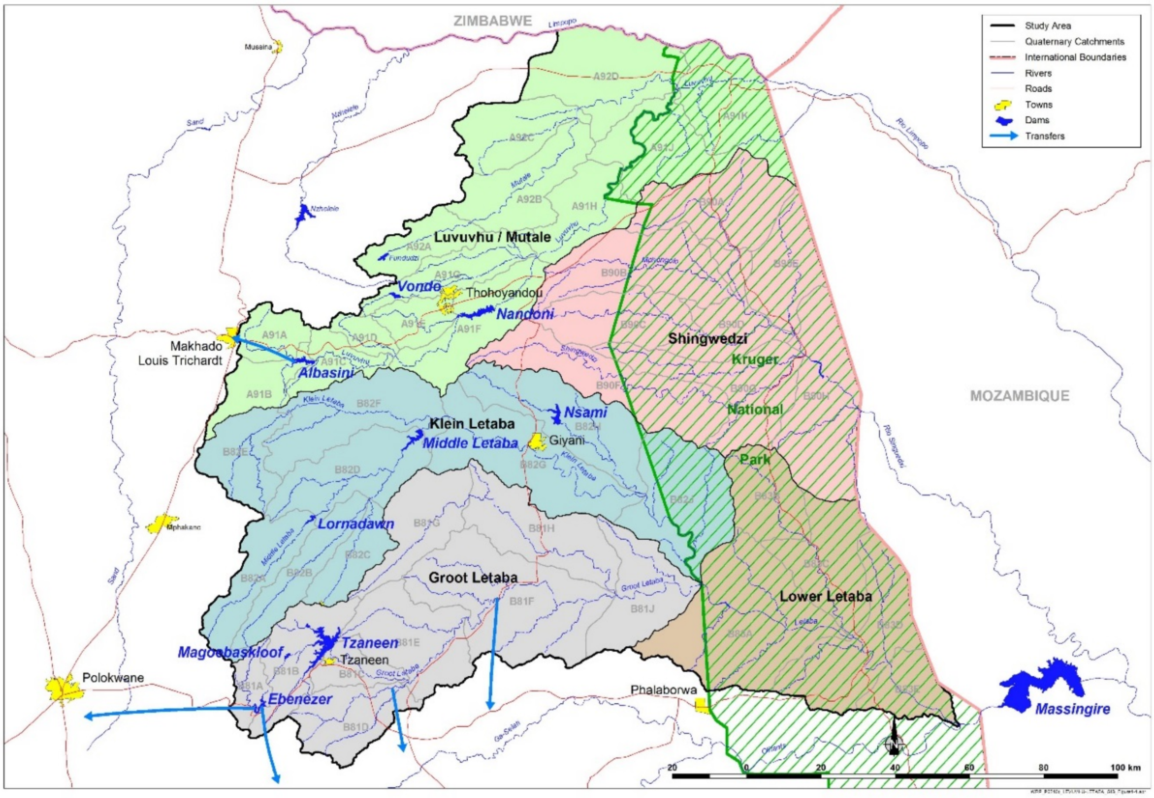


Figure 1-1 Study area

1.4 PURPOSE AND STRUCTURE OF REPORT

The purpose of this report is to present a compilation of the available data on groundwater resources. The modelling of the hydrology to generate new surface-groundwater interaction data utilising WRSM2000 is covered in Report No. P WMA 02/B810/00/1412/5, the Hydrology Report. The hydrological simulation calibrated the time series of recharge and baseflow, utilising time series of afforestation, alien vegetation, growth in dams, and surface and groundwater abstraction, against gauging station and dam level data. The time series was naturalised to derive mean annual values of recharge and baseflow (chapter 6.6), to quantify groundwater resources (chapter 6.5), and identify areas of groundwater surplus and shortfall to reconcile groundwater availability with demand (chapter 7).

This report covers Task 10 Groundwater Utilisation scenarios of the study.

The objectives of Task 10 were to focus on assessing various scenarios related to groundwater use. The sub-tasks were:

- Select the most favourable previously identified options for groundwater development
- Identify options for conjunctive use of surface and groundwater

Chapter 1 is an introduction to the objectives of the study and this report, and a background of the study area. Chapter 2 provides a description of the data sources and methods used. Chapter 3 is a description of the geology of the study area. Chapter 4 describes the hydrogeological characteristics of identified groundwater regions. Chapter 5 summarises the groundwater use and existing capacity of groundwater schemes. Chapter 6 is an analysis of groundwater availability in each Quaternary catchment and within each water supply scheme. Chapter 7 reconciles groundwater availability with demand. Chapter 8 identifies potential groundwater development options and limitations.

1.5 BACKGROUND AND OBJECTIVES OF THE GROUNDWATER ASSESSMENT

The objectives of study were to assess groundwater resources of the basin and identify areas where groundwater could be utilised to augment water shortfalls. The study consisted of the following approaches:

- Overview of the characteristics of the groundwater resource in terms of borehole yield, depth of water strikes and static water levels
- Delineation of groundwater units based on hydrogeological criteria and, the distribution of lithologies per Quaternary catchment
- Assessment of Groundwater harvest potential, exploitation potential and baseflow per Quaternary catchment or groundwater unit as per the GRAII database
- Assessment of basic groundwater quality in each groundwater unit
- Modelling of the surface-groundwater interactions using WRSM2000, using project derived estimates of groundwater use, and calibration against observed baseflow and recharge and dam volume data
- Derivation of a groundwater balance to determine baseflow and aquifer recharge
- Compare recharge, harvest and exploitation potential to the exiting level of use and future water demand to quantify available groundwater resources

2 INVESTIGATION APPROACH

2.1 UNITS OF ANALYSIS

Groundwater resources were assessed in terms of:

- Quaternary catchment
- Hydrogeological unit
- Water supply scheme

2.2 DATA SOURCES

The investigation was based on existing data collated from:

- The National Groundwater Data Base, also known as the NGA, the National Groundwater Archive
- The GRIP data base
- The GRAII data base
- The Harvest Potential map and data base of South Africa in WSAM
- WARMS
- Water use validation and verification study
- All towns studies

Additional data on the time series of recharge and baseflow was derived during this study by detailed sub-Quaternary WRSM2000 modelling, which is covered in the Hydrology Report (*P WMA 02/B810/00/1412/5).*

The National Groundwater Data base was used to collate information on borehole yield, water level and the depths of water strike. Since this database contains data on air lift yields when boreholes were established, it does not include subjective bias on sustainable yield, or recommendations, but is a measure of maximum borehole delivery, hence is generally higher than the sustainable yield of boreholes.

The GRIP data base provides information on infrastructure and recommended pumping rates, hence reflects the sustainable yield of existing boreholes, which may or not be the rate the borehole is currently utilised. When no recommended yield was given, boreholes equipped with motorised pumps were assumed to yield 50 m^3/d, and those equipped with submersible pumps 25 m^3/d, on the premise that the boreholes would not have been equipped with motorised systems if they were low yielding. The GRIP database is restricted to rural communal areas, hence does not include infrastructure in agricultural areas, nor towns and National or private game parks.

The GRAII data base DWA (2006) provides mean annual data on baseflow, recharge, aquifer storage and available resources on a Quaternary catchment level. This information was considered during calibration but was modified in the study by resimulation of the hydrology.

The WSAM data base provided data on Harvest and Exploitation Potential on a Quaternary catchment level.

The WARMS database and the water use validation study undertaken by Invirocon &Nyeleti Joint Venture (The Validation of small scale rural registrations and agricultural schemes and Verification of all water uses in the Luvuvhu (A9), Shingwedzi (B9), and Letaba catchment (B8) (DWA 2013b) were used to calculate groundwater use. Additional information on groundwater use for rural water supply was obtained from the All Towns study reports.

WRSM2000 was utilised in this study to resimulate the hydrology and provide calibrated data on the surface and groundwater balance and surface-groundwater interactions.

3 GEOLOGY AND HYDROGEOLOGY

3.1 STRATIGRAPHY AND LITHOLOGY

The study area is underlain by a diverse range of lithologies, spanning the geological time scale, from more than 3 Billion years old, to recent sediments. The stratigraphic units are shown in table 3.1. A simplified geological map is shown in figure 3.1. The lithological units were grouped into hydrogeological units based on lithological and topographical considerations that affect the occurrence of groundwater. The distribution of lithological units per Quaternary catchment is shown in Table 3.2.

Rocks of the Beitbridge complex occur in the NW portion of the Mutale basin. Although they form over 11% of catchment A92D, they don't occur elsewhere. These form part of the Central Zone of the Limpopo Mobile Belt. They consist of supracrustal gneisses which have been subjected to high grade metamorphism.

Old basement rocks of Swazian age, known as the Goudplaats gneiss, occupy nearly 50% of the study area, and are prevalent everywhere except the lower reaches of the Luvuvhu, the Mutale, and the lower reaches of the Letaba and Shingwedzi in the Kruger park. The Goudplaats Gneiss forms the basement on which the other existing lithologies were deposited and preserved. They consist of biotite gneiss, migmatite and re-melted granitic mobilizate. These gneissic bodies range from homogenous to strongly layered, fromleucocratic to dark grey, and from fine grained to pegmatoidal varieties.

The Bandelierskop complex occupies 1% of the study area and is found the upper reaches of the Luvuvhu and the Klein and Middle Letaba. The Bandelierskop Complex is a highly metamorphosed body infolded into the basement rocks consisting of amphibolites, mafic granulites, metapelites, metaquartzites, magnetites, pyroxenite and calc-silicates. It forms part of the southern marginal zone of the Limpopo Metamorphic Province and occurs as elongated bodies infolded with Goudplaats Gneiss.

Greenstones of the Murchison Sequence (Pietersburg, Giyani and Gravelotte Groups) form 5% of the study area and occupy a significant portion of the Klein and Middle Letaba catchments, and lower parts of the Groot Letaba and in the Shingwedzi catchments. The Murchison Sequence consists of ancient supra-crustal rocks preserved in the basement gneisses. Three large occurrences are present in the study area. The Giyani Group is a varied assemblage of volcano-sedimentary rocks consisting of ultramafic schists, amphibolite, banded iron formation, acid meta-lavas, garnetiferous schists, quartzite, dolomite, calc-silicate rocks and granulites. It outcrops primarily in the catchment of the middle reaches of the Klein Letaba, stretching SW to the Molototsi. The Gravelotte Group is only partially presented in the study area in the south. The green schist sequences consist of acid meta-lavas, andesite, chlorite schists, banded iron formation, mafic meta-lavas and ultramafic schists. It outcrops only on the southern margin of the Groot Letaba, where it forms the Murchison Range. The Pietersburg Group consists of amphibolites, quartzites and ultramafic schists. It is present as isolated outcrops in the Duiwelskloof region.

Small outcrops of Swazian age intrusive serpentinite, ultramafic schists and metapyroxenite occur in the basement rocks and the Murchison Sequence.

Vaalian and Randian granite intrusive plutons occupy nearly 8% of the area and occur predominantly in the Groot Klein and Middle Letaba catchment, but not in the lower reaches of the Letaba, where they intrude the basement complex. They are all essentially leucocratic muscovite, biotite granites.

Rocks of the Rooiwater Complex, The Wolkberg Group and Black Reef Formation are found in the upper reaches Letsitele and Thabina catchments, above the Groot Letaba confluence, where they form a watershed. The Rooiwater Complex is a layered intrusive ultra-mafic body in contact with the Gravelotte Group lithologies. The contact is structural and is thought to be due to thrusting. The Wolkberg Group consist of shale, quartzite and basalt.

Ultrabasic rocks of the Schiel complex occur largely in the northern portions of the Klein Letaba. The Schiel Complex is younger than the above granite intrusives and consists of a porphyritic hypersthene syenite and hornblende granite intrusives.

Soutpansberg Group rocks occupy nearly 13% of the area and are prevalent in the mountainous middle reaches of the Luvuvhu, Shingwedzi and Mutale basins, where they form an E-W mountain range.

Timbavati gabbros are found in the Nsama catchment, and the lower reaches of the Letaba and Shingwedzi. The Timbavati Gabbros are non-linear ultra-mafic sill like structures of varying width (can be larger than 1 km) which strikes in a general north/south direction. They consist of olivine gabbro. Of similar age and composition, are a series of NE trending diabase dykes that occur as swarms.

Table 3-1 Geology of the study area

Age (Ma)	Super Group/ Complex	Formation	Unit symbol	Lithology	Geological Unit	Groundwater Response Units
Quaternary 0.005-2.5			Q	Alluvium, sand	Quaternary	
Cretaceous 66-145		Malvernia	K	Conglomerate, sandstone, limestone	Malvernia	Lebombo
Jurassic 145-201		Tshokwane intrusive	Jt	Granophyre	Tshokwane	Lebombo
		Intrusive	do	Dolerite		
			gr	Granite		
	Karoo	Jozini	Jj	Rhyolite	Jozini	Lebombo
		Letaba	Jl	Basalt	Letaba	Lebombo, Limpopo basalts
Triassic 201-252		Clarens	Trc	Sandstone	Karoo	Karoo
		Bosbokpoort	Trb	Siltstone		
		Klopperfontein	Trk	Sandstone, conglomerate		
		Solitude	Trs	Shale mudstone, siltstone, sandstone		
		Fripp	Pf	Sandstone, conglomerate		
Permian 252-299		Mikambeni	Pmi	Mudstone, shale		
		Madzaringwe	Pma	Shale, carbonaceous shale, siltstone, coal, sandstone		

		Thidzi	Pt	Diamictite		
Namibian 570-1180		Intrusive	di	Diabase		
		Timbavati	Nt	Gabbro	Timbavati	Lowveld Plains
Mokolian 1180-2070	Soutpansberg	Intrusive	Mdi	diabase	Soutpansberg	Soutpansberg
		Mabiligwe	Mm	Quartzite, sandstone, shale, conglomerate		
		Nzhelele	Mn	Sandstone, basalt		
		Wylie's poort	Mw	Quartzite sandstone, conglomerate, shale		
		Funduzi	Mf	Sandstone, basalt		
		Sibasa	Ms	Basalt, minor sandstone		
		Tshifhefhe	Mt	Conglomerate, quartzite		
Vaalian 2070-2620		Black Reef	Vbr	Quartzite, lava, agglomerate, shale	Black Reef	Drakensberg Escarpment
	Wolkberg	Sadowa	Vws	Shale	Wolkberg	Drakensberg Escarpment
		Mabin	Vwm	Quartzite and shale		
		Selati	Vwe	Shale and quartzite		
		Schelem	Vwc	Quartzite and conglomerate		
		Abel Erasmus	Vwa	Lava, shale, quartzite		
		Sekoro	Vwk	Quartzite, conglomerate, limetsone		
		Palmietsfontein	Vpa	Granite	Granite intrusives	Bandelierskop
		Entabeni	Ve	Granite		Bandelierskop
	Schiel		Vsh	Granite	Schiel	Bandelierskop
			Vsg	Gabbro		

			Vss	Syenite		
		Leucocratic granite	Vlg	Granite	Granite intrusives	Drakensberg Escarpment, Foothills and Valleys, Lowveld Plain
		Turfloop	Vt	Granite		Drakensburg Escarpment
Randian 2620-3090		Baderouke	Rib	Granite		Lowveld Plains
		Pompey	Rip	Granite		Lowveld Plains
		Shirindi	Ra	Granite		Lowveld Plains
		Shamiriri	Rb	Granite		Lowveld Plains
		Macetse	Rc	Granite		Lowveld Plains
		Eiland	Re	Granite		Lowveld Plains
		Meriri	Rd	Granite		Lowveld Plains
	Rooiwater	Beesplaas	Rrb	Diorite	Rooiwater	Foothills and Valleys
		Novengilla	Rrn	Gabbro		
		Jerome	Rj	Granite	Granite intrusives	Lowveld Plains
Swazian 3800-3090			Zyx	Metapyroxenite	Giyani	Giyani-Gravelotte
			Zys	Serpentinite		
			Zgs	Serpenite, schist, metapyroxenite		
	Gravelotte	Rubbervale	Zgr	Schist, porphyry, pyroclastics	Gravelotte	Giyani-Gravelotte
		La France, Weigel, Mac kop	Zgw	Schist, quartzite, greywacke, chert		

		Leydsdorp	Zgl	Metalava, amphibolite		
		Mulati	Zgm	Schist		
	Giyani		Zym	metapyroxenite	Giyani	Giyani-Gravelotte
			Zy	Amphibolite, schist, metaquartzite. Dolomite, calc-silicates		
	Pietersburg	Zandrivierspoort	Zpz	Amphibolite, quartzite	Pietersburg	Drakensberg Escarpment, Foothills and Valleys, Bandelierskop
		Mothiba	Zpm	Schist, amphibolite, quartzite		
	Bandelierskop		Zbc	Marble, Calc-silicates	Bandelierskop	Bandelierskop
			Zbp	Metapelite		
			Zbq	Quartzite		
			Zbm	Amphibolite, granulite		
			Zbu	Peridotite, dunite, metapyroxenite		
	Beitbridge	Gumbu	Zgu	Calc-silicates, marble, gneiss, metaquartzite, amphibolite, metapelite	Beitbridge	Limpopo Mobile Belt
	Goudplaats		Zg	Gneiss, granite, migmatite	Goudplaats	Drakensberg Escarpment, Foothills and Valleys, Lowveld Plain

Table 3-2 Geological Units per Quaternary Catchment

Quat	Area	Goudplaats	Beitbridge	Bandelierskop	Pietersburg	Giyani	Gravelotte	Granite intrusives	Rooiwater	Schiel	Wolkberg	Blackreef	Soutpansberg	Timbavati	Karoo sediments	Letaba	Jozini	Tshokwane	Malvernia	Quaternary
Km^2	24920	12267.2	93.5	215.9	122.1	777.6	327	1889.5	239.9	178.1	89.5	12.8	3154.4	202.9	779.1	3561.8	112.1	122.8	80.7	693.1
%		49.2	0.4	0.9	0.5	3.1	1.3	7.6	1.0	0.7	0.4	0.1	12.7	0.8	3.1	14.3	0.4	0.5	0.3	2.8
A91A	232	37.1	0.0	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A91B	275	80.4	0.0	18.2	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A91C	250	84.8	0.0	1.2	0.0	0.0	0.0	4.2	0.0	0.8	0.0	0.0	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A91D	132	41.8	0.0	0.0	0.0	0.0	0.0	6.2	0.0	2.4	0.0	0.0	49.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A91E	223	40.1	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.0	59.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A91F	580	78.0	0.0	0.0	0.0	0.9	0.0	1.7	0.0	2.8	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A91G	406	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	97.8	0.0	0.0	0.0	0.0	0.0	0.0	2.2
A91H	450	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	99.8	0.0	0.0	0.0	0.0	0.0	0.0	0.2
A91J	570	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.9	0.0	32.1	6.5	0.0	0.0	0.0	0.5
A91K	669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.8	46.2	0.0	0.0	11.1	29.0
A92A	329	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	82.7	0.0	0.0	0.0	0.0	0.0	0.0	17.3
A92B	565	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80.7	0.0	0.0	0.0	0.0	0.0	0.0	19.3
A92C	455	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.4	0.0	36.0	1.1	0.0	0.0	0.0	4.5
A92D	805	0.0	11.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.5	0.0	21.1	38.4	0.0	0.0	0.8	18.5
B81A	169	42.0	0.0	0.0	1.8	0.0	0.0	56.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B81B	481	9.6	0.0	0.0	0.7	0.0	0.0	88.3	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B81C	208	49.7	0.0	0.0	0.2	0.0	0.0	49.7	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B81D	479	6.2	0.0	0.0	0.0	0.0	16.7	29.6	27.5	0.0	17.3	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B81E	665	46.7	0.0	0.0	2.9	0.0	0.0	34.3	16.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B81F	1201	83.6	0.0	0.0	0.9	0.0	1.6	13.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B81G	513	68.6	0.0	0.0	0.0	0.5	0.0	31.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B81H	668	76.6	0.0	0.0	0.0	5.5	0.0	17.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

B81J	568	79.5	0.0	0.0	0.0	0.0	16.2	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B82A	467	81.8	0.0	0.0	9.9	0.0	0.0	8.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B82B	406	77.6	0.0	0.0	8.6	0.0	0.0	13.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B82C	300	67.5	0.0	0.0	1.2	0.0	0.0	31.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B82D	632	95.9	0.0	2.4	0.0	0.0	0.0	0.2	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B82E	423	83.5	0.0	16.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B82F	760	72.2	0.0	8.6	0.0	0.0	0.0	0.1	0.0	19.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B82G	921	65.0	0.0	0.0	0.0	28.2	0.0	6.6	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B82H	749	64.7	0.0	0.0	0.0	33.6	0.0	0.3	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0
B82J	795	95.9	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0
B83A	1252	75.6	0.0	0.0	0.0	0.0	10.5	9.9	0.0	0.0	0.0	0.0	0.0	3.3	0.3	0.5	0.0	0.0	0.0	0.0
B83B	439	77.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	2.4	15.9	0.0	0.0	0.0	0.0
B83C	592	18.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	1.8	74.8	3.4	1.7	0.0	0.0
B83D	714	33.9	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	5.9	2.2	46.9	2.0	8.5	0.0	0.0
B83E	267	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	64.7	19.7	15.6	0.0	0.0
B90A	693	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.6	0.0	15.7	44.8	0.0	0.0	0.0	13.9
B90B	754	72.8	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	26.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B90C	535	99.5	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B90D	447	64.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.3	1.6	1.1	19.5	0.0	0.0	0.0	0.0
B90E	474	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	94.1	3.0	0.0	0.0	3.0
B90F	819	82.0	0.0	0.0	0.0	15.7	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
B90G	698	48.8	0.0	0.0	0.0	11.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6	2.3	29.0	0.0	0.0	0.0	0.0
B90H	890	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	93.1	1.2	1.2	0.0	4.5

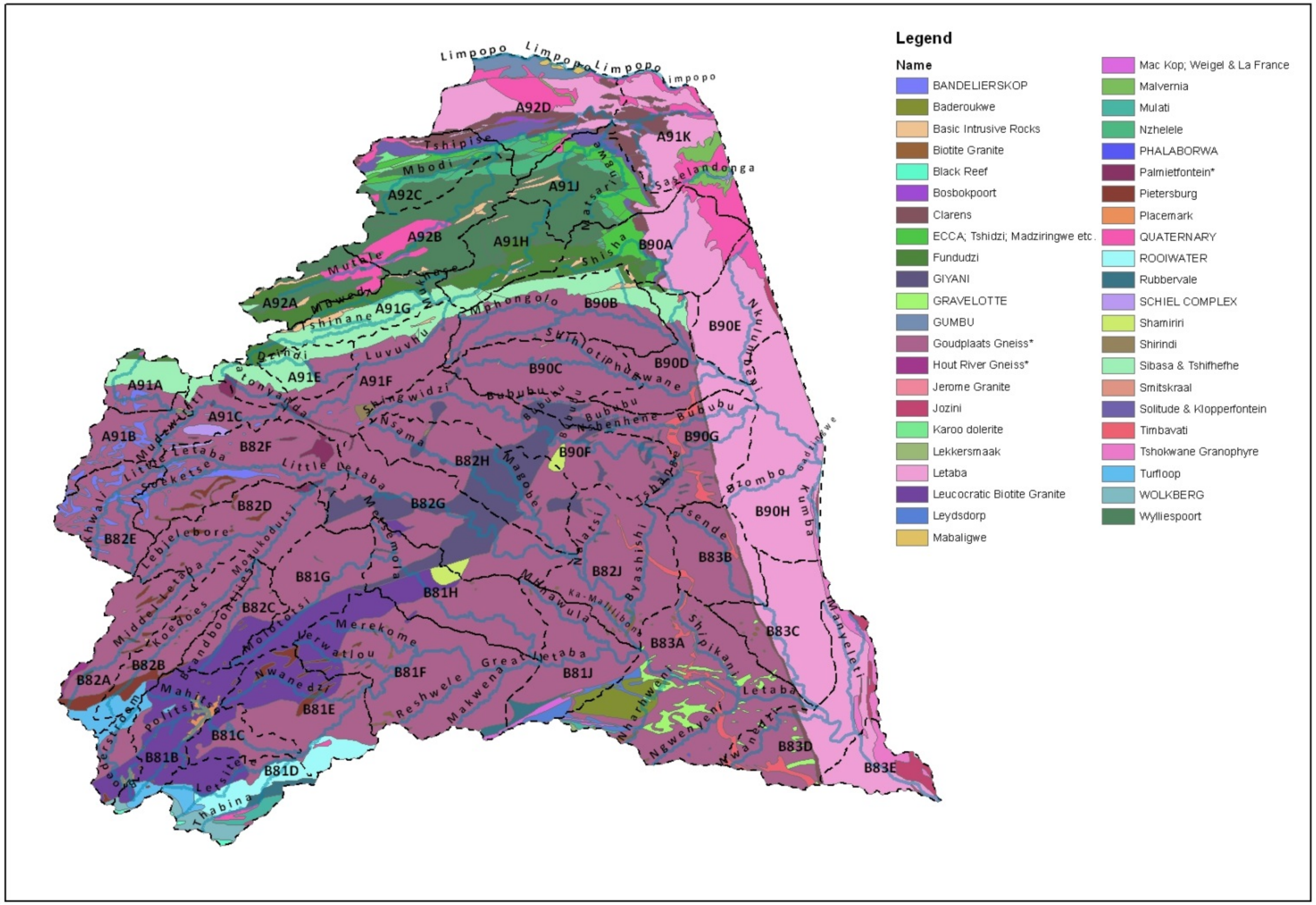


Figure 3-1 Geology of the study area

Karoo rocks occupy 18% of the area, with the Letaba basalts being the most common. They occur in the lower reaches of the Luvuvhu, Mutale and Letaba within the Kruger Park. The Letaba Formation consists of a thick layer of N-S striking basalt lava. The mountain range which forms the Lebombo range is made up Tshokwane Granophyre and Jozini Formation rhyolite. A small outcrop of N-S striking Clarens Formation sandstone of hydrogeological significance occurs on the western margin of the basalts. Other Karoo sediments occur in the north in the Luvuvhu and Mutale catchments.

Quaternary age alluvium is preserved in broad shallow depressions and in the valleys of the study area. These deposits are made up of sand, river terrace, gravel, high level gravels and scree. Quaternary colluvium is found over large areas of the mountainous region of the Mutale.

3.2 STRUCTURE

Structural geology greatly influences the water resouces by creating preferential pathways. The various intrusive phases, folding and faulting, and metamorphic events have created fracture patterns of higher permeability, and have influenced the surface drainage network.

The study area is located primarily on the north-eastern part of the Kaap Vaal craton and the southern marginal zone of the Limpopo Mobile Belt (figure 3.2).

The Hout River Shear Zone forms the southern margin of the Limpopo Mobile Belt and forms the boundary between the low grade metamorphism Basement lithologies of the Kaapvaal Craton and the higher grade rocks of the Limpopo Mobile Belt. The Shear Zone strikes E-W and consists of steeply dipping (to the north) thrusts and reverse faults, as well as several NE-SW striking strike-slip faults. North of this shear zone, several subsidiary E-W and NE trending shears can be observed. To the south on the Kaapvaal Craton, shears are oriented only to the NE.

The metapelites of the Bandelierkop Complex are only found in the Southern Marginal Zone, north of this Shear Zone.

The intrusive phases included the intrusion of Vaalian and Randian granite plutons, as well as diabase and dolerite dykes, gabbroic and basaltic extrusions. Diabase dyke and sill intrusions form negative topographic features in areas underlain by Soutpansberg rocks, and positive ones in basement rocks.

Dykes in the southern marginal zone strike ENE, while on the Kaapvaal cration they strike NE. Karoo dykes form concordant sheets in the lower part of the Karoo Supergroup rocks in the southern marginal zone and are oriented NNW.

Jointing however, has a predominant E-W orientation in the southern marginal zone, whereas joints are predominantly to the NW in the Kaapvaal Craton.

Folding in the Swazian age metamorphic rocks of the Murchison Sequence and Bandelierskop shows a strong NE-SW trend, hence creates a pattern of preferntial permeability.

Two intersecting fault systems cut across the Karoo and Soupansberg rocks in an ENE and WNW.

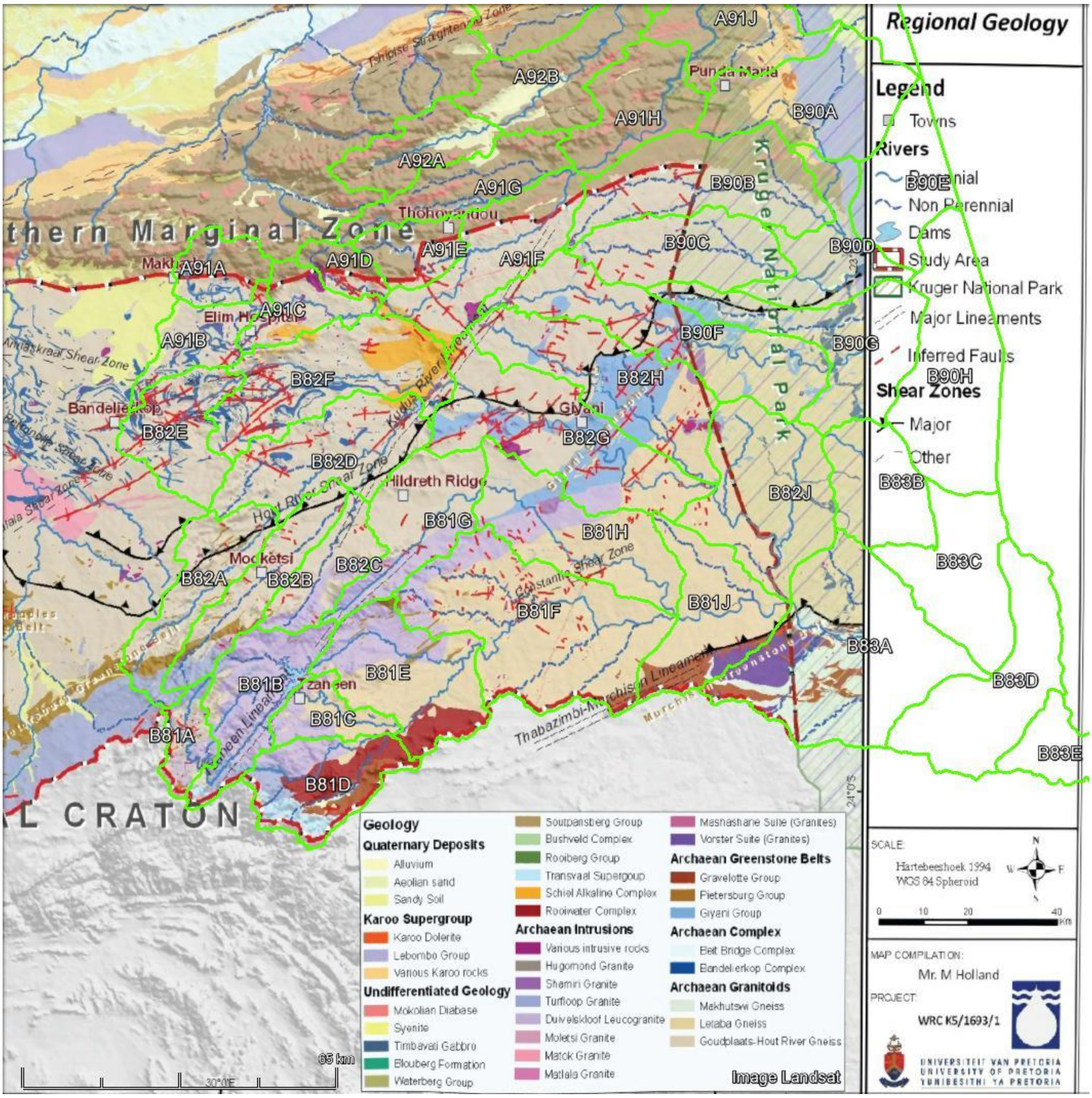


Figure 3-2 Structural domains in the Luvuvhu-Letaba

4 GROUNDWATER REGIONS AND RESPONSE UNITS

The study area encompasses several groundwater regions, as described by Vegter (2001). These groundwater regions are defined based on groundwater occurrence, physiography and climate. Physiography and climate and affect recharge, the availability of surface water and interactions, the re-emergence of recharge as interflow, the soil surface cover and evapotranspiration. The study area is underlain by the following Vegter groundwater regions:

- Limpopo granulite-gneiss belt: underlies the northern margin of the Mutale basin where the Gumbu Formation Beitbridge Complex is present
- Lowveld: The region underlain largely by Goudplaats gneiss, Randian and Vaalian plutons and subordinate complexes, which occupies 70% of the region
- Northern Lebombo: the region underlain by Letaba basalts and Jozini rhyolites
- Soutpansberg Hinterland: Region of the Mutale underlain by Letaba basalt and Karoo sediments
- Soutpansberg: The region of the Luvuvhu and Mutale underlain by Soutpansberg Group rocks, which occupies 15% of the study area

The Vegter groundwater regions can be further subdivided into several hydrogeological regions based on topography, surface groundwater interactions, and groundwater yield characteristics (figure 4.1). These units are:

- Drakensberg Escarpment
- Drakensberg Foothills and valleys
- Soutpansberg
- Bandelierskop
- Giyani-Gravelotte greenstones
- Low veld plains
- Lebombo
- Karoo
- Limpopo Mobile Belt
- Limpopo Basalts
- Alluvium

The groundwater regions were tabulated according to their total areas (table 4.1), and their distribution per Quaternary catchment (table 4.2).

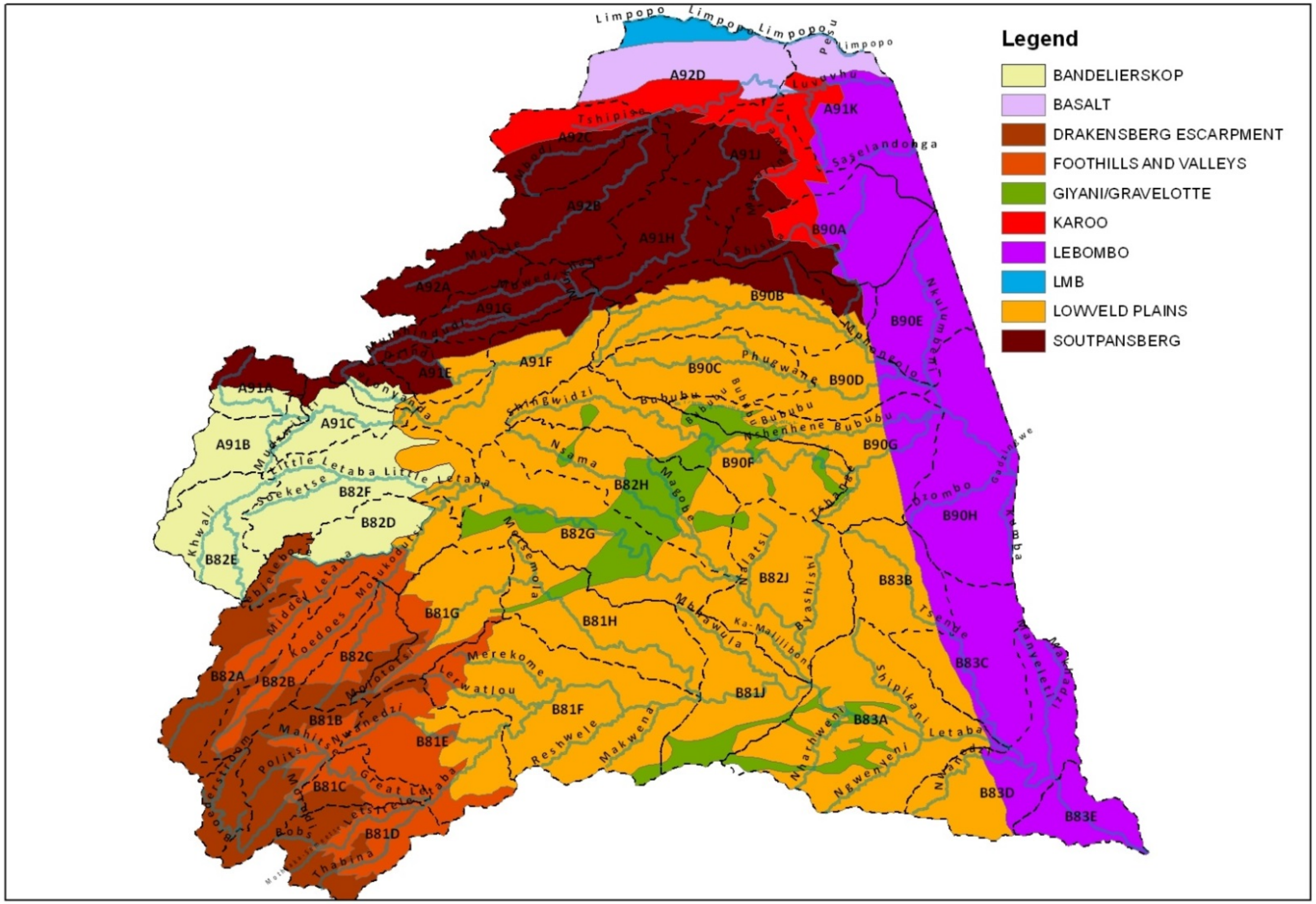


Figure 4-1 Groundwater response units.

Table 4-1 Areal Distribution of GRUs

GRU	Total	Total
BANDELIERSKOP	1877	7.30%
BASALT	557	2.17%
DRAKENSBERG ESCARPMENT	1539	5.99%
FOOTHILLS AND VALLEYS	1964	7.64%
GIYANI/GRAVELOTTE	1068	4.15%
KAROO	764	2.97%
LEBOMBO	3792	14.75%
LMB	119	0.46%
LOWVELD PLAINS	10682	41.56%
SOUTPANSBERG	3342	13.00%
Grand Total	25704	100.00%

Table 4-2 Distribution of GRUs per Quaternary catchment

	GRU										
QUAT	Bandelierskop	Basalt	Escarpment	Foothills and Valleys	Giyani Gravelotte	Karoo	Lebombo	LMB	Lowveld Plains	Soutpansberg	Total
A91A	44%	0%	0%	0%	0%	0%	0%	0%	0%	56%	100%
A91B	99%	0%	0%	0%	0%	0%	0%	0%	0%	1%	100%
A91C	85%	0%	0%	0%	0%	0%	0%	0%	5%	9%	100%
A91D	44%	0%	0%	0%	0%	0%	0%	0%	7%	49%	100%
A91E	0%	0%	0%	0%	0%	0%	0%	0%	39%	61%	100%
A91F	0%	0%	0%	0%	0%	0%	0%	0%	84%	16%	100%
A91G	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	100%
A91H	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	100%
A91J	0%	0%	0%	0%	0%	32%	6%	0%	0%	61%	100%
A91K	0%	19%	0%	0%	0%	17%	64%	0%	0%	0%	100%
A92A	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	100%
A92B	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	100%
A92C	0%	0%	0%	0%	0%	41%	0%	0%	0%	59%	100%
A92D	0%	53%	0%	0%	0%	24%	0%	15%	0%	9%	100%
B81A	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	100%
B81B	0%	0%	72%	28%	0%	0%	0%	0%	0%	0%	100%
B81C	0%	0%	25%	75%	0%	0%	0%	0%	0%	0%	100%
B81D	0%	0%	51%	49%	0%	0%	0%	0%	0%	0%	100%
B81E	0%	0%	6%	57%	0%	0%	0%	0%	37%	0%	100%
B81F	0%	0%	0%	8%	2%	0%	0%	0%	90%	0%	100%
B81G	0%	0%	11%	26%	0%	0%	0%	0%	63%	0%	100%
B81H	0%	0%	0%	0%	5%	0%	0%	0%	95%	0%	100%
B81J	0%	0%	0%	0%	17%	0%	0%	0%	83%	0%	100%
B82A	0%	0%	71%	29%	0%	0%	0%	0%	0%	0%	100%
B82B	0%	0%	26%	74%	0%	0%	0%	0%	0%	0%	100%
B82C	0%	0%	36%	64%	0%	0%	0%	0%	0%	0%	100%
B82D	37%	0%	14%	31%	0%	0%	0%	0%	18%	0%	100%

B82E	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
B82F	75%	0%	0%	0%	0%	0%	0%	0%	24%	0%	100%
B82G	0%	0%	0%	0%	22%	0%	0%	0%	78%	0%	100%
B82H	0%	0%	0%	0%	27%	0%	0%	0%	73%	0%	100%
B82J	0%	0%	0%	0%	1%	0%	0%	0%	99%	0%	100%
B83A	0%	0%	0%	0%	12%	0%	1%	0%	87%	0%	100%
B83B	0%	0%	0%	0%	0%	0%	18%	0%	82%	0%	100%
B83C	0%	0%	0%	0%	0%	0%	79%	0%	21%	0%	100%
B83D	0%	0%	0%	0%	0%	0%	63%	0%	37%	0%	100%
B83E	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	100%
B90A	0%	0%	0%	0%	0%	13%	59%	0%	0%	28%	100%
B90B	0%	0%	0%	0%	0%	0%	0%	0%	74%	26%	100%
B90C	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	100%
B90D	0%	0%	0%	0%	0%	0%	19%	0%	67%	14%	100%
B90E	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	100%
B90F	0%	0%	0%	0%	14%	0%	0%	0%	86%	0%	100%
B90G	0%	0%	0%	0%	10%	0%	26%	0%	64%	0%	100%
B90H	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	100%
Grand Total	7%	2%	6%	8%	4%	3%	15%	0%	42%	13%	100%

4.1 ESCARPMENT ZONE

This zone forms 6% of the total WMA, and is found in the south-western part of the WMA, where it constitutes the Transvaal Drakensberg mountain range. The Escarpment zone ranges from Wolkberg sedimentary rocks in the south, to primarily Vaalian age intrusive granites intruded into Goudplaats gneiss in the central zone, to Goudplaats gneiss in the northern region (figure 4.2). Scattered xenoliths of ultramafic schists, amphibolite and magnetite quartzite of the Pietersburg Group exist throughout. Numerous NE-SW striking dykes have also intruded the area.

Rainfall exceeds 1000 mm/a, except in the upper Koedoes and Middle Letaba valleys where rainfall is 600 mm/a due to the rain shadow effect of the Duiwelskloof mountains. The main aquifers are associated with fractured dyke contact zones and lithological contact zones. Although they may be highly permeable, storage in these fractured aquifers is very limited, especially where a deep overlying weathered zone is absent. As a result they may provide high initial yields, which decline rapidly as the larger joints and fractures are dewatered.

On the steep slopes that generally exceed 15^{o}, recharge to these aquifers is rapidly discharged in the forms of springs, which provide rapid baseflow via interflow to the rivers, hence much of the recharge is not stored in the regional aquifer for any length of time. Recharge may exceed 200 mm/a, however, since most generates interflow on the steep slopes, it does not reach the regional aquifers that occur in the valley bottoms, hence is not directly exploitable via boreholes.

To a lesser extent as a result of the steep topography, an intermittent weathered zone aquifer is found where deep weathering occurs. The steep topography generally inhibits deep weathered profiles, hence weathered zone aquifers are generally found only at the top of the escarpment where the Pietersburg plateau exists, or in valley bottoms. Where these weathered zones exist they provide storage of groundwater which feeds the underlying fractured aquifer when it is subjected to pumping.

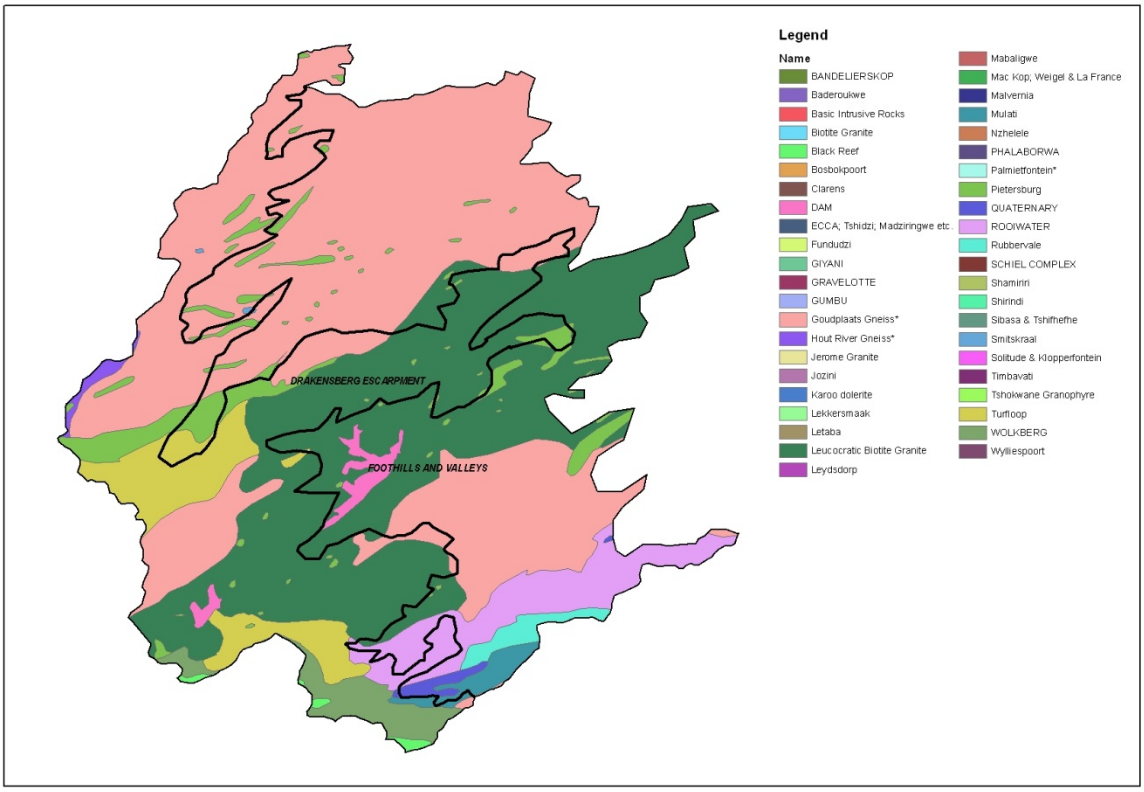


Figure 4-2 Geology of the Escarpment and foothills regions

Groundwater yields typically vary between 0.5 and 1.5 l/s and groundwater quality is expected to be good, with TDS being less than 500 mg/l. Groundwater generally occurs in fractures situated on average 10 m below the static water level.

Although recharge is high, up to 40% of boreholes are dry, further confirming that the bulk of recharge does not enter and is not stored in the regional fractured aquifer, but is shed as interflow from shallow fractures above the regional water level. Furthermore, it should be noted that groundwater has a rapid turn-over time in the aquifers and is soon discharged in the form of springs, contributing significantly to stream flow. Spring yields vary between 1 and 3 l/s and are the source for much of the baseflow in the Letaba system.

Forestry and natural forest occurs along the escarpment. The escarpment area is ecologically sensitive and represents an important groundwater recharge zone and interflow region where uncontrolled development will have adverse impacts on baseflow. Interflow has been depleted by commercial afforestation and alien vegetation that is found on the high lying areas, or by transmission losses downstream where abstraction causes the water level to drop below the river, inducing losses from the river to the aquifer.

4.2 DRAKENSBERG FOOTHILLS AND VALLEYS

The Drakensberg foothills and valleys form nearly 8% of the WMA and the geology is similar to the Escarpment zone, except that gabbroic and dioritic rocks of the Rooiwater Complex and greenstones of the Gravelotte Group are intruded by the Vaalian age granitoid rocks in the extreme south (figure 4.2). Rainfall is 500-1000 mm and slopes are generally flat to moderate, with slopes generally less than 15%.

The aquifers are of a composite type, consisting of fractured zone and overlying weathered zone aquifers. Deep weathering occurs along rivers and streams and dyke contact zones are highly fractured. The Rooiwater aquifer is deeply weathered and is generally of the weathered type.

Boreholes have yields ranging between 0.5 to 3.0 l/s and less than 30% are dry. Scientifically sited boreholes yield more than 3 l/s. Groundwater quality is good to fair and TDS of up to 1000 mg/l are expected. Borehole yields in the northern granite areas tend to be in the 2 – 5l/s range with local areas of deep weathering and good structural development supporting yields >5l/s.

The aquifers are extensively used by rural water supply boreholes. A fair proportion of these boreholes are situated in the granite aquifers. As a result of the lack of sanitation facilities, elevated nitrate concentrations commonly occur in groundwater. The hardness of granites and consequent shallow depth of weathering aggravates the impact of contamination of granite aquifers in the absence of adequate sanitation systems and uncontrolled animal grazing, both of which are part of the rural population's lifestyle.

The Granite aquifers meet the domestic demand of the communities in the area around Tzaneen and Letsitele. Extensive sub-tropical agriculture is practised in the south of the Lowveld plain east of Tzaneen, especially along the Letaba River. Groundwater is also used for supplementary irrigation along the Letaba River.

Groundwater development for irrigation purposes takes place on a large scale at Letsitele (1 to 2 million m^3/a), Mooketsi (2 to 5 million m^3/a). Very few intrusive hydrogeological investigations have been carried out to conceptualize and quantify groundwater flow, recharge and the water balance to enable long-term aquifer management.

Large-scale irrigation of permanent crops, i.e. citrus, mango, avocado, banana, litchi and macadamia nuts takes place at Letsitele and Mooketsi to the east and north of Tzaneen, conjunctively using surface and groundwater. The 1000 ha large tea plantations of SAPICO are situated on the plateau. The sole reliance of farmers on permanent crops makes agriculture, which is the most important economic activity in the greater Tzaneen area, very sensitive and highly dependent on the water supply conditions. In general, large-scale irrigation and agricultural activities reduce considerably towards the ‘drier’ east.

Due to low volumes of groundwater storage, these aquifers are very vulnerable and sensitive to changes in rainfall patterns during droughts. During times of drought, boreholes dry out if not managed properly. Extensive forestry and agricultural activities in and around Tzaneen also impacts on the volumes and quality of groundwater flowing back to the Letaba River as baseflow.

4.3 SOUTPANSBERG

This area comprises the eastern part of the east - west trending Soutpansberg Mountains. Rocks of the Soutpansberg underlie 13% of the WMA. They consist largely of sandstones and quartzite forming parallel ENE ridges. Faults separate a Horst and Graben topography and are the most permeable feature in these low permeability sediments (figure 4.3).

Rainfall exceeds 1000 mm/a in the upper reaches of the Luvuvhu and declines to less to 200 mm/a in an ENE direction. The main aquifers are associated with fractured dyke contact zones and fault contact zones. The Soutpansberg rocks are significantly faulted, and faults can provide high yields, in spite of the low storativity of the aquifers.

The steep topography and resistant nature of the rock generally inhibits deep weathered profiles and aquifers are fractured in nature.

Storage in these fractured aquifers is very limited, especially where a deep overlying weathered zone is absent. As a result they may provide high initial yields, which decline rapidly as the larger joints and fractures are dewatered.

The town of Thohoyandou is situated on the southern boundary of this lithological unit in A91E. This area mostly comprises communal lands. Quaternary catchments A91D, G & H and A92A & B are heavily settled, (Thohoyandou and Malamulele). There is widespread use of groundwater and many of the communities are supplied with conjunctive schemes using surface water together with groundwater as the source. Springs are also an important source of water supply for the rural communities.

Groundwater resources are generally low to moderate with sustainable borehole yields between 0.5 and 2 l/s, although higher yields (>3l/s) are found along fault and fracture zones. Boreholes vary from 60 – 150m in depth and static water levels vary from <10mbgl to >40mbgl, depending upon the topographical position.

The groundwater quality is mostly good; localised occurrences of elevated NO_3 are reported in the communal land areas.

The Soutpansberg Mountains are an important recharge area and provides significant volumes of baseflow to surface drainage. On the steep slopes that generally exceed 15^o, recharge to these aquifers is rapidly discharged in the forms of springs, which provide interflow to the rivers that may exceed 200 mm/a, however, these resources are not directly exploitable by the regional aquifers that occur in the valley bottoms. As a result, a large fraction of recharge cannot be directly exploited through boreholes.

Although recharge is high, up to 40% of boreholes are dry, indicating that the bulk of recharge does not enter the regional fractured aquifer, but is shed as interflow from shallow fractures above the regional water level.

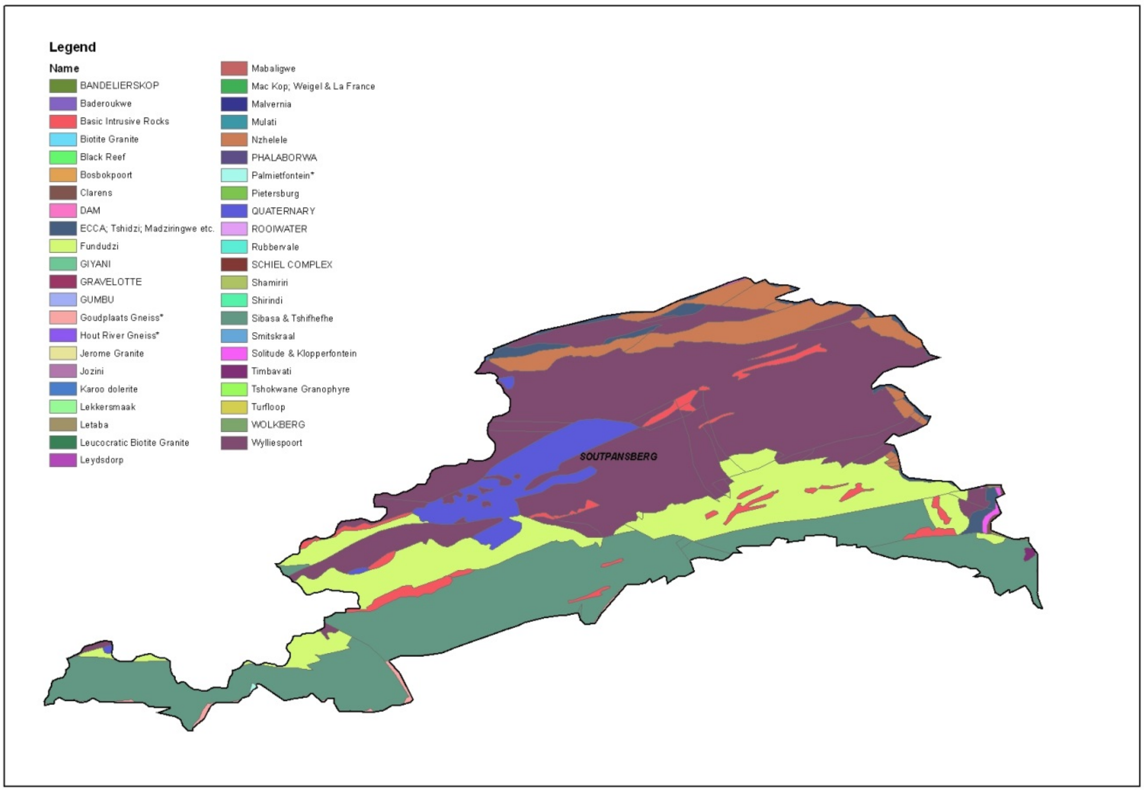


Figure 4-3 Geology of the Soutpansberg

4.4 BANDELIERSKOP

This granitic area lies immediately south of the Soutpansberg Mountains. The western areas form the escarpment trending north from Tzaneen towards Thohoyandou. Below the escarpment the Lowveld forms a gently rolling to flat landscape. The Luvuvhu River rises in the escarpment in the west.

The Bandelierskop region underlies 7% of the WMA. The geology of this region consists of mafic volcanic and pelitic rocks infolded into basement gneisses, as well numerous NE trending diabase dykes and some xenoliths of the Pietersburg Group. Intrusions of Vaalian age granites, and granites and gabbros of the Schiel complex also occur (figure 4.4).

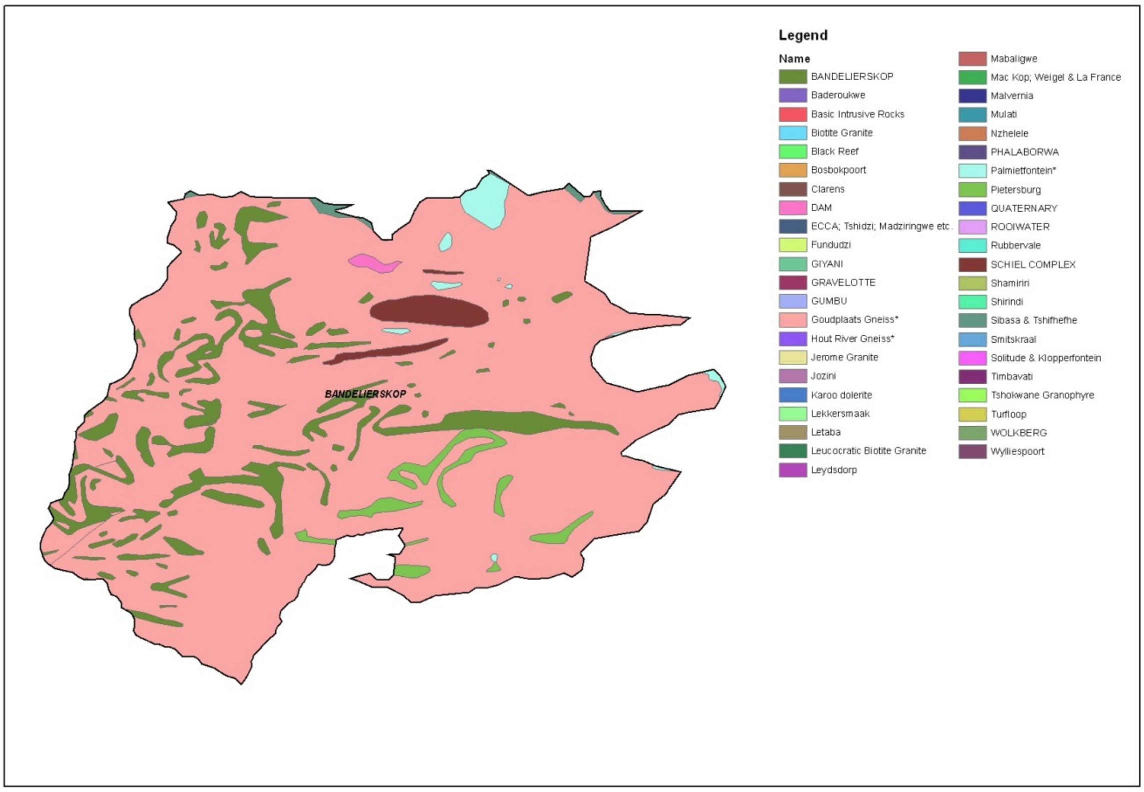


Figure 4-4 Geology of the Bandelierskop region

Significant faulting is also evident. The regional MAP is 500-1000 mm. The region is hilly and has slopes of 5-15^o.

There is heavy dependence on groundwater in Elim (A91B). Conjunctive use schemes supply many of the communities. Large scale irrigation takes place at Levubu (1 to 2 million m^3/a) right through to Louis Trichardt (which falls outside the Letaba catchment).

Groundwater occurrence is controlled by the presence of weathered zones and structural features. Fractures and faults formed by the various deformational phases and dykes are thought to constitute the main aquifers as a result of deeper weathering. A considerable number of water supply boreholes were installed in this aquifer to meet the basic human need requirements of rural communities. Borehole yields are generally less than 1.5 l/s, however higher yields are associated with faults. Local areas of deep weathering and good structural development can result in yields >5l/s, such as on well-developed regional structures and faults.

Boreholes are generally 70 – 100m deep and water levels 15 – 40m below surface depending upon the topography.

Groundwater quality is generally good (Class 1) to moderate (Class 2) with conductivities between 70 and 300mS/m. Elevated NO3 levels are reported in many of the settlements.

4.5 GIYANI-GRAVELOTTE

This greenstone belt region forms 4% of the WMA and includes highly metamorphosed ultramafic to mafic schist, amphibolite, mafic meta-lava, quartzitic schist, quartzite and ironstone. Local fractured aquifers dominate this region as a result of the intense folding and associated fracturing (figure 4.5). Rainfall varies from 500-600 mm/a and the topography is generally flat, except where steep ridges where quartzite and ironstone formations outcrop.

These lithologies form a SW – NE trending outcrop in the central part of the Letaba and Shingwedzi catchments between the Molototsi River in the south and Shingwedzi in the north, and a southern outcrop sub-paralleling the boundary with the Olifants catchment. These areas form a hilly landscape and are characterised by numerous gold, silver, copper, nickel and zinc deposits and small abandoned mines.

Much of the central area around Giyani and the area around Letsitele in the south comprises communal lands. These areas rely on groundwater for domestic supplies and stock watering. Large-scale groundwater abstraction currently takes place at Giyani for domestic purposes. Localized low yielding boreholes are also in use by various rural communities to meet their basic human need requirements.

Groundwater occurrence is controlled by the presence of weathering zones and structural features and tends to be favourably developed especially within the mafic and ultramafic units.

Borehole yields in the central area average 2 – 5l/s with local areas of deep weathering and good structural development supporting yields >5l/s. The groundwater resources are less well developed in the southern areas and yields tend to be between 0.5 and 2 l/s. Boreholes are generally 70 – 100m deep and water levels 15 – 30m below surface depending upon the topography.

Groundwater quality is generally moderate to good with conductivities between 70 and 300mS/m. Elevated NO_3 levels are reported in many of the settlements.

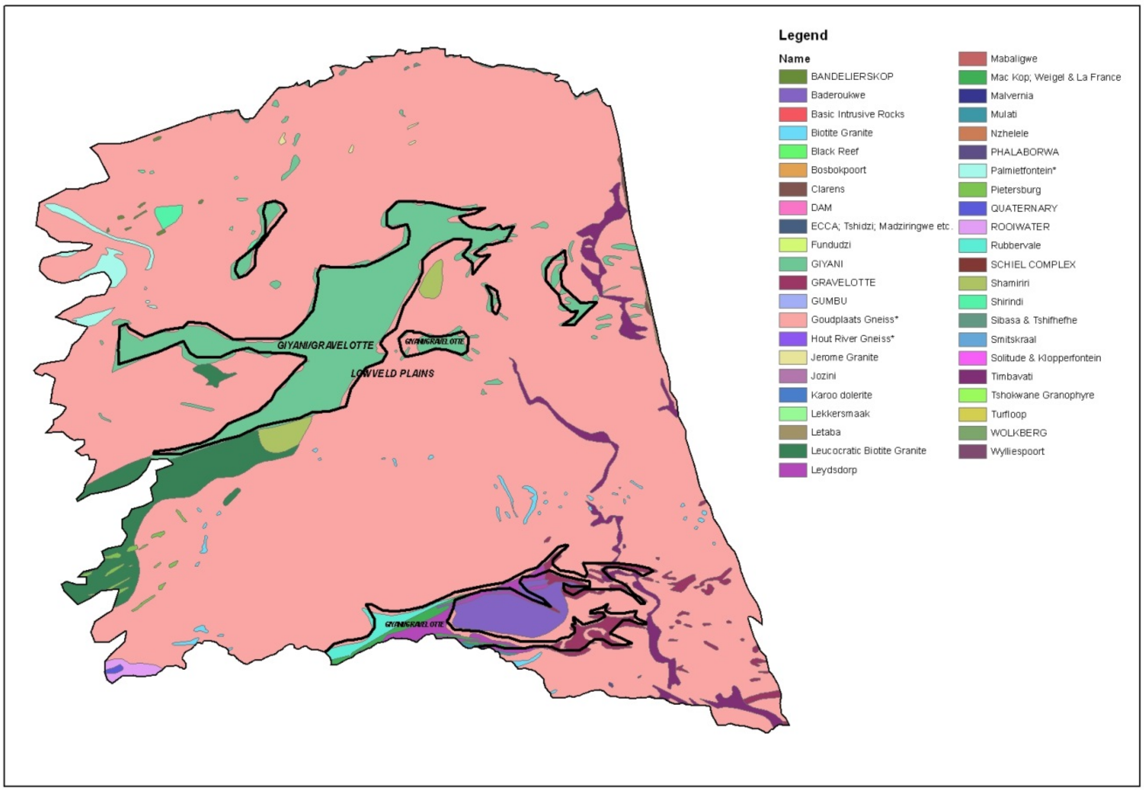


Figure 4-5 Geology of the Giyani-Gravelotte and Lowveld Plains regions

4.6 THE LOW VELD PLAINS

This region covers 42% of the study area and underlies the largest part of the plains of the central Letaba and Shingwedzi catchments to approximately the Kruger Park boundary.

These aquifers are composed largely of fractured Goudplaats gneiss, with xenoliths of undifferentiated metamorphic rocks and meta-arenaceous rocks (quartzite, gneiss and migmatite). In the east the Timbavati Gabbro and numerous diabase dykes are intrusive (figure 4.5).

Rainfall varies from 500-600 mm/a. Groundwater occurrence is controlled by the presence of weathering zones and structural features. Yields are lower than in the foothills to the west, and tend to be between 0.5-and 2 l/s. Where local weathering is shallow and structural features limited, yields are <0.5l/s. Boreholes are generally 70 – 100m deep and water levels 15 – 40m below surface depending upon the topography.

Much of the Lowveld area comprises communal lands. There is heavy dependence on groundwater in Malemulele (western parts of B90B, C & F), Giyani (B81H & J, B82F, G, H, & J), Sekgosese (B82D) Bolebedu (B81E, F & G), and NW of Phalaborwa (B81F & J). Conjunctive use schemes supply many of the communities, particularly in the Giyani area.

In addition to the above, localized groundwater use for domestic and game watering purposes is widespread at the various game farms in the area from Phalaborwa to Hoedspruit and various rural water supply boreholes exist with yields ranging between 0.5 and 3.0 l/s.

Localized use of granite aquifers for domestic and game watering purposes in granite aquifers also takes place on private game farm property to the east. Several boreholes have been drilled in the Kruger Park and are utilized by private game reserves in the vicinity. Although the Park obtains most of its domestic supplies from surface water, there is a concern that private game reserves might overexploit groundwater resources to supplement game viewing water holes.

Groundwater quality is generally moderate to good with conductivities between 70 and 300mS/m, Class 1 or 2. Elevated NO_3 levels are reported in many of the settlements.

Groundwater levels are generally below stream level, hence baseflow is unlikely to be generated except in exceptionally wet periods.

4.7 LEBOMBO

This region forms 6% of the WMA and is situated in the east and underlies the Kruger Park. The geology consists of a thin basal sequence of Clarens Formation sandstone overlain by basalts and rhyolites at the eastern margin (figure 4.6). Intrusions of granophyre also exist in the east. The MAP is less than 500 mm. Borehole yields are generally less than 0.5-1.5 l/s and a large fraction are dry. Static water levels are between 15 and 30 mbgl, and boreholes are generally 50 – 80m deep. The groundwater resources of the fine grained rhyolite are marginal.

The basalt forms the wide north south trending central plains and gently rolling countryside of the northern part of the Kruger National Park from Pafuri in the north to Letaba in the south. Rhyolite forms the higher ground of the degraded Lebombo range along the Mozambique border in B83C, D & E.

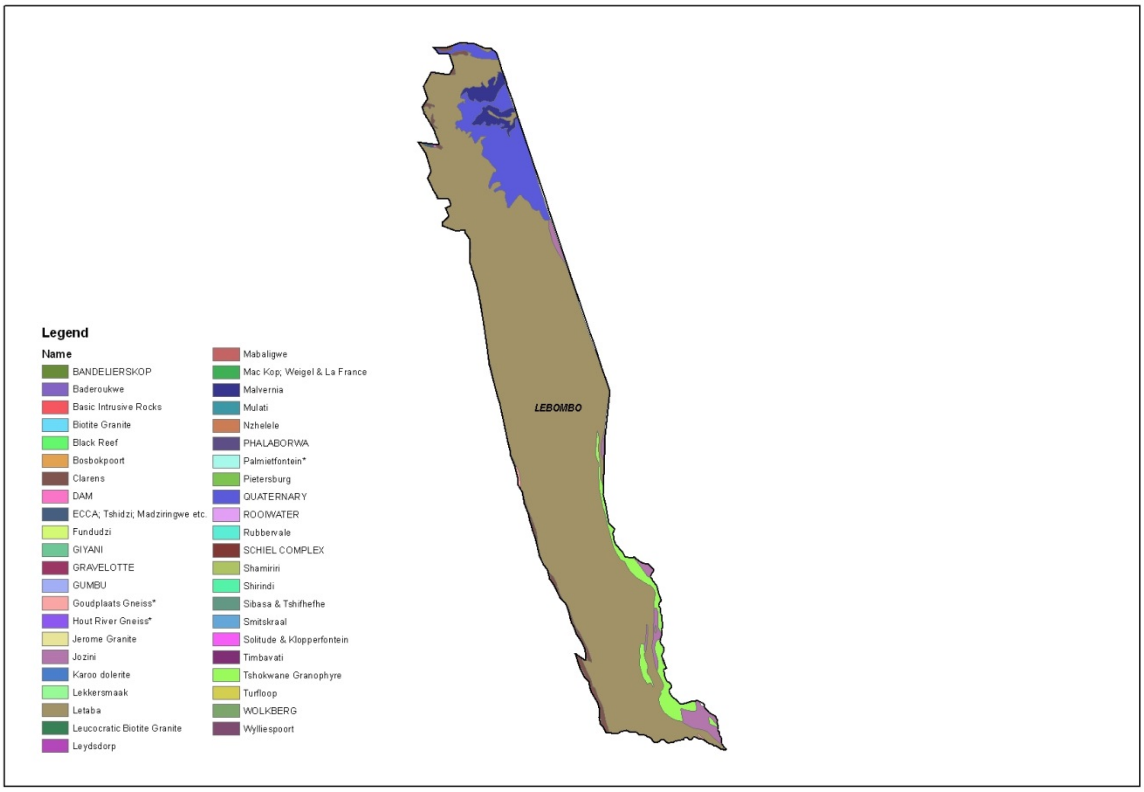


Figure 4-6 Geology of the Lebombo region

4.8 LIMPOPO MOBILE BELT

The Limpopo Mobile Belt occupies only 0.5% of the WMA and abuts against the Letaba basalts in a fault contact at the Bosbokpoort fault. This is the most northerly portion of A92D bounding the Limpopo River where the easternmost extension of the NE – SW trending metamorphic rock assemblage known as the Limpopo Mobile Belt The geology consists of calc-silicate rocks and leucocratic gneisses, some of which is covered by Quaternary deposits, and some small outliers of the Mabaligwe Formation of the Soutpansberg Group, which form koppies along the Limpopo (figure 4.7). Drainage is primarily towards the Limpopo River rather than to the Mutale and it is a dry region with less than 300 mm of rain per annum. It lies on a flat plain known as the Malonga flats. Groundwater resources are poor and less than 40% of boreholes are successful. Only 16% have a usable yield of greater than 1 l/s. The groundwater is generally of a poor quality as well due to elevated nitrates, salinity and fluorides.

The area is mostly stock and game farming and is sparsely populated. Irrigation is practised along the Limpopo River on the old flood plain.

Water levels vary between 20 and 30mbgl, boreholes are generally 50 – 80m deep. Impacts on groundwater quantity due to abstraction will be limited due to the low yield of boreholes.

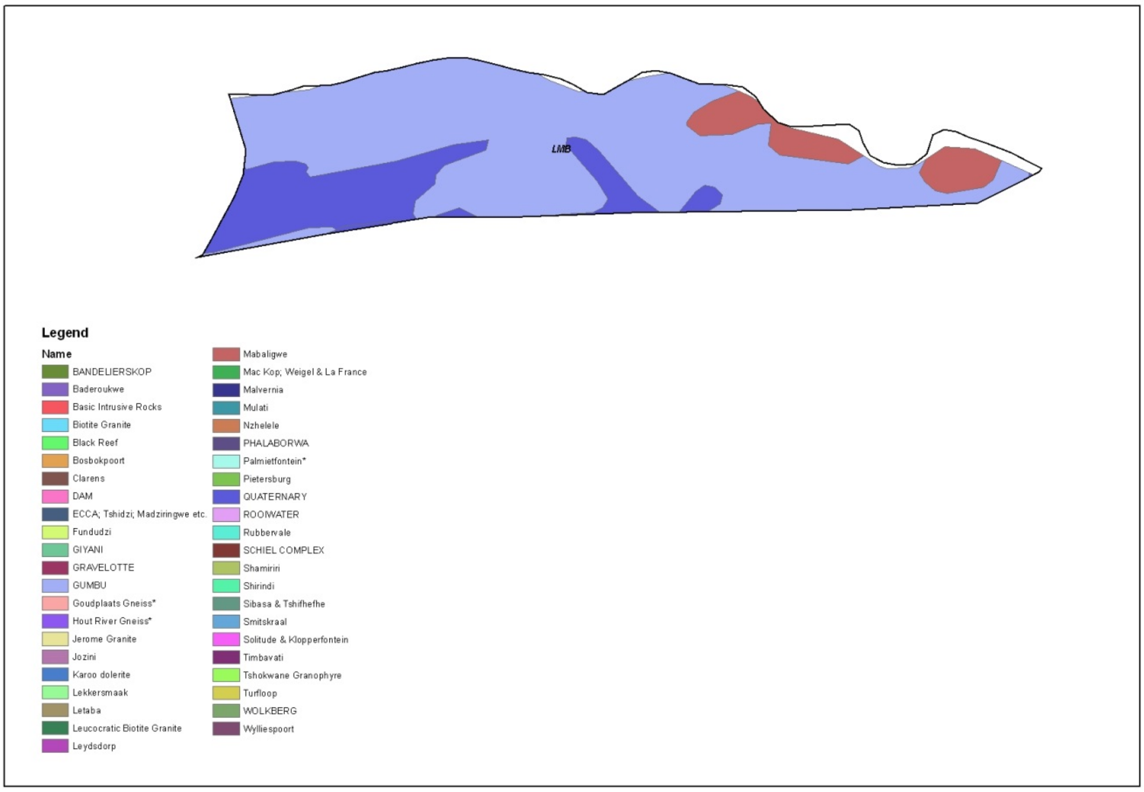


Figure 4-7 Geology of the LMB region

4.9 KAROO

Karoo rocks filling the Soutpansberg Karoo trough north of the Soutpansberg range occupy 3% of the WMA. This area is underlain by Karoo sandstone which forms a west – east trending outcrop across the Mutale catchment, becoming a north south trending outcrop zone along the western side of the Kruger National Park (KNP) (figure 4.8). The sandstone forms flat to hilly topography with ridges in the northern part of the KNP.

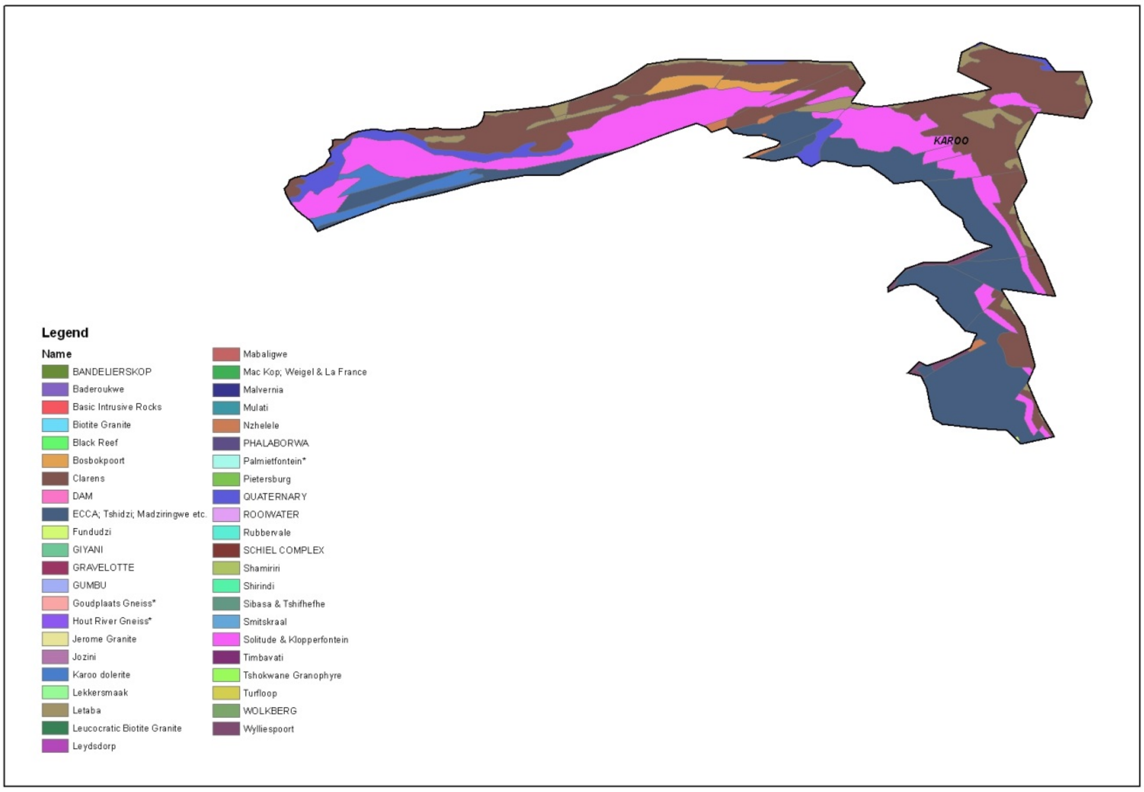


Figure 4-8 Geology of the Karoo region

They carry from coal bearing shales to Clarens sandstones which form E-W trending ridges. Groundwater tends to be saline due to the low rainfall and high proportion of mudstones and shales.

The area is agricultural with scattered communal land settlements in A92C and A92D reliant on groundwater for domestic supply and cattle watering. The area is pristine within the KNP.

Borehole yields are variable falling mainly within the range 0.5 – 2 l/s. Water levels range from 20 – 30mbgl and boreholes average 40 – 80m in depth.

Groundwater quality varies from s generally good (Class I) to moderate (Class 2) with conductivities below 300 mS/m, to very saline from south-north and increasing distance from the Soutpansberg.

4.10 BASALT

The basalts of the Soutpansberg Hinterland form a flat lying area known as the Malonga Plain (figure 4.9) in the north of the Mutale catchment. They are located immediately south of the Bosbokpoort Fault, and forms the wide north south trending central plains and gently rolling countryside of the northern part of the Kruger National Park from Pafuri in the north, south towards Shingwedzi. They cover 2% of the WMA. Very few surface drainage features exist, and are oriented towards the Limpopo. The groundwater quality is primarily good which is either Class 1 or 2. Isolated occurrences of elevated NO_3 occur in settlements. Rainfall is approximately 320 mm/a. Approximately 50% of boreholes are successful.

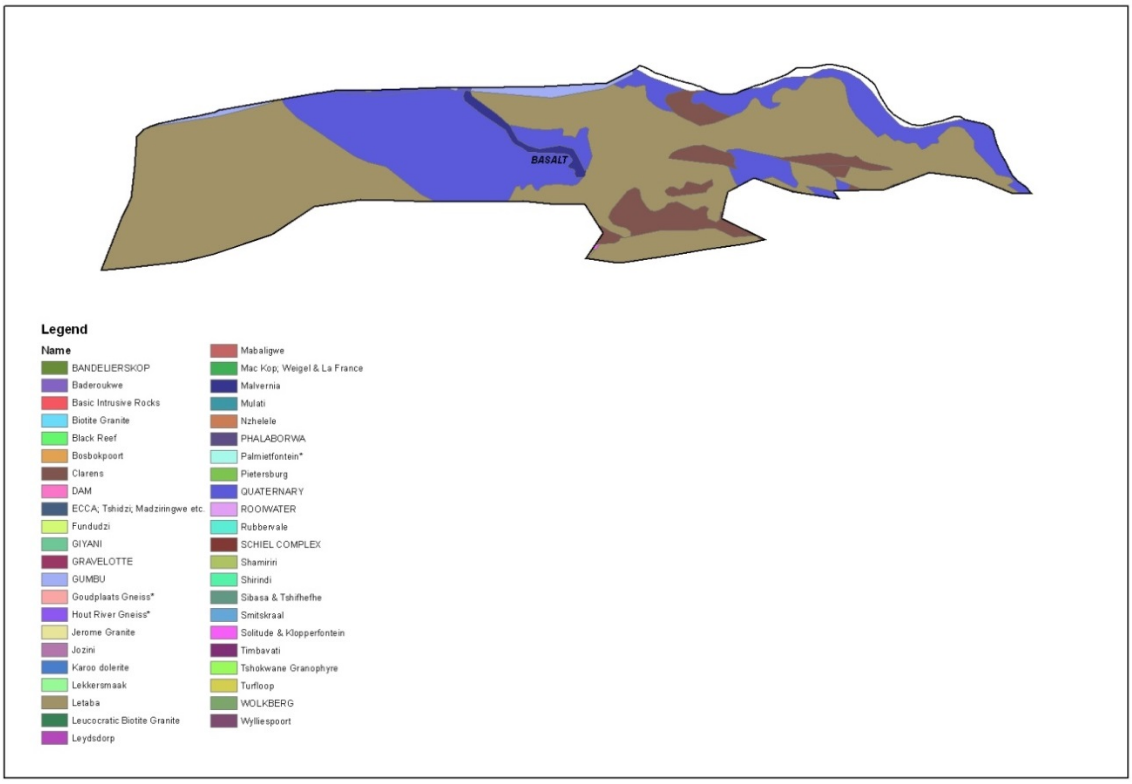


Figure 4-9 Geology of the Malonga Flats Basalt region

The northern area in Mutale catchment is agricultural with the few scattered settlements dependent upon groundwater for domestic supply and cattle watering. Borehole yields tend to be 0.5 - 2l/s. Aquifers within the basalt are generally of limited area extent. Yields >5l/s are locally present in major structural features, e.g. the boundary between the metamorphic rocks and the Karoo basalt in catchment A92D in the Bosbokpoort Fault area. Static water levels are between 15 and 30 mbgl, and boreholes are generally 50 – 80m deep.

4.11 ALLUVIUM

Primary aquifers, consisting of saturated alluvium, are often present along major river drainage systems and are composed of unconsolidated clayey silts to coarse gravels and boulders. The highest yielding aquifer of this type is present in the south-eastern and eastern regions of the Letaba catchment, mostly in the Kruger Park. In the middle and upper reaches of the Klein Letaba and Molototsi rivers alluvial deposits of up to 150 m wide and 8 m thick are present.

The average borehole yield of this aquifer is more than 5 l/s. During the rainy season, up to 20 l/s per borehole can be abstracted. However, the yield diminishes during the dry season if the volume of storage is limited or if there is no recharge from the host rock.

Groundwater quality in these aquifers is highly variable and a decrease in yield in the dry season is normally accompanied by an increase in salinity.

Alluvial aquifers form isolated local aquifers along major river courses and are recharged during periods of high streamflow and discharge once again to the river once stream stage drops. Since they are recharged by surface water rather than conventional direct groundwater recharge, their maintenance depends on ensuring periods of high flow to replenish bank storage, and their use results in significant flow depletion as transmission losses.

They exist in delicate equilibrium with surface water and ecosystems present along the river course. In terms of the future exploitation potential of these aquifers, the sensitivity of ecosystems along the Letaba River to a drop in water table resulting from a change in the flow regime, or by abstraction, needs to be evaluated.

These sand deposits generally obtain water, either directly from the surface flow of the river, hence abstraction is largely abstraction of surface water. They are tapped via from sand abstraction schemes such as infiltration galleries constructed in the river bed sediments. Wellpoints also offer a means of abstracting water from storage within the sand aquifers after the visible surface flow has ceased. Usually these schemes operate until the subsurface abstraction has diminished and the water level has declined to such an extent that the volume of water delivered is no longer viable for the intended use.

Wellpoints schemes and direct pumping from pits excavated in the river sand are operated along the Limpopo River in quaternary A92D to obtain water for irrigation.

5 GROUNDWATER USE

5.1 SOURCES OF DATA

Groundwater use per Quaternary catchment was obtained from the Validation and Verification study (DWA 2013b) based on validated irrigation areas. The study undertaken by consultants Invirocon & Nyeleti Joint Venture for DWA, referred to as *The Validation of small scale rural registrations and agricultural schemes and Verification of all water uses in the in the Luvuvhu Letaba comprising of the Luvuvhu (A9), Shingwedzi (B9) and the Letaba Catchment (B8)* (**DWA,2013b**), included three main components:

- A rapid assessment which provided a broad overview of the current water use situation in the catchment based on information obtained from aerial photographs and satellite imagery;

- Validation of the water use in the catchment by means of detailed investigations, including sampled field surveys. The results of the validation process are representative of various levels of development, including 2006 and 1998;

- Verification of the water use in the catchment to determine the extent of existing lawful use.

Results from the *validation*-component provided essential information to the hydrological analysis in terms of the current and historical characteristics of irrigation in the Letaba, Luvuvhu and Shingwedzi catchments, which include the extent of cultivated areas, crop types, irrigation systems and associated efficiencies, methodologies for irrigation volume calculations, sources of water and associated return flows; the current and historical characteristics of water bodies, including the locality, size and volume-surface area relationships for small storage dams; the current and historical characteristics of the afforestation developments in the catchments in terms of the types and % distribution of trees in each quaternary catchment. Differentiation between surface and groundwater irrigation was also made.

Estimates of domestic water use were undertaken in the All Towns study (DWA 2011). Estimates of water use were made from measured use, capacities of treatment works, and estimates of per capita use. These were subsequently adjusted in this study by water demand modelling by the project team based on existing infrastructure and population.

5.2 REGISTERED AND VERIFIED WATER USE

Groundwater demand is approximately 157.36 Mm^3/a, of which 141.42 Mm^3/a is for irrigation Table (5-1). The registered water use in the WARMS data base is 101-102 Mm^3/a, of which 91.65 Mm^3/a is for irrigation. Consequently, registered water use is significantly lower than actual use. A summary of the WARMS registered use for water supply is shown in table is shown in table 5.2. The registered water use for rural water supply is 9.4 Mm^3/a, which is unlikely to be represent actual groundwater use since many water supply schemes utilising groundwater don’t have a registered water use (table 5.2).

The All Towns study (DWA 2011) estimated a groundwater use of 9.0 Mm^3/a in the Letaba catchment (table 5.3). Groundwater use for water supply in the Letaba estimated for this study is 12.29 Mm^3/a.

Table 5-1 Groundwater Use 2010 in Mm^3/a

QUAT			WARMS							
	IRRIGATION	WATER SUPPLY	AGRICULTURE: IRRIGATION	AGRICULTURE: LIVESTOCK	INDUSTRY (NON-URBAN)	INDUSTRY (URBAN)	MINING	SCHEDULE 1	WATER SUPPLY	TOTAL
A91A	8.99	0.15	5.75	0.00	0.01	0.00	0.00	0.01	0.00	5.77
A91B	7.90	0.32	8.54	0.00	0.00	0.00	0.00	0.00	0.16	8.70
A91C	28.47	0.54	17.48	0.00	0.18	0.02	0.00	0.00	2.20	19.89
A91D	6.88	0.08	9.68	0.00	0.00	0.00	0.00	0.00	0.00	9.68
A91E	0	0.16	0.44	0.00	0.00	0.01	0.00	0.00	0.00	0.45
A91F	0	0.27	1.82	0.00	0.00	0.00	0.00	0.00	0.00	1.82
A91G	0	0.28	0.57	0.00	0.00	0.00	0.00	0.10	0.01	0.67
A91H	0	0.52	0.13	0.00	0.00	0.00	0.00	0.00	0.15	0.28
A91J	0	0.04	0.05	0.00	0.00	0.00	0.00	0.00	0.06	0.11
A91K	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A92A	0	0.20	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.14
A92B	0	0.17	0.60	0.00	0.00	0.00	0.00	0.00	0.03	0.63
A92C	0	0.36	0.35	0.00	0.00	0.00	0.00	0.00	0.74	1.09
A92D	0	0.56	0.26	0.00	0.00	0.00	0.00	0.00	0.46	0.72
B81A	0.15	0	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.13
B81B	2.64	0	2.86	0.00	0.00	0.00	0.00	0.01	0.00	2.87

B81C	5.47	0	1.54	0.00	0.00	0.01	0.00	0.01	0.80	2.37
B81D	1.13	3.00	0.87	0.00	0.00	0.00	0.00	0.00	0.02	0.89
B81E	22.70	0.14	5.67	0.03	0.03	0.00	0.01	0.10	0.03	5.87
B81F	12.46	0.73	9.06	0.00	0.00	0.01	0.00	0.00	0.00	9.07
B81G	5.06	0.50	0.34	0.00	0.00	0.00	0.00	0.00	0.81	1.15
B81H	2.62	1.20	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.18
B81J	0	0.12	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.06
B82A	1.48	0.19	4.61	0.00	0.00	0.00	0.00	0.00	0.00	4.62
B82B	20.31	0.38	8.71	0.00	0.00	0.00	0.00	0.00	0.00	8.71
B82C	11.00	0.00	7.99	0.00	0.00	0.01	0.00	0.00	0.18	8.18
B82D	0.52	1.28	0.68	0.00	0.00	0.00	0.00	0.00	0.01	0.69
B82E	1.45	0.24	0.67	0.00	0.02	0.00	0.00	0.00	0.10	0.78
B82F	1.43	1.73	1.09	0.00	0.00	0.00	0.00	0.00	0.00	1.09
B82G	0.6	1.67	0.20	0.00	0.00	0.01	0.00	0.00	3.60	3.81
B82H	0.16	0.46	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.18
B82J	0	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B83A	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B83B	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B83C	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B83D	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B83E	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

B90A	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B90B	0	0.06	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.76
B90C	0	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B90D	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B90E	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B90F	0	0.36	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.24
B90G	0	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B90H	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
total	141.42	15.94								
Total		157.36	91.65	0.03	0.23	0.06	0.01	0.23	9.37	101.59

Table 5-2 Registered water use for water supply

Property Name	Drainage Region	Use
		Mm^3/a
BLOEMTUIN LS 828/19		0.00
CHEVIOT LT 610/1	B81D	0.02
CHEVIOT LT 610/1 Total		0.02
DRIEFONTEIN LT 33/0 (REMAINING EXTENT)	A91C	0.02
DRIEFONTEIN LT 33/0 (REMAINING EXTENT) Total		0.02
GIYANI TOWN	B82G	3.60
GIYANI TOWN Total		3.60
LEDZEE LT 559 PTN 0	B81C	0.00
LEDZEE LT 559 PTN 0 Total		0.00

LETABA RANCH LU 17 PTN 22	B81J	0.00
LETABA RANCH LU 17 PTN 22 Total		0.00
LEVUBU LT 15/200	A91C	0.00
LEVUBU LT 15/200 Total		0.00
LUPHEPHE NWANEDZI	A92B	0.00
	A92C	0.66
	A92D	0.36
	B82E	0.00
	B82F	0.00
LUPHEPHE NWANEDZI Total		1.02
LUSHOF LT 540 GED 39	B81C	0.01
LUSHOF LT 540 GED 39 Total		0.01
MASISI RWS	A92D	0.06
MASISI RWS Total		0.06
MIDDLE LETABA	A91B	0.08
	A91C	2.00
MIDDLE LETABA Total		2.08
MODJADJES LOCATION LT424/0 (MODJADJI NATURE RESERVE)	B81G	0.00
MODJADJES LOCATION LT424/0 (MODJADJI NATURE RESERVE) Total		0.00
MORGENZON LT 9/0 (REMAINING EXTENT)	A91C	0.00
MORGENZON LT 9/0 (REMAINING EXTENT) Total		0.00
MUTALE RWS	A91E	0.00
	A91H	0.15
	A91J	0.06
	A92B	0.03
	A92D	0.03
MUTALE RWS Total		0.28
NWANEDSI\LUPHEPHE	A92C	0.07
	A92D	0.02
NWANEDSI\LUPHEPHE Total		0.09
PUSELA LT 555 PTN 6,51 ,316,394	B81C	0.80
PUSELA LT 555 PTN 6,51 ,316,394 Total		0.80

RIETVLEI LT 130 PTN 2	B82E	0.00
RIETVLEI LT 130 PTN 2 Total		0.00
ROOIBANDFONTEIN LT 611/0	B81D	0.01
ROOIBANDFONTEIN LT 611/0 Total		0.01
SCHRAALHANS LT450 PTN 73	B82C	0.18
SCHRAALHANS LT450 PTN 73 Total		0.18
STATELAND LT 0 PTN 0 - BALENI SALT PAN	B82G	0.00
STATELAND LT 0 PTN 0 - BALENI SALT PAN Total		0.00
STATELAND SEDIBENE LT0/0 NL6MB - MIDDLE LETABA (M) RWS BOLEBEDU NORTH WEST	B81G	0.80
STATELAND SEDIBENE LT0/0 NL6MB - MIDDLE LETABA (M) RWS BOLEBEDU NORTH WEST Total		0.80
TARENTAALRAND LT 524 / 11	B81E	0.03
TARENTAALRAND LT 524 / 11 Total		0.03
TSHITALE RWS	A91B	0.09
	B82D	0.01
	B82E	0.09
	B82F	0.00
TSHITALE RWS Total		0.19
VONDO RWS	A91G	0.01
VONDO RWS Total		0.01
WATERVAL LT 45 PTN 0	A91C	0.14
WATERVAL LT 45 PTN 0 Total		0.14
WELGEVONDEN LT 36/2 (REMAINING EXTENT)	A91C	0.04
WELGEVONDEN LT 36/2 (REMAINING EXTENT) Total		0.04
Grand Total		9.37

Table 5-3 Groundwater use from All Towns study

Demand Centre			**Source**	**Allocation**
Schematic	**System**	**Quaternary**	**Schematic**	Mm^3/a
Thabina	Tzaneen	B81D28	Ground water	2.25

Ritavi 2	Tzaneen	B81D01,16&28	Ground water	0.745
Ritavi 1	Lower G Letaba	B81E01	Ground water	0.26
Thapane	Lower G Letaba	B81E20	Ground water	0.328
Sekgopo	Middle Letaba	B82A	Ground water	1.445
Middle Letaba	Middle Letaba	B82D	Ground water	3.773
Sekgosese Individual	Middle Letaba	B82D	Ground water	0.202
TOTAL				9.003

5.3 POPULATION TO BE SERVED

The population to be served forecasts for each scheme under high growth are given in table 5.4. The population to be served rises from 2.1 million in 2010, to nearly 2.9 million.

Table 5-4 Population forecasts served by each water supply scheme

Water Scheme Name	2010	2015	2020	2025	2030	2035	2040
Botlokwa GWS	45703	48738	51666	54574	57454	60296	63273
Damani RWS	67398	70930	74312	77659	80952	84178	87559
Eiland Supply	138	147	155	163	171	179	187
Elim / Vleifontein RWS WS Elim/Waterval Rural only	17744	18629	19483	20330	21167	21993	22860
Elim / Vleifontein RWS WS excl Vleifontein, Waterval Urban & Elim/Waterval Rural	20648	22188	23679	25164	26639	28095	29623
Elim / Vleifontein RWS WS Vleifontein only	5040	5345	5632	5913	6186	6451	6725
Elim / Vleifontein RWS WS Waterval Urban only	9892	10697	11477	12254	13025	13789	14590
Giyani System A/B WS	51773	54775	57651	60493	63290	66038	68903
Giyani System C/D WS excl Giyani & Kremetart	49231	52725	56113	59490	62845	66170	69665
Giyani System C/D WS Giyani only	32816	34944	37019	39101	41180	43250	45438
Giyani System C/D WS Kremetart only	1587	1674	1757	1838	1917	1994	2074
Giyani System D : South West WS	26604	28053	29439	30806	32154	33475	34854
Giyani System F1 WS	23588	24922	26203	27466	28710	29934	31212
Giyani System F2 WS	12173	12785	13371	13947	14514	15072	15650
Greater Giyani LM Farms Supply	2459	2549	2631	2714	2796	2877	2960
Greater Letaba LM Farms Supply	12483	13132	13751	14361	14958	15542	16150
Greater Tzaneen LM Farms Supply	34227	36101	37894	39661	41397	43099	44871
Haenertsburg Individual Supply Clearwater Cove only	144	152	160	167	174	181	188
Haenertsburg Individual Supply Haenertsburg only	1352	1399	1443	1486	1527	1567	1608
Haenertsburg Individual Supply Misty Crown only	120	127	133	139	145	151	157
Lambani RWS	6661	7357	8022	8688	9343	9996	10677
Letaba Individual Supply	113	119	125	131	137	143	149
Levubu CBD WS	638	726	817	911	1008	1106	1213
Lower Molototsi RWS	18376	19335	20251	21153	22034	22893	23790
Luphephe / Nwanedzi Main RWS	19420	20491	21520	22542	23548	24538	25570
Makhado RWS excl Makhado & Tshikota	71	73	75	77	79	81	83
Makhado RWS Makhado only	9754	10089	10404	10709	11004	11289	11581
Makhado RWS Tshikota only	5179	5363	5536	5704	5867	6025	6187
Malamulele West RWS	50182	52701	55119	57501	59835	62130	64511
Mapuve / System N RWS	17207	18091	18930	19755	20562	21352	22169
Masisi RWS	12645	13325	13976	14616	15243	15857	16499
Middle Letaba RWS : Babangu	56231	59366	62366	65322	68225	71071	74038
Middle Letaba RWS : Bolobedu NW	40011	42510	44921	47310	49676	51999	54432
Middle Letaba RWS : Magoro	71785	75971	79969	83925	87826	91671	95711
Middle Letaba RWS : Majosi	84157	89142	93958	98755	103506	108191	113106
Middle Letaba RWS : Malamulele West	14779	15541	16266	16978	17675	18351	19055

Middle Letaba RWS : Vyeboom Masia	29857	31993	34066	36106	38132	40133	42222
Modjadji RWS excl Kgapane	66873	70508	73986	77416	80789	84096	87538
Modjadji RWS Kgapane only	14010	15040	16043	17047	18048	19043	20092
Mutale LM Farms Supply	377	395	412	429	446	462	479
Mutale Main RWS	60514	63766	66867	69918	72924	75871	78931
Mutale Mukuya RWS	8608	9061	9495	9923	10341	10752	11175
North Malamulele East RWS	70788	74175	77404	80575	83682	86724	89880
Nthabiseng GWS	4150	4342	4528	4715	4901	5084	5275
Prieska Supply	1292	1362	1429	1495	1559	1622	1688
Ramakgopa GWS	26895	28125	29291	30430	31542	32625	33745
Ritavi / Letaba RWS	97557	102815	107847	112796	117660	122428	127385
Ritavi II RWS Nkowankow only	28137	30877	33602	36383	39207	42063	45124
Sekgopo Local GWS	20669	21732	22746	23742	24719	25674	26665
Sekgosese Individual Groundwater Scheme	20634	21827	22977	24116	25239	26352	27517
Siluwane - Nondweni Extended RWS	19337	20529	21677	22809	23922	25014	26154
Sinthumule / Kutama RWS	78141	82384	86448	90453	94389	98246	102258
South Malamulele East RWS excl Malamulele	96885	102266	107421	112512	117516	122437	127570
South Malamulele East RWS Malamulele Town only	8660	9081	9485	9884	10277	10662	11066
Thabina RWS excl Lenyenye	45184	48069	50837	53591	56309	58985	61788
Thapane RWS	56887	60400	63772	67108	70393	73624	77001
Thulamela LM Farms Supply	2354	2415	2475	2533	2591	2645	2700
Tours RWS	14409	14972	15515	16048	16571	17086	17612
Tshakhuma RWS	37013	39132	41154	43140	45085	46988	48963
Tshifudi RWS	31798	33669	35468	37252	39019	40756	42564
Tshikondeni Mine Supply	512	512	512	512	512	512	512
Tshitale RWS	31576	33276	34896	36486	38051	39577	41163
Tzaneen / Modjadjiskloof WS Tzaneen only	7864	8154	8425	8688	8942	9187	9439
Valdezia RWS	10974	11605	12223	12837	13441	14035	14654
Vondo Central RWS excl Thoyandou & Tshisahulu	156982	172067	186748	201424	216040	230540	245818
Vondo Central RWS Thoyandou only	71069	72495	73867	75230	76578	77907	79304
Vondo Central RWS Tshisahulu only	21276	21800	22306	22809	23309	23805	24325
Vondo East RWS	16511	17805	19040	20254	21439	22601	23817
Vondo North Rural RWS	4443	4830	5199	5560	5912	6258	6620
Vondo South RWS	30575	32285	33937	35580	37199	38802	40471
Worcester / Mothobeki RWS	25822	26985	28091	29173	30235	31269	32341
Ritavi II RWS excl Nkowankowa	83767	88917	93879	98792	103647	108430	113443
Thabina RWS Lenyenye only	12271	13013	13716	14402	15069	15715	16382
Tzaneen / Modjadjiskloof WS Politsi only	387	408	428	448	468	487	507
Tzaneen / Modjadjiskloof WS Modjadjiskloof only	3220	3597	3973	4358	4750	5147	5573
Tzaneen / Modjadjiskloof WS Duiwelskloof only	1433	1487	1538	1587	1634	1679	1725
TOTAL	2142040	2268383	2389947	2510364	2629256	2746347	2868804

5.4 WATER SUPPLY SCHEMES AND INFRASTRUCTURE

Rural water supply is provided by several water supply schemes, some of which cut across catchment boundaries (figure 5.3). A significant portion of the population used to be serviced with groundwater, however, there has been a transition to surface water and regionalisation and many of the larger schemes, like the Middle Letaba, Giyani and the Vondo schemes.

Estimated water use (and transfers out of the catchment) is 116.6 Mm^3/a, of which 17.9 Mm^3/a is met from groundwater (table 5.5). The figures are higher than in table 5-1 since it includes schemes which cross the Luvuvhu Letaba catchment, and source water from outside the catchment. The volumes abstracted from groundwater in the Letaba is 12.52 Mm^3/a, which is significantly higher than the All Towns study (table 5.3).

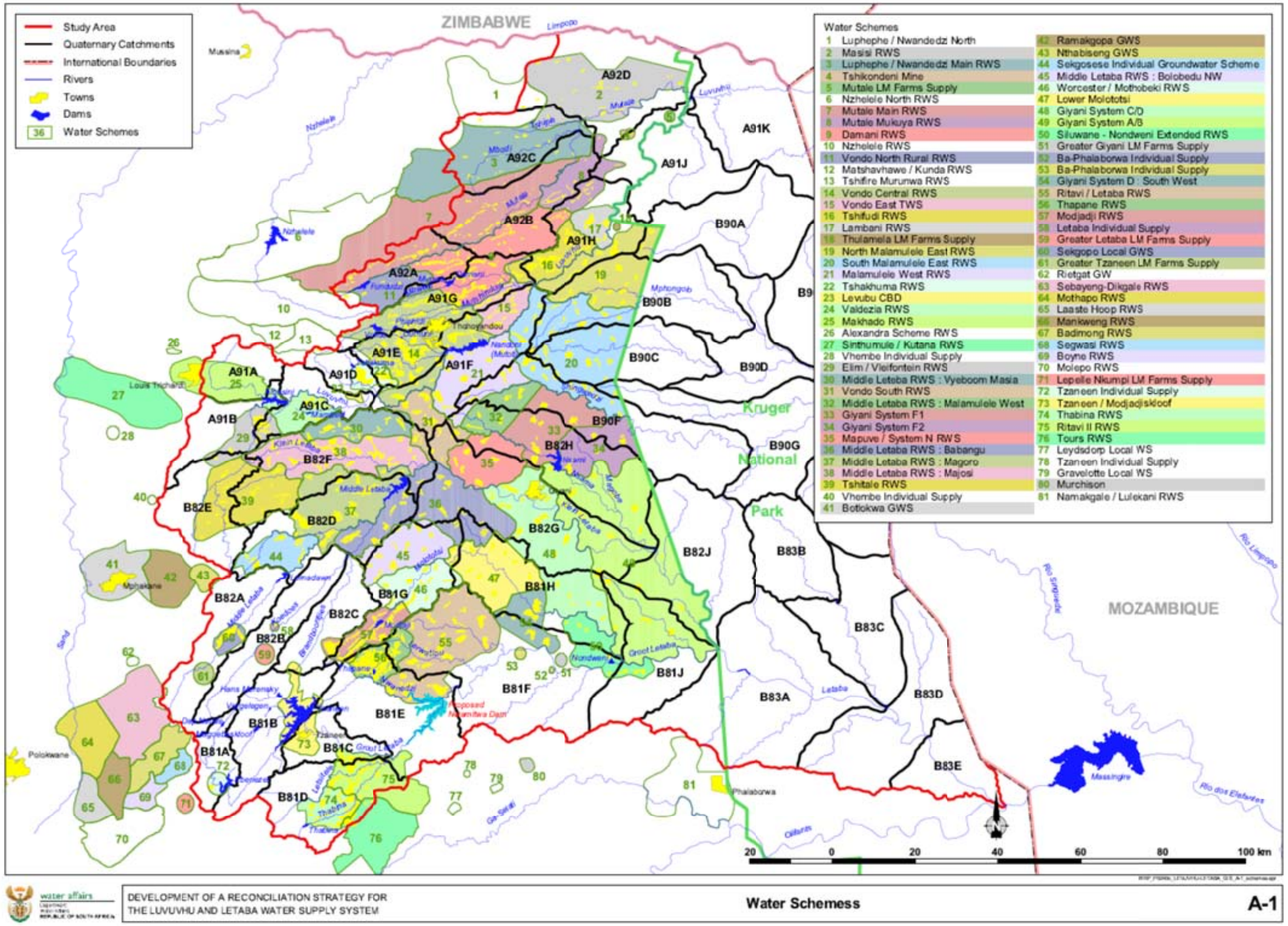


Figure 5-1 Rural water supply schemes

Table 5-5 Estimated water use per scheme

Catchment	Quaternary	Water Supply Scheme	Population	Groundwater Use	Surface water Use	Total water use	l/c/d	WARMS
				Mm^3	Mm^3	Mm^3		Mm^3
Luvuvhu	A71H A71D	Sinthumule/Kutama	78141	3.38		3.38	119	
	A71H	Makhado AFB		0.58		0.58		
	A91A A71H	Makhado RWS	26000	1.2	2.4	3.6	379	
	A91D A91E	Tshakhuma RWS	37013	0.17	1.41	1.58	117	
	A91C	Valdezia RWS	10974	0.313		0.313	78	
	A92A A92B A91G A91H	Damani RWS	67398	0.35	1.85	2.2	89	
	A91H	Thulamela LM Farms Supply	2354	0.08		0.08	93	
	A91H	Lambani RWS	6661	0	0.21	0.21	86	
	A91G A91H	Tshifudi RWS	31798	0.27	0.86	1.13	97	
	A91H B90A B90B	North Malamulele east RRWS	70788	0.17	2.9	3.06	118	
	A91F B90B B90C B90F B90G	South Malamulele east RWS	105545	0.12	3.5	3.61	94	
	A91F B90F B82H	Malamulele west RWS	50182	0.21	0.82	1.03	56	
	A91E A91G	Thohoyandou	71069					
	A91E A91F A91G	Vondo Central RWS	178258					
	A91F A91G	Vondo East RWS	16511					0.005
	A91G A92A	Vondo North Rural RWS	4443					
	A91F B82F B82G B82H	Vondo South RWS	30575	0.23	15.73	15.96	145	
	A91J	Mutale LM farms Supply	377	0.02		0.02	145	
	A91C	Levubu CBD	638	0.08		0.08	344	0.005
TOTAL				3.213	29.68	32.873		

Luvuvhu/Letaba	B82E B82F	Tshitale RWS	31576	0.44	0.39	0.83	72	0.19
Luvuvhu/Sand	A71C	Botlokwa	45703					
	A71C	Ramakgopa	26895					
	A71C	Nthabiseng RWS	4150	3.068		3.068	110	
Mutale	A92B A91H A91J A92D	Mutale Mukuya	8608	0.11	0.18	0.29	92	
	A92A A92B A92C A80C A80H	Mutale main RWS	60514	0.7	1.5	2.2	100	0.28
	A92D A92C	Masisi RWS	12645	0.5		0.5	108	0.057
	A92D	Tshikondeni mine	512	0.055	0.495	0.55	2943	
	A92C A92B A80J	Luphephe Nwandedzi main RWS	19420	0.55		0.55	78	1.02
	A92C A92D A80J	Luphephe Nwandedzi north		0.25		0.25		
TOTAL				2.165	2.175	4.34		
Groot Letaba	B81A	Tzaneen Individual	1616		0.584	0.584	990	
	B81B B81C	Tzaneen Modjadjiskloof	12904		2.946	2.946	625	
		Murchison			4.082	4.082		
		Polokwane			21.3	21.3		
		Vergelegen			2.1	2.1		
	B81D B72E	Ritavi II RWS	111904	0.75	8.56	9.31	228	
	B81E B81F	Ritavi Letaba RWS	97557	0.26	2.25	2.51	70	
	B81F B81H B81J	Siluwane Nondweni Extended RWS	19337	0	0.36	0.36	51	
	B81F	Ba Phalaborwa Individual Supply	15	0.004		0.004	731	
	B81D	Thabina RWS	57455	2.25	1.93	4.18	199	
	B81E B81F	Thapane RWS	56887	0.3	1.32	1.62	78	
	B81G B82C	Modjadji	80883		1.84	1.84	62	
	B81H	Lower Molototsi	18376		0.45	0.45	67	
	B81F	Greater Giyani LM Farms Supply	2459	0.076		0.076	85	
	B81G	Worcester Mothobeki RWS	25822		0.594	0.594	63	

TOTAL				3.64	48.316	51.956		
Middle Letaba	B82A	Sekgopo Local GWS	20669	0.19		0.19	25	
	B82D	Sekgosese Individual GWS	20634	0.24		0.23	31	
	B82A	Greater Tzaneen LM Farms Supply	34227		1.05	1.05	84	
	B82B	Letaba Individual Supply	113	0.004		0.004	97	0.002
	B82B	Greater Letaba LM Farms Supply	12483	0.38		0.38	83	
TOTAL				0.814	1.05	1.854		
Klein Letaba	A91B B82E A91C	Elim / Vleifontein RWS WS	53324	0.48	2.34	2.82	145	
	B82G B82H	Mapuve / System N RWS	17207	0.17	0.25	0.42	67	
	B82D B82F B81G B81H B82G	Middle Letaba RWS : Babangu	56231	0.51	1.05	1.56	76	
	B82D B82F	Middle Letaba RWS : Magoro	71785	1.05	0.66	1.71	65	
	B82F	Middle Letaba RWS : Majosi	84157	0.88	1.09	1.97	64	
	B82F	Middle Letaba RWS : Vyeboom Masia	29857	0.4	0.29	0.69	63	2.08
	B81G	Middle Letaba RWS : Bolobedu NW	40011	0.44	0.55	0.99	68	0.81
	B82H B90F	Middle Letaba RWS : Malamulele West	14779	0.11	0.21	0.32	59	
	B82H B82G B81H B81J B82J	Giyani System A/B WS	51773	0.51	1.88	2.39	126	
	B82H B90F	Giyani System F1 WS	23588	0.23	0.68	0.91	106	
	B82H B90F	Giyani System F2 WS	12173	0.28	0.14	0.42	95	
	B81H B81F	Giyani System D : South West WS	26604	0.61	0.61	1.22	126	
	B82G B81H	Giyani System C/D WS	83634	1.97	7.36	9.33	306	3.6
TOTAL				8.08	17.5	25.58		
GRAND TOTAL				17.912	98.721	116.603		8.049

5.5 EXISTING GROUNDWATER INFRASTRUCTURE CAPACITY

The GRIP data base was used to evaluate the yield of each borehole located within each water supply scheme. Boreholes were the yield is unknown were assumed to yield 50 m^3/d if equipped with a diesel mono pump, and 25 m^3/d if equipped with an electric submersible. The existing boreholes could yield 66.52 Mm^3/a (table 5.6).

These data include many boreholes which were tested but were equipped with hand pumps, or are not equipped, hence this capacity is not fully utilisable given the existing infrastructure. If only boreholes equipped with motorised pumps and with a power source are included, the infrastructure capacity is 32.68 Mm^3/a (table 5.7).

Table 5-6 Capacity of boreholes per scheme

Scheme	M^3/d	Mm^3/a	N
BA-PHALABORWA INDIVIDUAL SUPPLY	187	0.07	14
DAMANI RWS	4915	1.79	169
ELIM/VLEIFONTEIN RWS	8107	2.96	185
GIYANI SYSTEM A/B	4432	1.62	209
GIYANI SYSTEM C/D	14501	5.29	263
GIYANI SYSTEM D: SOUTH WEST	4376	1.60	90
GIYANI SYSTEM F1	1770	0.65	85
GIYANI SYSTEM F2	2783	1.02	84
LAMBANI	404	0.15	39
LEVUBU CBD	0	0.00	1
LOWER MOLOTOTSI	2740	1.00	124
LUPHEPHE/NWANEDZI MAIN RWS	7228	2.64	144
LUPHEPHE/NWANEDZI NORTH	4539	1.66	101
MAKHADO RWS	1014	0.37	30
MALAMULELE WEST RWS	3297	1.20	195
MAPUVE/SYSTEM N RWS	1506	0.55	75
MASISI RWS	7300	2.66	198
MATSHAVHAVE/KUNDA RWS	272	0.10	9
MIDDLE LETABA RWS: BABANGU	4791	1.75	227
MIDDLE LETABA RWS: MAGORO	8157	2.98	284
MIDDLE LETABA RWS: MAJOSI	9842	3.59	304
MIDDLE LETABA RWS: MALAMULELE WEST	1684	0.61	54
MIDDLE LETABA RWS: VYEBOOM MASIA	4715	1.72	96

MIDDLE LETABA: BOLOBEDU NW	4974	1.82	201
MODJADJI RWS	2765	1.01	281
MUTALE MAIN RWS	3233	1.18	181
MUTALE MUKUYA RWS	2120	0.77	83
NORTH MALAMULELE EAST RWS	4072	1.49	108
RITAVI II RWS	52	0.02	8
RITAVI/LETABA RWS	6662	2.43	419
SEKGOPO LOCAL GWS	2649	0.97	65
SEKGOSESE INDIVIDUAL GROUNDWATER SCHEME	6255	2.28	122
SILUWANE NONDWENI EXTENDED	3863	1.41	105
SOUTH MALAMULELE EAST RWS	5497	2.01	311
THABINA/RIITAVI II	13704	5.00	267
THAPANE RWS	1137	0.41	137
TSHAKUMA RWS	1407	0.51	33
TSHIFIRE MURUNWA RWS	405	0.15	33
TSHIFUDI RWS	1424	0.52	83
TSHITALE RWS	2575	0.94	228
TZANEEN INDIVIDUAL SUPPLY	0	0.00	1
TZANEEN/MODJADJISKLOOF	385	0.14	20
VALDEZIA RWS	3434	1.25	48
VONDO CENTRAL RWS	7306	2.67	288
VONDO EAST RWS	2029	0.74	121
VONDO NORTH RURAL RWS	26	0.01	13
VONDO SOUTH RWS	2622	0.96	90
WORCESTER/MOTHOBEKI RWS	5103	1.86	152
Grand Total	**182260**	66.52	**6378**

Table 5-7 Capacity of equipped boreholes per scheme

Scheme	M^3/d	Mm^3/a
BA-PHALABORWA INDIVIDUAL SUPPLY	187	0.07
DAMANI RWS	1251	0.46
ELIM/VLEIFONTEIN RWS	2451	0.89
GIYANI SYSTEM A/B	2148	0.78
GIYANI SYSTEM C/D	8237	3.01
GIYANI SYSTEM D: SOUTH WEST	2547	0.93
GIYANI SYSTEM F1	952	0.35
GIYANI SYSTEM F2	1217	0.44
LAMBANI	235	0.09
LOWER MOLOTOTSI	1985	0.72
LUPHEPHE/NWANEDZI MAIN RWS	1671	0.61
LUPHEPHE/NWANEDZI NORTH	1025	0.37
MAKHADO RWS	613	0.22
MALAMULELE WEST RWS	1172	0.43
MAPUVE/SYSTEM N RWS	871	0.32
MASISI RWS	1692	0.62
MATSHAVHAVE/KUNDA RWS	95	0.03
MIDDLE LETABA RWS: BABANGU	2533	0.92
MIDDLE LETABA RWS: MAGORO	5279	1.93
MIDDLE LETABA RWS: MAJOSI	4532	1.65
MIDDLE LETABA RWS: MALAMULELE WEST	612	0.22
MIDDLE LETABA RWS: VYEBOOM MASIA	2034	0.74
MIDDLE LETABA: BOLOBEDU NW	2297	0.84
MODJADJI RWS	1574	0.57
MUTALE MAIN RWS	2134	0.78
MUTALE MUKUYA RWS	364	0.13
NORTH MALAMULELE EAST RWS	1587	0.58
RITAVI II RWS	0	0.00
RITAVI/LETABA RWS	4567	1.67
SEKGOPO LOCAL GWS	1352	0.49
SEKGOSESE INDIVIDUAL GROUNDWATER SCHEME	3502	1.28
SILUWANE NONDWENI EXTENDED	2672	0.98
SOUTH MALAMULELE EAST RWS	2743	1.00
THABINA/RIITAVI II	10149	3.70
THAPANE RWS	832	0.30
TSHAKUMA RWS	860	0.31
TSHIFIRE MURUNWA RWS	301	0.11
TSHIFUDI RWS	725	0.26
TSHITALE RWS	1338	0.49
TZANEEN/MODJADJISKLOOF	173	0.06
VALDEZIA RWS	1336	0.49
VONDO CENTRAL RWS	2865	1.05
VONDO EAST RWS	714	0.26
VONDO NORTH RURAL RWS	26	0.01
VONDO SOUTH RWS	789	0.29
WORCESTER/MOTHOBEKI RWS	3293	1.20
Grand Total	89534	32.68

6 GROUNDWATER AVAILABILITY

6.1 BOREHOLE YIELDS

6.1.1 Yield per Quaternary catchment

The yield of boreholes drilled in each Quaternary catchment was obtained from the NGDB. These yields generally represent air lift yields when drilled, hence represent a maximum yield, not a sustainable yield. Generally, sustainable yields are < 66% of airlift yields, but need to be established from test pumping. Nevertheless, airlift lifts are representative of permeability and the potential for drilling a borehole suitable for equipping. Generally, an airlift yield of greater than 2 l/s is required to economically equip a borehole for reticulated water supply. Hence the number of boreholes yielding greater than 2 l/s is indicative of the number of boreholes that will need to be drilled to establish an economically viable reticulated water supply source.

Most of the study area has a geometric mean yield of more than 1 l/s, except A91 F and J, on the southern margin of the Soutpansberg region in the lower Luvuvhu, B81A, C and E of the Drakensberg escarpment in the Groot Letaba, B82A and B82B of the upper Middle Letaba in the Drakensberg region. B81D in the Drakensberg foothills underlain by greenstones and the Rooiwater complex has higher yields (table 6.1 and figures 6.1 and 6.2).

Table 6-1 shows the Quaternary catchments where less than 25% of boreholes have yields greater than 2 l/s, hence the development of groundwater would require proper exploration.

Table 6-1 Borehole yields per Quaternary catchment

	N	Lower Quartile (l/s)	MEDIAN (l/s)	Upper Quartile (l/s)	Geometric Mean (l/s)	Yield >2 l/s (%)
A91A	182	1	1.71	3.33	1.63	45.05
A91B	95	0.5	1.16	4.00	1.39	38.95
A91C	33	1.25	2.40	5.00	2.29	54.55
A91D	2	3.525	3.55	3.58	3.55	100.00
A91E	12	1.3775	2.50	3.00	2.20	58.33
A91F	90	0.4	1.13	3.39	0.96	36.67
A91G	53	0.63	1.70	3.01	1.42	37.74
A91H	58	0.815	1.46	3.00	1.44	36.21
A91J	24	0.375	0.98	3.22	0.70	37.50
A91K	32	0.3	1.03	5.33	1.03	40.63
A92A	28	0.545	1.75	3.00	1.64	28.57

A92B	17	0.41	1.41	2.96	1.07	35.29
A92C	43	0.425	1.00	3.65	1.09	32.56
A92D	34	1	2.50	4.75	2.19	52.94
B81A	4	0.3	0.57	1.07	0.43	0.00
B81B	4	0.85	1.50	2.16	1.21	25.00
B81C	11	0.34	0.76	1.68	0.75	9.09
B81D	112	1	2.20	4.55	1.66	51.79
B81E	64	0.1275	0.64	1.50	0.57	15.63
B81F	146	0.5	1.25	2.68	1.11	34.93
B81G	208	0.5775	1.38	3.40	1.37	34.13
B81H	89	0.8	2.50	6.60	2.07	56.18
B81J	25	1	1.70	3.80	1.65	44.00
B82A	46	0.4	0.80	1.42	0.83	13.04
B82B	3	0.68	0.70	0.95	0.82	0.00
B82C	14	1.05	1.73	3.17	1.56	42.86
B82D	144	0.63	1.46	4.83	1.53	44.44
B82E	265	0.5	1.21	3.20	1.31	37.36
B82F	61	0.6	1.32	2.50	1.25	37.70
B82G	155	0.8	2.50	4.43	1.79	53.55
B82H	73	0.74	1.50	3.30	1.40	41.10
B82J	23	0.7	2.30	3.30	1.64	52.17
B83A	30	1.0025	1.80	3.80	1.45	43.33
B83B	32	0.7	1.54	3.64	1.48	43.75
B83C	23	1.11	2.06	4.75	2.03	56.52
B83D	34	0.77	1.22	2.62	1.26	41.18
B83E	4	0.395	1.17	1.92	0.77	25.00
B90A	55	0.31	0.97	2.47	0.70	30.91
B90B	58	0.605	1.75	3.60	1.44	43.10
B90C	28	1.5325	2.12	3.48	2.02	53.57
B90D	15	0.7	0.90	1.47	1.06	20.00
B90E	25	0.31	0.54	0.90	0.44	4.00
B90F	92	0.6675	1.45	3.43	1.38	39.13
B90G	32	0.6	1.31	3.29	1.02	40.63
B90H	32	0.63	1.11	2.52	1.08	31.25

Number of boreholes

>75%
50-75%
25-50%
<25%, geometric mean less than 1 l/s

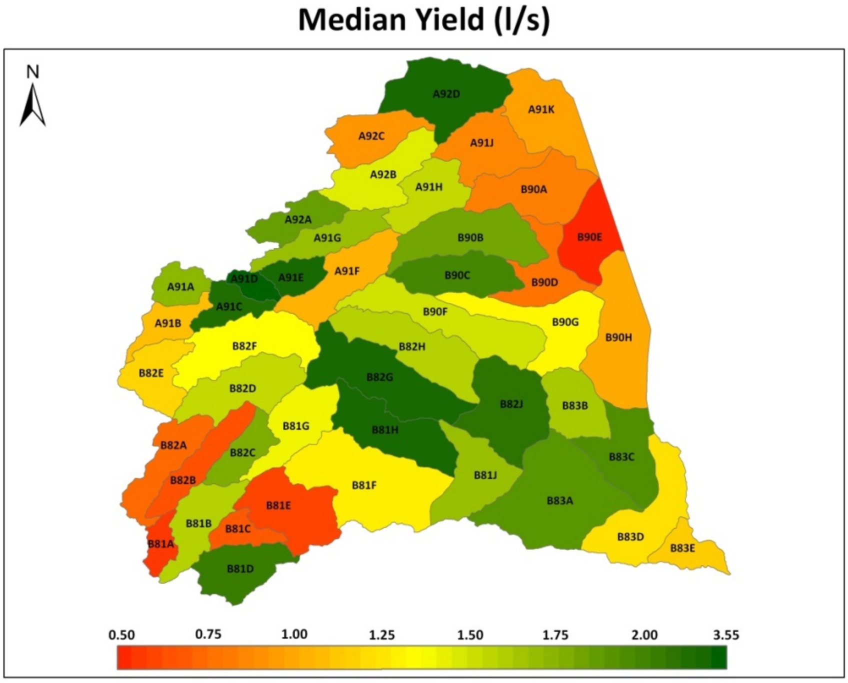


Figure 6-1 Mean borehole yield per Quaternary catchment

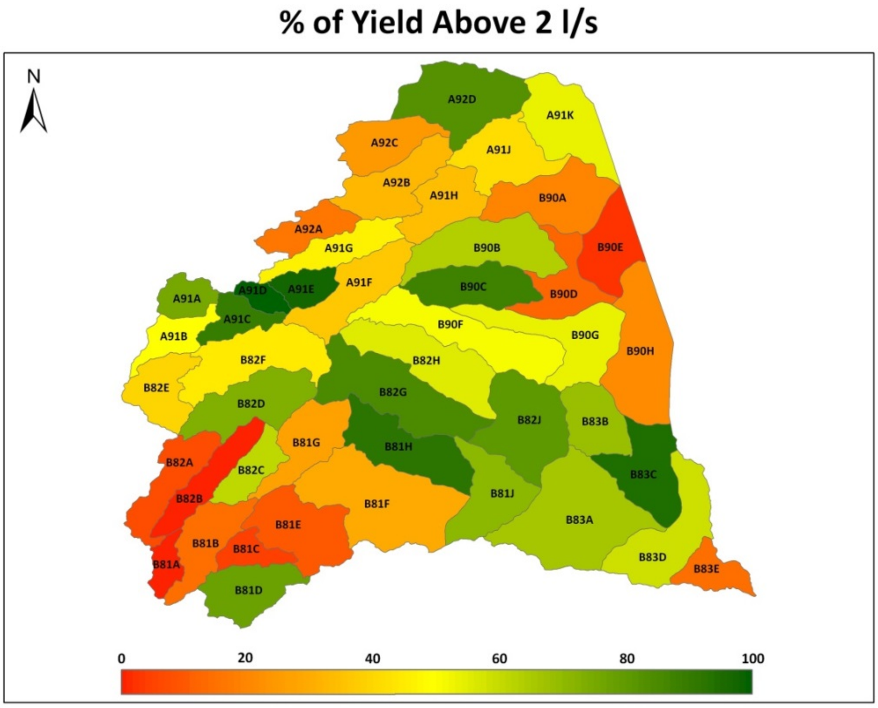


Figure 6-2 Percent of boreholes yielding more than 2 l/s

6.1.2 Yield per hydrogeological unit

Borehole yield data from the NGDB was segregated by hydrolithological unit and the yield of each unit was assessed (table 6.2).

The Goudplaats gneiss has a median yield of 1.5 l/s and is productive, with greater than 40% of boreholes yielding more than 2 l/s.

No boreholes in the Beitbridge Complex of the Limpopo Mobile Belt were in the NGDB within the study area, however, yields are generally low and only 15% of boreholes yield more than 1 l/s. These are located on fault zones.

No boreholes are located in the Bandelierskop Complex, however these rocks are infolded into the Goudplaats gneiss. Yields are generally low, unless boreholes are drilled into faults or dyke contacts. Yields in the gneiss adjacent to these rocks are generally higher due to the fracturing and weathering.

Only 1 borehole was located in the Pietersburg Group. The yield characteristics are likely to be similar to the other greenstone belts: the Gravelotte and Giyani belts. The Giyani and Gravelotte Groups both have median yields above 2.5 l/s, and support high yielding boreholes.

The Randian and Vaalian age granites have a lower yield than the rocks into which they intrude, with a median yield of 0.9 l/s.

The Rooiwater complex has a median yield of 2 l/s and nearly 50% of the boreholes have a yield greater than 2 l/s.

The Wolksberg Group and the Black Reef form the watershed of the Groot Letaba, hence these high lying lithologies have a low yield and are not exploited in the area.

The Soutpansberg Group is generally of low productivity except where it is faulted and intruded by diabase. The extensive faulting in the study area results in a high median yield of 1.5 l/s.

The Karoo sediments which consist of arenaceous formations generally are moderately yielding. They have a median yield of 2 l/s. The Letaba basalts have a lower yield, and the Jozini rhyolites which forms ridges, have a low median yield of 0.5 l/s.

Table 6-2 Borehole yields per lithological unit

	N	Lower Quartile	Median	Upper Quartile	Geometric Mean	% >2 l/s
Goudplaats gneiss	1497	0.60	1.50	3.79	1.44	41.22
Pietersburg Group	1		2.00		2.00	0.00
Giyani Group	136	0.86	2.50	5.13	2.14	58.09
Gravelotte Group	33	1.50	4.00	8.00	3.03	69.70
Granite intrusives	296	0.30	0.90	2.00	0.86	25.00
Rooiwater Complex	45	1.00	2.00	3.35	1.47	48.89
Wolkberg Group and Black Reef Fm	2		0.01	0.01	0.01	0.00
Soutpansberg Group	312	0.56	1.50	3.13	1.36	37.50
Karoo sediments	45	0.70	2.00	4.50	1.77	48.89
Letaba Formation	222	0.47	1.13	2.80	0.99	35.59
Jozini Fm and Tshokwane granophyre	7	0.31	0.50	1.14	0.47	14.29
Malvernia Fm	6	0.08	0.13	0.18	0.14	0.00

6.1.3 Yield per water supply scheme

Borehole yields for boreholes located within water supply schemes are given in table 6.3. In most of the schemes, sufficient boreholes exceed 2 l/s (>20%) to warrant groundwater supply. Low yields are encountered in the Sekgopo groundwater supply scheme in B82A and the Thapane rural water supply scheme in B81E, yet both of these schemes are reliant on groundwater.

Table 6-3 Borehole yield per water supply scheme

Scheme	Median Yield	N	Geomean	% of BH>2l/s
	l/s		l/s	%
SILUWANE - NONDWENI EXTENDED RWS	1.55	29	1.35	41.38
BA-PHALABORWA INDIVIDUAL SUPPLY	1.25	0		
DAMANI RWS	2	44	1.42	31.82
ELIM/VLEIFONTEIN RWS	3.9	46	3.29	67.39
GIYANI SYSTEM A/B	1.6	74	1.38	47.30
GIYANI SYSTEM D: SOUTH WEST	1.5	26	1.78	42.31
GIYANI SYSTEM F1	1.19	25	1.55	36.00
GIYANI SYSTEM F2	1.875	30	1.76	46.67
GIYNAI SYSTEM C/D	2.59	125	2.32	61.60
GREATER GIYANI LM FARMS SUPPLY	1.25			
GREATER LETABA LM FARMS SUPPLY	0.7			
GREATER TZANEEN LM FARMS SUPPLY	0.8			
LAMBANI RWS	1.2	12	1.00	33.33
LETABA INDIVIDUAL SUPPLY	0.7			
LEVUBU CBD	3.5	1	3.50	100.00
LOWER MOLOTOTSI	4.025	20	3.07	60.00
LUPHEPHE/NWANEDZI MAIN RWS	1.05	50	1.37	40.00
LUPHEPHE/NWANEDZI NORTH	1.4	20	1.58	35.00

MAKHADO RWS	2	239	1.85	48.54
MALAMULELE WEST RWS	1.39	47	1.26	36.17
MAPUVE/SYSTEM N RWS	1.5	21	1.25	38.10
MASISI RWS	2.53	38	2.32	55.26
MATSHAVHAVE/KUNDA RWS	1.29	6	0.84	33.33
ELIM/VLEIFONTEIN RWS	3.9	46	3.29	67.39
MIDDLE LETABA RWS: BABANGU	1.5	87	1.27	41.38
MIDDLE LETABA RWS: MAGORO	2.035	74	1.56	50.00
MIDDLE LETABA RWS: MAJOSI	1.13	43	1.23	34.88
MIDDLE LETABA RWS: VYEBOOM MASIA	3	3	3.68	66.67
MIDDLE LETABA: BOLOBEDU NW	1.76	41	2.20	39.02
MIDDLE LETABA RWS: MALAMULELE WEST	1.35	24	1.29	41.67
MODJADJI RWS	1	149	1.02	28.86
MUTALE LM FARMS SUPPLY	0.98			
MUTALE MAIN RWS	1.415	54	1.35	38.89
MUTALE MUKUYA RWS	1.785	16	1.87	43.75
NORTH MALAMULELE EAST RWS	1.67	43	1.63	44.19
RITAVI II RWS	1.84	45	1.19	40.00
RITAVI/LETABA RWS	1.425	110	1.17	36.36
SEKGOPO LOCAL GWS	0.67	17	0.93	11.76
SEKGOSESE INDIVIDUAL GROUNDWATER SCHEME	2.25	26	2.35	50.00
SOUTH MALAMULELE EAST RWS	2	76	1.77	47.37
THABINA RWS	2.655	58	2.11	60.34
THAPANE RWS	0.7	53	0.59	15.09
LAMBANI	1.46			
TOURS RWS	2.5	54	2.23	57.41
TSHAKUMA RWS	2.25	2	2.24	50.00
TSHIFIRE MURUNWA RWS	11.25	4	9.74	100.00
TSHIFUDI RWS	1.67	25	1.85	44.00
TSHIKONDENI MINE	2.5			
TSHITALE RWS	1	73	0.98	27.40
TZANEEN/HAERNETSBURG INDIVIDUAL SUPPLY	1.03	2	0.35	0.00
TZANEEN/MODJADJISKLOOF	1.7	7	1.21	42.86
VALDEZIA RWS	1.26	5	1.24	20.00
VONDO CENTRAL RWS	1.01	51	0.85	37.25
VONDO EAST RWS	1.6	44	1.28	36.36
VONDO NORTH RURAL RWS	2	5	1.23	40.00
VONDO SOUTH RWS	0.265	2	0.19	0.00
WORCESTER/MOTHOBEKI RWS	2.83	27	3.32	55.56

Number of boreholes

Dark green	>75%
Light green	50-75%
Yellow	25-50%
Red	<25%, geometric mean less than 1 l/s

6.2 WATER LEVELS

6.2.1 Water levels per Quaternary catchment

The water level of boreholes drilled in each Quaternary catchment was obtained from the NGDB. These water levels generally represent water levels when the borehole was drilled, but many have water levels taken before the start of test pumping, or measurements over different periods of time, for which the most recent was taken. Average water levels are shown in table 6.4 and figures 6.3 and 6.4.

Table 6-4 Average water level below ground level per Quaternary catchment

Quaternary	N	Average (m)	Maximum (m)
A91A	75	22.1	65.0
A91B	49	27.9	65.8
A91C	23	19.6	51.6
A91D	2	19.5	20.5
A91E	3	13.7	18.3
A91F	58	17.1	48.8
A91G	17	10.4	22.0
A91H	31	12.6	26.7
A91J	15	10.1	29.3
A91K	30	10.8	36.9
A92A	10	17.8	30.0
A92B	8	21.4	59.2
A92C	17	16.9	48.0
A92D	8	15.8	30.0
B81A	4	45.4	70.1
B81B	2	14.0	18.9
B81C	5	32.7	85.3
B81D	86	12.4	50.0
B81E	53	14.8	60.0
B81F	101	14.4	60.0
B81G	156	14.4	84.0
B81H	63	15.6	62.0
B81J	18	13.3	32.0

B82A	37	21.2	50.3
B82B	3	12.4	20.0
B82C	13	16.5	34.6
B82D	121	22.9	76.0
B82E	119	22.2	60.8
B82F	31	19.6	32.0
B82G	109	15.3	70.0
B82H	55	18.7	45.7
B82J	15	8.7	24.9
B83A	29	9.5	42.7
B83B	23	7.9	23.2
B83C	23	9.2	21.3
B83D	30	12.8	33.8
B83E	4	12.6	28.3
B90A	47	15.6	36.6
B90B	53	16.5	44.2
B90C	24	15.2	43.0
B90D	14	10.6	28.0
B90E	22	9.4	18.0
B90F	71	21.9	52.7
B90G	28	9.7	34.8
B90H	27	7.2	24.4
Grand Total	**1732**		

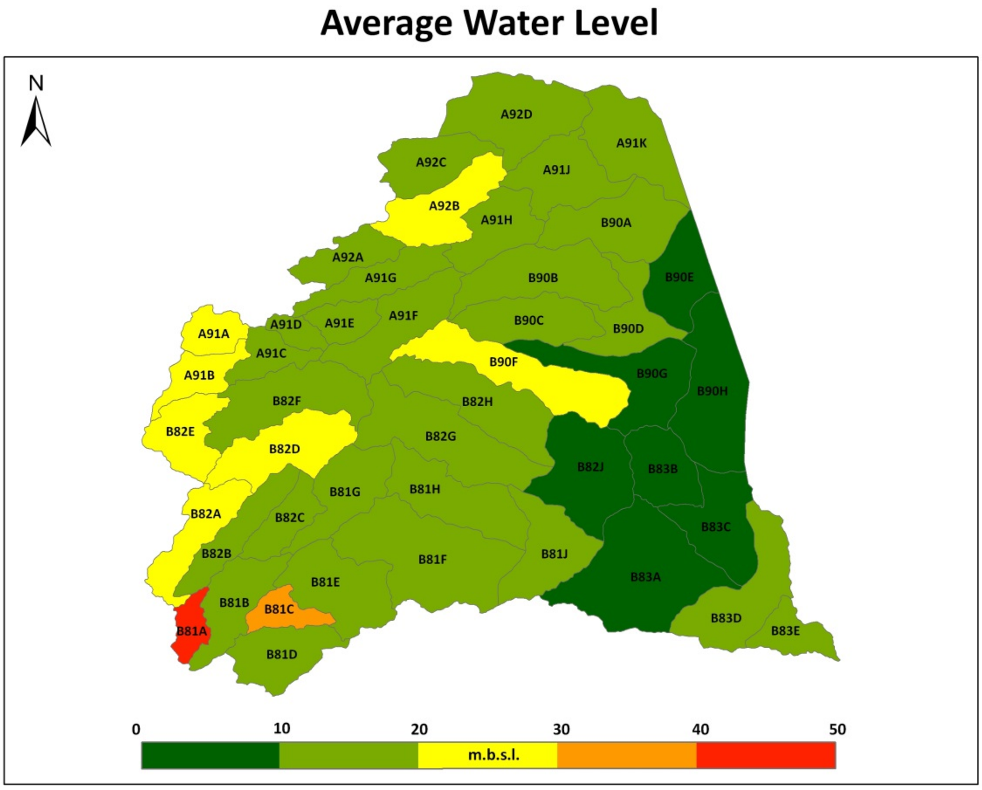


Figure 6-3 Average water levels per Quaternary catchment

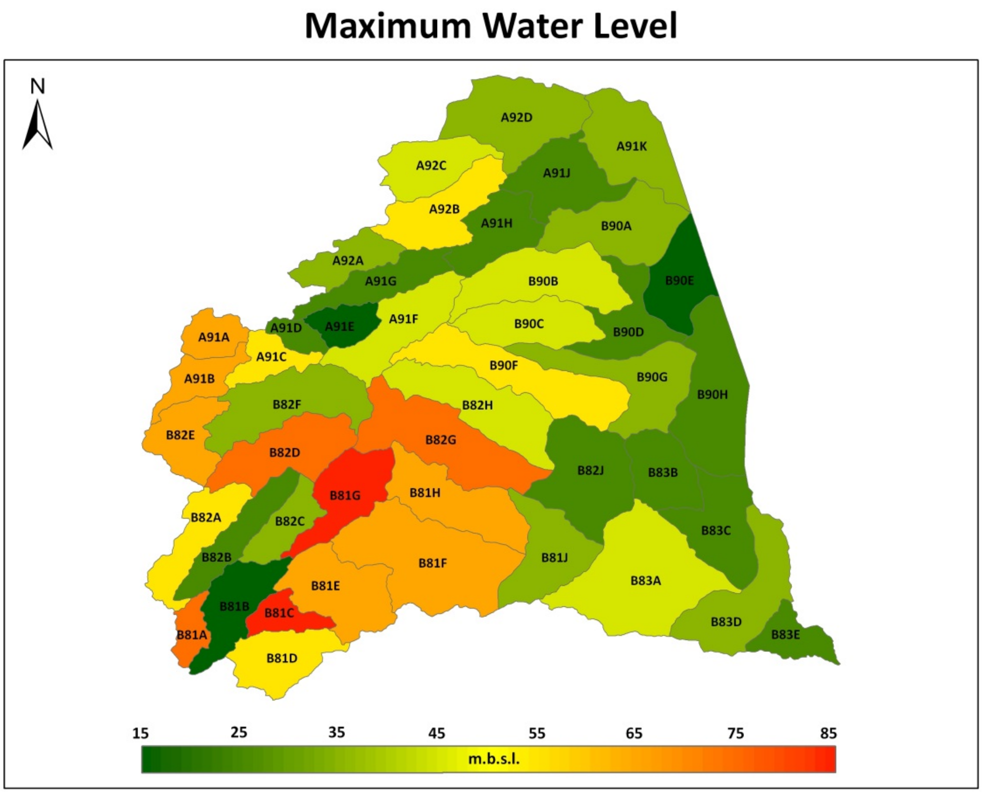


Figure 6-4 Maximum water level per Quaternary catchment

6.2.2 Water level per Water Supply Scheme

The GRIP data base was used to evaluate the water level of boreholes located within each water supply scheme (Table 6.5).

Table 6-5 Average water levels per water supply scheme

Water Supply Scheme	N	Average water level (m)	Maximum (m)
BA-PHALABORWA INDIVIDUAL SUPPLY	2	9.9	10.4
DAMANI RWS	86	10.8	32.0
ELIM/VLEIFONTEIN RWS	89	17.6	72.6
GIYANI SYSTEM A/B	88	13.7	54.0
GIYANI SYSTEM D: SOUTH WEST	51	9.8	27.0
GIYANI SYSTEM F1	26	12.7	26.0
GIYANI SYSTEM F2	43	15.9	48.0
GIYNAI SYSTEM C/D	137	11.8	34.2
LEVUBU CBD			
LOWER MOLOTOTSI	44	14.7	38.0
LUPHEPHE/NWANEDZI MAIN RWS	77	11.2	48.0
LUPHEPHE/NWANEDZI NORTH	59	18.3	39.7
MAKHADO RWS	12	21.2	35.9
MALAMULELE WEST RWS	79	15.9	53.7
MAPUVE/SYSTEM N RWS	32	21.1	44.7
MASISI RWS	86	14.6	63.5
MATSHAVHAVE/KUNDA RWS	3	7.1	8.4
MIDDLE LETABA RWS: BABANGU	98	13.7	40.0
MIDDLE LETABA RWS: MAGORO	111	20.1	70.4
MIDDLE LETABA RWS: MAJOSI	101	16.8	38.8
MIDDLE LETABA RWS: MALAMULELE WEST	36	20.2	47.3
MIDDLE LETABA RWS: VYEBOOM MASIA	35	17.8	46.2
MIDDLE LETABA: BOLOBEDU NW	77	14.3	53.8
MODJADJI RWS	128	12.3	35.5
MUTALE MAIN RWS	74	15.7	110.1
MUTALE MUKUYA RWS	31	16.3	46.7
NORTH MALAMULELE EAST RWS	71	10.9	28.3
NZHELELE NORTH RWS	4	9.0	20.6
NZHELELE RWS	97	9.7	58.0
RITAVI II RWS	1	14.6	14.6
RITAVI/LETABA RWS	153	12.9	41.7

SEKGOPO LOCAL GWS	33	18.0	45.5
SEKGOSESE INDIVIDUAL GROUNDWATER SCHEME	49	21.0	47.8
SILUWANE NONDWENI EXTENDED	44	11.6	28.1
SOUTH MALAMULELE EAST RWS	141	17.0	59.0
THAPANE RWS	64	12.6	42.3
LAMBANI	11	10.6	23.8
TSHAKUMA RWS	15	8.4	17.3
TSHIFIRE MURUNWA RWS	12	12.3	25.5
TSHIFUDI RWS	30	8.8	18.5
TSHITALE RWS	74	20.7	70.8
TZANEEN INDIVIDUAL SUPPLY			
TZANEEN/MODJADJISKLOOF	10	14.7	42.5
VALDEZIA RWS	27	13.5	23.7
VONDO CENTRAL RWS	121	12.2	51.3
VONDO EAST RWS	38	12.0	28.0
VONDO NORTH RURAL RWS	3	20.6	53.4
VONDO SOUTH RWS	36	12.0	42.4
WORCESTER/MOTHOBEKI RWS	47	16.8	44.7
Grand Total	**2686**		

6.3 WATER STRIKE DEPTH

6.3.1 Water Strike depth per Quaternary Catchment

The water strike depth of boreholes drilled in each Quaternary catchment was obtained from the NGDB. These water levels represent depths where water was encountered when the borehole was drilled. Average water levels are shown in table 6.6.

The average depth provides an indication of the minimum depths to which boreholes must be drilled, and the maximum depth provides an indication of maximum drilling depths.

Table 6-6 Water strike depths in metres below ground per Quaternary catchment

QUATERNARY	N	Average Depth	Maximum
A91A	138	43	198
A91B	118	49	124
A91C	61	43	120
A91D	84	34	90

A91E	38	33	108
A91F	118	35	126
A91G	91	40	141
A91H	80	39	94
A91J	13	27	52
A91K	32	20	56
A92A	33	41	102
A92B	17	53	90
A92C	77	66	149
A92D	61	64	123
B81A	5	76	146
B81B	6	52	91
B81C	18	41	102
B81D	140	32	114
B81E	73	49	150
B81F	106	42	114
B81G	163	48	114
B81H	68	47	102
B81J	23	31	60
B82A	67	38	95
B82B	8	37	79
B82C	15	58	102
B82D	135	43	128
B82E	209	44	120
B82F	135	41	120
B82G	122	37	84
B82H	49	37	72
B82J	23	27	79
B83A	36	24	52
B83B	39	23	70
B83C	23	21	52
B83D	39	29	120
B83E	2	9	10
B90A	57	35	100
B90B	64	34	120
B90C	28	43	120
B90D	32	20	50
B90E	27	33	62

B90F	80	38	96
B90G	38	23	50
B90H	53	30	114
Grand Total	2844		

6.3.2 Water strike per lithological unit

The water strike depth of boreholes drilled in each lithological unit was obtained from the NGDB. These water levels represent depths where water was encountered when the borehole was drilled and determines the depths to which boreholes should be drilled, hence the costs of establishing a water supply point. Average water levels are shown in **Table 6.7**.

Table 6-7 Water strike depth per lithological unit

Unit	N	Average (m)	Maximum (m)
Jozini Fm and Tshokwane granophyre	7	21	30
Letaba Formation	277	30	120
Malvernia Fm	5	38	56
Soutpansberg Group	459	42	198
Karoo sediments	64	60	132
Rooiwater Complex	39	33	150
Granite intrusives	267	44	146
Wolkberg Group and Black Reef Fm	2	37	43
Goudplaats and Makhutsi gneiss	1571	40	148
Gravelotte Group	47	29	114
Giyani Group	94	40	101
Limpopo Mobile belt	4	77	120
Pietersburg Group	4	64	79
Total	2840		

6.3.3 Water strike depth per water supply scheme

The water strike depth of boreholes drilled in each water supply scheme unit was obtained from the NGDB. These water levels represent depths where water was encountered when the borehole was drilled. Water strikes are generally 30-40 mbgl (table 6.8), except in the Lupephe Nwandezi and Masisi area in A92C and D.

Table 6-8 Water strike depth per water supply scheme

Scheme	N	Average (m)	Maximum (m)
DAMANI RWS	46	39	87
ELIM/VLEIFONTEIN RWS	22	35	86
GIYANI SYSTEM A/B	47	36	63
GIYANI SYSTEM D: SOUTH WEST	20	42	88
GIYANI SYSTEM F1	16	35	66
GIYANI SYSTEM F2	22	33	78
GIYNAI SYSTEM C/D	97	35	70
LAMBANI RWS	15	30	66
LEVUBU CBD	3	26	27
LOWER MOLOTOTSI	12	57	98
LUPHEPHE/NWANEDZI MAIN RWS	67	54	149
LUPHEPHE/NWANEDZI NORTH	29	63	158
MAKHADO RWS	130	34	148
MALAMULELE WEST RWS	46	32	76
MAPUVE/SYSTEM N RWS	14	40	66
MASISI RWS	55	62	132
MATSHAVHAVE/KUNDA RWS	6	34	74
MIDDLE LETABA RWS: BABANGU	45	37	84
MIDDLE LETABA RWS: MAGORO	26	40	101
MIDDLE LETABA RWS: MAJOSI	38	36	65
MIDDLE LETABA RWS: MALAMULELE WEST	18	38	54
MIDDLE LETABA RWS: VYEBOOM MASIA	11	42	76
MIDDLE LETABA: BOLOBEDU NW	24	43	101
MODJADJI RWS	77	35	101
MUTALE MAIN RWS	90	42	108
MUTALE MUKUYA RWS	8	40	66
NORTH MALAMULELE EAST RWS	28	22	70
RITAVI II RWS	46	27	49
RITAVI/LETABA RWS	65	33	82

SEKGOPO LOCAL GWS	15	31	68
SEKGOSESE INDIVIDUAL GROUNDWATER SCHEME	19	51	128
SILUWANE - NONDWENI EXTENDED RWS	10	28	50
SOUTH MALAMULELE EAST RWS	64	37	92
THABINA RWS	69	26	60
THAPANE RWS	32	42	102
TOURS RWS	25	25	49
TSHAKUMA RWS	14	55	108
TSHIFUDI RWS	39	39	94
TSHITALE RWS	81	43	92.96
TZANEEN INDIVIDUAL SUPPLY	2	49	62.07
TZANEEN/MODJADJISKLOOF	10	36	85
VALDEZIA RWS	15	42	74
VONDO CENTRAL RWS	60	32	141
VONDO EAST RWS	54	38	90
VONDO NORTH RURAL RWS	4	53	72
VONDO SOUTH RWS	7	28	35
WORCESTER/MOTHOBEKI RWS	11	40	78

6.4 GROUNDWATER QUALITY

6.4.1 Groundwater Quality by Quaternary Catchment

Groundwater quality is one of the main factors restricting the development of available groundwater resources. Although there are numerous problems associated with groundwater quality, some of which are relatively easily remediated, high concentration of total dissolved solids (TDS), nitrates (NO_3 and NO_2) and Fluoride (F) are considered to be the most common and serious problems associated with water quality on a regional scale.

Water quality data was obtained from boreholes in the study area and classified using the DWA's potable water quality standards for domestic consumption in terms of nitrates and total dissolved solids. The potable portion of groundwater was considered, as that water that was classified as ideal, good and marginal according to DWA domestic water quality standards (Class 0,1 and 2) (table 6.9). Groundwater classified as poor or unacceptable was considered not to be potable (Class 3 or 4).

Table 6-9 DWA classification of Water Quality for drinking water

Water quality class	Description	Drinking health effects
Class 0	Ideal water quality	No effects, suitable for many generations.
Class 1	Good water quality	Suitable for lifetime use. Rare instances of sub-clinical effects.
Class 2	Marginal water quality, water suitable for short-term use only	May be used without health effects by majority of users, but may cause effects in some sensitive groups. Some effects possible after lifetime use.
Class 3	Poor water quality	Poses a risk of chronic health effects, especially in babies, children and the elderly. May be used for short-term emergency supply with no alternative supplies available.
Class 4	Unacceptable water quality	Severe acute health effects, even with short-term use.

Good quality groundwater exists throughout the study area (table 6.10), with the following exceptions:

- B81B exhibits elevated nitrates and TDS, however the numbers of boreholes sampled is small.
- B81 F and H in the low veld plains exhibit high levels of nitrate. These catchments are densely settled and elevated nitrate is probably associated with the removal of vegetation.
- B82D G and H, shows elevated nitrates due to dense settlement.
- B90B and C F and G show elevated nitrates

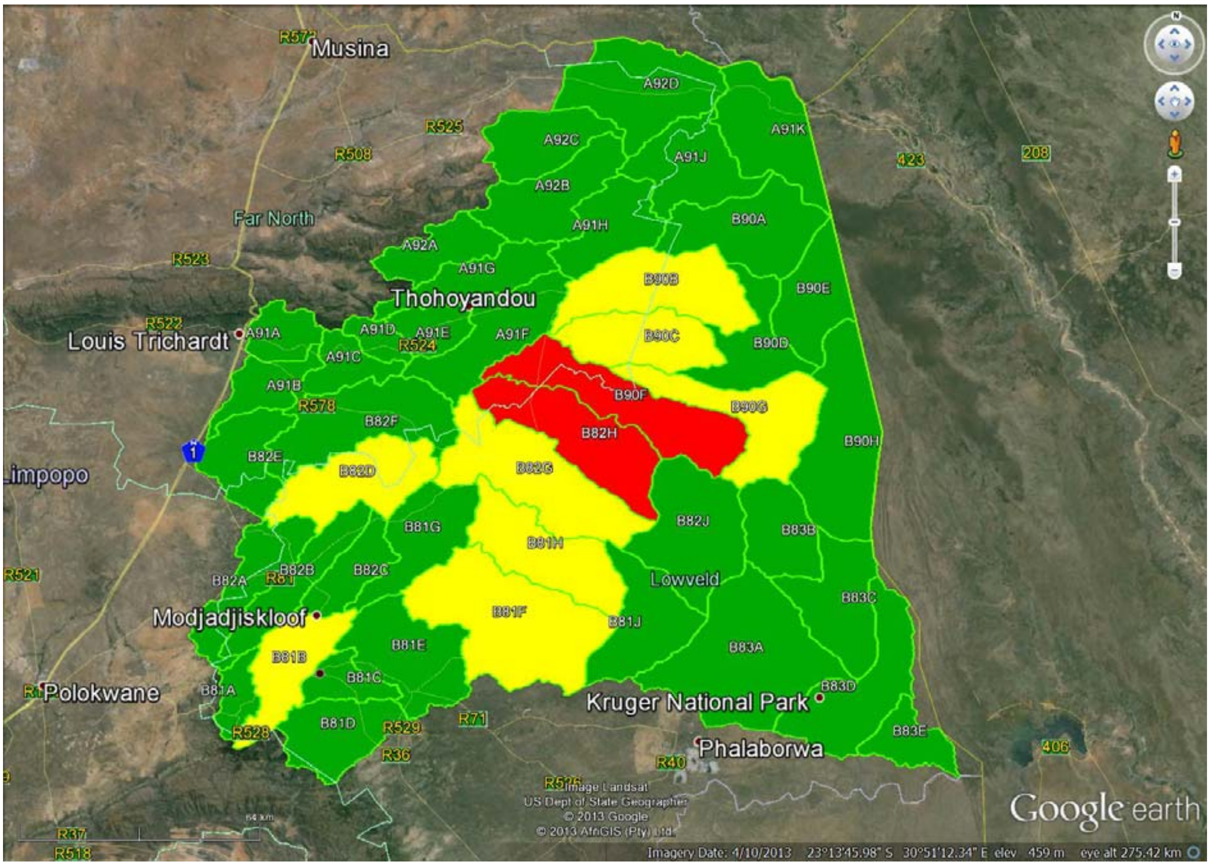
The distribution of catchments with elevated nitrates is shown in figure 6.5.

Table 6-10 Groundwater quality class per Quaternary

Catchment	TDS - Class						Potable	Nitrates - Class						Potable
	0	1	2	3	4	N	%	0	1	2	3	4	N	%
A91A	5	4				9	100	9	1				10	100
A91B	22	3	2			27	100	32	4	3			39	100
A91C	48	5	1			54	100	88	4	2	3		97	97
A91D	12					12	100	11	3				14	100
A91E	46	4		1		51	98	55	2	4	3		64	95
A91F	47	145	13			205	100	166	35	41	35	14	291	83
A91G	71	23				94	100	99	13	9	3	1	125	97
A91H	55	17	7			79	100	87	6	6	3		102	97
A91J	10		3	2		15	87	18					18	100
A91K	3	12	6		1	22	95	37	1				38	100

A92A	48		1			49	100	56	4	3			63	100
A92B	43	10	2			55	100	70	1	3			74	100
A92C	25	14	21	6	7	73	82	105	14	19	14	7	159	87
A92D	6	35	47	3	3	94	94	90	24	18	11	19	162	81
B32F		1				1	100	1					1	100
B81A	1					1	100	1					1	100
B81B	4		1	2		7	71	5	1		1	1	8	75
B81C	15	7				22	100	53	5		1		59	98
B81D	98	32	1			131	100	137	20	16		1	174	99
B81E	74	37	5			116	100	124	8	11	2	1	146	98
B81F	19	79	82	8	2	190	95	103	22	57	54	28	264	69
B81G	78	100	57	2	3	240	98	189	43	31	44	19	326	81
B81H	2	26	88	3	3	122	95	64	17	31	41	17	170	66
B81J	2	10	43	2	2	59	93	42	13	20	5	5	85	88
B82A	28	17	1	1		47	98	36	5	6	2	1	50	94
B82B	1	1				2	100	2	2	1			5	100
B82C	30	1				31	100	23	6	2	1		32	97
B82D	42	128	32			202	100	104	23	50	56	21	254	70
B82E	34	33	9			76	100	54	15	26	10	4	109	87
B82F	84	91	3			178	100	114	32	51	25	7	229	86
B82G	4	69	58	8	1	140	94	111	15	40	30	16	212	78
B82H	3	17	30	1		51	98	15	7	13	16	8	59	59
B82J		2	22			24	100	22	4	4	3	4	37	81
B83A		2	19	1		22	95	24					24	100
B83B		9	9	1		19	95	34					34	100
B83C		7	5			12	100	12					12	100
B83D	1	1	12			14	100	16	1				17	100
B90A	1	7	24	1		33	97	48	3		1	1	53	96
B90B	4	58	21			83	100	50	10	11	13	7	91	78
B90C	3	23	31			57	100	32	6	8	8	12	66	70
B90D		4	3			7	100	7					7	100
B90E		3	16	1		20	95	18	2				20	100
B90F	3	63	47	4	5	122	93	35	11	26	50	13	135	53
B90G		9	11			20	100	13		2	5	1	21	71
B90H		16	10			26	100	32	1				33	100

>80%
60-80%
<60%,



>80%

60-80%

<60%,

Figure 6-5 Percent of boreholes with potable groundwater in terms of nitrate levels

6.4.2 Groundwater quality by Water Supply Scheme

Water quality data in the GRIP data base, on a village level, was utilised to characterise groundwater quality by water supply scheme (table 6.11). Since GRIP data represents boreholes currently utilised, or to be equipped, the data may be biased by not including boreholes abandoned due to high salinity, but with the boreholes being predominantly in built up areas, could include boreholes with poor quality due to contamination.

Poor quality water due to elevated nitrates appears to be widespread amongst the water supply schemes.

Table 6-11 Groundwater quality class per Water supply scheme

Scheme	TDS Class						TDS Percent						Nitrates Class						Nitrates - Percent					
	0	1	2	3	4	N	0	1	2	3	4	% Potable	0	1	2	3	4	N	0	1	2	3	4	% Potable
BA-PHALABORWA INDIVIDUAL SUPPLY			1	1		2	0	0	50	50	0	50	2					2	100	0	0	0	0	100
DAMANI RWS	62	1				63	98	2	0	0	0	100	53	5	2			60	88	8	3	0	0	100
ELIM/VLEIFONTEIN RWS	38	7	1			46	83	15	2	0	0	100	36	5	3	1	1	46	78	11	7	2	2	96
GIYANI SYSTEM A/B	3	12	31	2		48	6	25	65	4	0	96	18	5	11	7	7	48	38	10	23	15	15	71
GIYANI SYSTEM D: SOUTH WEST	2	4	26	1		33	6	12	79	3	0	97	11	4	4	11	3	33	33	12	12	33	9	58
GIYANI SYSTEM F1		1	11	1	2	15	0	7	73	7	13	80	3	3	1	6	2	15	20	20	7	40	13	47
GIYANI SYSTEM F2	1	20	11			32	3	63	34	0	0	100	7	3	10	9	2	31	23	10	32	29	6	65
GIYNAI SYSTEM C/D	2	32	30	8	1	73	3	44	41	11	1	88	27	8	20	7	9	71	38	11	28	10	13	77
LAMBANI RWS	16	2				18	89	11	0	0	0	100	18					18	100	0	0	0	0	100
LOWER MOLOTOTSI	1	7	31	3	1	43	2	16	72	7	2	91	14	5	5	8	11	43	33	12	12	19	26	56
LUPHEPHE/NWANEDZI MAIN RWS	9	8	10		3	30	30	27	33	0	10	90	20	3	6	2		31	65	10	19	6	0	94
LUPHEPHE/NWANEDZI NORTH		4	7		1	12	0	33	58	0	8	92	3	2	1	4	2	12	25	17	8	33	17	50
MALAMULELE WEST RWS	6	57	6			69	9	83	9	0	0	100	34	3	6	19	7	69	49	4	9	28	10	62
MAPUVE/SYSTEM N RWS		11	5			16	0	69	31	0	0	100	2	1	3	8	2	16	13	6	19	50	13	38

MASISI RWS	3	18	24	2	5	52	6	35	46	4	10	87	26	4	9	3	7	49	53	8	18	6	14	80
MIDDLE LETABA RWS: BABANGU	3	32	11			46	7	70	24	0	0	100	12	3	8	14	8	45	27	7	18	31	18	51
MIDDLE LETABA RWS: MAGORO	5	59	6			70	7	84	9	0	0	100	20	5	14	25	6	70	29	7	20	36	9	56
MIDDLE LETABA RWS: MAJOSI	32	53	2			87	37	61	2	0	0	100	28	15	23	14	5	85	33	18	27	16	6	78
MIDDLE LETABA RWS: MALAMULELE WEST		15	3	2		20	0	75	15	10	0	90	4	4	3	7	2	20	20	20	15	35	10	55
MIDDLE LETABA RWS: VYEBOOM MASIA	20	12				32	63	38	0	0	0	100	14	7	7	3	1	32	44	22	22	9	3	88
MIDDLE LETABA: BOLOBEDU NW	4	35	16	1		56	7	63	29	2	0	98	24	5	6	13	8	56	43	9	11	23	14	63
MODJADJI RWS	51	13	2		1	67	76	19	3	0	1	99	53	6	3	4	1	67	79	9	4	6	1	93
MUTALE MAIN RWS	34					34	100	0	0	0	0	100	30	2	2			34	88	6	6	0	0	100
MUTALE MUKUYA RWS	19	6	2			27	70	22	7	0	0	100	26					26	100	0	0	0	0	100
NORTH MALAMULELE EAST RWS	2	20	12			34	6	59	35	0	0	100	17	3	1	8	5	34	50	9	3	24	15	62
NZHELELE RWS	3					3	100	0	0	0	0	100	3					3	100	0	0	0	0	100
RITAVI II RWS	1	1				2	50	50	0	0	0	100	2					2	100	0	0	0	0	100
RITAVI/LETABA RWS	15	44	35	3		97	15	45	36	3	0	97	32	8	24	21	10	95	34	8	25	22	11	67

SEKGOPO LOCAL GWS	3	7				10	30	70	0	0	0	100	5		5			10	50	0	50	0	0	100
SEKGOSESE INDIVIDUAL GROUNDWATER SCHEME	21	19	1			41	51	46	2	0	0	100	23	4	9	4	1	41	56	10	22	10	2	88
SILUWANE NONDWENI EXTENDED		11	28		1	40	0	28	70	0	3	98	14	5	14	3	4	40	35	13	35	8	10	83
SOUTH MALAMULELE EAST RWS	9	56	44			109	8	51	40	0	0	100	32	9	17	27	24	109	29	8	16	25	22	53
THAPANE RWS	33	6				39	85	15	0	0	0	100	34		2	2		38	89	0	5	5	0	95
TSHAKUMA RWS	8					8	100	0	0	0	0	100	8					8	100	0	0	0	0	100
TSHIFIRE MURUNWA RWS	1					1	100	0	0	0	0	100	1					1	100	0	0	0	0	100
TSHIFUDI RWS	17	4				21	81	19	0	0	0	100	16	1	2			19	84	5	11	0	0	100
TSHITALE RWS	50	31	4			85	59	36	5	0	0	100	40	14	19	10	2	85	47	16	22	12	2	86
TZANEEN/MODJADJISKLOOF	5					5	100	0	0	0	0	100	5					5	100	0	0	0	0	100
VALDEZIA RWS	12					12	100	0	0	0	0	100	12					12	100	0	0	0	0	100
VONDO CENTRAL RWS	73	41	1			115	63	36	1	0	0	100	87	9	11	6		113	77	8	10	5	0	95
VONDO EAST RWS	20	46				66	30	70	0	0	0	100	28	17	15	5	1	66	42	26	23	8	2	91
VONDO NORTH RURAL RWS	1					1	100	0	0	0	0	100	1					1	100	0	0	0	0	100
VONDO SOUTH RWS	6	31	6			43	14	72	14	0	0	100	23	4	5	11		43	53	9	12	26	0	74
WORCESTER/MOTHOBEKI RWS	1	21	12	1	2	37	3	57	32	3	5	92	6	3	11	9	6	35	17	9	31	26	17	57
Total	**592**	**747**	**379**	**25**	**17**	**1760**	34	42	22	1	1	98	**874**	**175**	**282**	**271**	**137**	**1739**	50	10	16	16	8	77

6.5 GROUNDWATER RESOURCES

Data on the volumes of groundwater that can be exploited were obtained from:

- The Harvest Potential database
- Groundwater Resources Assessment Phase II (GRAII) database
- Modifications to the GRAII data base undertaken by WSM Leshika
- Modelling of surface groundwater interactions using the WRSM2000 model

6.5.1 Harvest and Exploitation Potential

The Ground Water Harvest Potential provides a basis for the evaluation of the volume of groundwater resources. The Harvest Potential is defined as the maximum volume of groundwater that is available for abstraction without depleting the aquifer systems, and takes into account recharge, storage and drought periods. The Harvest Potential for the study area is 271.09 Mm^3/a (table 6.12).

It is however not possible to abstract all the ground water available. This is mainly due to economic and/or environmental considerations. The main contributing factor is the hydraulic conductivity or transmissivity of the aquifer systems. As no regional information is available, a qualitative evaluation has been done using available borehole yield information, as there is a good relationship between borehole yield and transmissivity.

The geometric mean of borehole yield (table 6.3) was determined for each Quaternary catchment using information available from the National Ground Water Archive. The Harvest Potential was then reduced by an exploitation factor, determined from borehole yield data, to obtain an exploitation potential, i.e. the portion of the Harvest Potential which can practically be exploited (Table 6.12). The Exploitation Potential for the study area is 183.82 Mm^3/a.

Table 6-12 Groundwater resources in the catchments

Catchment	Area	Harvest Potential		Exploitation potential		GRAII EP		Modified GRAII EP		Recharge		Aquifer recharge	
	km^2	mm	Mm^3/a	factor	Mm^3/a	mm	Mm^3/a	mm	Mm^3/a	mm	Mm^3/a	mm	Mm^3/a
A91A	232	12.21	2.83	0.7	1.98	41.64	9.66	23.45	5.44	93.55	21.70	48.46	11.24
A91B	275	15.84	4.36	0.7	3.05	33.26	9.15	14.72	4.05	32.46	8.93	28.46	7.83
A91C&F3	282	15.73	4.44	0.7	3.10	51.44	14.51	33.23	9.37	181.16	51.09	109.25	30.81
A91D	132	11.67	1.54	0.7	1.08	89.47	11.81	77.72	10.26	443.43	58.53	134.49	17.75
A91E	223	13.12	2.93	0.7	2.05	63.69	14.20	51.00	11.37	189.22	42.20	64.92	14.48
A91F1&F2	548	14.89	8.16	0.6	4.90	24.08	13.20	13.02	7.13	19.27	10.56	19.27	10.56
A91G	406	8.40	3.41	0.7	2.39	76.35	31.00	67.43	27.37	217.59	88.34	92.24	37.45
A91H	450	8.48	3.82	0.7	2.67	27.23	12.25	17.87	8.04	32.00	14.40	16.00	7.20
A91J	570	7.17	4.09	0.6	2.45	16.58	9.45	9.15	5.21	10.71	6.10	10.67	6.08
A91K	669	10.36	6.93	0.7	4.85	8.57	5.73	3.80	2.54	6.44	4.31	6.44	4.31
A92A	329	8.40	2.76	0.7	1.93	72.73	23.93	74.53	24.52	223.08	73.39	39.43	12.97
A92B	565	8.27	4.67	0.7	3.27	30.29	17.11	33.04	18.67	15.58	8.80	7.79	4.40
A92C	455	6.56	2.98	0.7	2.09	20.10	9.14	18.67	8.50	2.90	1.32	2.90	1.32
A92D	805	4.01	3.22	0.7	2.26	6.35	5.11	5.48	4.41	1.27	1.02	1.27	1.02
B81A	169.8	16.04	2.72	0.5	1.36	73.33	12.45	58.30	9.90	299.43	50.84	60.91	10.34
B81B	481	16.04	7.72	0.7	5.40	57.74	27.77	47.54	22.87	195.73	94.15	42.24	20.32
B81C	208	16.00	3.33	0.6	2.00	28.17	5.86	14.83	3.09	133.73	27.82	78.20	16.27
B81D	477	16.28	7.77	0.7	5.44	32.74	15.62	20.89	9.96	189.21	90.25	26.92	12.84
B81E	666	13.45	8.95	0.6	5.37	27.36	18.22	14.18	9.45	31.43	20.93	27.33	18.20
B81F	1200	12.00	14.40	0.7	10.08	19.02	22.82	8.53	10.23	15.39	18.47	15.39	18.47
B81G	517	13.12	6.78	0.7	4.75	29.50	15.25	14.74	7.62	35.43	18.32	24.33	12.58
B81H	664	12.00	7.97	0.7	5.58	18.92	12.57	7.26	4.82	13.26	8.80	13.26	8.80
B81J	568	11.37	6.46	0.7	4.52	20.23	11.49	9.21	5.23	11.28	6.40	11.17	6.34
B82A	467	15.77	7.37	0.6	4.42	30.98	14.47	14.33	6.69	37.43	17.48	24.33	11.36

B82B	406	16.00	6.50	0.6	3.90	34.77	14.12	17.18	6.97	36.23	14.71	23.40	9.50
B82C	300	15.85	4.76	0.7	3.33	31.21	9.36	16.94	5.08	38.02	11.41	23.79	7.14
B82D	632	15.99	10.11	0.7	7.08	24.90	15.74	8.72	5.51	21.29	13.46	16.37	10.35
B82E	423	15.15	6.41	0.7	4.49	28.75	12.16	10.78	4.56	19.60	8.31	19.02	8.05
B82F	760	15.86	12.05	0.7	8.44	28.17	21.41	11.94	9.07	19.53	14.84	18.82	14.30
B82G	921	11.97	11.02	0.7	7.72	19.64	18.08	7.71	7.10	11.72	10.80	11.67	10.75
B82H	749	11.31	8.47	0.7	5.93	17.21	12.89	6.79	5.09	11.41	8.55	11.37	8.52
B82J	795	8.07	6.42	0.7	4.49	17.42	13.85	9.55	7.59	11.66	9.27	11.66	9.27
B83A	1252	9.65	12.08	0.7	8.46	21.27	26.63	11.15	13.96	9.40	11.77	9.40	11.77
B83B	439	8.00	3.51	0.7	2.46	21.49	9.43	14.37	6.31	13.00	5.71	13.00	5.71
B83C	592	8.00	4.74	0.7	3.32	22.39	13.25	12.11	7.17	13.00	7.70	13.00	7.70
B83D	714	9.30	6.64	0.7	4.65	18.86	13.46	12.12	8.66	11.03	7.88	11.03	7.88
B83E	267	9.28	2.48	0.6	1.49	13.39	3.57	8.30	2.22	11.63	3.11	11.63	3.11
B90A	692	7.97	5.51	0.6	3.31	12.15	8.41	6.53	4.52	9.78	6.77	9.78	6.77
B90B	753	9.96	7.50	0.7	5.25	21.07	15.87	8.19	6.17	8.82	6.64	8.82	6.64
B90C	534	10.55	5.64	0.7	3.95	17.73	9.47	8.02	4.28	9.61	5.13	9.61	5.13
B90D	446	7.82	3.49	0.7	2.44	13.25	5.91	6.72	3.00	8.50	3.79	8.50	3.79
B90E	473	8.00	3.78	0.5	1.89	9.15	4.33	5.40	2.56	7.92	3.75	7.92	3.75
B90F	818	10.32	8.44	0.7	5.91	17.27	14.13	7.90	6.46	10.81	8.84	10.81	8.84
B90G	697	8.26	5.75	0.7	4.03	16.38	11.41	10.55	7.35	10.27	7.16	10.27	7.16
B90H	775	8.00	6.20	0.7	4.34	14.14	10.96	11.77	9.13	9.45	7.32	9.45	7.32
TOTAL	24796.80		271.09		183.82		607.21		369.50		921.06		466.37

6.5.2 GRAII Exploitation Potential

GRAII provided a National data set of the Groundwater Resource Potential, which provides estimates of the maximum volumes of groundwater that are potentially available for abstraction on a sustainable basis. This calculation took into account the volumes of water held in aquifer storage in the upper 5 m of the aquifer, and the recharge from rainfall, less the natural baseflow. The feasibility of abstracting this water is limited by many factors due mainly to the physical attributes of a particular aquifer system, economic and/or environmental considerations. One of the most important of these is the inability to establish a network of suitably spaced production boreholes to 'capture' all the available water in an aquifer system or on a more regional scale. The factors limiting the ability to develop such a network of production boreholes, includes the low permeability or transmissivity of certain aquifer units, accessibility of terrain to drilling rigs, and unknown aquifer boundary conditions. An Exploitability Factor based on borehole yield and the probability of drilling boreholes of greater than 2 l/s was developed and utilised to calculate and Exploitation Potential.

The Exploitation Potential for the study area in GRAII is 607.21 Mm^3/a.

6.5.3 Modified GRAII Exploitation Potential

The exploitation potential values in GRAII were considered to be too high due to incorrect storage estimates. The data used in the calculation in the original GRAII report was re-examined. The aquifer storage volumes utilised (DWA, 2006) were considered to be too high and were recalculated, and subsequently the Exploitation Potential was recalculated by the same GRAII methodology. This modified Exploitation Potential was calculated as 369.5 Mm^3/a.

6.5.4 Simulation of Aquifer Recharge

GRAII exploitation potential is calculated based on rainfall recharge, which assumes all recharge enters the aquifer. This assumption doesn't consider that some recharge rapidly re-emerges as interflow in high lying areas and is not available to the regional aquifer as a resource, hence the values calculated in terms of recharge to the regional aquifer may be too high, especially in regions like the Drakensberg Escarpment and Foothills, where much of the recharge emerges as springs in high lying areas before reaching the regional aquifer. The high interflow component is evident by the high volumes of rapid response baseflow immediately following rain events with a raid recession rate.

The surface groundwater interaction component in WRSM2000 was utilised to derive recharge, aquifer recharge and baseflow. Recharge and baseflow were calibrated against gauging stations and dam water levels to ensure a water balance between groundwater recharge and baseflow.

The mean annual aquifer recharge to Quaternary catchments is shown in figure 6.6.

Recharge to the regional aquifer (aquifer recharge) is often significantly less than the recharge volumes, especially in the escarpment region, where much of the recharge is lost as interflow and not available to boreholes. The calculated aquifer recharge for the study area is 466 Mm^3/a, whereas the total recharge is 921 Mm^3/a (table 6.14). The aquifer recharge can be considered the upper limit of what can be abstracted, as it is the average rainfall recharge to the regional aquifer. However, abstracting this volume would deplete the source of groundwater baseflow, which provides low flows during the dry season.

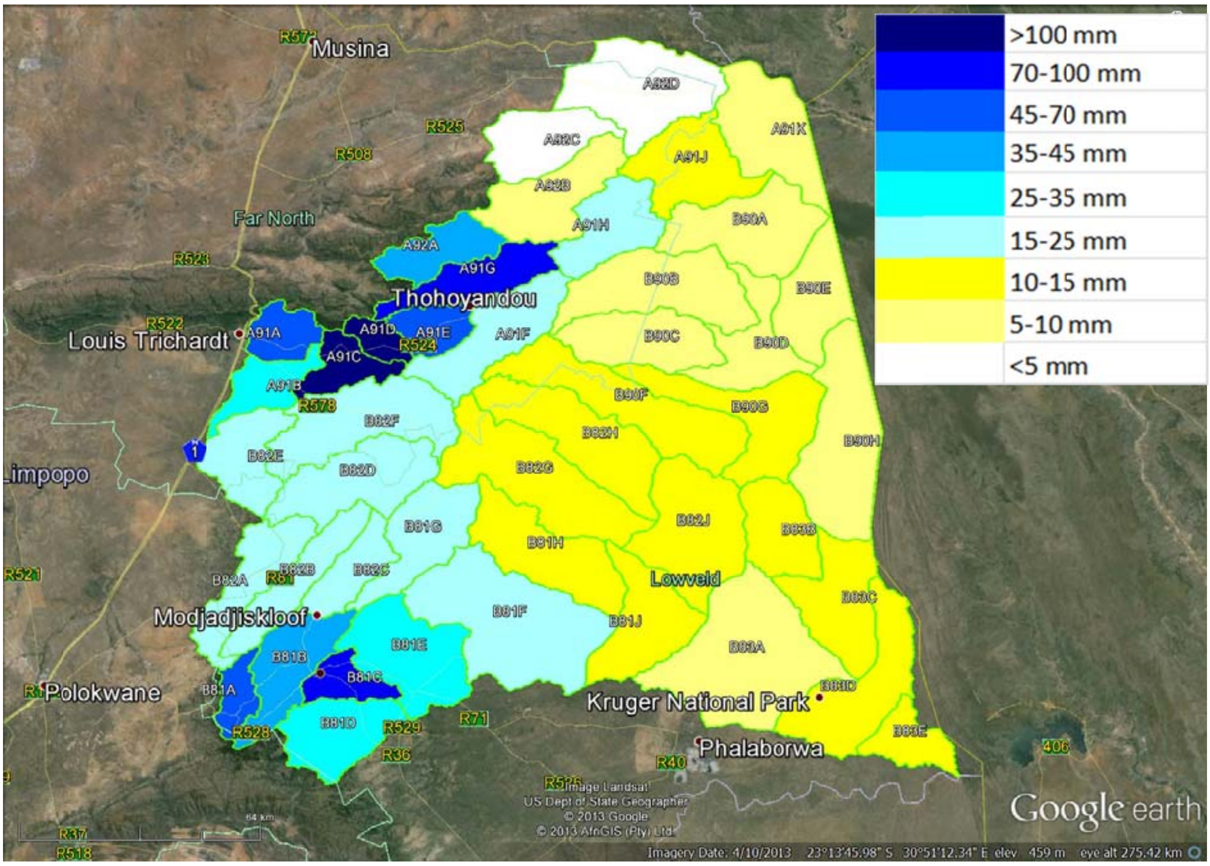


Figure 6-6 Mean annual aquifer recharge

6.5.5 Potable Exploitation Potential

The potability of groundwater may also impact on its viability as a resource. The Potable Groundwater Exploitation Potential was obtained by multiplying the Exploitation Potential by the Potability Factor, which is the fraction of boreholes considered to be potable (Class 0-2). The Potable volume of groundwater that can be exploited is 234-333 Mm^3/a (table 6.13).

Table 6-13 Potable Harvest and Exploitation Potential

Quat	Potability factor	Potable Harvest Potential	Potable Exploitation Potential	Potable modified GRAII Exploitation Potential
	Mm^3/a	Mm^3/a	Mm^3/a	Mm^3/a
A91A	1.00	2.83	1.98	5.44
A91B	1.00	4.36	3.05	4.05
A91C	0.94	4.19	2.93	8.85
A91D	1.00	1.54	1.08	10.26
A91E	0.94	2.76	1.93	10.73
A91F	0.82	6.68	4.01	5.84
A91G	0.97	3.30	2.31	26.53
A91H	0.96	3.68	2.58	7.75
A91J	0.87	3.54	2.13	4.52
A91K	0.95	6.62	4.63	2.43
A92A	1.00	2.76	1.93	24.52
A92B	1.00	4.67	3.27	18.67
A92C	0.73	2.19	1.53	6.24
A92D	0.76	2.43	1.70	3.33
B81A	1.00	2.72	1.36	9.90
B81B	1.00	7.72	5.40	22.87
B81C	0.71	2.38	1.43	2.20
B81D	0.95	7.41	5.19	9.51
B81E	0.99	8.89	5.33	9.37
B81F	0.97	14.03	9.82	9.97
B81G	0.65	4.40	3.08	4.95
B81H	0.78	6.18	4.32	3.74
B81J	0.66	4.24	2.96	3.43
B82A	0.85	6.24	3.74	5.67
B82B	0.94	6.09	3.65	6.54

B82C	1.00	4.76	3.33	5.08
B82D	0.97	9.78	6.85	5.33
B82E	0.67	4.28	3.00	3.05
B82F	0.86	10.33	7.23	7.78
B82G	0.85	9.42	6.60	6.07
B82H	0.70	5.95	4.16	3.57
B82J	0.56	3.58	2.50	4.23
B83A	0.88	10.57	7.40	12.21
B83B	0.95	3.35	2.35	6.02
B83C	0.95	4.49	3.14	6.79
B83D	1.00	6.64	4.65	8.66
B83E	1.00	2.48	1.49	2.22
B90A	0.91	5.01	3.01	4.11
B90B	0.77	5.78	4.05	4.76
B90C	0.68	3.86	2.70	2.93
B90D	1.00	3.49	2.44	3.00
B90E	0.95	3.59	1.80	2.43
B90F	0.52	4.36	3.05	3.34
B90G	0.75	4.32	3.02	5.51
B90H	1.00	6.20	4.34	9.13
Total		234.09	158.47	333.52

6.6 BASEFLOW

The WRSM2000 model was utilised to simulate recharge and baseflow. The WRSM2000 model simulates the following surface water and groundwater interactions:

<u>BASEFLOW</u>

- Interflow occurring from the unsaturated zone contributing to hydrograph recession following a large storm event, or discharge from perched water tables via temporary or perennial springs located above low permeability layers, which may cause prolonged baseflow following rain events, even when the regional water table is below the stream channel
- Groundwater baseflow discharged from the regional aquifer to surface water as baseflow to river channels, either to perennial effluent or intermittent streams.

RIVER LOSSES

- Transmission losses of surface water when river stage is above the groundwater table in phreatic aquifers with a water table in contact with the river.
- Groundwater baseflow reduction and induced recharge caused by pumping of aquifer systems in the vicinity of rivers causing a flow reversal.

The distinction between the two baseflow components distinguishes that not all subsurface water pathways incur passage through the regional aquifer. Subsurface water which does not flow through the regional aquifer is not available to boreholes in terms of conventional groundwater resource assessment; hence a distinction needs to be made between groundwater baseflow originating from the regional aquifer and baseflow originating from other, more rapid, subsurface pathways (interflow), which includes discharge from saturated soils, perched aquifers, high lying springs, excess recharge that is not accepted by the aquifer.

The wet catchments of the Escarpment and Foothills regions may have a very high recharge, but very limited groundwater resource potential since much of the recharge is lost as interflow.

WRSM2000 was utilised to simulate the hydrology of the catchments and the baseflow component was calibrated against:

- Observed flows at gauging stations
- Dam inflows and levels
- GRAII recharge estimates

The calibration statistics are reported in (DWA, 2014). Calibration was undertaken against the observed time series of flow, taking into account:

- the time series of changes in surface and groundwater abstractions
- point source discharges and return flows
- Growth in dams, alien vegetation and afforestation.

These activities significantly affect baseflow at gauging stations but are non-stationary in time, hence calibrated flows cannot be used to obtain mean annual figures. The hydrology was naturalised to obtain virgin recharge and baseflows (table 6.14). The subareas simulated are shown in figure 6-7.

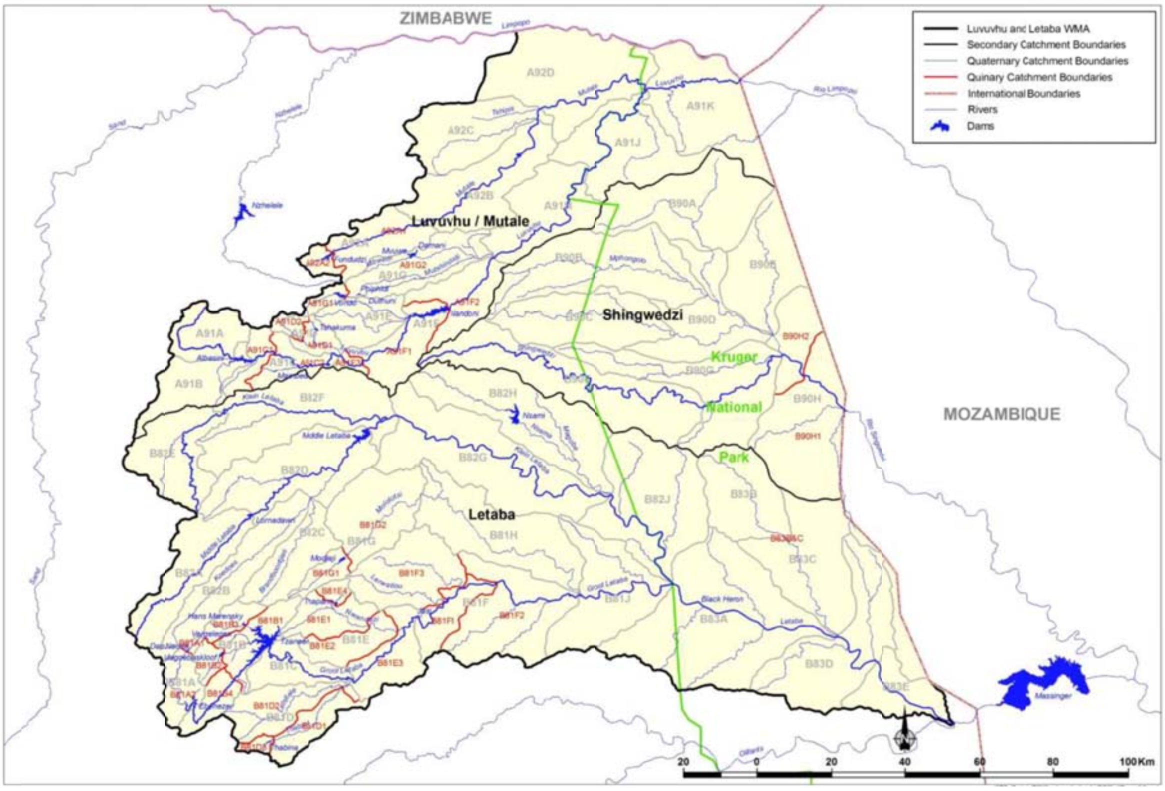


Figure 6-7 Quaternary and Quinary catchments

6.6.1 Virgin conditions

Tabulations of naturalised baseflow were obtained from WRSM2000 (table 6.14). Baseflow is 41% of the MAR, of which groundwater baseflow is 7.15% of MAR. The location of baseflow generation is shown in figure 6-8.

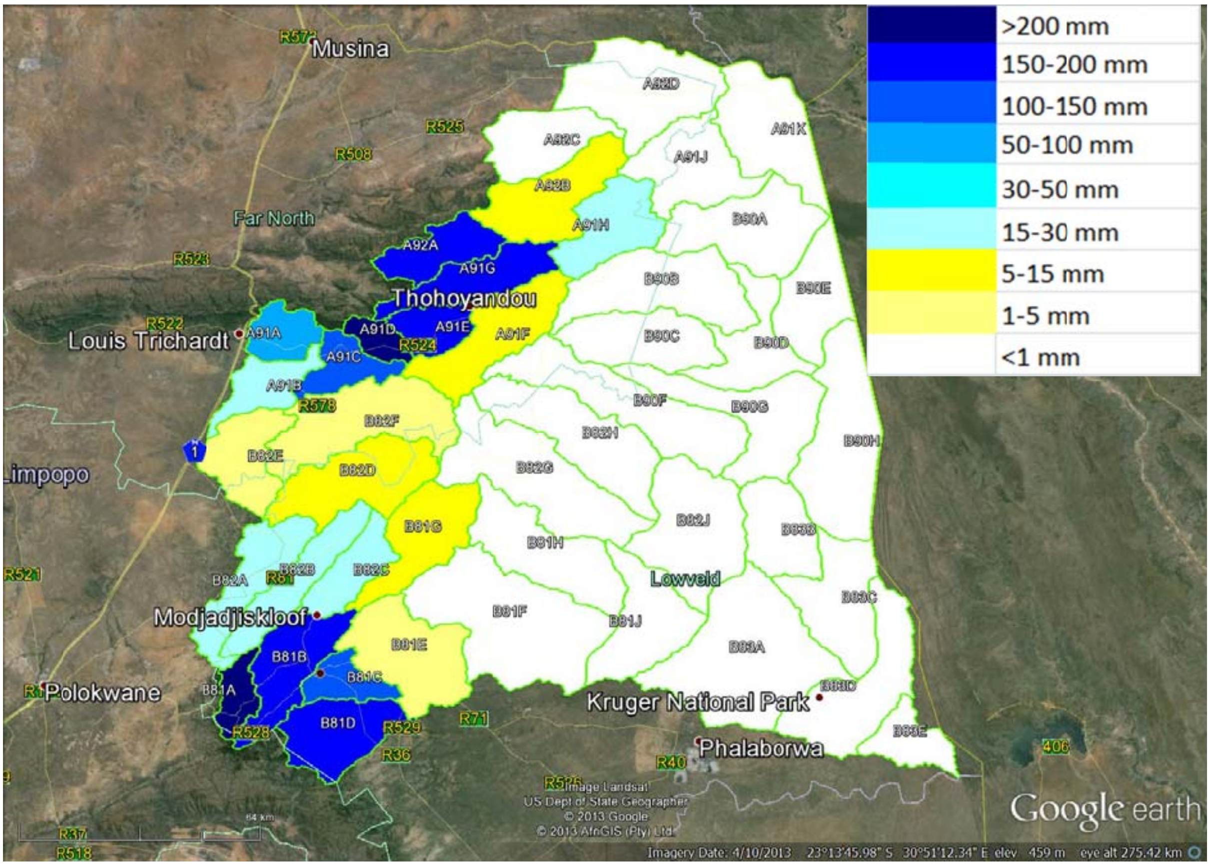


Figure 6-8 Mean annual baseflow

Table 6-14 Naturalised recharge and baseflow

Catchment	Area	MAP	Aquifer recharge	interflow	Recharge	Recharge	GRA2 Recharge	Baseflow	MAR
	km2	mm/a	mm	Mm^3	Mm^3	mm	mm	Mm3/a	Mm3/a
B81A10	14.1	1570	80.34	**4.3**	5.43			4.9	9.53
B81A01	155.7	1178	59.15	36.2	45.41			43.17	66.17
B81A	**169.8**	**1211**	**60.91**	**40.5**	**50.84**	**299.43**	**199.22**	**48.07**	**75.71**
B81B10-16	124	1147	51.05	16.78	23.11			17.53	29.44
B81B20	62	1359	33.79	17.95	20.04			18.23	33.64
B81B01	183	1147	42.38	17.48	25.24			17.56	38.67
B81B30	89	1147	35.54	19.46	22.62			19.46	27.68
B81B01A	23	1147	42.38	2.16	3.13			2.17	4.83
B81B	**481**	**1174**	**42.24**	**73.83**	**94.15**	**195.73**	**162.64**	**74.95**	**134.26**
B81C	**208**	**870**	**78.20**	**11.55**	**27.82**	**133.73**	**51.65**	**22.09**	**28.7**
B81D1	179.7	822	24.16	5.49	9.83			5.74	20.88
B81D2	269	1000	29.03	66.14	73.95			67.44	80.63
B81thabina	28.3	950	24.40	5.78	6.47			5.82	6.34
B81D	**477**	**930**	**26.92**	**77.41**	**90.25**	**189.21**	**56.62**	**79**	**107.85**

Thapane	41	750	21.12	2.53	3.40			2.54	4.70
B81E01&E10	242	664	27.75	0.04	6.76			0.06	10.13
B81E01&E10(2)	13	664	27.63	0.02	0.38			0.02	0.56
B81E20&23	148	664	27.75	0.02	4.13			0.02	6.20
B81E20&23(2)	50	664	27.63	0.09	1.47			0.09	2.16
B81E25&30	172	664	27.75	0.03	4.80			0.04	7.21
B81E	**666**	**669**	**27.33**	**2.73**	**20.93**	**31.43**	**29.75**	**2.77**	**30.96**
B81F30	186	541	15.39	0	2.86			0.01	3.67
B81F10&20	430	541	15.39	0	6.62			0.02	8.48
B81F01	584	541	15.39	0	8.99			0.03	11.52
B81F	**1200**	**541**	**15.39**	**0**	**18.47**	**15.39**	**14.91**	**0.06**	**23.67**
B81G	437	624	24.32	0.02	10.65			0.05	13.60
Modjadji	80	850	24.36	5.72	7.67			5.82	11.89
B81G	**517**	**659**	**24.33**	**5.74**	**18.32**	**35.43**	**26.79**	**5.87**	**25.49**
B81H	**664**	**508**	**13.26**	**0**	**8.80**	**13.26**	**9.97**	**0.01**	**9.69**
B81J	529.2	500	11.17	0	5.91	6.40		0	8.39
B81J2	38.8	500	11.10	0.06	0.49			0.06	0.67
B81J	**568**	**500**	**11.17**	**0.06**	**6.40**	**11.27**	**12.59**	**0.06**	**9.06**
B82A1	429.6	712	24.39	5.24	15.72			11.10	25.5
B82A2	37.4	712	23.65	0.88	1.76			1.47	2.7
B82A	**467**	**712**	**24.33**	**6.12**	**17.48**	**37.43**	**35.79**	**12.57**	**28.20**
B82B1	365.4	694	23.47	4.29	12.87			9.12	20.35
B82B2	40.6	694	22.77	0.92	1.84			1.56	2.78
B82B	**406**	**694**	**23.40**	**5.21**	**14.71**	**36.23**	**43.29**	**10.68**	**23.13**
B82C1	240	703	23.93	2.87	8.61			5.34	13.12
B82C2	60	703	23.21	1.4	2.80			2.20	4.11
B82C	**300**	**703**	**23.79**	**4.27**	**11.41**	**38.04**	**42.80**	**7.54**	**17.23**
B82D1	600	615	16.38	2.81	12.64			7.26	19.6
B82D2	32	615	16.15	0.3	0.82			0.61	1.25
B82D	**632**	**615**	**16.37**	**3.11**	**13.46**	**21.29**	**22.02**	**7.87**	**20.85**
B82E1	349.8	648	19.04	0.06	6.72			0.34	9.23
B82E2	73.2	648	18.9	0.21	1.59			0.24	2.06
B82E	**423**	**648**	**19.02**	**0.27**	**8.31**	**19.65**	**26.12**	**0.58**	**11.29**
B82F1	609.6	668	18.85	0.14	11.63			0.47	17.33
B82F2	150.4	668	18.71	0.4	3.21			1.07	5.26

B82F	**760**	**668**	**18.82**	**0.54**	**14.84**	**19.53**	**29.59**	**1.54**	**22.59**
B82G	**921**	**524**	**11.67**	**0.05**	**10.80**	**11.72**	**11.96**	**0.06**	**15.21**
B82H	**749**	**516**	**11.37**	**0.03**	**8.55**	**11.41**	**10.78**	**0.04**	**11.71**
B82J	**795**	**540**	**11.66**	**0**	**9.27**	**11.66**	**15.22**	**0.01**	**14.36**
B83A	**1252**	**511**	**9.40**	**0**	**11.77**	**9.40**	**13.88**	**0.01**	**19.63**
B83B	**439**	**563**	**13.00**	**0**	**5.71**	**13.00**	**20.73**	**0.004**	
B83C	**592**	**563**	**13.00**	**0**	**7.70**	**13.00**	**14.01**	**0.006**	**17.42**
B83D	**714**	**548**	**11.03**	**0**	**7.88**	**11.03**	**18.09**	**0**	**10.31**
B83E	**267**	**582**	**11.63**	**0**	**3.11**	**11.63**	**15.52**	**0**	**4.73**
B90A	**692**	**463**	**9.78**	**0**	**6.77**	**9.78**	**10.58**	**0**	**7.21**
B90B	**753**	**468**	**8.82**	**0**	**6.65**	**8.82**	**11.34**	**0**	**12.04**
B90C	**534**	**496**	**9.61**	**0**	**5.13**	**9.61**	**11.76**	**0**	**9.03**
B90D	**446**	**469**	**8.50**	**0**	**3.79**	**8.50**	**10.24**	**0**	**5.87**
B90E	**473**	**464**	**7.92**	**0**	**3.74**	**7.92**	**9.50**	**0**	**5.85**
B90F	**818**	**537**	**10.81**	**0**	**8.84**	**10.81**	**13.90**	**0.01**	**19.11**
B90G	**697**	**533**	**10.27**	**0**	**7.16**	**10.27**	**18.17**	**0**	**15.46**
B90H1	229	536	9.54	0	2.18		17.20	0	4.99
B90H2	546	536	9.41	0	5.14			0	11.84
B90H	**775**	**536**	**9.45**	**0**	**7.32**	**9.45**	**17.20**	**0**	**16.83**
TOTAL Letaba and Shingwedzi								**273.80**	**753.45**
A91A	**232**	**692**	**48.46**	**10.46**	**21.70**	**93.55**	**47.70**	**14.92**	**22.44**
A91B	**275**	**616**	**28.46**	**1.1**	**8.93**	**32.46**	**29.27**	**6.58**	**10.77**
A91C1	107	950	110.48	11.6	23.42		80.35	16.04	22.45
A91C2&F3	175	860	108.50	8.68	27.67			15.76	23.54
A91C&F3	**282**	**894**	**109.25**	**20.28**	**51.09**	**181.17**	**80.35**	**31.8**	**45.99**

A91D1	84.7	1278	133.20	26.1	37.38	`		27.94	40.83
A91D2	47.3	1315	136.80	14.68	21.15			15.55	23.56
A91D	**132**	**1291**	**134.49**	**40.78**	**58.53**	**443.43**	**173.79**	**43.49**	**64.39**
A91E	**223**	**1070**	**64.92**	**27.72**	**42.20**	**189.22**	**117.94**	**36.04**	**69.43**
A91F1	276	860	22.28	0	6.15			4.81	30.27
A91F2	272	667	16.21	0	4.41			1.37	13.58
A91F1&F2	**548**	**764**	**19.27**	**0**	**10.56**	**19.27**	**25.18**	**6.18**	**43.85**
A91G1	48	1943	158.62	11.56	19.17			12.67	49.45
A91G2	358	943	85.66	38.5	69.17			47.61	79.31
A91G	**406**	**1061**	**94.29**	**50.06**	**88.34**	**217.58**	**165.25**	**60.28**	**128.76**
A91H	**450**	**727**	**16.00**	**7.2**	**14.40**	**32.00**	**35.43**	**7.47**	**27.27**
A91J	**570**	**453**	**10.67**	**0.02**	**6.10**	**10.71**	**13.15**	**0.02**	**6.23**
A91K	**669**	**376**	**6.44**	**0**	**4.31**	**6.44**	**6.00**	**0**	**3.24**
A92A1	282	885	39.43	51.86	62.98			53.11	90.52
A92A2	47	885	39.43	8.56	10.41			8.73	15.00
A92A	**329**	**885**	**39.43**	**60.42**	**73.39**	**223.08**	**156.11**	**61.84**	**105.52**
A92B	**565**	**716**	**7.79**	**4.4**	**8.80**	**15.58**	**45.01**	**6.68**	**44.52**
A92C	**455**	**426**	**2.90**	**0**	**1.32**	**2.90**	**14.94**	**0**	**4.64**
A92D	**805**	**303**	**1.27**	**0**	**1.02**	**1.27**	**3.08**	**0.01**	**0.80**
TOTAL Luvuvhu and Mutale								275.31	577.85

Of 467 Mm^3/a of aquifer recharge, 95 Mm^3/a, emerges as groundwater baseflow from the regional aquifer (table 6.15). The remainder of the 549 Mm^3/a of baseflow is generated as interflow in the high lying areas in the west along the Drakensberg, the Drakensberg foothills, and the Soutpansberg. This baseflow represents virgin conditions. Under present day conditions, the interflow component is significantly depleted by afforestation and alien vegetation, while groundwater baseflow is impacted by abstraction.

The difference between aquifer recharge and groundwater baseflow is lost as evapotranspiration from groundwater by riverine vegetation and from areas of shallow groundwater. Theoretically, much of this 372 Mm^3/a could be abstracted without affecting baseflow, however, this will depend on the location of the abstraction relative to water courses, and the transmissivity and storativity of the aquifer. In reality, since evapotranspiration and baseflow occur concurrently, groundwater abstraction impacts on both.

Table 6-15 Baseflow and recharge

Catchment	area	MAP	MAR	Baseflow		GW baseflow				interflow	Evapotrans
	km^2	mm	Mm^3/a	mm	Mm^3/a	mm	Mm^3/a	% of MAR	% recharge	Mm^3/a	Mm^3/a
A91A	232	692	22.44	64.31	14.92	19.22	4.46	19.88	20.55	10.46	6.78
A91B	275	616	10.77	23.93	6.58	19.93	5.48	50.88	61.39	1.1	2.35
A91C	282	894	45.99	112.77	31.80	40.85	11.52	25.05	22.55	20.28	19.29
A91D	132	1291	64.39	329.47	43.49	20.53	2.71	4.21	4.63	40.78	15.04
A91E	223	1070	69.43	161.61	36.04	37.31	8.32	11.98	19.72	27.72	6.16
A91F	548	764	43.85	11.28	6.18	11.28	6.18	14.09	58.52	0	4.38
A91G	406	1061	128.76	148.47	60.28	25.17	10.22	7.94	11.57	50.06	28.06
A91H	450	727	27.27	16.60	7.47	0.60	0.27	0.99	1.88	7.2	6.93
A91J	570	453	6.23	0.04	0.02	0.00	0.00	0.00	0.00	0.02	6.08
A91K	669	376	3.24	0.00	0.00	0.00	0.00	0.00	0.00	0	4.31
A92A	329	885	105.52	187.96	61.84	4.32	1.42	1.35	1.93	60.42	11.55
A92B	565	716	44.52	11.82	6.68	4.04	2.28	5.12	25.91	4.4	2.12
A92C	455	426	4.64	0.00	0.00	0.00	0.00	0.00	0.00	0	1.32
A92D	805	303	0.8	0.00	0.00	0.00	0.00	0.00	0.00	0	1.02
B81A	169.8	1211	75.71	283.10	48.07	44.58	7.57	10.00	14.89	40.5	2.77
B81B	481	1174	134.26	155.82	74.95	2.33	1.12	0.83	1.19	73.83	19.20
B81C	208	870	28.7	106.20	22.09	50.67	10.54	36.72	37.89	11.55	5.73
B81D	477	930	107.85	165.62	79.00	3.33	1.59	1.47	1.76	77.41	11.25
B81E	666	669	30.96	4.16	2.77	0.06	0.04	0.13	0.19	2.73	18.16
B81F	1200	541	23.67	0.05	0.06	0.05	0.06	0.25	0.32	0	18.41
B81G	517	659	25.49	11.35	5.87	0.25	0.13	0.51	0.71	5.74	12.45
B81H	664	508	9.69	0.02	0.01	0.02	0.01	0.10	0.11	0	8.79
B81J	568	500	9.06	0.11	0.06	0.00	0.00	0.00	0.00	0.06	6.34
B82A	467	712	28.2	26.92	12.57	13.81	6.45	22.87	36.89	6.12	4.91
B82B	406	694	23.13	26.31	10.68	13.47	5.47	23.65	37.18	5.21	4.03
B82C	300	703	17.23	25.13	7.54	10.93	3.28	19.04	28.78	4.27	3.86
B82D	632	615	20.85	12.12	7.66	7.36	4.65	22.71	34.82	3.11	5.70
B82E	423	648	11.29	1.13	0.48	0.69	0.29	2.69	3.52	0.27	7.76
B82F	760	668	22.59	2.03	1.54	1.32	1.00	4.43	6.74	0.54	13.30
B82G	921	524	15.21	0.07	0.06	0.01	0.01	0.07	0.09	0.05	10.74
B82H	749	516	11.71	0.05	0.04	0.01	0.01	0.09	0.12	0.03	8.51
B82J	795	540	14.36	0.01	0.01	0.01	0.01	0.07	0.11	0	9.26
B83A	1252	511	19.63	0.01	0.01	0.01	0.01	0.05	0.08	0	11.76
B83B	439	563	7.42	0.00	0.00	0.00	0.00	0.00	0.00	0	5.71
B83C	592	563	10	0.02	0.01	0.02	0.01	0.10	0.13	0	7.69
B83D	714	548	10.31	0.00	0.00	0.00	0.00	0.00	0.00	0	7.88

B83E	267	582	4.73	0.00	0.00	0.00	0.00	0.00	0.00	0	3.11
B90A	692	463	7.21	0.00	0.00	0.00	0.00	0.00	0.00	0	6.77
B90B	753	468	12.04	0.00	0.00	0.00	0.00	0.00	0.00	0	6.64
B90C	534	496	9.03	0.00	0.00	0.00	0.00	0.00	0.00	0	5.13
B90D	446	469	5.87	0.00	0.00	0.00	0.00	0.00	0.00	0	3.79
B90E	473	464	5.85	0.00	0.00	0.00	0.00	0.00	0.00	0	3.75
B90F	818	537	19.11	0.01	0.01	0.01	0.01	0.05	0.11	0	8.83
B90G	697	533	15.46	0.00	0.00	0.00	0.00	0.00	0.00	0	7.16
B90H	775	536	16.83	0.00	0.00	0.00	0.00	0.00	0.00	0	7.32
Total			1331.30		549.00		95.14	7.15		453.86	372.06

6.6.2 Impact under present day abstraction

The naturalised setup of WRSM2000 was run for the period 1920-2010 under current groundwater abstraction conditions to determine the impact of current abstraction on runoff by a reduction in baseflow and the increased potential for transmission losses. This reduction in runoff does not include flow reductions due to afforestation and alien vegetation. The long term abstraction utilised is somewhat less than the present day abstraction, which is considered unsustainable, since it has only been implemented over the recent wet years, and some of the irrigation is opportunistic, occurring only when sufficient water exists.

The long term impacts of present day groundwater abstraction on baseflow are shown in table 6.16. For the Letaba system, a groundwater abstraction of 80 Mm^3/a reduces runoff from 753 Mm^3/a to 727 Mm^3/a, with the most heavily impacted region being the Middle Letaba in catchments B82B and B82C, where runoff has been decreased by nearly 40%. In the Luvuvhu system a groundwater abstraction of 52 Mm^3/a reduces the MAR from 578 Mm^3/a to 538 Mm^3/a, with the upper Luvuvhu, A91A-C being the most heavily impacted with flow reductions of 33-50%.

Base flow depletion is 10% in the Letaba system and 15% in the Luvuvhu.

Table 6-16 MAR under current groundwater abstraction conditions

Catchment	Area	Natural Baseflow	Natural MAR	MAR present abstraction	Abstraction	MAR Reduction	MAR Reduction	Baseflow Reduction
	km^2	Mm^3/a	Mm^3/a	Mm^3/a	Mm^3/a	Mm^3/a	%	%
B81A10	14.1	4.9	9.53	9.53	0	**0.00**	0.00	0.0
B81A01	155.7	43.17	66.17	66.03	0.15	**0.14**	0.22	0.3
B81A	**169.8**	**48.07**	**75.71**	**75.56**	**0.15**	**0.15**	0.19	0.3
B81B10-16	124	17.53	29.44	29.44	0	**0.00**	0.00	0.0
B81B20	62	18.23	33.64	33.64	0	**0.00**	0.00	0.0
B81B01	183	17.56	38.67	37.96	1.91	**0.71**	1.84	4.0
B81B30	89	19.46	27.68	27.26	0.73	**0.42**	1.52	2.2
B81B01A	23	2.17	4.83	4.83	0	**0.00**	0.00	0.0
B81B	**481**	**74.95**	**134.26**	**133.13**	**2.64**	**1.13**	0.84	1.5
B81C	**208**	**22.09**	**28.7**	**26**	**5.47**	**2.70**	9.41	12.2
B81D1	179.7	5.74	20.88	20.46	2.28	**0.42**	2.01	7.3
B81D2	269	67.44	80.63	79.22	1.85	**1.41**	1.75	2.1
B81thabina	28.3	5.82	6.34	6.34	0	**0.00**	0.00	0.0
B81D	**477**	**79**	**107.85**	**106.02**	**4.13**	**1.83**	1.70	2.3
Thapane	41	2.54	4.70	4.70	0.00	**0.00**	0.00	0.0
B81E01&E10	242	0.06	10.13	9.87	5.64	**0.26**	2.57	100.0
B81E01&E10(2)	13	0.02	0.56	0.56	0	**0.00**	0.00	0.0
B81E20&23	148	0.02	6.20	5.92	5.25	**0.28**	4.52	100.0
B81E20&23 (2)	50	0.09	2.16	2.16	0.00	**0.00**	0.00	0.0
B81E25&30	172	0.04	7.21	6.98	4.86	**0.23**	3.26	100.0
B81E	**666**	**2.77**	**30.96**	**30.19**	**15.75**	**0.77**	2.50	28.0
B81F30	186	0.01	3.67	3.67	1.51	**0.00**	0.07	27.5
B81F10&20	430	0.02	8.48	8.36	3.52	**0.12**	1.44	100.0
B81F01	584	0.03	11.52	11.45	2.91	**0.07**	0.61	100.0
B81F	**1200**	**0.06**	**23.67**	**23.48**	**7.94**	**0.19**	0.82	100.0
B81G	437	0.05	13.60	13.44	5.06	**0.16**	1.17	100.0
Modjadji	80	5.82	11.89	11.89	0.00	**0.00**	0.00	0.0
B81G	**517**	**5.87**	**25.49**	**25.33**	**5.06**	**0.16**	0.63	2.7
B81H	**664**	**0.01**	**9.69**	9.64	2.62	**0.05**	0.48	100.0
B81J	529.2	0	8.39	8.39	0	**0.00**	0.00	

B81J2	38.8	0.06	0.67	0.67	0.00	**0.00**	0.00	0.0
B81J	**568**	**0.06**	**9.06**	9.06	0	**0.00**	0.00	0.0
B82A1	429.6	11.10	25.5	23.97	2.93	**1.53**	6.00	13.8
B82A2	37.4	1.47	2.7	2.70	0	**0.00**	0.00	0.0
B82A	**467**	**12.57**	**28.20**	26.67	**2.93**	**1.53**	5.44	12.2
B82B1	365.4	9.12	20.35	12.68	12	**7.67**	37.69	84.1
B82B2	40.6	1.56	2.78	1.44	2.00	**1.34**	48.20	85.9
B82B	**406**	**10.68**	**23.13**	14.12	**14.00**	**9.01**	38.95	84.4
B82C1	240	5.34	13.12	8.2	9	**4.92**	37.50	100.0
B82C2	60	2.20	4.11	2.79	2	**1.32**	32.12	60.0
B82C	**300**	**7.54**	**17.23**	10.99	11	**6.24**	36.22	82.8
B82D1	600	7.26	19.6	17.21	4.52	**2.39**	12.19	32.9
B82D2	32	0.61	1.25	1.25	0	**0.00**	0.00	0.0
B82D	**632**	**7.87**	**20.85**	18.46	4.5	**2.39**	11.46	30.4
B82E1	349.8	0.34	9.23	9.11	1.45	**0.12**	1.30	35.3
B82E2	73.2	0.24	2.06	2.06	0	**0.00**	0.00	0.0
B82E	**423**	**0.58**	**11.29**	11.17	**1.45**	**0.12**	1.06	20.7
B82F1	609.6	0.47	17.33	17.23	1.43	**0.10**	0.58	21.3
B82F2	150.4	1.07	5.26	5.26	0	**0.00**	0.00	0.0
B82F	**760**	**1.54**	**22.59**	22.49	**1.43**	**0.10**	0.44	6.5
B82G	**921**	**0.06**	**15.21**	15.20	0.6	**0.01**	0.05	12.5
B82H	**749**	**0.04**	**11.71**	11.71	0.16	**0.00**	0.00	0.0
B82J	**795**	**0.01**	**14.36**	14.36	0	**0.00**	0.00	8.8
B83A	**1252**	**0.01**	**19.63**	19.63	0	**0.00**	0.00	0.0
B83B	**439**	**0.004**				**0.00**		
B83C	**592**	**0.006**	**17.42**	17.42	0	**0.00**	0.00	
B83D	**714**	**0**	**10.31**	10.31	0	**0.00**	0.00	
B83E	**267**	**0**	**4.73**	4.73	0	**0.00**	0.00	
B90A	**692**	**0**	**7.21**	**7.21**	**0**	**0.00**	0.00	
B90B	**753**	**0**	**12.04**	**12.04**	**0**	**0.00**	0.00	

B90C	**534**	**0**	**9.03**	**9.03**	**0**	**0.00**	0.00	
B90D	**446**	**0**	**5.87**	**5.87**	**0**	**0.00**	0.00	
B90E	**473**	**0**	**5.85**	**5.85**	**0**	**0.00**	0.00	
B90F	**818**	**0.01**	**19.11**	**19.11**	**0**	**0.00**	0.00	
B90G	**697**	**0**	**15.46**	**15.46**	**0**	**0.00**	0.00	
B90H1	229	0	4.99	4.99	0	**0.00**	0.00	
B90H2	546	0	11.84	**11.84**	**0**	**0.00**	0.00	
B90H	**775**	**0**	**16.83**	**16.83**	**0**	**0.00**	0.00	
TOTAL B81-B90		**273.80**	**753.45**	**727.07**	**79.83**	**26.38**	3.50	9.6
A91A	**232**	**14.92**	**22.44**	**14.87**	**10.91**	**7.57**	33.73	50.7
A91B	**275**	**6.58**	**10.77**	**5.21**	**7.96**	**5.56**	51.62	84.5
A91C1	107	16.04	22.45	15.78	7.21	**6.67**	29.71	41.6
A91C2&F3	175	15.76	23.54	**10.98**	**15.5**	**12.56**	53.36	79.7
A91C&F3	**282**	**31.8**	**45.99**	**26.76**	**22.71**	**19.23**	41.81	60.5
A91D1	84.7	27.94	40.83	33.24	9.05	**7.59**	18.59	27.2
A91D2	47.3	15.55	23.56	23.56	0	**0.00**	0.00	0.0
A91D	**132**	**43.49**	**64.39**	**56.8**	**9.05**	**7.59**	11.79	17.5
A91E	**223**	**36.04**	**69.43**	**69.29**	**0.22**	**0.14**	0.20	0.4
A91F1	276	4.81	30.27	30.27	0	**0.00**	0.00	0.0
A91F2	272	1.37	13.58	13.57	0.11	**0.01**	0.07	0.7
A91F1&F2	**548**	**6.18**	**43.85**	**43.84**	**0.11**	**0.01**	0.02	0.2
A91G1	48	12.67	49.45	49.45	0.00	**0.00**	0.00	0.0
A91G2	358	47.61	79.31	79.13	0.35	**0.18**	0.23	0.4
A91G	**406**	**60.28**	**128.76**	**128.58**	**0.35**	**0.18**	0.14	0.3
A91H	**450**	**7.47**	**27.27**	**27.26**	**0.11**	**0.01**	0.04	0.1
A91J	**570**	**0.02**	**6.23**	**6.23**	**0**	**0.00**	0.00	0.0
A91K	**669**	**0**	**3.24**	**3.24**	**0**	**0.00**	0.00	

A92A1	282	53.11	90.52	90.52	0.00	**0.00**	0.00	0.0
A92A2	47	8.73	15.00	15	0.00	**0.00**	0.00	0.0
A92A	**329**	**61.84**	**105.52**	**105.52**	**0.00**	**0.00**	0.00	0.0
A92B	**565**	**6.68**	**44.52**	**44.52**	**0**	**0.00**	0.00	0.0
A92C	**455**	**0**	**4.64**	**4.6**	**0.7**	**0.04**	0.86	
A92D	**805**	**0.01**	**0.80**	**0.8**	**0**	**0.00**	0.00	0.0
TOTAL A91+A92		275.31	577.85	537.52	52.12	40.33	6.98	14.6

7 RECONCILIATION OF DEMAND AND GROUNDWATER AVAILABILITY

7.1 CLASSIFICATION OF GROUNDWATER STATUS

This chapter identifies localities catchments and water supply schemes where groundwater is underutilised or heavily stressed.

To calculate the available groundwater resources, the standard DWA methodology (Parsons & Wentzel, 2007) was adopted to determine the stress index (groundwater use/ recharge), and a present status allocated according to the stress index.

According to the DWA methodology, to determine the class of a water resource, reference conditions must be identified and present status assessed (PES). Assigned to each unit is a single PES, comprising classification according to sustainable use, level(s). The level of stress is based on the volume of groundwater abstracted compared to the volume recharged (stress index).

Once the single PES has been assigned to each resource unit, then the groundwater resource category can be determined (Table 7.1).

Table 7-1 Terminology and classes used during the classification process.

Category	Present Status Category (PES)	Stress Index (Use/recharge)	Water Resource Category
A	Unmodified natural	<0.05	Natural
B	Largely natural	0.05-0.2	Good
C	Moderately modified	0.2-0.4	Fair
D	Largely modified	0.4-0.65	Poor
E	Seriously modified	0.65-0.95	
F	Critically modified	0.95	

A fundamental flaw with this approach is that the use of recharge to calculate stress on groundwater resources ignores the fact that large part of recharge never enters the regional aquifers and is discharged as interflow from high lying regions, following rain events, or from saturated areas. Consequently, it is proposed that the stress index rather be calculated as the ratio of use to aquifer recharge.

7.2 RECONCILIATION BY QUATERNARY CATCHMENT

Section 5.1 showed that estimates of groundwater use for water supply is close to 16 Mm^3/a for water supply and 141 Mm^3/a for irrigation. If water use for industry, livestock, and Schedule 1 water use is added from WARMS, total use is 157.94 Mm^3/a. Section 5.4 showed that the existing rural water supply infrastructure can deliver 32.7 Mm^3/a, however, the capacity of the existing boreholes is 66.5 Mm^3/a, if the available boreholes were equipped and hand pumps were converted to motorised systems. This is significantly more than the existing demand.

Table 6.12 shows that only 50% of recharge reaches the regional aquifers and is accessible to groundwater users. Consequently, the stress index of groundwater use was assessed relative to aquifer recharge (table 7.2). Stressed catchments where use is greater than 65% of aquifer recharge include:

- the upper Luvuvhu in the vicinity of Albisini dam (A91A-C),
- the lower Groot Letaba in the vicinity of the proposed Nwamitwa dam (B811E-F),
- the Koedoes and Brandboontjies catchments, parts of the Middle Letaba system (B82B-C) (Figure7.1).

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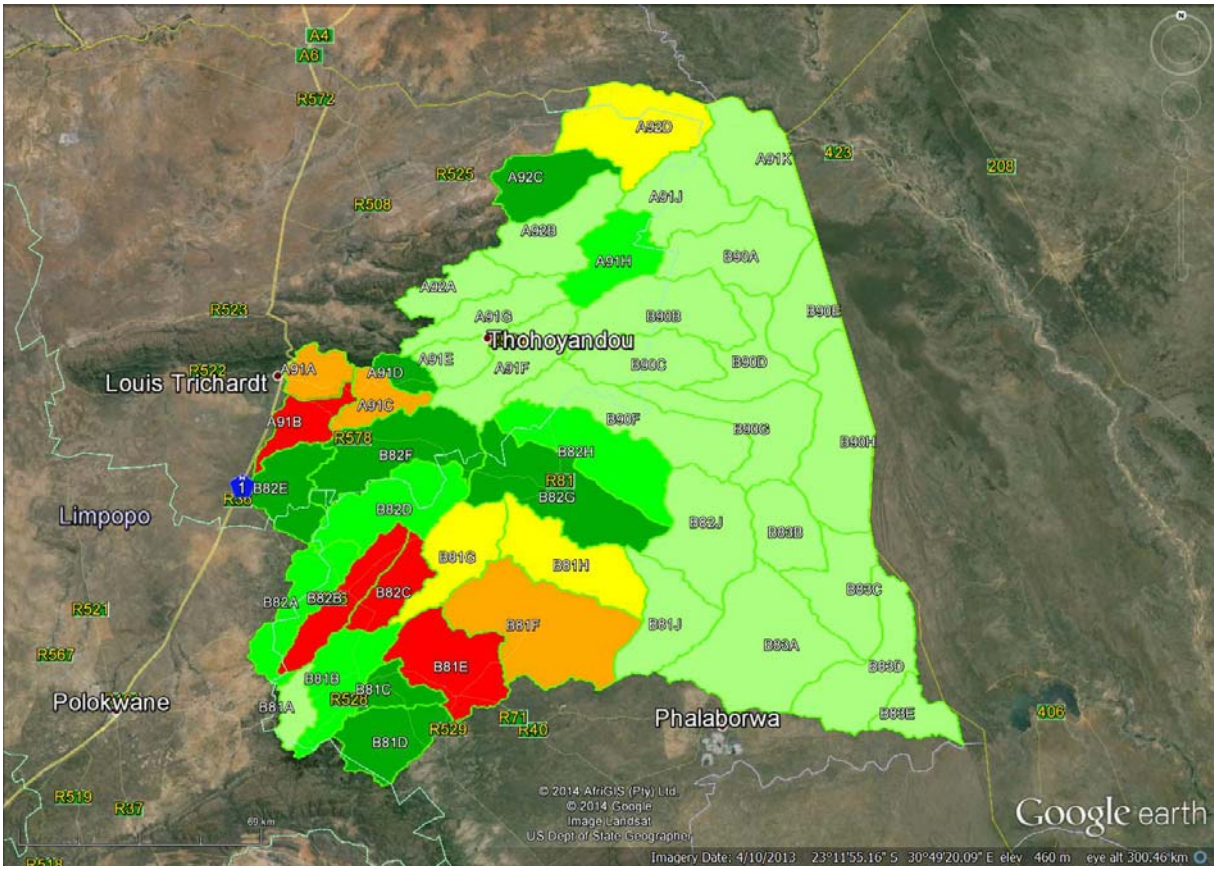

Use/aquifer recharge

- >0.95
- 0.65-0.95
- 0.4-0.65
- 0.2-0.4
- 0.05-0.2
- <0.05

Figure 7-1 Stress index of Quaternary catchments

Groundwater use was also classified according to Harvest and Exploitation Potential to determine the degree to which the groundwater resources are utilised (table 7.2). If:

- Use < 66% of Exploitation Potential = Under utilised
- Use > than 66% of EP and < 66% of Harvest Potential = Moderately utilised
- Use 66%-100% of HP = Significantly utilised
- Use > HP and < Aquifer recharge = heavily utilised
- Use > Aquifer recharge = Over utilised

Table 7-2 Groundwater use and classification

(red)	> 95% of aquifer recharge or recharge
(orange)	>65% of aquifer recharge or recharge
(yellow)	>40% of aquifer recharge or recharge
(dark green)	>20% of aquifer recharge or recharge
(green)	>5% of aquifer recharge or recharge
(light green)	<05% of aquifer recharge or recharge

Catchment	Total Use Mm^3/a	% aquifer recharge	Present Status	Catchment classification	Available groundwater Mm^3/a		
					Harvest Pot	Exploitation Pot	Aquifer recharge
A91A	9.16	81.47	E	Heavily utilised	0.00	0.00	2.08
A91B	8.22	105.03	F	Over utilised	0.00	0.00	0.00
A91C&F3	29.21	94.81	E	Heavily utilised	0.00	0.00	1.60
A91D	6.96	39.21	C	Heavily utilised	0.00	0.00	10.79
A91E	0.17	1.17	A	Underutilised	2.76	1.88	14.31
A91F1&F2	0.27	2.56	A	Underutilised	7.89	4.63	10.29
A91G	0.38	1.01	A	Underutilised	3.03	2.01	37.07
A91H	0.52	7.22	B	Underutilised	3.30	2.15	6.68
A91J	0.04	0.66	A	Underutilised	4.05	2.41	6.04
A91K	0.00	0.00	A	Underutilised	6.93	4.85	4.31
A92A	0.20	1.54	A	Underutilised	2.56	1.73	12.77
A92B	0.17	3.86	A	Underutilised	4.50	3.10	4.23
A92C	0.36	27.28	C	Underutilised	2.62	1.73	0.96
A92D	0.56	54.78	D	Underutilised	2.66	1.70	0.46
B81A	0.15	1.45	A	Underutilised	2.57	1.21	10.19
B81B	2.65	13.04	B	Underutilised	5.07	2.75	17.67

B81C	5.49	33.75	C	Heavily utilised	0.00	0.00	10.78
B81D	4.13	32.16	C	Moderately utilised	3.64	1.31	8.71
B81E	23.01	126.42	F	Over utilised	0.00	0.00	0.00
B81F	13.20	71.47	E	Significantly utilised	1.20	0.00	5.27
B81G	5.56	44.20	D	Significantly utilised	1.22	0.00	7.02
B81H	3.82	43.39	D	Moderately utilised	4.15	1.76	4.98
B81J	0.12	1.89	A	Underutilised	6.34	4.40	6.22
B82A	1.67	14.70	B	Underutilised	5.70	2.75	9.69
B82B	20.69	217.78	F	Over utilised	0.00	0.00	0.00
B82C	11.01	154.27	F	Over utilised	0.00	0.00	0.00
B82D	1.80	17.40	B	Underutilised	8.31	5.28	8.55
B82E	1.71	21.25	C	Underutilised	4.70	2.78	6.34
B82F	3.16	22.09	C	Underutilised	8.89	5.28	11.14
B82G	2.28	21.21	C	Underutilised	8.74	5.44	8.47
B82H	0.62	7.28	B	Underutilised	7.85	5.31	7.90
B82J	0.13	1.40	A	Underutilised	6.29	4.36	9.14
B83A	0.00	0.00	A	Underutilised	12.08	8.46	11.77
B83B	0.00	0.00	A	Underutilised	3.51	2.46	5.71
B83C	0.00	0.00	A	Underutilised	4.74	3.32	7.70
B83D	0.00	0.00	A	Underutilised	6.64	4.65	7.88
B83E	0.00	0.00	A	Underutilised	2.48	1.49	3.11
B90A	0.00	0.00	A	Underutilised	5.51	3.31	6.77
B90B	0.06	0.90	A	Underutilised	7.44	5.19	6.58
B90C	0.07	1.36	A	Underutilised	5.57	3.88	5.06
B90D	0.00	0.00	A	Underutilised	3.49	2.44	3.79
B90E	0.00	0.00	A	Underutilised	3.78	1.89	3.75
B90F	0.36	4.07	A	Underutilised	8.08	5.55	8.48
B90G	0.03	0.42	A	Underutilised	5.72	4.00	7.13

B90H	0.00	0.00	A	Underutilised	6.20	4.34	7.32
TOTAL	157.94				190.20	119.75	328.69

7.3 RECONCILIATION BY SCHEME

The existing water supply schemes were categorised according to the stress index (current groundwater use/ aquifer recharge). Where schemes overlap 2 or more quaternary catchments, recharge was area weighted according to recharge in each Quaternary. The classification is shown in table 7.3.

Table 7-3 Water supply schemes and level of stress

Red	> 95% of aquifer recharge
Orange	>65% of aquifer recharge
Yellow	>40% of aquifer recharge
Dark green	>20% of aquifer recharge
Green	>5% of aquifer recharge
Light green	<05% of aquifer recharge

Scheme	Aquifer Recharge	Groundwater Use	Stress Index
	Mm^3/a	Mm^3/a	
Badimong RWS	1.53		0.00
Ba-Phalaborwa Individual Supply	0.13	0.004	0.03
Damani RWS	18.01	0.35	0.02
Giyani System A/B	12.30	0.51	0.04
Giyani System C/D	6.16	1.97	0.32
Giyani System D : South West	1.87	0.61	0.33
Giyani System F1	2.86	0.23	0.08
Giyani System F2	2.22	0.28	0.13
Greater Giyani LM Farms Supply	0.12	0.076	0.62
Greater Letaba LM Farms Supply	0.44	0.38	0.87
Greater Tzaneen LM Farms Supply	0.50		0.00
Lambani RWS	1.20	0	0.00
Letaba Individual Supply	0.09	0.004	0.05
Levubu CBD	0.83	0.08	0.10
Lower Molototsi	3.46	0	0.00
Luphephe / Nwandedzi North	0.78	0.25	0.32
Luphephe / Nwanedzi Main RWS	2.55	0.55	0.22
Makhado RWS	7.12	1.2	0.17
Malamulele West RWS	4.75	0.21	0.04
Mapuve / System N RWS	2.21	0.17	0.08
Masisi RWS	0.63	0.5	0.79
Matshavhawe / Kunda RWS	0.90		0.00
Middle Letaba RWS : Malamulele West	1.46	0.11	0.08
Elim / Vleifontein RWS	5.46	0.48	0.09

Middle Letaba RWS : Babangu	6.38	0.51	0.08
Middle Letaba RWS : Bolobedu NW	4.78	0.44	0.09
Middle Letaba RWS : Magoro	5.73	1.05	0.18
Middle Letaba RWS : Majosi	6.20	0.88	0.14
Middle Letaba RWS : Vyeboom Masia	2.72	0.4	0.15
Modjadji RWS	3.16	0	0.00
Mutale LM Farms Supply	0.06	0.02	0.35
Mutale Main RWS	12.43	0.7	0.06
Mutale Mukuya RWS	1.71	0.11	0.06
Namakgale / Lulekani RWS	0.94		0.00
North Malamulele East RWS	3.73	0.16	0.04
Nthabiseng GWS	0.30		0.00
Nzhelele RWS	8.01		0.00
Ritavi / Letaba RWS	8.00	0.26	0.03
Ritavi II RWS	7.45	0.75	0.10
Sebayeng-Dikgale RWS	2.53		0.00
Sekgopo Local GWS	0.90	0.19	0.21
Sekgosese Individual Groundwater Scheme	2.04	0.23	0.11
Siluwane - Nondweni Extended RWS	2.17	0	0.00
South Malamulele East RWS	6.54	0.11	0.02
Thabina RWS	2.62	2.25	0.86
Thapane RWS	2.67	0.3	0.11
Thulamela LM Farms Supply	0.04	0.08	1.93
Tours RWS	5.93		0.00
Tshakhuma RWS	5.86	0.17	0.03
Tshifire Murunwa RWS	2.94		0.00
Tshifudi RWS	4.14	0.27	0.07
Tshikondeni Mine	0.05	0.055	1.12
Tshitale RWS	5.97	0.44	0.07
Tzaneen / Modjadjiskloof	7.31	0	0.00
Tzaneen Individual Supply	1.35	0	0.00
Valdezia RWS	10.94	0.313	0.03
Vondo Central RWS	31.33	0.23	0.01
Vondo East TWS	4.47		0.00
Vondo North Rural RWS	5.35		0.00
Vondo South RWS	2.64		0.00
Worcester / Mothobeki RWS	3.74	0	0.00
Grand Total	**260.69**	**17.88**	

The schemes that are stressing water resources within the supply area include:

- Greater Letaba LM farms supply
- Masisi RWS
- Thabina RWS
- Thulamela LM farms supply
- Tshikondeni Mine

To determine level of stress within the catchments occupied by water supply schemes, total use was utilised relative to aquifer recharge (table 7-4). The following schemes are located in stressed catchments:

- Ba-Phalaborwa
- Elim Vleifontein RWS
- Giyani system D: southwest
- Greater Giyani LM Farms Supply
- Greater Letaba LM Farms Supply
- Letaba Individual Supply
- Ritavi / Letaba RWS
- Makhado RWS
- Thapane RWS
- Valdezia RWS

Table 7-4 Level of stress in catchments occupied by rural water schemes

Scheme	Area Km^2	Scheme	Area Km^2	Scheme	Area Km^2	Scheme	Area Km^2
Badimong RWS	104	**Luphephe / Nwanedzi Main RWS**	483	**Mutale Mukuya RWS**	172	**Tshakhuma RWS**	57
B82A	1	A92B	53	A91H	47	A91D	32
Ba-Phalaborwa Individual Supply	8	A92C	295	A91J	22	A91E	23
B81F	8	**Makhado RWS**	188	A92B	90	A91F	1
Damani RWS	399	A91A	127	A92C	0	**Tshifire Murunwa RWS**	80
A91G	146	A91B	9	A92D	13	A91A	0
A91H	23	A91C	0	**Namakgale / Lulekani RWS**	262	A91D	7
A92A	75	**Malamulele West RWS**	284	B83A	0	A91G	0
A92B	154	A91F	198	**North Malamulele East RWS**	334	**Tshifudi RWS**	143
Elim / Vleifontein RWS	123	B82H	16	A91F	0	A91F	0
A91B	74	B90F	70	A91H	105	A91G	24
A91C	27	**Mapuve / System N RWS**	191	B90A	30	A91H	119
B82E	17	B82G	137	B90B	198	A92B	0
B82F	5	B82H	54	**Nthabiseng GWS**	32	**Tshikondeni Mine**	7
Giyani System A/B	1066	**Masisi RWS**	450	B82A	2	A91J	4
B81F	0	A92C	37	**Nzhelele RWS**	397	A92D	3
B81H	51	A92D	413	A91G	0	**Tshitale RWS**	316
B81J	263	**Matshavhawe / Kunda RWS**	40	A92A	14	B82D	2
B82G	192	A91A	1	**Ritavi / Letaba RWS**	445	B82E	151
B82H	314	**Middle Letaba RWS : Babangu**	437	B81E	96	B82F	163
B82J	247	B81G	27	B81F	348	**Tzaneen / Modjadjiskloof**	135
B83A	0	B81H	41	B81G	1	B81B	76
B90F	1	B82B	0	B81H	1	B81C	50
Giyani System C/D	504	B82C	0	**Ritavi II RWS**	238	B81E	3
B81H	174	B82D	137	B81C	23	B82C	6
B82G	330	B82F	31	B81D	127	**Tzaneen Individual Supply**	24

B82H	0	B82G	202	B81E	21	B81A	22
Giyani System D : South West	131	**Middle Letaba RWS : Bolobedu NW**	204	**Sebayeng-Dikgale RWS**	243	B81B	1
B81F	63	B81G	182	B82A	3	**Valdezia RWS**	107
B81H	68	B82C	2	**Sekgopo Local GWS**	37	A91B	9
Giyani System F1	256	B82D	14	B82A	37	A91C	98
B82G	3	B82G	6	B82B	0	B82F	0
B82H	146	**Middle Letaba RWS : Magoro**	339	**Sekgosese Individual Groundwater Scheme**	124	**Vondo Central RWS**	499
B90F	107	B82D	269	B82A	0	A91E	190
Giyani System F2	198	B82F	71	B82D	124	A91F	130
B82H	127	**Middle Letaba RWS : Majosi**	329	B82E	0	A91G	179
B90F	72	A91B	0	**Siluwane - Nondweni Extended RWS**	159	A92A	0
Greater Giyani LM Farms Supply	8	B82D	0	B81F	59	**Vondo East TWS**	115
B81F	8	B82E	8	B81H	70	A91F	85
Greater Letaba LM Farms Supply	19	B82F	321	B81J	29	A91G	31
B82B	19	**Middle Letaba RWS : Malamulele West**	131	**South Malamulele East RWS**	605	A91H	0
Greater Tzaneen LM Farms Supply	21	B82H	73	A91F	72	**Vondo North Rural RWS**	120
B82A	21	B90F	59	A91H	0	A91G	12
Lambani RWS	75	**Middle Letaba RWS : Vyeboom Masia**	145	B90B	158	A92A	107
A91H	75	A91C	0	B90C	245	**Vondo South RWS**	163
Letaba Individual Supply	4	A91F	5	B90F	115	A91F	78
B82B	4	B82F	140	B90G	15	B82F	22
Levubu CBD	7	**Modjadji RWS**	130	**Thabina RWS**	97	B82G	48
A91C	5	B81E	3	B81D	97	B82H	14
A91D	2	B81F	1	**Thapane RWS**	116	**Worcester / Mothobeki RWS**	158
Lower Molototsi	251	B81G	109	B81E	70	B81F	0
B81F	0	B82C	17	B81F	41	B81G	149

B81G	13	**Mutale LM Farms Supply**	5	B81G	5	B81H	8
B81H	236	A91J	5	**Thulamela LM Farms Supply**	3		
B82G	3	**Mutale Main RWS**	760	A91H	3		
Luphephe / Nwandedzi North	267	A92A	132	**Tours RWS**	216		
A92C	57	A92B	268	B81D	22		
A92D	32	A92C	41				

7.4 GROUNDWATER POTENTIAL PER SCHEME

An analysis was undertaken to determine which water supply schemes could feasibly be supplied with additional groundwater. This was undertaken by evaluating:

- Population (table 5.4) and projected water demand at 100 l/c/d
- The area of the scheme to determine aquifer recharge and harvest potential (table 6.12)
- Existing borehole capacity (table 5.6)
- Proportion of boreholes with potable water (Class 0, 1 and 2) (table 6.11).
- Proportion of boreholes yielding > 2 l/s per second as an indicator of the feasibility of drilling boreholes that could be equipped with motorised systems (table 6.3)

It was assumed that per capita demands would grow at 2% per annum and that present demand met by surface water sources would remain constant, so that additional demands would be met from groundwater.

Table 7.5 presents the analysis undertaken with regards to aquifer recharge, and table 7.6 with regards to harvest potential.

Table 7.7 is a summary for each water supply scheme listing the limitations to meeting water demands from groundwater.

Table 7-5 Domestic water demand with regards to aquifer recharge, water quality and existing borehole capacity

Water Demand	Water Quality	Yield > 2/s
> 95% of aquifer recharge	>80% of boreholes	>75%
>65% of aquifer recharge	60-80% of boreholes	50-75%
>40% of aquifer recharge	<60% of boreholes	25-50%
>20% of aquifer recharge		<25%, geometric mean less than 1 l/s
>5% of aquifer recharge		
<05% of aquifer recharge		

scheme	Median Yield	B'holes >2 l/s	Area	Aquifer recharge	Existing BH capacity	Use		Use	Groundwater demand Mm^3/a							Potable TDS	Potable Nitrate
	l/s	%	km2	Mm3/a	Mm3/a	Surface	G'water	l/c/d	2010	2015	2020	2025	2030	2035	2040	%	%
SILUWANE - NONDWENI EXTENDED RWS	1.55	41.38	158.68	2.17	1.41	0.36	0	51	0.00	0.04	0.07	0.10	0.13	0.16	0.20	98	83
BA-PHALABORWA INDIVIDUAL SUPPLY	1.25		8.18	0.13		0	0.004	731	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50	100
DAMANI RWS	2	31.82	398.65	18.01	1.79	1.85	0.35	89	0.35	0.56	0.72	0.89	1.07	1.24	1.43	100	100
ELIM/VLEIFONTEIN RWS	3.9	67.39	122.97	5.46	2.96	2.34	0.48	145	0.48	0.79	1.04	1.30	1.57	1.85	2.14	100	96
GIYANI SYSTEM A/B	1.6	47.30	1066.29	12.30	1.62	1.88	0.51	126	0.51	0.75	0.94	1.14	1.35	1.55	1.77	96	71
GIYANI SYSTEM D: SOUTH WEST	1.5	42.31	131.15	1.87	1.60	0.61	0.61	126	0.61	0.73	0.82	0.92	1.02	1.12	1.23	97	58
GIYANI SYSTEM F1	1.19	36.00	256.31	2.86	0.65	0.68	0.23	106	0.23	0.32	0.39	0.47	0.54	0.62	0.70	80	47
GIYANI SYSTEM F2	1.875	46.67	198.38	2.22	1.02	0.14	0.28	95	0.28	0.32	0.35	0.38	0.41	0.45	0.48	100	65
GIYNAI SYSTEM C/D	2.59	61.60	503.85	6.16	5.29	7.36	1.97	306	1.97	3.01	3.87	4.77	5.69	6.64	7.66	88	77
GREATER GIYANI LM FARMS SUPPLY	1.25		7.91	0.12			0.076	85	0.08	0.08	0.09	0.09	0.10	0.10	0.11		
GREATER LETABA LM FARMS SUPPLY	0.7		18.70	0.44			0.38	83	0.38	0.42	0.44	0.47	0.50	0.53	0.56		
GREATER TZANEEN LM FARMS SUPPLY	0.8		20.74	0.50		1.05		84	0.00	0.10	0.18	0.27	0.35	0.44	0.53		

LAMBANI RWS	1.2	33.33	75.19	1.20	0.15	0.21		86	0.00	0.03	0.06	0.09	0.12	0.14	0.18	100	100
LETABA INDIVIDUAL SUPPLY	0.7		3.79	0.09			0.004	97	0.00	0.00	0.00	0.01	0.01	0.01	0.01		
LEVUBU CBD	3.5	100.00	7.19	0.83			0.08	344	0.08	0.09	0.11	0.12	0.14	0.16	0.17		
LOWER MOLOTOTSI	4.025	60.00	250.96	3.46	1.00	0.45		67	0.00	0.04	0.08	0.11	0.15	0.18	0.22	91	56
LUPHEPHE/NWANEDZI MAIN RWS	1.05	40.00	482.59	2.55	2.64		0.55	78	0.55	0.60	0.65	0.69	0.74	0.78	0.83	90	94
LUPHEPHE/NWANEDZI NORTH	1.4	35.00	267.23	0.78	1.66		0.25		0.25	0.00	0.00	0.00	0.00	0.00	0.00	92	50
MAKHADO RWS	2	48.54	187.78	7.12	0.37	2.4	1.2	657	1.20	1.48	1.68	1.88	2.09	2.30	2.52		
MALAMULELE WEST RWS	1.39	36.17	283.94	4.75	1.20	0.82	0.21	56	0.21	0.31	0.38	0.46	0.54	0.62	0.70	100	62
MAPUVE/SYSTEM N RWS	1.5	38.10	190.76	2.21	0.55	0.25	0.17	67	0.17	0.21	0.24	0.27	0.30	0.34	0.37	100	38
MASISI RWS	2.53	55.26	450.20	0.63	2.66		0.5	108	0.50	0.55	0.59	0.63	0.67	0.71	0.75	87	80
MATSHAVHAVE/KUNDA RWS	1.29	33.33	39.91	0.90	0.10				0.00	0.00	0.00	0.00	0.00	0.00	0.00		
MIDDLE LETABA RWS: BABANGU	1.5	41.38	437.42	6.38	1.75	1.05	0.51	76	0.51	0.66	0.79	0.91	1.04	1.17	1.31	100	51
MIDDLE LETABA RWS: MAGORO	2.035	50.00	339.27	5.73	2.98	0.66	1.05	65	1.05	1.22	1.36	1.50	1.65	1.80	1.96	100	56
MIDDLE LETABA RWS: MAJOSI	1.13	34.88	329.19	6.20	3.59	1.09	0.88	64	0.88	1.08	1.24	1.41	1.59	1.76	1.95	100	78
MIDDLE LETABA RWS: VYEBOOM MASIA	3	66.67	144.67	2.72	1.72	0.29	0.4	63	0.40	0.48	0.55	0.61	0.68	0.75	0.83	90	55
MIDDLE LETABA: BOLOBEDU NW	1.76	39.02	204.08	4.78	1.82	0.55	0.44	68	0.44	0.54	0.63	0.72	0.81	0.90	1.00	100	88
MIDDLE LETABA RWS: MALAMULELE WEST	1.35	41.67	131.47	1.46	0.61	0.21	0.11	59	0.11	0.14	0.16	0.19	0.21	0.24	0.26	98	63
MODJADJI RWS	1	28.86	130.04	3.16	1.01	1.84		62	0.00	0.18	0.33	0.49	0.64	0.80	0.97	99	93
MUTALE LM FARMS SUPPLY	0.98		5.39	0.06			0.02	145	0.02	0.02	0.02	0.02	0.03	0.03	0.03		
MUTALE MAIN RWS	1.415	38.89	760.47	12.43	1.18	1.5	0.7	100	0.70	0.91	1.08	1.25	1.43	1.61	1.80	100	100
MUTALE MUKUYA RWS	1.785	43.75	171.68	1.71	0.77	0.18	0.11	92	0.11	0.14	0.16	0.18	0.20	0.23	0.25	100	100
NORTH MALAMULELE EAST RWS	1.67	44.19	333.57	3.73	1.49	2.9	0.16	118	0.16	0.44	0.65	0.87	1.09	1.32	1.56	100	62
NZHELELE RWS	1.26	42.10	397.16	8.01	1.56				0.00	0.00	0.00	0.00	0.00	0.00	0.00	100	100
RITAVI II RWS	1.84	40.00	238.04	7.45	2.21	8.56	0.75	228	0.75	1.81	2.70	3.61	4.56	5.54	6.59	100	100

RITAVI/LETABA RWS	1.425	36.36	445.19	8.00	2.43	2.25	0.26	70	0.26	0.50	0.69	0.89	1.09	1.30	2.44	97	67
SEKGOPO LOCAL GWS	0.67	11.76	36.95	0.90	0.97		0.19	25	0.19	0.21	0.22	0.24	0.25	0.27	0.28	100	100
SEKGOSESE INDIVIDUAL GROUNDWATER SCHEME	2.25	50.00	124.31	2.04	2.28		0.23	31	0.23	0.25	0.27	0.29	0.31	0.33	0.35	100	88
SOUTH MALAMULELE EAST RWS	2	47.37	605.37	6.54	2.01	3.5	0.11	94	0.11	0.46	0.74	1.03	1.33	1.63	1.95	100	53
THABINA RWS	2.655	60.34	97.20	2.62	2.81	1.93	2.25	199	2.25	2.69	3.05	3.42	3.80	4.19	4.60		
THAPANE RWS	0.7	15.09	116.12	2.67	0.42	1.32	0.3	78	0.30	0.47	0.61	0.75	0.89	1.04	1.20	100	95
THULAMELA LM FARMS SUPPLY	1.46		2.60	0.04			0.08	93	0.08	0.09	0.09	0.09	0.10	0.10	0.11		
TOURS RWS	2.5	57.41	215.92	5.93					0.00	0.00	0.00	0.00	0.00	0.00	0.00		
TSHAKUMA RWS	2.25	50.00	56.73	5.86	0.51	1.41	0.17	117	0.17	0.33	0.45	0.58	0.71	0.85	0.99	100	100
TSHIFIRE MURUNWA RWS	11.25	100.00	79.70	2.94	0.15				0.00	0.00	0.00	0.00	0.00	0.00	0.00	100	100
TSHIFUDI RWS	1.67	44.00	143.40	4.14	0.52	0.86	0.27	97	0.27	0.38	0.48	0.57	0.67	0.77	0.88	100	100
TSHIKONDENI MINE	2.5		7.47	0.05		0.495	0.055	2943	0.06	0.08	0.09	0.10	0.11	0.12	0.14		
TSHITALE RWS	1	27.40	315.75	5.97	0.94	0.39	0.44	72	0.44	0.52	0.58	0.65	0.71	0.78	0.85	100	86
TZANEEN/HAERNETSBURG INDIVIDUAL SUPPLY	1.03	0.00	24.20	1.35		0.584		990	0.00	0.05	0.08	0.12	0.15	0.19	0.23		
TZANEEN/MODJADJISKLOOF	1.7	42.86	134.71	7.31	0.14	2.946		625	0.00	0.30	0.53	0.78	1.04	1.30	1.58	100	100
VALDEZIA RWS	1.26	20.00	106.88	10.94	1.25		0.313	78	0.31	0.34	0.37	0.40	0.42	0.45	0.48	100	100
VONDO CENTRAL RWS	1.01	37.25	498.85	31.33	2.67											100	95
VONDO EAST RWS	1.6	36.36	115.31	4.47	0.74											100	91
VONDO NORTH RURAL RWS	2	40.00	119.55	5.35	0.01											100	100
VONDO SOUTH RWS	0.265	0.00	162.56	2.64	0.96	15.73	0.23	145	0.23	2.00	3.47	4.99	6.55	8.16	9.88	100	74
WORCESTER/MOTHOBEKI RWS	2.83	55.56	157.53	3.74	1.86	0.594		63	0.00	0.05	0.09	0.13	0.17	0.22	0.26	92	57
TOTAL			12320.14	255.38	66.15	71.239	17.882	123	17.88	26.79	34.22	41.88	49.73	57.78	67.30		

Table 7-6 Domestic water demand with regards to harvest potential, water quality and existing borehole capacity

Water Demand	Water Quality	Yield > 2/s
> 95% of aquifer recharge	>80% of boreholes	>75%
>65% of aquifer recharge	60-80% of boreholes	50-75%
>40% of aquifer recharge	<60% of boreholes	25-50%
>20% of aquifer recharge		<25%, geometric mean less than 1 l/s
>5% of aquifer recharge		
<05% of aquifer recharge		

scheme	Median Yield	B'holes >2 l/s	Area	Harvest Potential	Existing BH capacity	Use		Use	Groundwater demand Mm^3/a							Potable TDS	Potable Nitrate
	l/s	%	km2	Mm3/a	Mm3/a	Surface	G'water	l/c/d	2010	2015	2020	2025	2030	2035	2040	%	%
SILUWANE - NONDWENI EXTENDED RWS	1.55	41.38	158.68	1.89	1.41	0.36	0	51	0.00	0.04	0.07	0.10	0.13	0.16	0.20	98	83
BA-PHALABORWA INDIVIDUAL SUPPLY	1.25		8.18	0.10		0	0.004	731	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50	100
DAMANI RWS	2	31.82	398.65	3.33	1.79	1.85	0.35	89	0.35	0.56	0.72	0.89	1.07	1.24	1.43	100	100
ELIM/VLEIFONTEIN RWS	3.9	67.39	122.97	1.93	2.96	2.34	0.48	145	0.48	0.79	1.04	1.30	1.57	1.85	2.14	100	96
GIYANI SYSTEM A/B	1.6	47.30	1066.29	11.44	1.62	1.88	0.51	126	0.51	0.75	0.94	1.14	1.35	1.55	1.77	96	71
GIYANI SYSTEM D: SOUTH WEST	1.5	42.31	131.15	1.57	1.60	0.61	0.61	126	0.61	0.73	0.82	0.92	1.02	1.12	1.23	97	58
GIYANI SYSTEM F1	1.19	36.00	256.31	2.80	0.65	0.68	0.23	106	0.23	0.32	0.39	0.47	0.54	0.62	0.70	80	47
GIYANI SYSTEM F2	1.875	46.67	198.38	2.17	1.02	0.14	0.28	95	0.28	0.32	0.35	0.38	0.41	0.45	0.48	100	65
GIYNAI SYSTEM C/D	2.59	61.60	503.85	6.04	5.29	7.36	1.97	306	1.97	3.01	3.87	4.77	5.69	6.64	7.66	88	77
GREATER GIYANI LM FARMS SUPPLY	1.25		7.91	0.09			0.076	85	0.08	0.08	0.09	0.09	0.10	0.10	0.11		
GREATER LETABA LM FARMS SUPPLY	0.7		18.70	0.30			0.38	83	0.38	0.42	0.44	0.47	0.50	0.53	0.56		
GREATER TZANEEN LM FARMS SUPPLY	0.8		20.74	0.33		1.05		84	0.00	0.10	0.18	0.27	0.35	0.44	0.53		

LAMBANI RWS	1.2	33.33	75.19	0.64	0.15	0.21		86	0.00	0.03	0.06	0.09	0.12	0.14	0.18	100	100
LETABA INDIVIDUAL SUPPLY	0.7		3.79	0.06			0.004	97	0.00	0.00	0.00	0.01	0.01	0.01	0.01		
LEVUBU CBD	3.5	100.00	7.19	0.11			0.08	344	0.08	0.09	0.11	0.12	0.14	0.16	0.17		
LOWER MOLOTOTSI	4.025	60.00	250.96	3.03	1.00	0.45		67	0.00	0.04	0.08	0.11	0.15	0.18	0.22	91	56
LUPHEPHE/NWANEDZI MAIN RWS	1.05	40.00	482.59	3.07	2.64		0.55	78	0.55	0.60	0.65	0.69	0.74	0.78	0.83	90	94
LUPHEPHE/NWANEDZI NORTH	1.4	35.00	267.23	1.18	1.66		0.25		0.25	0.00	0.00	0.00	0.00	0.00	0.00	92	50
MAKHADO RWS	2	48.54	187.78	2.22	0.37	2.4	1.2	657	1.20	1.48	1.68	1.88	2.09	2.30	2.52		
MALAMULELE WEST RWS	1.39	36.17	283.94	3.85	1.20	0.82	0.21	56	0.21	0.31	0.38	0.46	0.54	0.62	0.70	100	62
MAPUVE/SYSTEM N RWS	1.5	38.10	190.76	2.25	0.55	0.25	0.17	67	0.17	0.21	0.24	0.27	0.30	0.34	0.37	100	38
MASISI RWS	2.53	55.26	450.20	1.90	2.66		0.5	108	0.50	0.55	0.59	0.63	0.67	0.71	0.75	87	80
MATSHAVHAVE/KUNDA RWS	1.29	33.33	39.91	0.34	0.10				0.00	0.00	0.00	0.00	0.00	0.00	0.00		
MIDDLE LETABA RWS: BABANGU	1.5	41.38	437.42	5.94	1.75	1.05	0.51	76	0.51	0.66	0.79	0.91	1.04	1.17	1.31	100	51
MIDDLE LETABA RWS: MAGORO	2.035	50.00	339.27	5.42	2.98	0.66	1.05	65	1.05	1.22	1.36	1.50	1.65	1.80	1.96	100	56
MIDDLE LETABA RWS: MAJOSI	1.13	34.88	329.19	5.21	3.59	1.09	0.88	64	0.88	1.08	1.24	1.41	1.59	1.76	1.95	100	78
MIDDLE LETABA RWS: VYEBOOM MASIA	3	66.67	144.67	2.29	1.72	0.29	0.4	63	0.40	0.48	0.55	0.61	0.68	0.75	0.83	90	55
MIDDLE LETABA: BOLOBEDU NW	1.76	39.02	204.08	2.72	1.82	0.55	0.44	68	0.44	0.54	0.63	0.72	0.81	0.90	1.00	100	88
MIDDLE LETABA RWS: MALAMULELE WEST	1.35	41.67	131.47	1.43	0.61	0.21	0.11	59	0.11	0.14	0.16	0.19	0.21	0.24	0.26	98	63
MODJADJI RWS	1	28.86	130.04	1.75	1.01	1.84		62	0.00	0.18	0.33	0.49	0.64	0.80	0.97	99	93
MUTALE LM FARMS SUPPLY	0.98		5.39	0.04			0.02	145	0.02	0.02	0.02	0.02	0.03	0.03	0.03		
MUTALE MAIN RWS	1.415	38.89	760.47	5.91	1.18	1.5	0.7	100	0.70	0.91	1.08	1.25	1.43	1.61	1.80	100	100
MUTALE MUKUYA RWS	1.785	43.75	171.68	1.35	0.77	0.18	0.11	92	0.11	0.14	0.16	0.18	0.20	0.23	0.25	100	100
NORTH MALAMULELE EAST RWS	1.67	44.19	333.57	3.11	1.49	2.9	0.16	118	0.16	0.44	0.65	0.87	1.09	1.32	1.56	100	62
NZHELELE RWS	1.26	42.10	397.16	3.32	1.56				0.00	0.00	0.00	0.00	0.00	0.00	0.00	100	100

RITAVI II RWS	1.84	40.00	238.04	3.96	2.21	8.56	0.75	228	0.75	1.81	2.70	3.61	4.56	5.54	6.59	100	100
RITAVI/LETABA RWS	1.425	36.36	445.19	5.48	2.43	2.25	0.26	70	0.26	0.50	0.69	0.89	1.09	1.30	2.44	97	67
SEKGOPO LOCAL GWS	0.67	11.76	36.95	0.58	0.97		0.19	25	0.19	0.21	0.22	0.24	0.25	0.27	0.28	100	100
SEKGOSESE INDIVIDUAL GROUNDWATER SCHEME	2.25	50.00	124.31	1.99	2.28		0.23	31	0.23	0.25	0.27	0.29	0.31	0.33	0.35	100	88
SOUTH MALAMULELE EAST RWS	2	47.37	605.37	6.55	2.01	3.5	0.11	94	0.11	0.46	0.74	1.03	1.33	1.63	1.95	100	53
THABINA RWS	2.655	60.34	97.20	1.58	2.81	1.93	2.25	199	2.25	2.69	3.05	3.42	3.80	4.19	4.60		
THAPANE RWS	0.7	15.09	116.12	1.50	0.42	1.32	0.3	78	0.30	0.47	0.61	0.75	0.89	1.04	1.20	100	95
THULAMELA LM FARMS SUPPLY	1.46		2.60	0.02			0.08	93	0.08	0.09	0.09	0.09	0.10	0.10	0.11		
TOURS RWS	2.5	57.41	215.92	4.13					0.00	0.00	0.00	0.00	0.00	0.00	0.00		
TSHAKUMA RWS	2.25	50.00	56.73	0.70	0.51	1.41	0.17	117	0.17	0.33	0.45	0.58	0.71	0.85	0.99	100	100
TSHIFIRE MURUNWA RWS	11.25	100.00	79.70	0.69	0.15				0.00	0.00	0.00	0.00	0.00	0.00	0.00	100	100
TSHIFUDI RWS	1.67	44.00	143.40	1.21	0.52	0.86	0.27	97	0.27	0.38	0.48	0.57	0.67	0.77	0.88	100	100
TSHIKONDENI MINE	2.5		7.47	0.04		0.495	0.055	2943	0.06	0.08	0.09	0.10	0.11	0.12	0.14		
TSHITALE RWS	1	27.40	315.75	4.90	0.94	0.39	0.44	72	0.44	0.52	0.58	0.65	0.71	0.78	0.85	100	86
TZANEEN/HAERNETSBURG INDIVIDUAL SUPPLY	1.03	0.00	24.20	0.38		0.584		990	0.00	0.05	0.08	0.12	0.15	0.19	0.23		
TZANEEN/MODJADJISKLOOF	1.7	42.86	134.71	2.15	0.14	2.946		625	0.00	0.30	0.53	0.78	1.04	1.30	1.58	100	100
VALDEZIA RWS	1.26	20.00	106.88	1.68	1.25		0.313	78	0.31	0.34	0.37	0.40	0.42	0.45	0.48	100	100
VONDO CENTRAL RWS	1.01	37.25	498.85	5.93	2.67											100	95
VONDO EAST RWS	1.6	36.36	115.31	1.52	0.74											100	91
VONDO NORTH RURAL RWS	2	40.00	119.55	1.00	0.01											100	100
VONDO SOUTH RWS	0.265	0.00	162.56	2.25	0.96	15.73	0.23	145	0.23	2.00	3.47	4.99	6.55	8.16	9.88	100	74
WORCESTER/MOTHOBEKI RWS	2.83	55.56	157.53	2.06	1.86	0.594		63	0.00	0.05	0.09	0.13	0.17	0.22	0.26	92	57
Total			12320.14	139.41	66.15	71.239	17.882	123	17.88	26.79	34.22	41.88	49.73	57.78	67.30		

Table 7-7 Summary table of limitations of meeting domestic water requirements from groundwater

Note [1]: Ratio of MAR reduction to abstraction

Scheme	Impact on baseflow[1]	Demand relative to							Limitations
	%	Catchment	Harvest Potential (%)	Aquifer Recharge (%)	BH >2 l/s (%)	Existing capacity (%)	TDS % potable	Nitrates % potable	
SILUWANE - NONDWENI EXTENDED RWS	2	Moderately utilised	0	0	41.38	0	98	83	None
BA-PHALABORWA INDIVIDUAL SUPPLY	2	Significantly utilised	4	3			50	100	50% of boreholes have elevated salinity. Catchment significantly utilised
DAMANI RWS	51	Underutilised	10	2	31.82	20	100	100	Abstraction reduces runoff by 50% of abstraction
ELIM/VLEIFONTEIN RWS	70-85	Over utilised	25	9	67.39	16	100	96	Abstraction reduces runoff by 70-85% of abstraction. Catchment over utilised
GIYANI SYSTEM A/B	<2	Underutilised	4	4	47.30	32	96	71	none
GIYANI SYSTEM D: SOUTH WEST	2	Moderately utilised	39	33	42.31	38	97	58	>40% of boreholes have excessive nitrates.
GIYANI SYSTEM F1	0	Underutilised	8	8	36.00	36	80	47	>50% of boreholes have elevated nitrates
GIYANI SYSTEM F2	0	Underutilised	13	13	46.67	28	100	65	35% of boreholes have elevated nitrates
GIYNAI SYSTEM C/D	2	Underutilised	33	32	61.60	37	88	77	none
GREATER GIYANI LM FARMS SUPPLY	2	Significantly utilised	79	61					Catchment significantly utilised
GREATER LETABA LM FARMS SUPPLY	64	Over utilised	127	87					Abstraction reduces runoff by 64% of abstraction. Catchment over utilised

GREATER TZANEEN LM FARMS SUPPLY	52	Underutilised	0	0					Abstraction reduces runoff by 52% of abstraction. Only 11% of boreholes yield > 2/s
LAMBANI RWS	9	Underutilised	0	0	33.33	0	100	100	None. Abstraction reduces runoff by <10% of abstraction
LETABA INDIVIDUAL SUPPLY	64	Over utilised	6	4					Abstraction reduces runoff by 64% of abstraction. Catchment over utilised
LEVUBU CBD	85	Heavily utilised	76	10	100.00				.Abstraction reduces runoff by 85% of abstraction. Catchment heavily utilised
LOWER MOLOTOTSI	2	Moderately utilised	0	0	60.00	0	91	56	Nearly 50% of boreholes have excessive nitrates.
LUPHEPHE/NWANEDZI MAIN RWS	6	Underutilised	23	43	40.00	21	90	94	None
LUPHEPHE/NWANEDZI NORTH	6	Underutilised	51	125	35.00	15	92	50	50% of boreholes have excessive nitrates. Scheme already heavily utilised
MAKHADO RWS	69	Heavily utilised	71	19	48.54	324			Abstraction reduces runoff by69% of abstraction. Catchment heavily utilised. Infrastructure over utilised
MALAMULELE WEST RWS	9	Underutilised	5	4	36.17	17	100	62	None. Abstraction reduces runoff by <10% of abstraction. 38% of boreholes have elevated nitrates
MAPUVE/SYSTEM N RWS	<2	Underutilised	8	8	38.10	31	100	38	>60% of boreholes have excessive nitrates.

MASISI RWS	<1	Underutilised	26	79	55.26	19	87	80	None
MATSHAVHAVE/KUNDA RWS		Heavily utilised	0	0	33.33	0			
MIDDLE LETABA RWS: BABANGU	2-53	Underutilised	9	8	41.38	29	100	51	Nearly 50% of boreholes have elevated nitrates
MIDDLE LETABA RWS: MAGORO	53	Underutilised	19	18	50.00	35	100	56	Nearly 50% of boreholes have elevated nitrates. Abstraction reduces runoff by 53% of abstraction
MIDDLE LETABA RWS: MAJOSI	7	Underutilised	17	14	34.88	24	100	78	None
MIDDLE LETABA RWS: VYEBOOM MASIA	7	Underutilised	28	28	66.67	23	90	55	45% of boreholes have elevated nitrates
MIDDLE LETABA: BOLOBEDU NW	3	Significantly utilised	19	16	39.02	24	100	88	Catchment is significantly utilised
MIDDLE LETABA RWS: MALAMULELE WEST	0	Underutilised	4	2	41.67	18	98	63	None
MODJADJI RWS	3	Significantly utilised	0	0	28.86	0	99	93	Catchment is significantly utilised
MUTALE LM FARMS SUPPLY	<1	Underutilised	49	33					None
MUTALE MAIN RWS	>50	Underutilised	20	10	38.89	59	100	100	Abstraction reduces runoff by 50% of abstraction
MUTALE MUKUYA RWS	9	Underutilised	8	6	43.75	14	100	100	None. Abstraction reduces runoff by <10% of abstraction
NORTH MALAMULELE EAST RWS	<5	Underutilised	5	4	44.19	11	100	62	Abstraction reduces runoff by <5% of abstraction. 38% of boreholes have elevated nitrates
NZHELELE RWS		Underutilised	0	0	42.10	0	100	100	None. May impact on inflows to Nzhelele dam
RITAVI II RWS	44	Moderately utilised	28	13	40.00	34	100	100	Abstraction reduces runoff by 44% of

									abstraction
RITAVI/LETABA RWS	2	Significantly utilised	5	3	36.36	11	97	67	Catchment is significantly utilised
SEKGOPO LOCAL GWS	52	Underutilised	33	21	11.76	20	100	100	Abstraction reduces runoff by 52% of abstraction. Only 11% of boreholes yield > 2/s
SEKGOSESE INDIVIDUAL GROUNDWATER SCHEME	53	Underutilised	12	11	50.00	10	100	88	Abstraction reduces runoff by >50% of abstraction
SOUTH MALAMULELE EAST RWS	0	Underutilised	2	2	47.37	5	100	53	47% of boreholes have elevated nitrates
THABINA RWS	44	Moderately utilised	143	86	60.34	80			Abstraction reduces runoff by 44% of abstraction
THAPANE RWS	5	Over utilised	20	11	15.09	72	100	95	Catchment is over utilised
THULAMELA LM FARMS SUPPLY	9	Underutilised	348	185					None. Abstraction reduces runoff by <10% of abstraction. Scheme heavily utilised due to small area, however catchment is under utilised
TOURS RWS		Moderately utilised	0	0	57.41				
TSHAKUMA RWS	63-83	Heavily utilised	24	3	50.00	33	100	100	Abstraction reduces runoff by >60% of abstraction. Catchment heavily utilised
TSHIFIRE MURUNWA RWS		Heavily utilised	0	0	100.00	0	100	100	None
TSHIFUDI RWS	9	Underutilised	22	7	44.00	52	100	100	None. Abstraction reduces runoff by <10% of abstraction
TSHIKONDENI MINE	<1	Underutilised	125	107					Scheme heavily utilised

									however catchment is under utilised
TSHITALE RWS	7-8	Underutilised	9	7	27.40	47	100	86	none
TZANEEN/HAERNETSBURG INDIVIDUAL SUPPLY	100	Underutilised	0	0	0.00				Abstraction reduces runoff by 100% of abstraction
TZANEEN/MODJADJISKLOOF	43-49	Underutilised	0	0	42.86	0	100	100	Abstraction reduces runoff by 43-49% of abstraction
VALDEZIA RWS	85	Heavily utilised	19	3	20.00	25	100	100	Abstraction reduces runoff by 85% of abstraction. Catchment heavily utilised
VONDO CENTRAL RWS	51-63	Underutilised			37.25		100	95	Abstraction reduces runoff by> 50% of abstraction
VONDO EAST RWS	9	Underutilised			36.36		100	91	Abstraction reduces runoff by <10% of abstraction
VONDO NORTH RURAL RWS	>50	Underutilised			40.00		100	100	Abstraction reduces runoff by 50% of abstraction.
VONDO SOUTH RWS	9	Underutilised	2	1	0.00	5	100	74	Abstraction reduces runoff by <10% of abstraction
WORCESTER/MOTHOBEKI RWS	3	Significantly utilised	0	0	55.56	0	92	57	Catchment is significantly utilised

Note [1]: Ratio of MAR reduction to abstraction

8 EVALUATION OF ARTIFICIAL RECHARGE AND SAND ABSTRACTION FROM THE MULELE SAND AQUIFER

8.1 INTRODUCTION

The potential scheme considers impounding surface water by means of a weir to artificially recharge the underlying alluvial sand aquifer in order to abstract alluvial groundwater. The weir is to be located on the Molototsi to supply water to Mulele in the Lower Molototsi water supply scheme. The scheme is to be located SW of Giyani (figure 8.1).

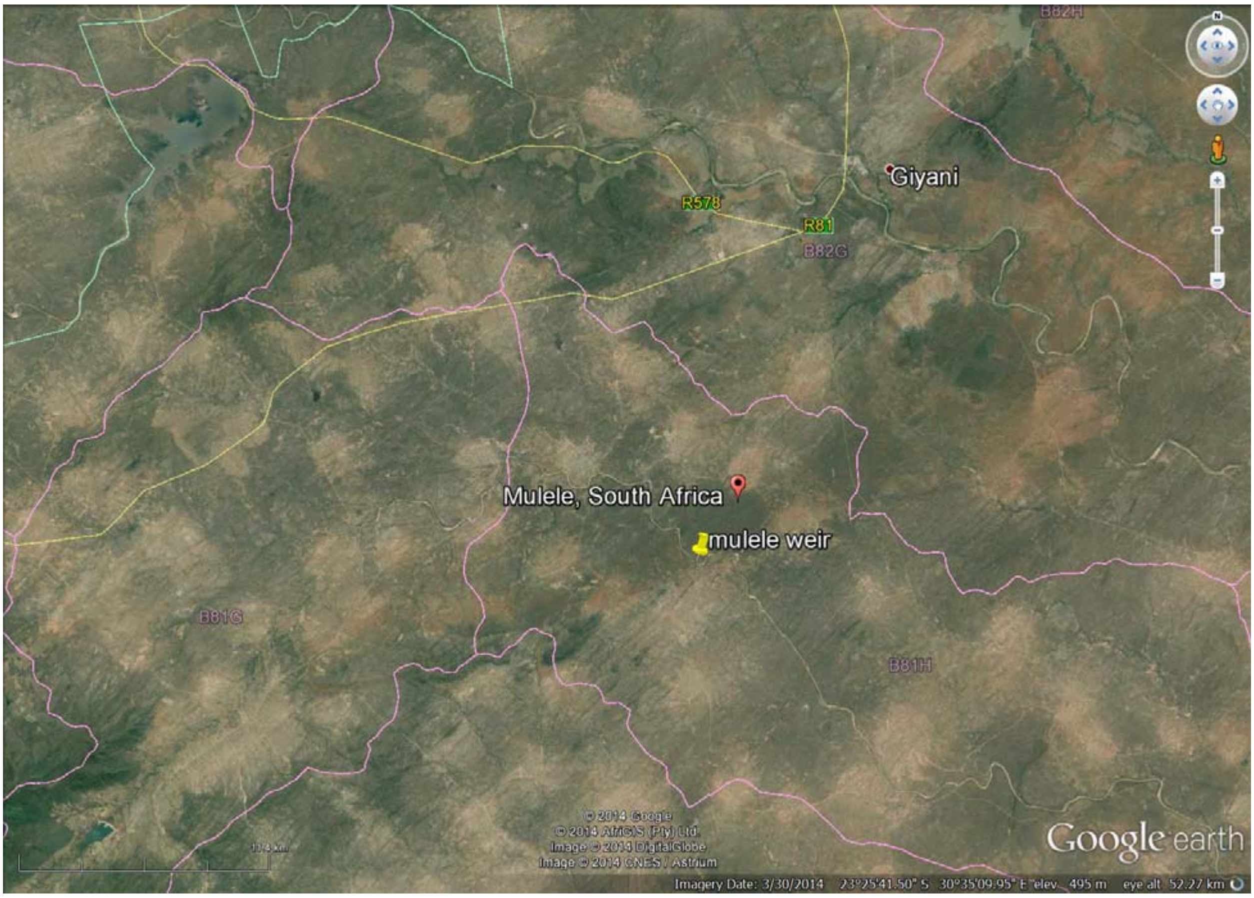

Figure 8-1 Location of Mulele weir

8.2 METHODOLOGY

The yield of the sand aquifer was assessed using:

- The flow records simulated by WRSM2000 for the Molototsi at the outlet of B81G
- Aquifer characteristics as determined by WSM (1996), during field investigations

- Modelling of the yield of the aquifer at various assurance levels based on the extent of the aquifer and the time series of flow (8.5). This was undertaken for natural conditions and with a weir structure

8.3 AVAILABLE RUNOFF

The Molototsi at Mulele is downstream of B81G. No gauging weir exists, however, the monthly discharges were simulated by WRSM2000. The MAR is 14.3 Mm^3/a, with a mean monthly flow of 1.19 Mm^3. However, for 83% of the time, flows are below 0.07 Mm^3/month (figure 8-2), consequently, recharge to the aquifer is highly variable and demand has to be met from the storage component of the sand aquifer.

The catchment area above the alluvium, which is a source of water to recharge the alluvium, is about 513 km^2, with an MAP of 627 mm. To determine the water availability in the Molototsi, the WRSM2000 model was run from 1920-2010.

8.4 AQUIFER CHARACTERISTICS

WSM (1996) probed 1 km of the alluvium at 20 m intervals in 3 parallel lines and dug 2 test pits. Test pumping was under taken to determine hydraulic parameters.

The alluvium is on average 2.35 m thick and varies from 0.7 m to 4.6 m. Below the sands weathered bedrock exists to 18 m below ground level. The alluvium is compartmentalised by outcrops of bedrock. It has a length of 950 m and an average width of 40 m. The geology at the proposed outcrop for the weir is metamorphosed lava, it is compartmentalised 950 m upstream by an outcrop of schist, which forms part of the Giyani greenstone belt.

The alluvium consists of well sorted round quartzitic sand and gravel with a static water level 18 cm below surface. It has a specific capacity (drainable volume), of about 0.1. With an average saturated thickness of 2.17 m, the volume of water in storage is 0.00817 Mm^3. The underlying weathered material stores an additional 0.006 Mm^3.

Test pumping indicates a transmissivity of 396 m^2/d in the sands, however the underlying weathered bedrock is of low permeability so it is not possible to exploit the storage in the weathered material.

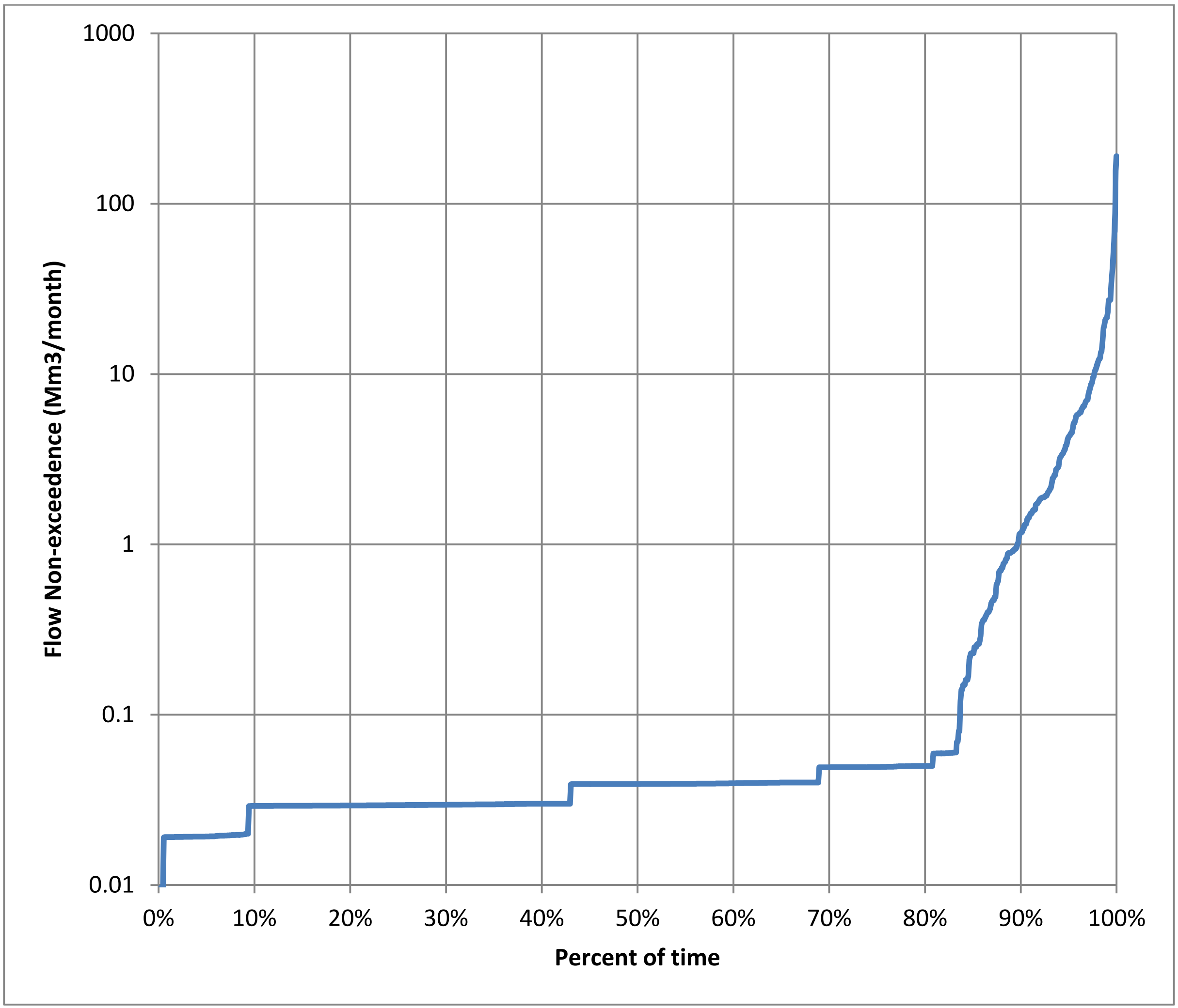

Figure 8-2 Duration curve of flow for B81G

The water quality has an EC of below 35 mS/m. Nitrates are below 1 mg/l.

Due to the shallow depth of the saturated sand, available drawdown is limited and the aquifer can best exploited by infiltration galleries buried in the deeper zones of the sand.

8.5 MODELLING OF YIELDS

A spreadsheet based model was established to simulate a time series water balance model of the aquifer based on rainfall recharge and transmission losses. This allows a time series of aquifer inflows and outflows to be used to calculate sustainable yields at various levels of assurance based on simulated monthly aquifer water levels. No water level data was available for calibration.

The sustainable yield of an aquifer is based not only on recharge, and the balance between inflows and outflows, but also on aquifer storage relative to the variability in inflows and outflows over time. The variability in recharge is largely determined by flow in the Molototsi. The ability of aquifer storage to buffer water balance deficits during dry periods controls the sustainable yield of the aquifer. Consequently, the yield depends on the length of the period over which the aquifer is under low flow conditions.

The yield of the aquifer was assessed based on rainfall records for catchment B81H between 1920-2010. (MAP =530 mm), and flow simulated from B81G in the Molototsi by WRSM2000.

8.5.1 Recharge

Rainfall recharge directly to the sand aquifer was calculated using the CRD method:

$$CRD = \frac{1}{m}\sum_{i-1}^{i} Rain - \frac{1}{n}\sum_{i-(n-1)}^{i} Rain$$

Due to the shallow and permeable nature of the alluvium, both m and n were set equal to 1 month.

The CRD for positive instances was related to monthly recharge monthly using a recharge threshold equation of the form:

Recharge = A*(CRD-B).

B is the rainfall threshold to initiate recharge and was calibrated to 30 mm/month. The assumption made that with an average unsaturated zone of 15 cm, a porosity of 0.3, and a specific capacity of 0.1, 30 mm of water need to be added to the unsaturated zone to reach the specific capacity. The fraction of rainfall above this threshold contributing to recharge was set at 0.7, which gave a mean annual recharge of 207 mm/a.

8.5.2 Evapotranspiration

Where a shallow water table exists, riverine vegetation is thought to be sustained by groundwater. Without accounting for evapotranspiration from groundwater, virtually every aquifer would generate baseflow to discharge rainfall recharge under natural conditions and groundwater levels would be at surface. Consequently, a routine to deplete groundwater storage is required to provide a realistic water balance. The green zone along the Molototsi was identified as an evapotranspiration zone.

Figure 8-3 Mulele sand aquifer

A Mean annual A-Pan evaporation (2090 mm/a) was utilised, with factors for the percent monthly distribution of evaporation, and Bushveld crop factors applied from WR2005 over the area over which evapotranspiration is thought to take place. This was measured on Google earth and was 62.5% of the alluvial area of 0.038 km^2.

Monthly evapotranspiration demand is calculated by the product of mean annual evaporation, monthly distribution factor and crop factor. Rainfall is subtracted from evapotranspiration to obtain evapotranspiration demand from groundwater. When rainfall exceeds evapotranspiration demand evapotranspiration from groundwater is defaulted to 0, since it is assumed that the evapotranspiration demand will be met from soil moisture storage prior to recharge.

Evapotranspiration demand is scaled by an aquifer storage factor to allow evaporation to decrease as groundwater storage is depleted. Evapotranspiration occurs at the maximum rate when groundwater storage is at surface (SURF) and declines towards 0 as groundwater storage drops to a specific level below the surface, defined by a parameter of extinction depth, which was set as 2.3 m below the channel surface (467 mamsl), the depth of the alluvium, or 4.3 m below the adjacent land surface.

Evapotranspiration from groundwater is calculated monthly by:

$$((MAE \times MDISTxCROP) - RAIN) \times AREA \times (STORE - EXTINCT\ /(SURF - EXTINCT\ ))$$

Where:

MAE = mean annual evaporation

MDIST = monthly distribution fraction of evaporation

CROP = monthly S pan factor for catchment ET

RAIN = input variable data of monthly rainfall

AREA = riverine area where evapotranspiration from groundwater can take place

STORE= variable of groundwater level

EXTINCT= parameter of extinction depth (464.7 mamsl)

SURF=surface elevation (469 mamsl)

An error check is included to ensure evapotranspiration does not become negative if groundwater level drops below the extinction depth due to high levels of abstraction.

Evapotranspiration is subsequently decremented from groundwater storage.

8.5.3 Groundwater inflow and outflow

Groundwater is allowed to flow in and out of the aquifer to simulate underflow out of the compartment across dykes, and regional groundwater flow that does not emerge in the surface water channel.

Groundwater outflow is calculated using the Darcian approach of the product of parameters of transmissivity T, a fluctuating hydraulic gradient HG, and the aquifer width where outflow occurs (40 m). The Transmissivity was set at a low value (2 m^2/d) since the outlet of the alluvium consists of a weathered rock outcrop. The hydraulic gradient fluctuates as a function of aquifer storage. The maximum hydraulic gradient is defined by a parameter HGRAD, assumed to be equal to the channel gradient (0.002). This gradient is the hydraulic gradient oriented out of the catchment. The hydraulic gradient HG is decremented as the groundwater storage drops to the extinction depth by:

$$HG = HGRADx(STORE - EXTINCT)/(SURF - EXTINCT)$$

Where:

HGRAD= parameter of maximum hydraulic gradient

This format allows groundwater outflow to occur at a decreasing rate as the water level drops, until outflow stops when the extinction depth is reached. Groundwater outflow is allowed to become negative to simulate drawing in of water from adjacent catchments under conditions of large scale abstraction.

Groundwater outflow is decremented from groundwater storage.

Groundwater inflow is calculated using the Darcian method as the product of the transmissivity of the hard rock aquifer surrounding the alluvium (2 m^2/d), the aquifer length over which inflow takes place (1.8 km), and the hydraulic gradient (0.005) which fluctuates according to the CRD, and the drop in water level which occurs due to abstraction. Due to the cone of depression which occurs due to large scale abstraction, gradients oriented towards the aquifer fluctuated between 0.0049-0.0051.

8.5.4 Baseflow and Transmission losses

When groundwater level is higher than elevation of the channel (467 mamsl), groundwater baseflow is generated, simulating seepage to the channel. Baseflow is decremented from groundwater storage. When groundwater levels are below this level, losses to the aquifer are generated, to a maximum dictated by the volume of water in the channel, and the maximum volume of water the aquifer can accept, determined from the water level to the level of the channel. The volume of water in the channel was equal to inflow from upstream, as calculated by WRSM2000 Model.

Groundwater baseflow and transmission losses are calculated as a function of the head difference between groundwater and the surface, and a permeability parameter.

Surface and groundwater interactions are known to not be linearly related to head due to hydraulic resistance, hence Darcian methods are not suited to calculate baseflow. A non-linear equation was used to calculate baseflow and transmission losses (FLOW) to account for the effects of hydraulic resistance:

$$FLOW = (1 - e^{(HEAD \times BPOW)}) \times KxLENGTH * WP$$

Where:

K= the permeability of the channel bed or the maximum rate of groundwater baseflow (100 mm/d)

BPOW = relationship between head difference and baseflow (0.05)

HEAD= variable of the head difference between the groundwater level (STORE) and river stage

LENGTH = channel length (0.95 km)

WP= discharge dependent variable of seepage width dependent on flow volume and calculated using the Manning's N equation. This parameter varied from 7.2-62 m (during the 2000 floods).

To account for a weir structure, the flow width was doubled for any given flow stage, up to a height of 1.3 m, the maximum height of a weir in that channel section.

8.6 RESULTS

The simulated water levels are shown in figure 8.4. Aquifer water levels fluctuate from 0.2 m above and below the channel elevation.

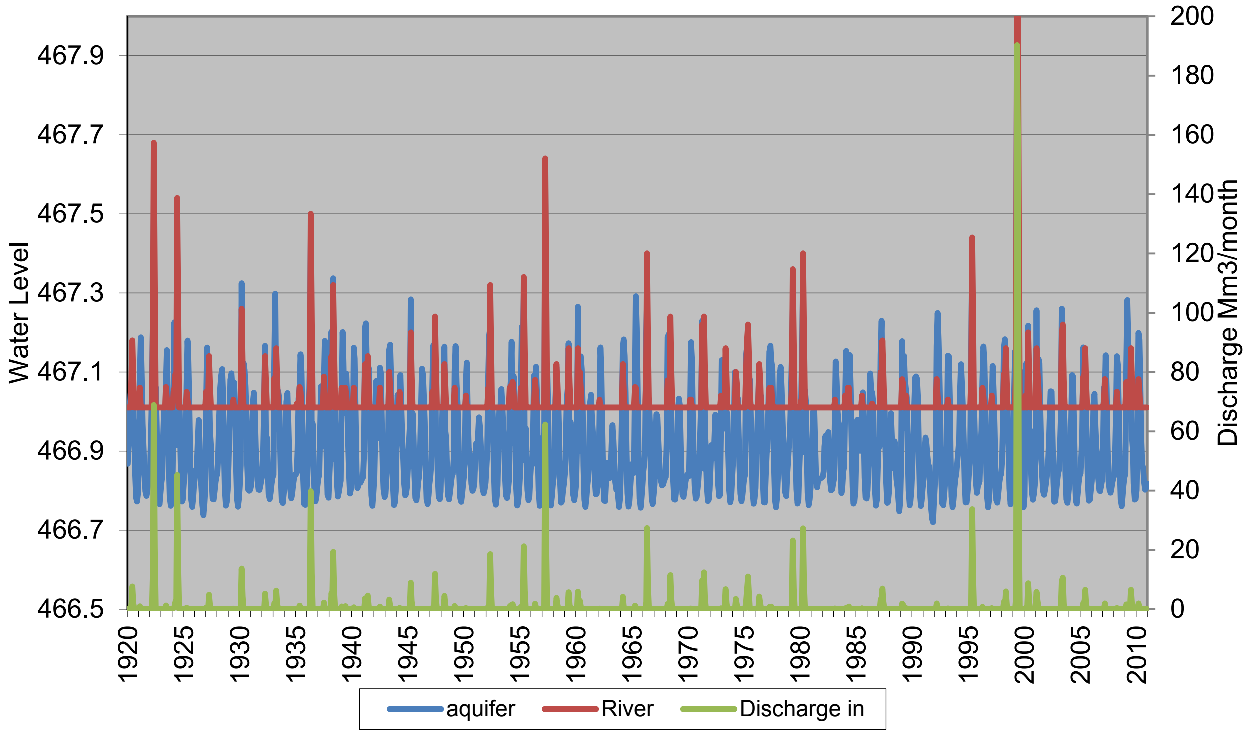

Figure 8-4 simulated aquifer water levels discharge entering the alluvium

The simulated natural water balance of the aquifer based on 1092 months of the rainfall and flow time series is shown in Table 8-1.

Table 8-1 Water balance of the sand aquifer

INFLOWS	M^3/Month	OUTFLOWS	M^3/Month
Recharge	656	GW Outflow	3
GW inflow	543	abstraction	0
Trans. Losses % of flow	0.02	Baseflow	186
Trans. Losses	465	Evaporation	1 475
Total Inflow	1 663	Total Outflow	1 663

Figure 8.5 shows simulated aquifer water levels if 4600 m^3/month is abstracted from the system. It can be seen that aquifer water levels drop to the minimum water level of 464.7, 2.3 m below the channel, the point at which failure is expected to occur, hence determining a sustainable yield is based on ensuring water levels stay above the required water level within an acceptable frequency of failure.

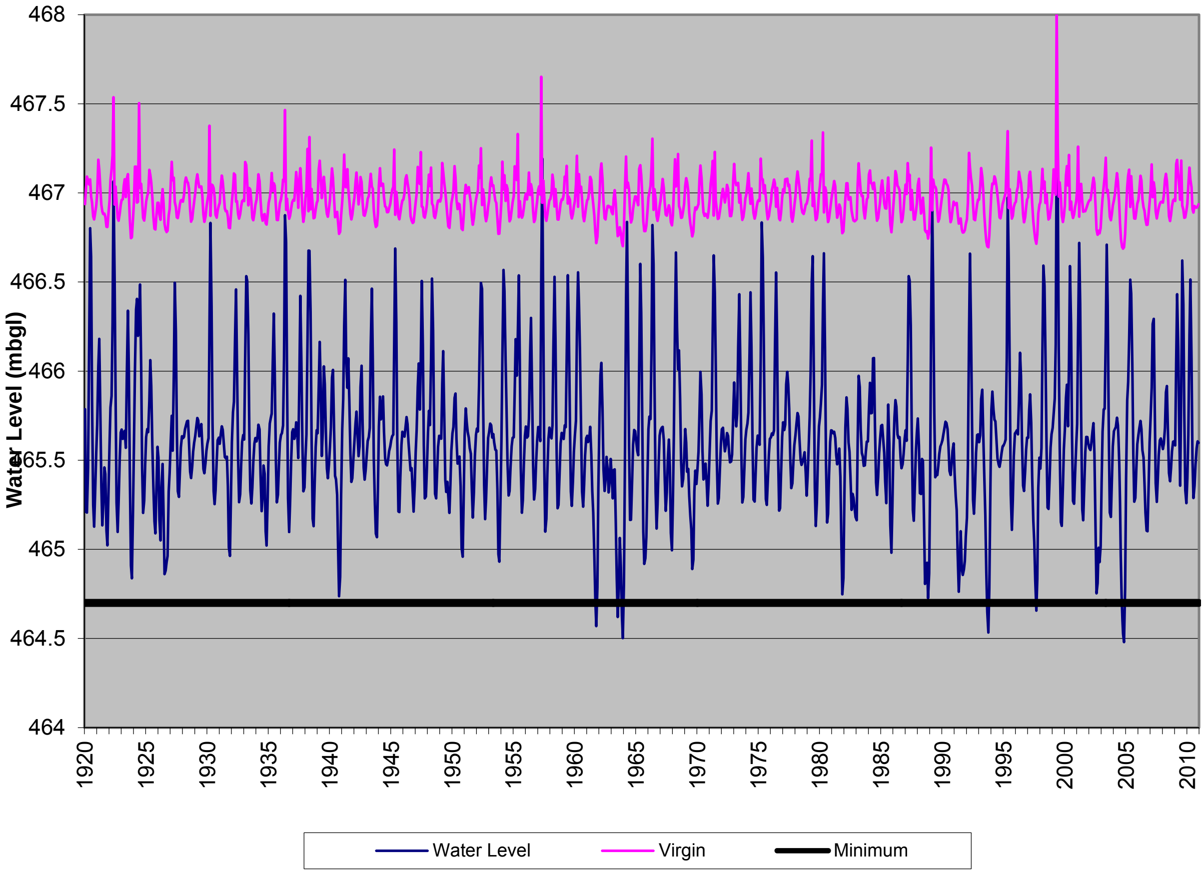

Figure 8-5 Water levels under an abstraction of 4600 m^3/month

The sustainable yield of the aquifer is based not only on rainfall recharge and transmission losses, the balance between inflows and outflows, but also on aquifer storage relative to the variability in inflows and outflows over time. The ability of aquifer storage to buffer water balance deficits during dry periods ultimately controls the sustainable yield of the aquifer. The level of assurance at which the water is required also determines sustainable yield. The yield of the aquifer is higher if a higher risk of failure, or lower level of assurance, is accepted.

To determine the yield of an aquifer at various levels of assurance, statistical probabilistic methods are required to calculate the risk of failure at various risk levels. Aquifer yields were calculated from simulated water levels as abstraction increases using statistical distributions. Such methods are standard when calculating the yield of surface water reservoirs. The Generalised Extreme Value Distribution (GEV) was utilised as providing the best distribution to match highly skewed water level data.

Monthly water levels were plotted cumulatively and the parameters of the GEV calibrated until the theoretical values of the distribution matched water levels under conditions of abstraction and without abstraction, and for various effluent discharges. Subsequently, the risk of failure could be calculated at increasing water abstraction levels.

The following aquifer yields were calculated at various levels of assurance (table 8-2):

Table 8-2 Aquifer yield at various levels of assurance

Level of Assurance	Natural	Weir
%	M^3/month	M^3/month
99.9	4216	4375
99	4266	4542
98	4333	4708
95	4450	5042
90	4600	5416

The water balance of the aquifer under various abstraction levels is given in table 8-3.

Table 8-3 Water balance of the sand aquifer under various abstraction levels

	INFLOWS			**OUTFLOWS**	
	No weir	weir		No weir	weir
	99.9 % level of assurance				
	M^3/month	M^3/Month		M^3/Month	M^3/Month
Recharge	656	656	**GW Outflow**	1	1
GW inflow	875	833	**abstraction**	4217	4375
Trans. Losses % of flow	0.27	0.3	**Baseflow**	76	17
Trans. Losses	3235	3574	**Evaporation**	528	673
Total Inflow	4766	5063	**Total Outflow**	4771	5067
	99% level of assurance				
Recharge	656	656	**GW Outflow**	1	1
GW inflow	879	844	**abstraction**	4267	4542
Trans. Losses % of flow	0.;27	0.31	**Baseflow**	25	16
Trans. Losses	3270	3698	**Evaporation**	517	643
Total Inflow	4805	5198	**Total Outflow**	4810	5202
	98% level of assurance				
Recharge	656	656	**GW Outflow**	1	1
GW inflow	881	855	**abstraction**	4333	4708
Trans. Losses % of flow	0.28	0.32	**Baseflow**	25	15
Trans. Losses	3316	3823	**Evaporation**	503	613
Total Inflow	4856	5334	**Total Outflow**	4682	5338
	95% level of assurance				
Recharge	656	656	**GW Outflow**	1	1

GW inflow	893	877	**abstraction**	4450	5042
Trans. Losses % of flow	0.28	0.34	**Baseflow**	24	13
Trans. Losses	3398	4074	**Evaporation**	477	555
Total Inflow	4947	5607	**Total Outflow**	4952	5611
	90% level of assurance				
Recharge	656	656	**GW Outflow**	1	1
GW inflow	904	901	**abstraction**	4600	5417
Trans. Losses % of flow	0.29	0.37	**Baseflow**	24	12
Trans. Losses	3503	4360	**Evaporation**	445	493
Total Inflow	5063	5917	**Total Outflow**	5069	5922

8.7 CONCLUSION

Artificial recharge of the Mulele sand aquifer could provide 0.05-0.06 Mm^3/a to the lower Molototsi rural water supply, largely by inducing transmission losses from the river. This is sufficient for 1500-2000 people. Boreholes in the area have elevated levels of nitrates, hence the potential of the scheme is for the dilution of poorer quality groundwater.

9 SUMMARY AND CONCLUSIONS

The following conclusions can be drawn from the groundwater analysis:

- Groundwater demand is approximately 157.36 Mm^3/a, of which 141.42 Mm^3/a is for irrigation Table (5-1). The registered water use in the WARMS data base is 101-102 Mm^3/a, of which 91.65 Mm^3/a is for irrigation. Consequently, registered water use is significantly lower than actual use.
- Estimated water use (and transfers out of the catchment) is 116.6 Mm^3/a, of which 17.9 Mm^3/a is met from groundwater. Some of this groundwater use is met from outside the catchment boundaries for rural water schemes which straddle the catchment boundary, of which Makhado is the most significant.
- Borehole yields for boreholes located within water supply schemes are sufficient (>20% exceed 2 l/s) to warrant groundwater supply. Low yields are encountered in the Sekgopo groundwater supply scheme in B82A and the Thapane rural water supply scheme in B81E, yet both of these schemes are reliant on groundwater.
- Good quality groundwater exists throughout the study area (table 6.10), with the following exceptions: B81B exhibits elevated nitrates and TDS, however the numbers of boreholes sampled is small. B81 F and H in the low veld plains exhibit high levels of nitrate. These catchments are densely settled and elevated nitrate is probably associated with the removal of vegetation.B82D G and H, shows elevated nitrates due to dense settlement. B90B and C F and G show elevated nitrates
- Water quality data from the GRIP data base, on a village level, suggests elevated nitrates appear to be widespread amongst the water supply schemes. However, GRIP data represents boreholes currently utilised in settled areas and where vegetation removal is increased, hence include boreholes with poor quality due to contamination.
- The Harvest Potential for the study area is 271.09 Mm^3/a. The Exploitation Potential for the study area is 183.82 Mm^3/a.
- Recharge to the regional aquifer (aquifer recharge) is often significantly less than the recharge volumes, especially in the escarpment region, where much of the recharge is lost as interflow and not available to boreholes. The calculated aquifer recharge for the study area is 466 Mm^3/a, whereas the total recharge is 921 Mm^3/a (table 6.14). The aquifer recharge can be considered the upper limit of what can be abstracted, as it is the average rainfall recharge to the regional aquifer. However, abstracting this volume would deplete the source of groundwater baseflow, which provides low flows during the dry season.

- Baseflow is 41% of the MAR, of which groundwater baseflow is 7.15% of MAR. In the Letaba and Shingwedzi, baseflow is 274 Mm^3/a of a MAR of 753 Mm^3/a. In the Luvuvhu and Mutale, baseflow is 275 Mm^3/a of a MAR of 578 Mm^3/a. Of 467 Mm^3/a of aquifer recharge, 95 Mm^3/a, emerges as groundwater baseflow from the regional aquifer. The remainder of the 549 Mm^3/a of baseflow is generated as interflow in the high lying areas in the west along the Drakensberg, the Drakensberg foothills, and the Soutpansberg.
- For the Letaba system, a groundwater abstraction of 80 Mm^3/a reduces runoff from 753 Mm^3/a to 727 Mm^3/a, with the most heavily impacted region being the Middle Letaba in catchments B82B and B82C, where runoff has been decreased by nearly 40%. In the Luvuvhu system a groundwater abstraction of 52 Mm^3/a reduces the MAR from 578 Mm^3/a to 538 Mm^3/a, with the upper Luvuvhu, A91A-C being the most heavily impacted with flow reductions of 33-50%. Baseflow depletion is 10% in the Letaba system and 15% in the Luvuvhu.
- Stressed catchments where use is greater than 65% of aquifer recharge include: the upper Luvuvhu in the vicinity of Albisini dam (A91A-C), the lower Groot Letaba in the vicinity of the proposed Nwamitwa dam (B811E-F), the Koedoes and Brandboontjies catchments, parts of the Middle Letaba system (B82B-C.
- The rural water schemes that are stressing groundwater resources within the supply area include: Greater Letaba LM farms supply, Masisi RWS, Thabina RWS, Thulamela LM farms supply, Tshikondeni Mine. The following schemes are located in stressed catchments: Ba-Phalaborwa, Elim Vleifontein RWS, Giyani system D: southwest, Greater Giyani LM Farms Supply, Greater Letaba LM Farms Supply, Letaba Individual Supply, Ritavi / Letaba RWS, Makhado RWS, Thapane RWS, Valdezia RWS
- An analysis was undertaken to determine which water supply schemes could feasibly be supplied with additional groundwater. This was undertaken by evaluating population (and projected water demand at 100 l/c/d, the area of the scheme to determine aquifer recharge and harvest potential, Existing borehole capacity, the proportion of boreholes with potable water, and the proportion of boreholes yielding > 2 l/s per second as an indicator of the feasibility of drilling boreholes that could be equipped with motorised systems. It was assumed that per capita demands would grow at 2% per annum and that present demand met by surface water sources would remain constant, so that additional demands would be met from groundwater. The following limitations of on development were identified

Scheme	Limitations
SILUWANE - NONDWENI EXTENDED RWS	None
BA-PHALABORWA INDIVIDUAL SUPPLY	50% of boreholes have elevated salinity. Catchment significantly utilised
DAMANI RWS	Abstraction reduces runoff by 50% of abstraction
ELIM/VLEIFONTEIN RWS	Abstraction reduces runoff by 70-85% of abstraction. Catchment over utilised
GIYANI SYSTEM A/B	none
GIYANI SYSTEM D: SOUTH WEST	>40% of boreholes have excessive nitrates.
GIYANI SYSTEM F1	>50% of boreholes have elevated nitrates
GIYANI SYSTEM F2	35% of boreholes have elevated nitrates
GIYNAI SYSTEM C/D	none
GREATER GIYANI LM FARMS SUPPLY	Catchment significantly utilised
GREATER LETABA LM FARMS SUPPLY	Abstraction reduces runoff by 64% of abstraction. Catchment over utilised
GREATER TZANEEN LM FARMS SUPPLY	Abstraction reduces runoff by 52% of abstraction. Only 11% of boreholes yield > 2/s
LAMBANI RWS	None. Abstraction reduces runoff by <10% of abstraction
LETABA INDIVIDUAL SUPPLY	Abstraction reduces runoff by 64% of abstraction. Catchment over utilised
LEVUBU CBD	.Abstraction reduces runoff by 85% of abstraction. Catchment heavily utilised
LOWER MOLOTOTSI	Nearly 50% of boreholes have excessive nitrates.
LUPHEPHE/NWANEDZI MAIN RWS	None
LUPHEPHE/NWANEDZI NORTH	50% of boreholes have excessive nitrates. Scheme already heavily utilised
MAKHADO RWS	Abstraction reduces runoff by69% of abstraction. Catchment heavily utilised. Infrastructure over utilised
MALAMULELE WEST RWS	None. Abstraction reduces runoff by <10% of abstraction. 38% of boreholes have elevated nitrates
MAPUVE/SYSTEM N RWS	>60% of boreholes have excessive nitrates.
MASISI RWS	None
MATSHAVHAVE/KUNDA RWS	
MIDDLE LETABA RWS: BABANGU	Nearly 50% of boreholes have elevated nitrates
MIDDLE LETABA RWS: MAGORO	Nearly 50% of boreholes have elevated nitrates. Abstraction reduces runoff by 53% of abstraction
MIDDLE LETABA RWS: MAJOSI	None
MIDDLE LETABA RWS: VYEBOOM MASIA	45% of boreholes have elevated nitrates
MIDDLE LETABA: BOLOBEDU NW	Catchment is significantly utilised
MIDDLE LETABA RWS: MALAMULELE WEST	None
MODJADJI RWS	Catchment is significantly utilised

MUTALE LM FARMS SUPPLY	None
MUTALE MAIN RWS	Abstraction reduces runoff by 50% of abstraction
MUTALE MUKUYA RWS	None. Abstraction reduces runoff by <10% of abstraction
NORTH MALAMULELE EAST RWS	Abstraction reduces runoff by <5% of abstraction. 38% of boreholes have elevated nitrates
NZHELELE RWS	None. May impact on inflows to Nzhelele dam
RITAVI II RWS	Abstraction reduces runoff by 44% of abstraction
RITAVI/LETABA RWS	Catchment is significantly utilised
SEKGOPO LOCAL GWS	Abstraction reduces runoff by 52% of abstraction. Only 11% of boreholes yield > 2/s
SEKGOSESE INDIVIDUAL GROUNDWATER SCHEME	Abstraction reduces runoff by >50% of abstraction
SOUTH MALAMULELE EAST RWS	47% of boreholes have elevated nitrates
THABINA RWS	Abstraction reduces runoff by 44% of abstraction
THAPANE RWS	Catchment is over utilised
THULAMELA LM FARMS SUPPLY	None. Abstraction reduces runoff by <10% of abstraction. Scheme heavily utilised due to small area, however catchment is under utilised
TOURS RWS	
TSHAKUMA RWS	Abstraction reduces runoff by >60% of abstraction. Catchment heavily utilised
TSHIFIRE MURUNWA RWS	None
TSHIFUDI RWS	None. Abstraction reduces runoff by <10% of abstraction
TSHIKONDENI MINE	Scheme heavily utilised however catchment is under utilised
TSHITALE RWS	none
TZANEEN/HAERNETSBURG INDIVIDUAL SUPPLY	Abstraction reduces runoff by 100% of abstraction
TZANEEN/MODJADJISKLOOF	Abstraction reduces runoff by 43-49% of abstraction
VALDEZIA RWS	Abstraction reduces runoff by 85% of abstraction. Catchment heavily utilised
VONDO CENTRAL RWS	Abstraction reduces runoff by> 50% of abstraction
VONDO EAST RWS	Abstraction reduces runoff by <10% of abstraction
VONDO NORTH RURAL RWS	Abstraction reduces runoff by 50% of abstraction.
VONDO SOUTH RWS	Abstraction reduces runoff by <10% of abstraction
WORCESTER/MOTHOBEKI RWS	Catchment is significantly utilised

- A potential scheme for impounding surface water by means of a weir to artificially recharge the underlying alluvial sand aquifer in order to abstract alluvial groundwater in the Molototsi was considered to supply water to Mulele in the Lower Molototsi water supply scheme. The scheme is to be located SW of Giyani. The scheme could provide

0.05-0.055 Mm^3/a without the construction of a weir, or 0.05-0.065 Mm^3/a with a 1.3 m weir, depending on the level of assurance of supply selected.

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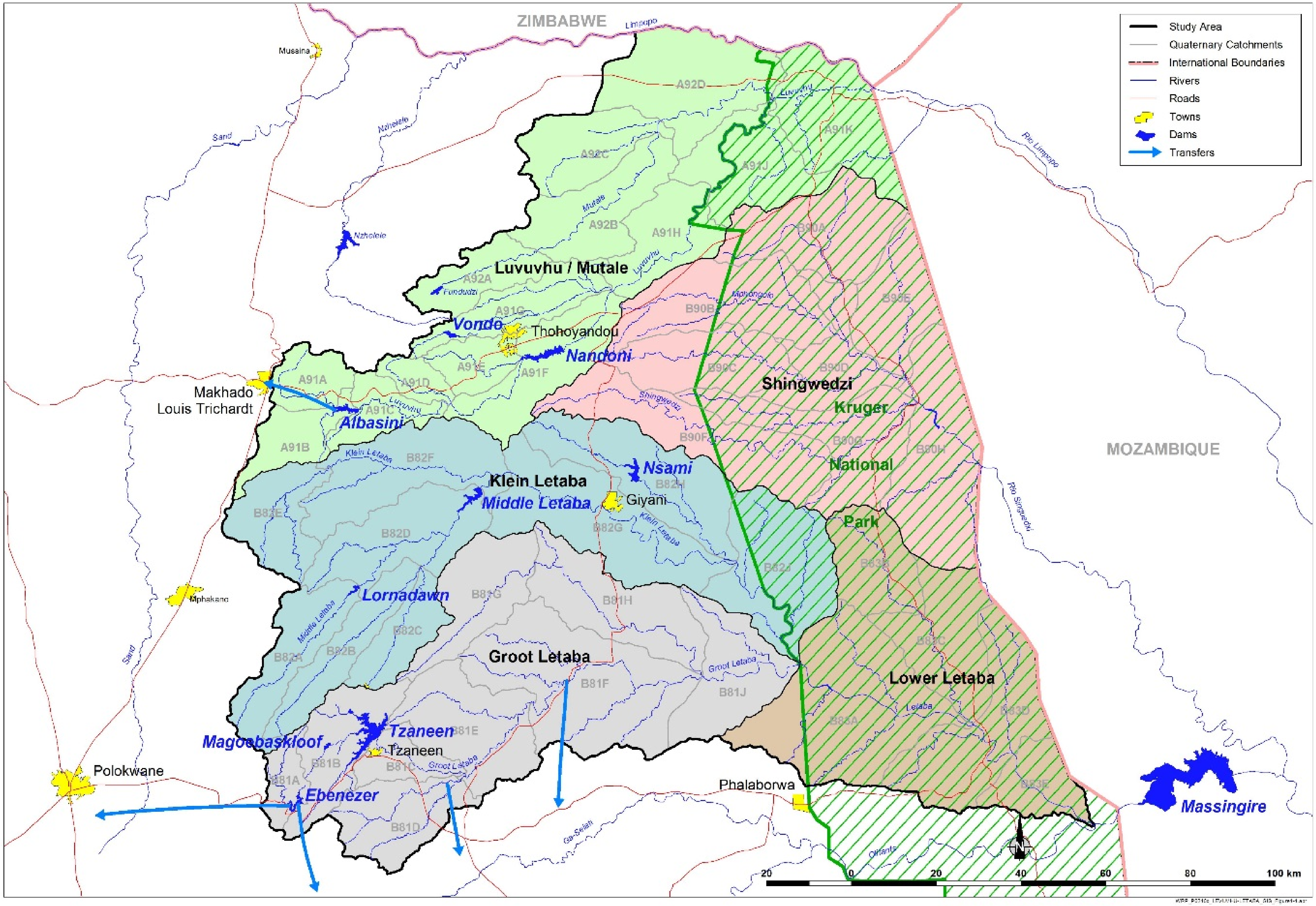
Appendix A

Maps


ZIMBABWE
MOZAMBIQUE
Study Area
Quaternary Catchments
International Boundaries
Rivers
Roads
Towns
Dams
Transfers
Luvuvhu / Mutale
Shingwedzi
Klein Letaba
Groot Letaba
Lower Letaba
Kruger
National
Park
Vondo
Nandoni
Albasini
Nsami
Middle Letaba
Lornadawn
Tzaneen
Magoebaskloof
Ebenezer
Massingire
Thohoyandou
Makhado
Louis Trichardt
Giyani
Tzaneen
Polokwane
Phalaborwa
Musina
A92D
A92C
A92B
A92A
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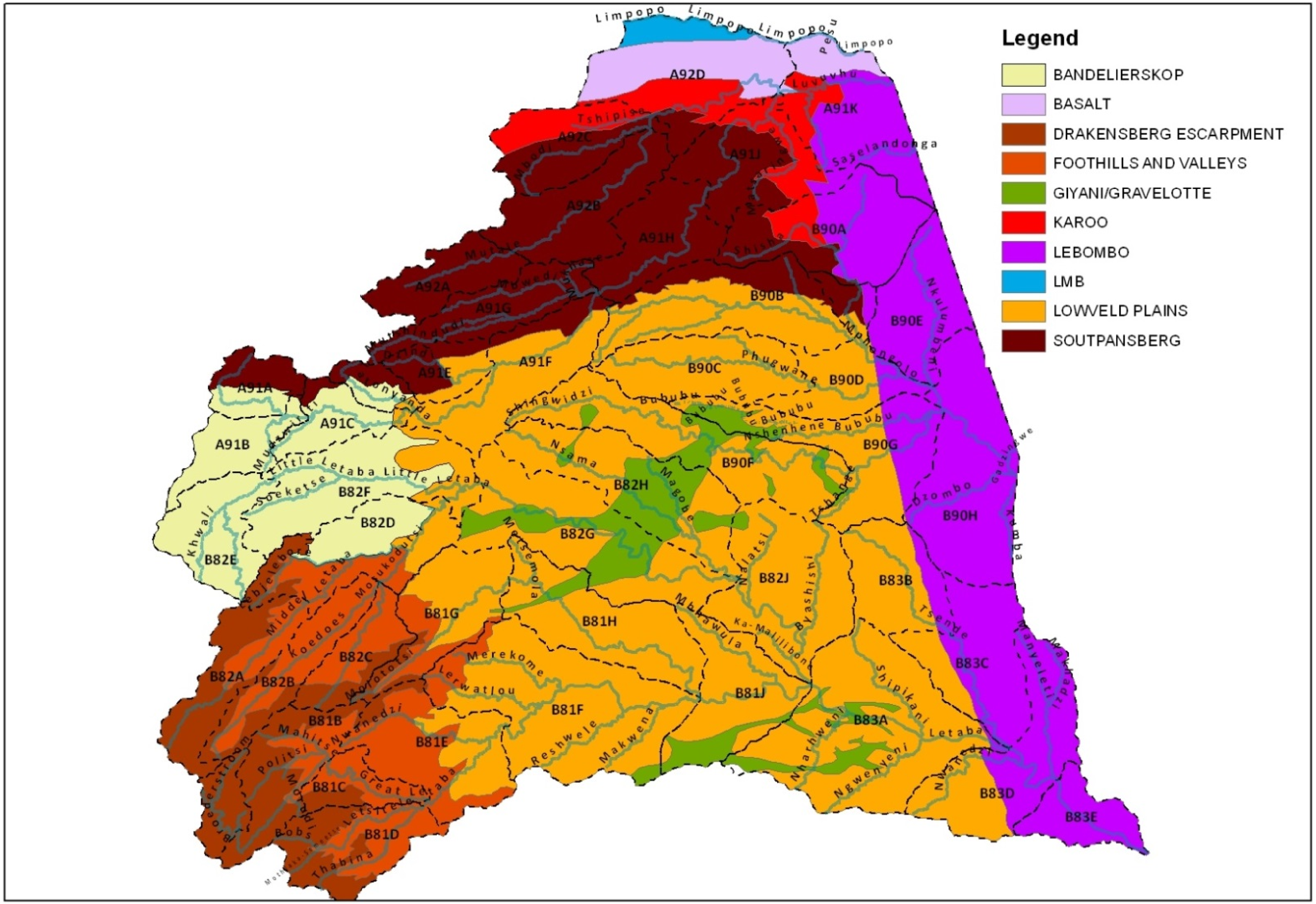
20
0
20
40
60
80
100 km

Groundwater Response Units



Rural water supply schemes