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# Groundwater Reserve Determination Study in the Thukela Catchment: High level assessment

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# DEFINITIONS



# List of Geohydrological and Reserve Terminology

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**ABSTRACTION:** the removal of water from a resource, e.g. pumping groundwater from an aquifer.

**ALLUVIAL AQUIFER:** an aquifer formed by unconsolidated material deposited by water, typically occurring adjacent to river channels and in buried or palaeochannels.

**ALLUVIUM:** a general term for unconsolidated deposits of inorganic materials (clay, silt, sand, gravel, boulders) deposited by flowing water.

**AQUATIC:** associated with and dependent on water, e.g. aquatic vegetation.

**AQUATIC ECOSYSTEMS:** not defined by the National Water Act (Act No. 36 of 1998), but defined elsewhere as the *abiotic* (physical and chemical) and *biotic* components, habitats and ecological processes contained within rivers and their riparian zones and reservoirs, lakes, wetlands and fringing vegetation.

**AQUIFER:** a geological formation, which has structures or textures that hold water or permit appreciable water movement through them [from National Water Act (Act No. 36 of 1998)].

**AQUIFER SYSTEM:** a heterogeneous body of intercalated permeable and less permeable material that acts as a water-yielding hydraulic unit of regional extent.

**AQUIFER TESTING:** the process whereby an aquifer is subjected to pumping from a borehole under controlled test conditions in order to determine the hydraulic parameters of the groundwater system through its response to the stress of abstraction.

**ARTESIAN BOREHOLE:** commonly used to describe a flowing borehole, where the piezometric level is at an elevation higher than ground level.

**AVAILABLE DRAWDOWN:** the height of water above the depth at which the pump is set in a borehole at the time of water level measurement (m).

**BANK STORAGE:** water that percolates laterally from a river in flood into the adjacent geological material, some of which may flow back into the river during low-flow conditions.

**BASEFLOW:** sustained low flow in a river during dry or fair weather conditions, but not necessarily all contributed by groundwater; includes contributions from delayed interflow and groundwater discharge.

**BASIC HUMAN NEED:** the least amount of water required to satisfy basic water requirements; this is currently set at 25 ℓ/cap-d.

**BOREHOLE:** includes a well, excavation, or any other artificially constructed or improved groundwater cavity that can be used for the purpose of intercepting, collecting or storing water from an aquifer; observing or collecting data and information on water in an aquifer; or recharging an aquifer [from National Water Act (Act No. 36 of 1998)].

**BRACKISH:** water that contains between 1 000 and 10 000 mg/ℓ of dissolved solids.

**CATCHMENT:** the area from which any rainfall will drain into the watercourse, contributing to the run-off at a particular point in a river system; synonymous with the term *river basin*.

**COMPREHENSIVE RESERVE ASSESSMENT:** an assessment of the Reserve based on detailed data and observation; may include numerical modelling; also referred to as a full Reserve assessment.

**CONE OF DEPRESSION:** the cone-shaped area around a borehole that results from lowering the water table or piezometric surface by abstraction.

**CONFINED AQUIFER:** an aquifer overlain by a confining layer of significantly lower hydraulic conductivity in which groundwater is under greater pressure than that of the atmosphere; also known as an artesian aquifer.

**CONJUNCTIVE USE:** combined use of surface and groundwater.

**DESIRED ECOLOGICAL STATUS:** the future desired status of groundwater within the resource unit as used in setting the groundwater component of the ecological Reserve.

**DISCONNECTED STREAM:** a stream detached from and not in hydrological contact with the groundwater system below; a special case of an influent stream; also referred to as a detached stream.

**DISSOLVED SOLIDS:** minerals and organic matter dissolved in water.

**DRAWDOWN:** the difference between the observed groundwater level during pumping and the non-pumping or rest groundwater level in a borehole.

**ECOLOGICAL WATER REQUIREMENT:** This term is widely used for both rivers and estuaries when referring to both quantity and quality requirements. When referring to river quantity, the term *Inflow Stream Requirement* is used.

**ECOREGIONS:** regions within which there is a relative similarity in the mosaic of ecosystems and ecosystem components (*biotic* and *abiotic*, *aquatic* and *terrestrial*).

**ECOSYSTEM:** an organic community of plants, animals and bacteria and the physical and chemical environment they inhabit.

**EPHEMERAL RIVERS:** these rivers are generally storm-event driven and flow occurs less than 20% of the time; these rivers have a limited (if any) baseflow component with no groundwater discharge.

**ESTUARY:** a partially or fully enclosed body of water, that is open to the sea permanently or periodically, and within which the sea water can be diluted, to an extent that is measurable, with fresh water drained from the land [from National Water Act (Act No. 36 of 1998)].

**EVAPOTRANSPIRATION:** the loss of moisture from the combined effects of direct evaporation from land and sea and transpiration from vegetation.

**EXPLOITATION POTENTIAL:** the rate at which groundwater can be withdrawn from a catchment without causing any detrimental impacts.

**FAULT:** a zone of displacement in rock formations resulting from forces of tension or compression in the earth's crust.

**FORMATION:** a general term to describe a sequence of rock layers.

**FRACTURE:** cracks, joints or breaks in the rock that can enhance water movement.

**FRACTURED AQUIFER:** an aquifer that owes its water-bearing properties to fracturing caused by folding and faulting; see *secondary aquifer*.

**GEOHYDROLOGY:** the study of the properties, circulation and distribution of groundwater; in practice used interchangeably with hydrogeology; but in theory *hydrogeology* is the study of geology from the perspective of its role and influence in hydrology, while *geohydrology* is the study of hydrology from the perspective of the influence on geology.

**GROUNDWATER:** water found in the subsurface in the saturated zone below the water table or piezometric surface, i.e. the water table marks the upper surface of groundwater systems.

**GROUNDWATER CONTRIBUTION TO BASEFLOW OR RIVER FLOW:** that groundwater that discharges into effluent streams and sustains baseflow.

**GROUNDWATER FLOW:** the movement of water through openings and pore spaces in rocks below the water table, i.e. in the saturated zone.

**GROUNDWATER RESOURCE UNIT:** a groundwater body that has been delineated or grouped into a single significant water resource based on one or more characteristics that are similar across that unit; also referred to as a *groundwater unit*.

**HARVEST POTENTIAL:** maximum amount of groundwater that can be abstracted per square kilometer per annum without depleting the aquifers.

**HYDRAULIC CONDUCTIVITY:** measure of the ease with which water will pass through earth material; defined as the rate of flow through a cross-section of one square metre under a unit hydraulic gradient at right angles to the direction of flow (in m/d).

**HYDRAULIC GRADIENT:** the slope of the water table or piezometric surface. It is a ratio of the change of hydraulic head divided by the distances between the two points of measurement.

**HYDROGRAPH:** a graphical plot of hydrological measurements over a period of time, e.g. water level, flow, discharge.

**INFLUENT RIVER:** water is discharged from the river into the groundwater system.

**INFLUENT STREAM:** a *losing stream* above the water table that discharges into the underlying groundwater system; opposite of *effluent stream*.

**INSTREAM FLOW REQUIREMENTS:** Also referred to as the “ecological flow component of the Reserve”. The flow patterns (magnitude, timing and duration) required to maintain a riverine ecosystem in a particular condition.

**INTERFLOW:** the rapid flow of water along essentially unsaturated flow paths, water that infiltrates the subsurface and moves both vertically and laterally before discharging into other water bodies.

**INTERMITTENT RIVER:** conditions range seasonally between discharge from the river into the groundwater system and discharge from the groundwater system into the river; not to be confused with an *ephemeral river*.

**LATRINE:** a pit used for the disposal of human excreta, particularly prevalent in rural areas.

**LITHOLOGY:** the physical character of rocks.

**LOW FLOW:** The low flow component of the flow regime, determined graphically from time series of flows.

**MAINTENANCE FLOW:** The flow required to meet the requirements of the riverine ecosystem at a particular site and maintain the resource base in a particular condition, or Ecological Class during “normal” climatic years, as opposed to “drought” years.

**MAJOR AQUIFER SYSTEM:** highly permeable formations, usually with a known or probable presence of significant fracturing; may be highly productive and able to support large abstractions for public supply and other purposes; water quality is generally very good.

**MINOR AQUIFER SYSTEM:** fractured or potentially fractured rocks that do not have a high primary permeability, or other formations of variable permeability; aquifer extent may be limited and water quality variable. Although these aquifers seldom produce large quantities of water, they are important both for local supplies and supplying base flow for rivers.

**PERCHED AQUIFERS:** aquifers that contain perched groundwater, i.e. bodies of groundwater separated from an underlying body of groundwater by an unsaturated zone.

**PERCHED SPRINGS:** springs fed by water in the unsaturated zone and interflow.

**PERENNIAL:** lasting through a year or several years, i.e. a river that flows all year round or a wetland that remains wet all year round.

**PIEZOMETRIC LEVEL:** the elevation to which groundwater levels rise in boreholes that penetrate confined or semi-confined aquifers.

**PIEZOMETRIC SURFACE:** an imaginary surface representing the piezometric pressure or hydraulic head throughout all or part of a confined or semi-confined aquifer; analogous to the *water table* of an *unconfined aquifer*.

**POLLUTION:** the introduction into the environment of any substance by human action that is, or results in, significant harmful effects to man or the environment.

**POTABLE WATER:** water that is safe and palatable for human use.

**PRESENT ECOLOGICAL CLASS:** current status of groundwater within the resource unit as used in setting the groundwater component of the ecological Reserve.

**PRISTINE:** remaining in a pure or natural state.

**QUATERNARY CATCHMENT:** a fourth-order catchment in a hierarchal classification system in which a primary catchment is the major unit.

**RADIUS OF INFLUENCE:** the maximum extent of the *cone of depression*.

**RECHARGE:** the addition of water to the zone of saturation, either by the downward percolation of precipitation or surface water and/or the lateral migration of groundwater from adjacent aquifers.

**RECHARGE AREA:** an area over which recharge occurs.

**RESERVE:** the quantity and quality of water required to supply the basic needs of the people to be supplied with water from that resource, and to protect aquatic ecosystems in order to secure ecologically sustainable development and the use of water resources.

**RESOURCE:** a substance or item available for use. A natural resource is a resource that man can use, but not manufacture or create.

**RESOURCE QUALITY:** the quality of all aspects of a water resource, including (a) the quality, pattern, timing, water level and assurance of instream flow, (b) the water quality, including the physical, chemical and biological characteristics of water, (c) the characteristic and condition of the instream and riparian habitat, and (d) the characteristics, condition and distribution of aquatic biota.

**RESOURCE QUALITY OBJECTIVE:** Resource Quality Objectives are used to put a Classification and Reserve into practice by specifying conditions that will ensure that the Class is not compromised and the Reserve can be met. Resource quality may relate to critical flows, groundwater levels and quality that must be maintained. The objectives are to articulate goals that result from the catchment visioning process, but must be based on DWAF policy statements and methodologies, and aligned with the National Water Resource Strategy.

**RESOURCE UNITS:** areas of similar physical or ecological properties that is grouped or typed to simplify the Reserve determination process.

**REST WATER LEVEL:** the groundwater level in a borehole not influenced by abstraction; synonymous with *static water level*, but no groundwater levels are ever truly static, as they continually respond to recharge, discharge and abstraction.

**RIPARIAN:** area of land directly adjacent to a stream or river, influenced by stream-induced or related processes.

**RIVER:** a physical channel in which run-off will flow; generally larger than a *stream*, but often used interchangeably.

**RUNOFF:** all surface and subsurface flow from a catchment, but in practice refers to the flow in a river, i.e. excludes groundwater not discharged into a river.

**SAFE YIELD:** amount of water that can be withdrawn from an aquifer without producing an undesired effect.

**SALINE INTRUSION:** replacement of fresh water by saline water in an aquifer, usually as a result of groundwater abstraction.

**SANITATION:** the treatment and disposal of waste from the human body and grey water generated through household activity.

**SATURATED ZONE:** the subsurface zone below the water table where interstices are filled with water under pressure greater than that of the atmosphere.

**SEASONAL RIVER:** these rivers are driven by seasonal rainfall patterns and flow occurs between 20% and 80% of the time. These rivers have a limited baseflow component with little or no groundwater discharge.

**SEMI-CONFINED AQUIFER:** an aquifer that is partly confined by layers of lower permeability material through which recharge and discharge may occur; also referred to as a *leaky aquifer*.

**SIGNIFICANT WATER RESOURCES:** used but not defined by the National Water Act (Act 36 of 1998); relates to the size of the water resource rather than its importance; a resource is deemed significant if it is large enough to warrant its own Reserve determination.

**SOIL:** the usually thin upper surface layer of the earth's crust, comprising living organisms, organic matter, decomposed rock or unconsolidated sediments, water and gases with properties attributable to the interaction of its parent material, time, climate, fauna and flora.

**SOLE SOURCE AQUIFERS:** an aquifer that supplies 50% or more of the domestic water for a given area, and for which there are no reasonably available alternative water sources, should the aquifer be impacted upon or depleted.

**SPECIFIC YIELD:** ratio of the volume of water that a given mass of saturated rock or soil will yield by gravity from that mass.

**SPRING:** a point where groundwater emerges, usually as a result of topographical, lithological or structural controls.

**STATIC WATER LEVEL:** see *rest water level*

**STORAGE COEFFICIENT:** the volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head.

**STORMFLOW:** increased run-off in a river or stream associated with a particular rainfall event or storm; includes contributions from *channel precipitation*, *quickflow* and *rapid interflow*.

**STREAM:** a small narrow river; often used interchangeably with *river*.

**STRESSED AQUIFER:** not defined by the National Water Act (Act No. 36 of 1998), but using the stress index presented in this manual, an aquifer is said to be stressed when at least 65% of estimated recharge is abstracted from that aquifer.

**SURFACE RUN-OFF:** that part of the total run-off that travels over the ground surface to reach a stream or river channel.

**TRANSMISSIVITY:** the rate at which a volume of water is transmitted through a unit width of aquifer under a unit hydraulic head ( $m^2/d$ ); product of the thickness and average hydraulic conductivity of an aquifer.

**UNCONFINED AQUIFER:** an aquifer with no confining layer between the water table and the ground surface where the water table is free to fluctuate.

**UNSATURATED ZONE:** that part of the geological stratum above the water table where interstices and voids contain a combination of air and water; synonymous with *zone of aeration* or *vadose zone*.

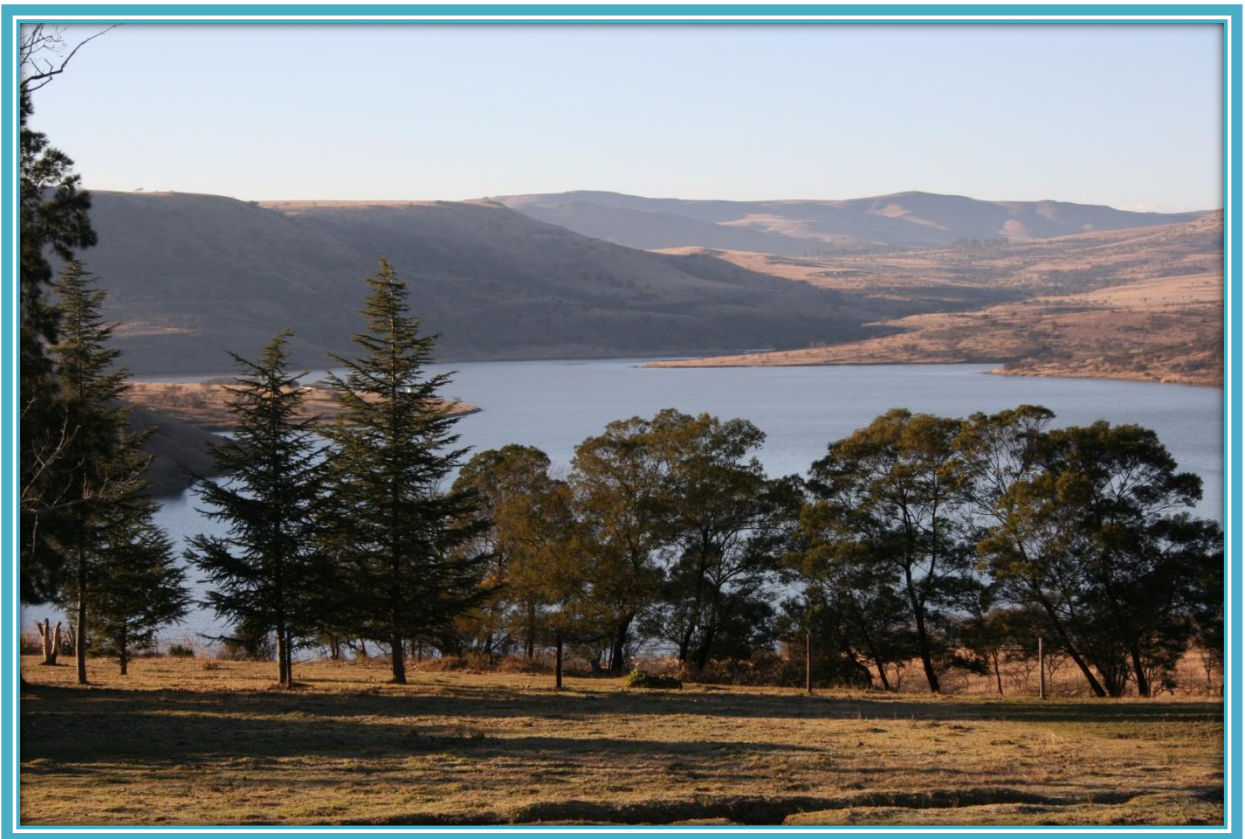
**VULNERABILITY:** the tendency or likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer.

**WATER TABLE:** the upper surface of the saturated zone of an unconfined aquifer at which pore pressure is at atmospheric pressure, the depth to which may fluctuate seasonally.

**WELL FIELD:** a group of boreholes in a particular area usually used for groundwater abstraction purposes.

**WETLAND:** land that is transitional between terrestrial and aquatic systems, where the *water table* is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated *soil* [from National Water Act (Act No. 36 of 1998)].

# SUMMARY OF THE SURFACE WATER RESERVE



# Summary of Surface Water Reserve

## 33.1 Background

The IWR Source-to-Sea was responsible for the surface water Reserve in the Thukela River Catchment. This Chapter contains extracts of the reports generated by IWR Source-to-Sea in 2004.

## 33.2 Delineation of Resource Units

The Thukela system is the second largest South African river (in terms of Mean Annual Run-off (MAR)), and the main stem of the Thukela River alone is approximately 500km long. In order to study this extensive system, it is necessary to divide it into manageable units on the basis of physical and biological criteria. The major units are termed Resource Units (RUs) and are measured on a scale of kilometres. Each RU is delineated on the basis of having sufficiently unique physical or biological characteristics to set it apart from the other RUs and to warrant its own RD. Within the Resource Units, IFR sites are selected, and these form the study sites at which the quantity component of the Ecological Reserve is determined. These are measured at a scale of metres. The breakdown of a catchment into RUs for the purpose of determining the Reserve for rivers is primarily determined on a biophysical basis, according to the occurrence of different ecological regions (eco-regions) within the catchment, as supplied by DWAF. Since the endpoint of an RD is an ecological one, the idea is to divide the catchment into individual units that are relatively homogenous (from end to end) on an ecological basis. The RUs are shown in Figure 1 and Figure 2. The river sections are homogenous in terms of water quality, and form water quality subunits. Each RU may have more than one Quality Resource Unit (QRU). The selection of QRUs is influenced by activities in the catchment, the availability of water quality data, and the length of the data series.

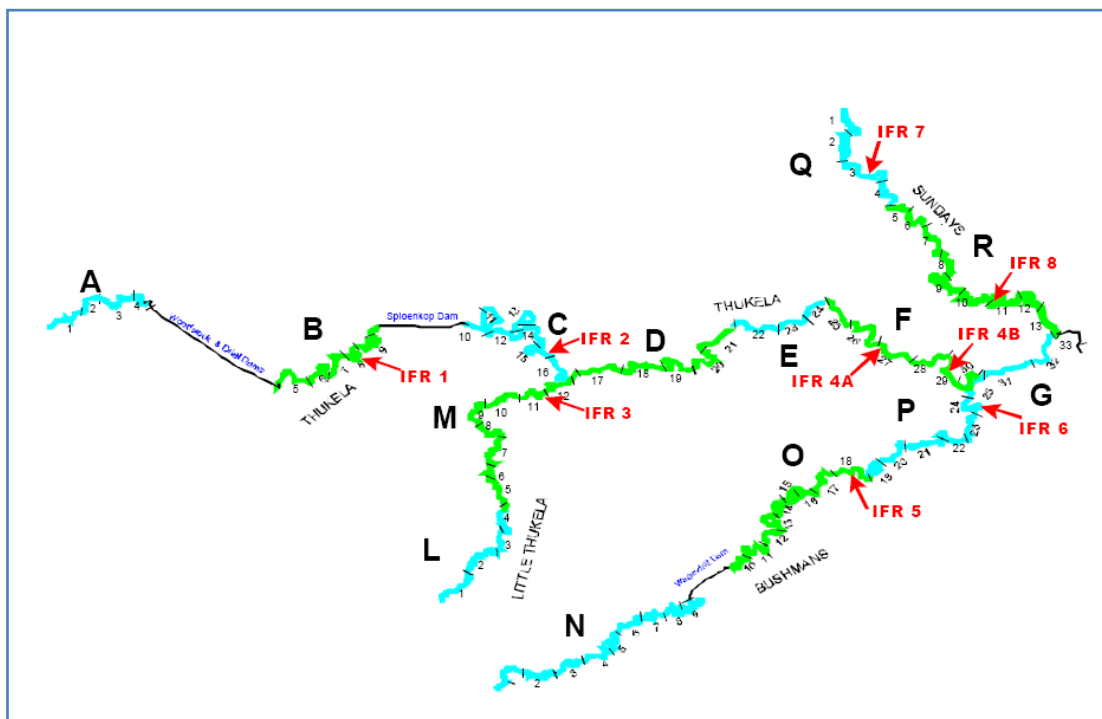


Figure 1: RUs in the Upper Thukela study area

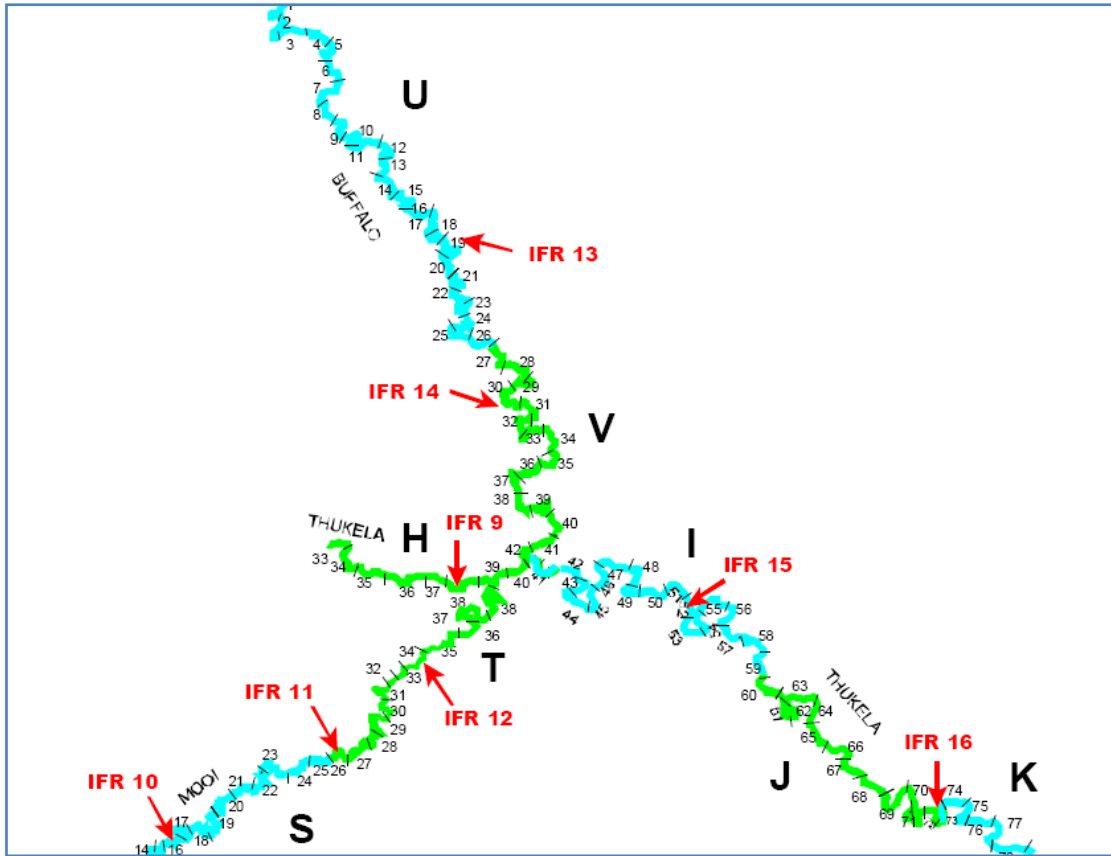


Figure 2: RUs in the Lower Thukela study area

The QRUs identified are documented in Table 1 and Table 2.

Table 1: Resource Units, QRUs and information for the Upper Thukela catchment

Upper Thukela River Catchment: Thukela River			
QRU no.	Segment no. (RU)	Description	Monitoring point data available and used for assessing RC + PES
Q1	1 – 4 (A)	Rugged Glen to upstream of Woodstock and Driel Dams	DWAF mon. points V1H035 (RC) and V1H036 (PES)
Q2	5 – 7 (B)	Woodstock and Driel Dams to upstream of Bergville.	DWAF mon. points V1H058 (data no suitable).
Q3	7 – 9 (B)	Bergville to upstream of Spioenkop Dam .	DWAF mon. points V1H026 (PES) and V1H031. <i>Combine QRUs 2 and 3, and use V1H035 from QRU 1 for RC.</i>
Q4	10 – 16 (C)	Spioenkop Dam to upstream of Thukela – Little Thukela confluence	DWAF mon. points V1H035 (RC) and V1H036 (PES)
Q5	17 – 20 (D)	Thukela – Little Thukela confluence to upstream of Colenso.	No water quality data. <i>Combine QRUs 5 and 6.</i>
Q6	21 – 24 (D, E)	Colenso to upstream of Thukela – Klip River confluence near Ladysmith.	DWAF mon. point V1H001 (RC and PES) at Colenso
Q7	25 – 29 (F)	Thukela – Klip River confluence to upstream of the Thukela – Bloukrans confluence.	There are no DWAF mon. points in the segment. DWAF data on the Klip River will therefore be used, i.e. V1H038 just upstream of Thukela – Klip River confluence. It is important to acknowledge the dilution effects when the Klip and Thukela Rivers join. WQ site 5 data (PES) is also available for the stretch below the Klip confluence and above the Bloukrans confluence with the Thukela River.
Q8	29 – 30 (F)	Thukela –Bloukrans confluence to	No water quality dat. <i>Combine QRUs 7 and 8.</i>

		upstream of the Thukela – Bushmans confluence.	
Q9	31 -33 (G)	Thukela – Bushmans confluence to upstream of Thukela – Sundays confluence.	No water quality data. <i>Combine with QRU 10.</i> There is also a significant short tributary called the Sikhehlengeni River in this reach.
<b>Upper Thukela River Catchment: Little Thukela River</b>			
QRU no.	Segment no. (RU)	Description	Monitoring point data available and used for assessing RC + PES
Q14	1-9 (L, M)	Wonder Valley to upstream of Winterton.	No water quality data. <i>Combine with QRU 15.</i>
Q15	10-12 (M)	Winterton to the confluence of the Little Thukela and Thukela Rivers.	DWAF mon. point V1H010 (RC and PES).
<b>Upper Thukela River Catchment: Bushmans River</b>			
Q16	1-9 (N)	Elands Park to upstream of Wagendrift Dam.	DWAF mon. points V7H016 on the Ncibidwane River (a tributary of the Bushmans, joining it at segment 2), and V7H017 (RC and PES) on the Bushmans River, at the confluence with the Ncibidwane.
Q17	10-11 (O)	Wagendrift Dam to upstream of the Little Bushmans River – Bushmans River confluence (including Estcourt).	DWAF mon. points V7H018 and V1H012 (at Estcourt, PES) on the Little Bushmans River. V7R001 at the outlet of Wagendrift Dam (RC due to setting in dam).
Q18	12-20 (O, P)	Little Bushmans River – Bushmans River confluence to upstream of Weenen.	No water quality data. <i>Combine with QRU 19.</i>
Q19	21-25 (P)	Weenen to the confluence of the Bushmans and Thukela Rivers.	There are no DWAF monitoring points in this segment. Use WQ site 4 (PES) data.
<b>Upper Thukela River Catchment: Sundays River</b>			
Q20	1-6 (Q, R)	Sundays River from the Ladysmith/Newcastle road to upstream of the Wasbank – Sundays River confluence.	DWAF mon. point V6H006 (above study area, RC) and V6H004 (segment 2, PES).
Q21	7-13 (R)	Wasbank – Sundays River confluence to the confluence of the Sundays and Thukela Rivers.	DWAF mon. point V6H003 on the Wasbank River, WQ site 3 (PES) on the lower Sundays River (around IFR 8). Use V6H006 or RC (as for QRU 20).

**Table 2: Resource Units, QRUs and information for the Lower Thukela catchment**

<b>Lower Thukela River Catchment: Thukela River</b>			
QRU no.	Segment no. (RU)	Description	Monitoring point data available and used for assessing RC + PES
Q10	34 -39 (H)	Thukela – Sundays confluence to upstream of Thukela – Mooi River confluence.	DWAF mon. point V6H002 (RC and PES) at Tugela Ferry.
Q11	39-41 (H, I)	Thukela – Mooi River confluence to upstream of Thukela – Buffalo river confluence.	No water quality data. <i>Combine with QRU 12.</i> Use WQ site 1 (PES) at Jameson’s Drift.
Q12	42-73 (I,J)	Thukela – Buffalo River confluence to upstream of the Mandini/Sundumbili industrial complex.	DWAF mon. point V5H002 (RC and PES) (Segments 52 – 73).
Q13	74 – estuary at 78 (K)	Mandini/Sundumbii industrial complex to the Thukela estuary	DWAF mon. point V5H002 (segment 73-74) and water quality data from Sappi Tugela. Note: This QRU is not covered in the water quality section, as dealt with as part of the estuarine assessment.
Q22	1-15 (S)	Beginning of study area to upstream of Mooi River town	DWAF mon. point V2H006 on the Little Mooi River and V2H005 (RC and PES on the Mooi River).
Q23	16-30 (S, T)	Mooii River Town to upstream of Mudén.	DWAF mon. point V2H004 (PES) at Mooi River town, and V2H04 on segment 26 (around IFR 11). Use V2H005 for RC (as for QRU

			22).
Q24	30-38 (S, T)	Muden to the confluence of the Mooi and Thukela Rivers.	DWAF mon. point V2H008 (PES) at Keate's Drift. Use V2H005 for RC (as for QRU 22 and 23).
<b>Lower Thukela River Catchment: Mooi River</b>			
Q25		Above the study area, including the Newcastle industrial area, the Ncandu and Ngagane tributaries of the Buffalo River Osizweni and Madendeni.	DWAF mon. point V3 h009 on the Hom River, a tributary of the Ngagane River and V3H027 on the Ngagane River. No RC point, therefore default to benchmark tables. Use V3H011 (blood River) for PES.
Q26	1-42 (U, V)	From the Utrecht – Osizweni road bridge to the confluence of the Buffalo and Thukela Rivers (area includes IFR 13 and 14).	No DWAF monitoring data available; use WQ site 2 (PES), around IFR 14. Use V3H011 for RC.

### 33.3 Determination of IFR sites

IFR sites are critical points within individual RUs, and must meet certain criteria. A sequential process is followed to determine the IFR sites. The sites were selected on the basis of the aerial habitat assessment video and groundtruthed through site visits. Seventeen sites were selected; nine in the Upper Thukela and eight in the lower Thukela (Figure 1 and Figure 2).

### 33.4 Basic Human Need Requirements (BHNRS)

The BHNRS has been generated by following a number of steps. The first step was to use demographic data supplied by the Directorate Water Services: DWAF as a basis for analysis. The base information supplied by DWAF was adjusted data from the 1996 census. This data source utilised information collected at an enumerator area (EA) level. The EA is the most fine-grained demographic information available. The EA data for the purposes of this study were further broken down to reflect the likely direct users of the surface water resources of the Thukela. This involved demarcating a 5 km buffer zone on either side of the Thukela and its major tributaries. For the purpose of this exercise, and in keeping with the Thukela Reserve Determination Study, the relevant river reaches were those defined as the Thukela, Little Thukela (Injasuthi), Bushmans (Mchezi), Buffalo (Mzinyathi), Sundays and Mooi Rivers. It was assumed that people outside of this area, although they might be making use of water from the rivers via a formal urban supply or a community water supply scheme, would mainly be using springs, minor streams or groundwater.

The analysed data are presented in Table 3 and Table 4. These tables are based on the entire population of the Thukela catchment, i.e. in an area greater than the 5km buffer zone already discussed. Table 3 and Table 4 consider the likely water needs of the population of the catchment in its entirety. Scenarios are presented for the currently accepted RDP norm of 25l per capita per day, as well as more liberal allowances of 60l and 100l per day. In addition, the population growth is projected up to 2020. It should be noted that accurately projecting population growth is problematic, given the uncertainty around the impact of HIV/AIDS. Figure 3 illustrates the population within the Thukela Catchment. In order to err on the side of caution, a 1.5% per annum population growth rate was allowed for. Current estimates are that many rural areas, and the Thukela catchment is predominately rural, will have a zero or even a negative growth rate over the medium term.

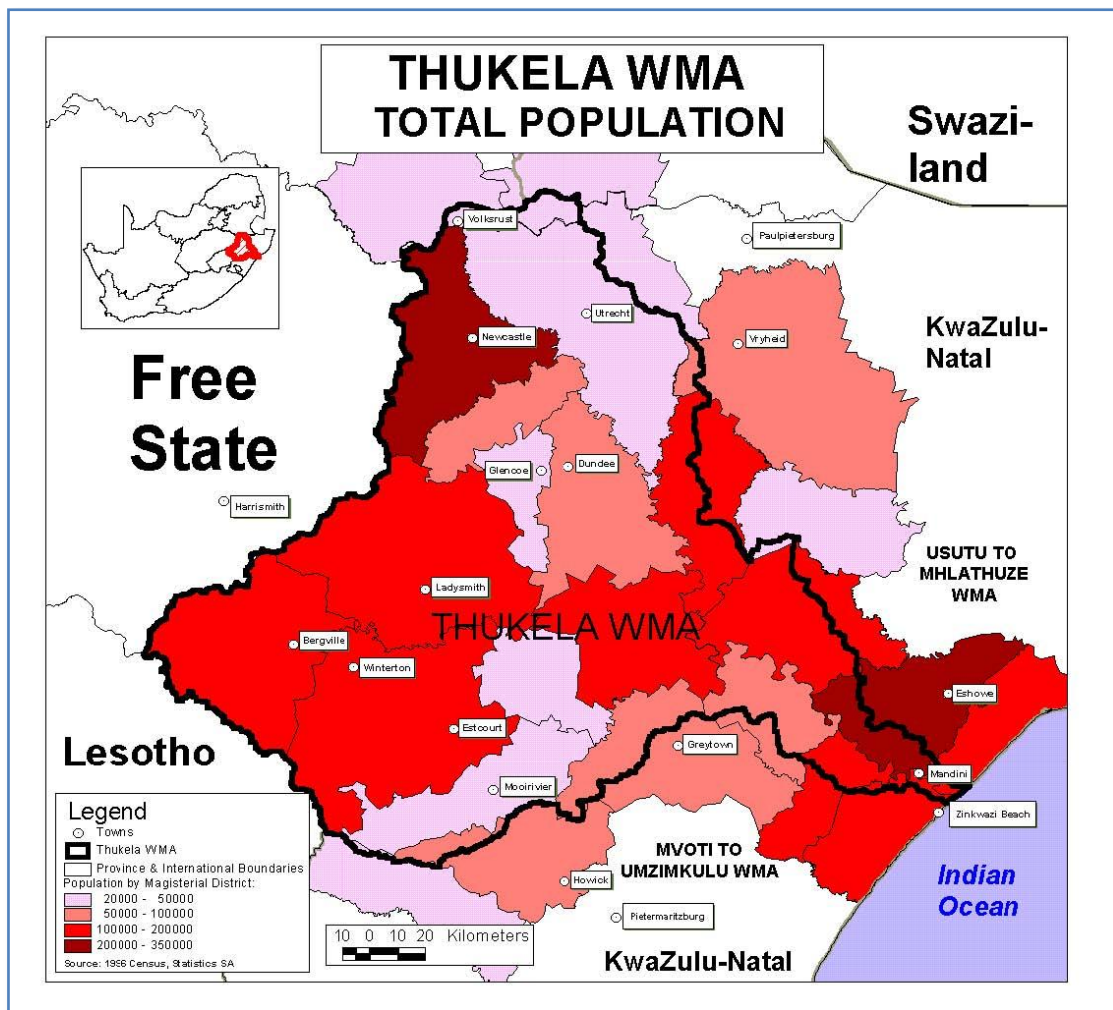


Figure 3: Population distribution in the Thukela WMA

Table 3: Annual potential BHNr in the entire catchment expressed in MCM

Year	2001	2005	2010	2015	2020
Population	1 567 246	1 663 418	1 791 973	1 930 464	2 079 658
Water use at 25l per capita per day	14.30	15.17	16.35	17.61	18.97
Water use at 60l per capita per day	34.32	36.42	39.24	42.27	45.54
Water use at 100l per capita per day	57.20	60.71	65.40	70.46	75.90

**Table 4: Analysis of water demand by settlement type**

Year	2001	Water need in MCM per annum	2010	Water need in MCM per annum	2020	Water need in MCM per annum
Settlement	Population		Population		Population	
Rural village	291214	2.66	329723	6.02	338049	12.34
Scattered rural	876548	8.00	944524	8.62	944524	8.62
Urban	312478	22.81	380909	27.81	464326	33.90
Peri-urban	87066	3.18	106133	5.81	129375	9.44
Total population	1567306		1761289		1876274	
Total water needs		36.64		48.25		64.30

Table 4 examines the total population of the catchment in more detail. In Table 5, the population in the catchment is disaggregated into four logical categories of settlement. These are rural villages (18.6% of the population of the catchment), scattered rural settlement (55.9%), urban (19.9%) and peri-urban (5.6%). Growth rates are applied to each category, based on current, settlement-based projections. These projections consider a fairly high growth rate of 2% for the urban and peri-urban areas over the next 20 years. A lower growth rate starting at 1.5% and declining to nil is considered for rural areas. This is in keeping with trends towards urbanisation, and taking into account the expected impacts of AIDS. Figures for the total catchment differ fairly substantially from those presented in Table 3. By the year 2020, a more fine-grained analysis predicts a population of 1.87 million people, whereas the coarse-grained analysis, as summarised in Table 3, predicts a population of 2.07 million. Table 5 allows for different water demand and consumption levels. A per capita allowance of 200l/c/d has been allocated for urban areas. The peri-urban areas start with an allowance of 100l/c/d at present, growing to 200l/c/d per person per day by the year 2020. This would be consistent with a “high road” scenario, assuming electrification and increasing in prosperity in these areas, leading to the purchase of appliances using larger volumes of water, such as washing machines. Rural villages start with 25l/c/d, increasing to 50l/c/d per person per day by the year 2010, and 100l/c/d by 2015. This again assumes a growth in prosperity and village electrification. Scattered rural areas retain a 25l/c/d allocation for the entire period under consideration. This is based on the assumption that they will probably never have house connections, and experience shows that the effort involved in transporting water from stand pipes or protected springs caps consumption at about 25l/c/d.

Table 5 presents the summarised estimates for the areas within the 5km buffer zone, as already defined. The total population living within the 5km buffer zone in 2001 is calculated at 715281 or 45.6% of the total population at the catchment. A per capita allowance of 200l/c/d has been allocated for urban areas. The peri-urban areas start with an allowance of 100l/c/d at present, increasing to 200l/c/d per person per day by the year 2020. Rural villages start with 25l/c/d, increasing to 50l/c/d per person per day by the year 2010, and 100l/c/d by 2015. Scattered rural areas retain a 25l/c/d allocation for the entire period under consideration. Table 5 reflects the probable demand pattern for those living within the buffer zone and dependent upon river flow. It is not, however, necessarily a BHNR, as the amounts applied to some of the settlement types probably exceed the amounts that could be defined as making up a basic human need.

For those living outside the buffer zone, it is assumed that groundwater is probably of great importance. It is estimated that the current groundwater abstraction for BHNR is in the region of 18 MCM/a. According to this estimate, the population outside the buffer zone uses approximately 57l/c/d.

**Table 5: Water demand for 5 km buffer zone (expressed in MCM/a)**

Year	2001	Annual water need	2010	Annual water need	2020	Annual water need
Settlement	Population		Population		Population	
Rural village	87364	0.80	99741	1.82	101415	3.70
Scattered rural	316989	2.89	323169	2.95	323169	2.95
Urban	249982	18.25	304727	22.25	352968	25.77
Peri-urban	60946	2.22	90208	4.94	103500	7.56
TOTAL	715281	24.16	817845	31.95	881051	39.97

### **33.1 Classification of the Resource**

This section documents the results of the water quality and ecological classification. It follows the classification system documented in Section 2.3. Table 6 documents the water quality classification for each Quality Resource Unit (QRU) evaluated during the study.

The objective of the ecological classification step is to create an understanding of the Present Ecological State (PES) and the ecological functioning of the river in each of the Resource Units (RUs) and, based on this, to set realistic ecological aims/objectives for the river. The PES is derived from, or described as, deterioration from a described reference condition (that ideally relates to an A category condition). The degree of change is indicated by assigning a PES category to the RU from the range of categories provided in DWAF’s present classification system (i.e. A to F). The PES of the river is assessed for each of the following components: habitat (habitat integrity), biophysical (fish, riparian vegetation, aquatic invertebrates and geomorphology) and water quality (chemistry) integrity. Each component is assigned a category level (A -F).

**Table 6: Water quality classification**

QRU	Overall site classification for water quality	
	A – F system	Descriptive system
Resource Unit A <i>Thukela River (QRU 1)</i>	B	Good
Resource Unit B <i>Thukela River (QRU 2 &amp; 3)</i>	B/C	Lower Good
Resource Unit C <i>Thukela River (QRU 4)</i>	B	Good
Resource Unit D - E <i>Thukela River (QRU 5 &amp; 6)</i>	B	Good
Resource Unit F <i>Thukela River (QRU 7 &amp; 8)</i>	C	Upper Fair
Resource Unit G - H <i>Thukela River (QRU 9 &amp; 10)</i>	C	Upper Fair
Resource Unit I <i>Thukela River (QRU 11 &amp; 12)</i>	B/C	Lower Good
Resource Unit J <i>Thukela River (QRU 13)</i>	C	Upper Fair
Resource Unit L - M <i>Little Thukela River (QRU 14 &amp; 15)</i>	B/C	Lower Good
Resource Unit N <i>Bushmans River (QRU 16)</i>	B	Good
Resource Unit O <i>Bushmans River (QRU 17)</i>	B/C	Lower Good
Resource Unit P <i>Bushmans River (QRU 18 &amp; 19)</i>	B	Good
Resource Unit Q <i>Sundays River (QRU 20)</i>	C	Upper Fair
Resource Unit R <i>Sundays River (QRU 21)</i>	C	Upper Fair
Resource Unit R <i>Wasbank River (QRU -)</i>	C - C/D	Upper Fair - Fair
Resource Unit S <i>Mooi River (QRU 22)</i>	B	Good
Resource Unit S - T <i>Mooi River (QRU 23)</i>	B	Good
Resource Unit T <i>Mooi River (QRU 24)</i>	C	Upper Fair
Resource Unit U <i>Buffalo River (QRU 25)</i>	D	Lower Fair
Resource Unit V <i>Buffalo River (QRU 26)</i>	C/D	Fair

The ecological importance and sensitivity (EIS) of a river is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales. The Socio importance (SI) is also taken into account to recommend a final ecological category (EC) for the management of a system. The results of the ecological classification are documented in Table 7.

Table 7: Ecological classification

Dark blue = B; dark blue to light green = B/C; light green = C; light green to dark green = C/D; dark green = D

RU	PES	EIS	SI	EC
<b>THUKELA</b>				
A	B/C	Moderate	Moderate	B/C
B	D	Moderate	Low	D
C	C	Moderate	Moderate	C
D	C	Moderate	Moderate	C
E	B	Moderate	High	B
F	B/C	High	High	B (B/C)
G	C/D	Moderate/High	Moderate	C/D
H	D	Moderate	Moderate	D
I	C	High	High	C (C/D)
J	C/D	Moderate	Moderate	C/D (D)
Estuary	C	High	Moderate	C

RU	PES	EIS	SI	EC
<b>LITTLE THUKELA</b>				
L	C	Moderate	Moderate	C (C/D)
M	C/D	Moderate	Moderate	C/D (D)

RU	PES	EIS	SI	EC
<b>BUSHMANS</b>				
N	B/C	Moderate	Moderate	B/C
O	D	Moderate	Moderate	D
P	B/C	High	Moderate	B/C

RU	PES	EIS	SI	EC
<b>SUNDAYS</b>				
Q	C/D	High	High	C/D
R	D	Moderate	High	D

RU	PES	EIS	SI	EC
<b>MOOI</b>				
S	C	Moderate	Moderate	C
T	B/C	Moderate	High	B/C

RU	PES	EIS	SI	EC
<b>BUFFALO</b>				
U	D	Moderate	Moderate	D (D/E)
V	B/C	High	High	B (B/C)

### 33.2 Inflow Stream Requirements

The objective of this task was to provide flow regimes (IFR) for different sites in the rivers, to achieve a specific ecological state as described in Table 7. The IFR results are documented in Table 8.

Please note:

- % Long (Long-term percentage): This refers to the % of the natural MAR required to match the IFR time series generated by the IFR rules, i.e. including periods of drought, maintenance, between drought and maintenance and above maintenance flows.
- %Tot: the total maintenance IFR a percentage of natural MAR.
- % Low: This refers to the maintenance low flow IFR as a percentage of the natural MAR.

Table 8: IFR results

RU	IFR	LOWER SCENARIO				RECOMMENDED SCENARIO				UPPER SCENARIO				CONFIDENCE
		ERC	% Long	% tot	% low	ERC	% Long	% tot	% low	ERC	% Long	% tot	% low	
<b>LITTLE THUKELA RIVER</b>														
L		D				C				B				Low, extrapolated
M	3	D		18.6	6.1	C/D		24.7	11.1	B/C		42.8	21.4	IFR components: Med (low flow), med-high (high flow) Hydraulics: High MED (low flow), MED-HIGH (high flow)
<b>BUSHMENS RIVER</b>														
N		C/D	-	31.3	13.1	B/C	-	44.3	22	B	-	49.8	27.5	Low, extrapolated
O	5	C/D	37.5	32.7	13.3	B/C	47.4	45.4	22.4	-	-	-	-	IFR components: Med (low flow), med-high (high flow) Hydraulics: High MED (low flow), MED-HIGH (high flow)
P	6	C/D	-	32.1	13.1	B/C	-	44.7	22.2	-	-	-	-	Low, extrapolated
<b>SUNDAYS RIVER</b>														
Q	7	C/D	29.3	25.8	10.9	B/C	35.8	36.7	28.6	-	-	-	-	IFR components: Med Hydraulics: Med MED
R	8	-	-	-	-	D	24.1	19.6	6.8	C	29.5	28.7	13.1	IFR components: Med Hydraulics: High MED-HIGH (low flow), MED (high flow)
<b>MOOI RIVER</b>														
S	10	D	24.9	18.6	9	C	32.4	29.9	17.2	B	41.9	43.6	28.04	IFR components: Low-med to Med-high Hydraulics: Low (droughts), Med-high (low flow) LOW (droughts), MED (high flow)
T	11	C/D	27.2	23.5	12.4	B/C	35.4	36.3	22.1	B	39.5	42	27.7	IFR components: Med-high Hydraulics: Med-high MED-HIGH

RU	IFR	LOWER SCENARIO				RECOMMENDED SCENARIO				UPPER SCENARIO				CONFIDENCE
		ERC	% Long	% tot	% low	ERC	% Long	% tot	% low	ERC	% Long	% tot	% low	
<b>THUKELA RIVER</b>														
A		C/D	-	22	9.2	B/C	-	35.5	19.1	B	-	40.84	24.4	Low, extrapolated
B	1	-	-	-	-	D	22.3	17.3	7	C	31.7	29.9	14.9	IFR components: Med-high to high Hydraulics: Med-high MED-HIGH
C	2	D	22	18.2	4.2	C	29	27.4	11.1	B	37.5	38.5	19.2	IFR components: Med-low (low flow), med-high (high flow). Hydraulics: High. MED-LOW (low flow), MED-High (high flow)
D		D	-	19.1	6.1	C	-	24.8	10.5	B	-	35.1	18	Low, extrapolated
E		C	-	25.4	10.1	B	-	35.3	18	-	-	-	-	Low, extrapolated
F	4 *1	B/C	29	28.4	12.4	B	31.8	31.8	14.7	-	-	-	-	IFR components: Med-high Hydraulics: Med-high MED-HIGH
G		D	-	18.94	-	C/D	-	22.1	9	B/C	-	30.8	14	Low, extrapolated
H	9	-	-	-	-	D	24.3	20.3	6.1	C	28.2	27.8	12	IFR components: Med-low Hydraulics: Med-high MED-HIGH*2
I	15	D	22.7	18.2	6.2	C	27	25.5	12.6	-	-	-	-	IFR components: Med-high Hydraulics: Low (low flow), med-high (high flow) LOW (low flow), MED-HIGH (high flow)
J	16	D	29.6	23.7	8.4	C/D	32.6	28.4	11.4	B/C	36	36.1	18	IFR components: Med (low flow), med-high (high flow) Hydraulics: Med (drought), med-high (rest) MED (low flow) MED-HIGH (high flow)

RU	IFR	LOWER SCENARIO				RECOMMENDED SCENARIO				UPPER SCENARIO				CONFIDENCE
		ERC	% Long	% tot	% low	ERC	% Long	% tot	% low	ERC	% Long	% tot	% low	
<b>BUFFALO RIVER</b>														
U	13	-	-	-	-	D	18.1	16	3.9	C	23.1	22.2	9.2	IFR components: Med-high Hydraulics: Low-med (low), med-high (intermediate) 0 LOW-MEDIUM (low flow), MEDIUM (>1.8)
V	14	C/D	20	18.1	5	B/C	24.1	24.8	10.2	-	-	-	-	IFR components: Med-high Hydraulics: High MED-HIGH

\*1 Even though the IFR component evaluation is med-low, flows should be managed from Spioenkop to cater for IFR 4 which is a higher REC than IFR 9. IFR 9 should therefore get more flows than recommended and the confidence in achieving the REC is therefore linked to the hydraulics, i.e. med-high.

\*2 IFR 4: 3 scenarios were supplied, B (recommended), B/C (alternative and PES), C/D (lower than PES). Only the B and B/C scenario fit into the table and C/D information needs to be used within the design of additional scenarios if necessary.

# APPENDICES



# Appendix A: Groundwater levels

## 33.1 Generation of groundwater levels

Water levels were generated across the study area using interpolation of existing data. The interpolation technique used is referred to as Bayesian interpolation where water levels are correlated with the surface topography. All available levels were plotted against the topography in Figure A 1. The results indicate a very good regional correlation of 99% between the data sets. Therefore, Bayesian interpolation is a valid technique to generate water levels for the area. As groundwater levels follow topography it can be assumed that groundwater flow takes place under unconfined and semi-confined conditions.

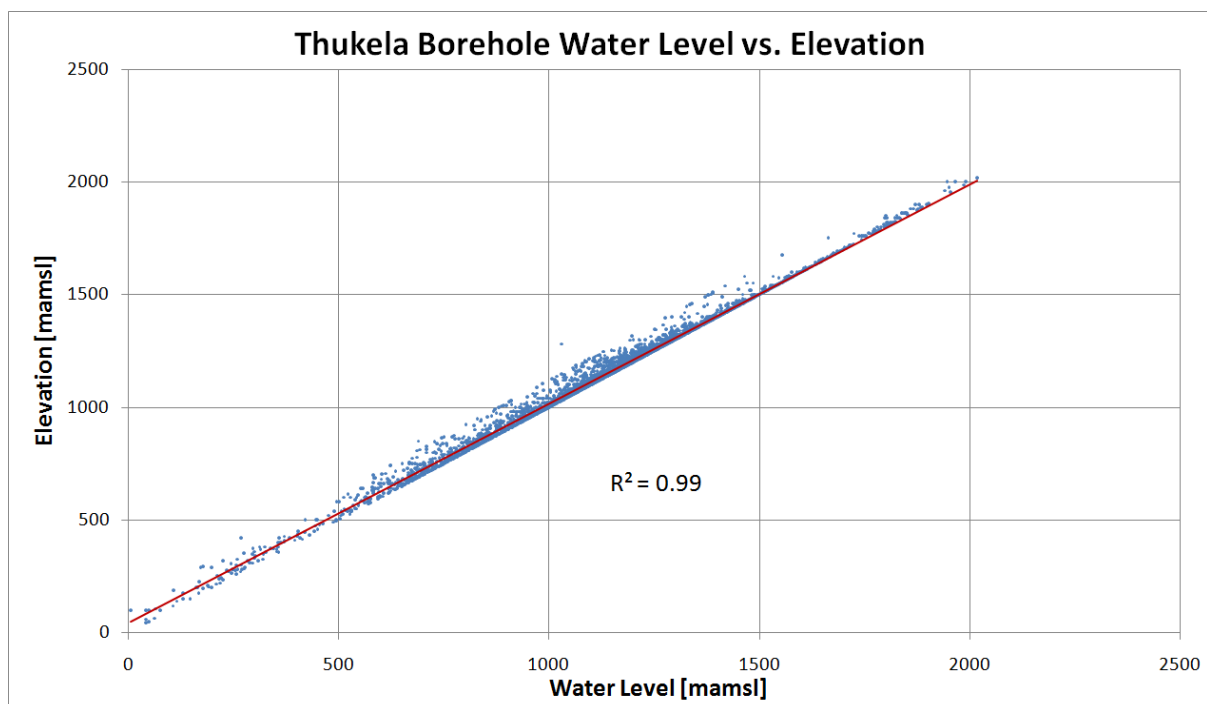


Figure A 1: Correlation between water levels and topography

### 33.3 Generation of depth to groundwater level histograms

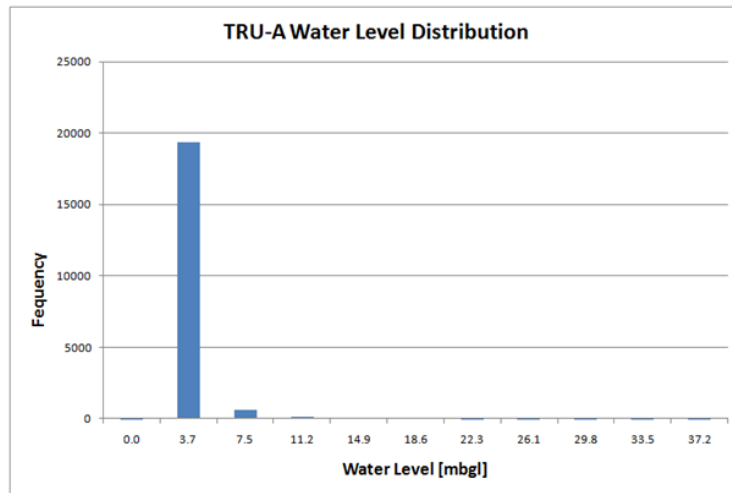


Figure A 2: Depth to groundwater in RUA

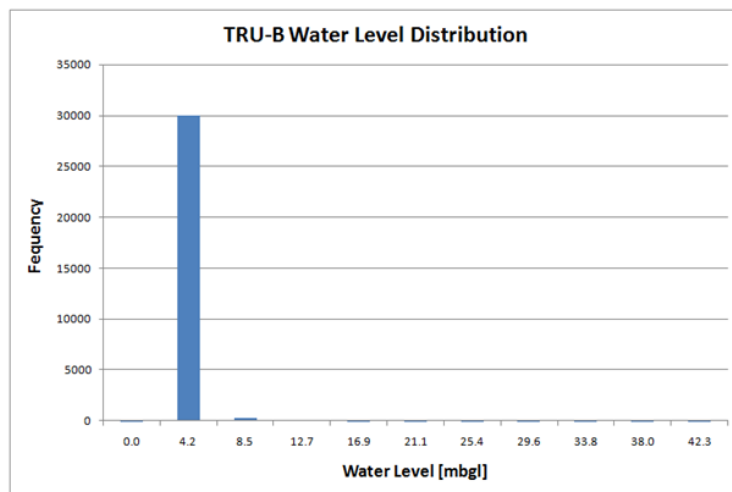


Figure A 3: Depth to groundwater in RUB

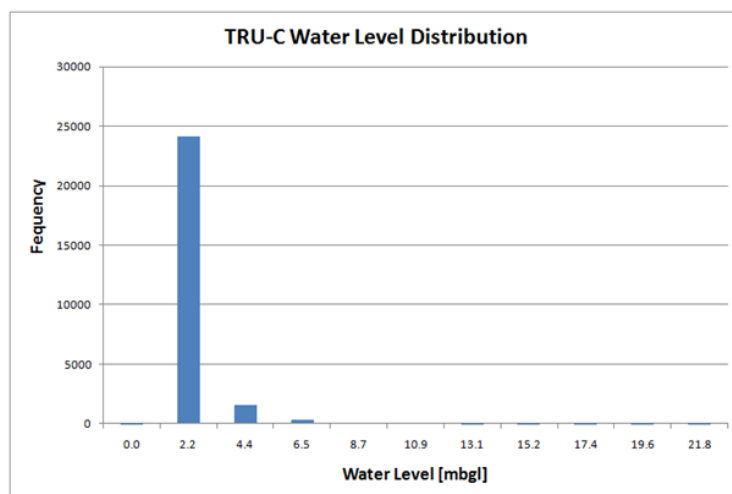


Figure A 4: Depth to groundwater in RUC

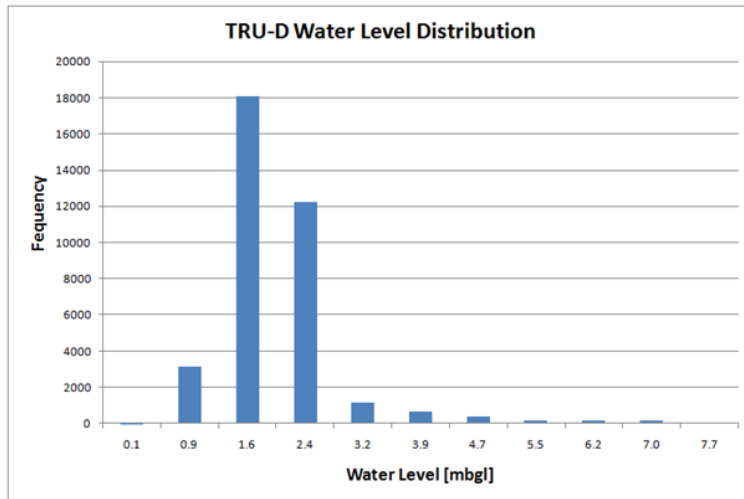


Figure A 5: Depth to groundwater in RUD

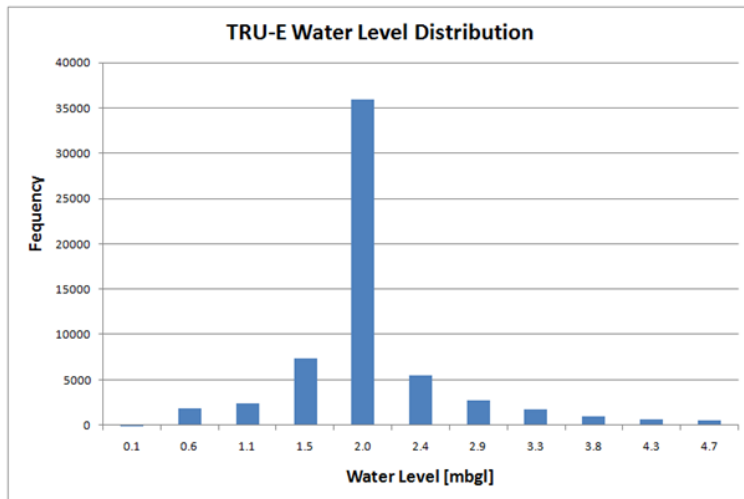


Figure A 6: Depth to groundwater in RUE

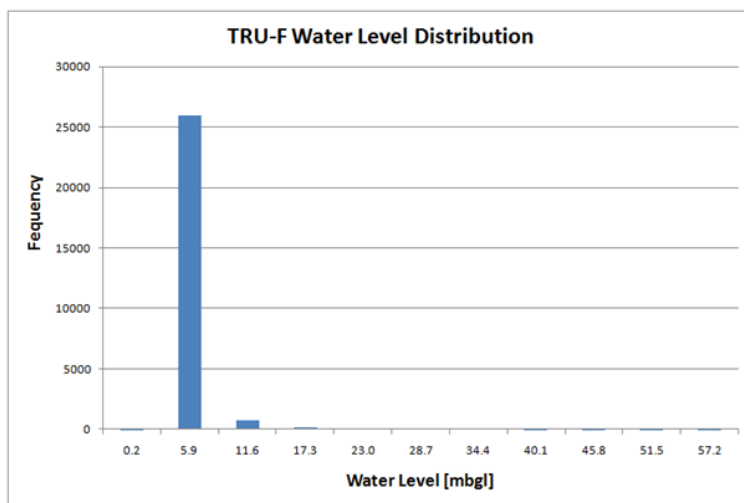


Figure A 7: Depth to groundwater in RUF

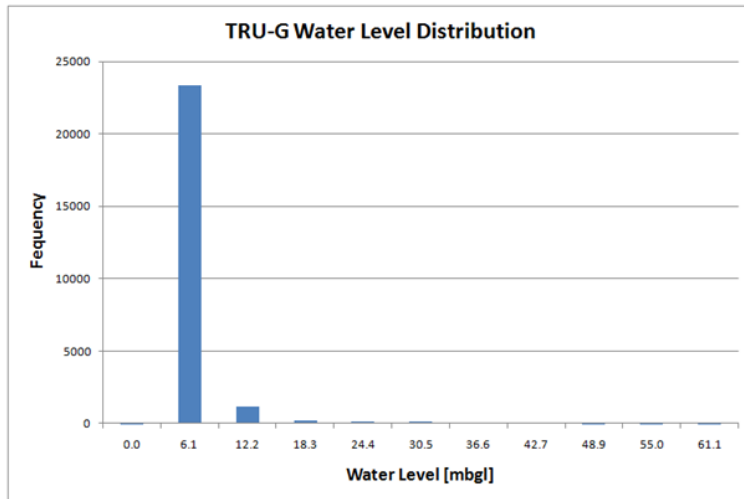


Figure A 8: Depth to groundwater in RUG

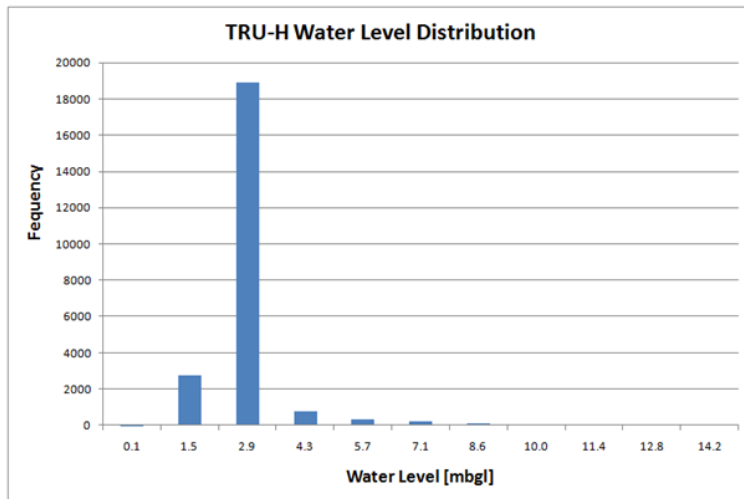


Figure A 9: Depth to groundwater in RUH

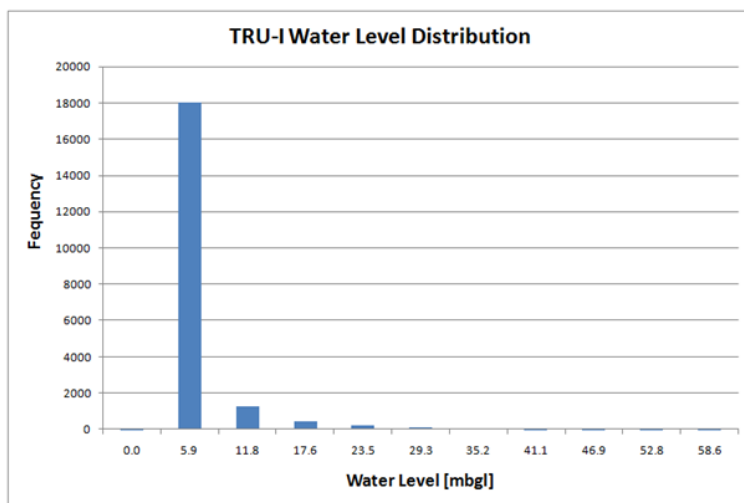


Figure A 10: Depth to groundwater in RUI

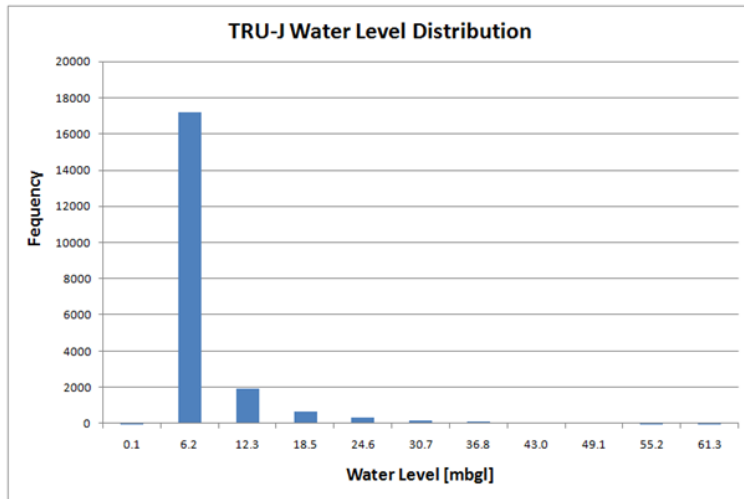


Figure A 11: Depth to groundwater in RUJ

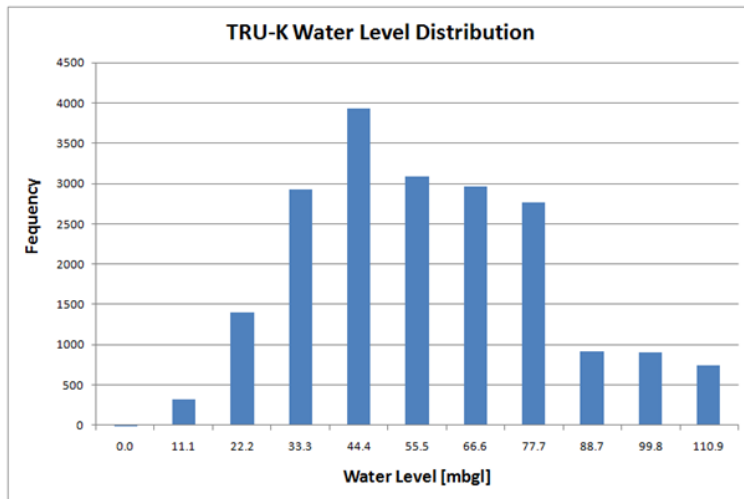


Figure A 12: Depth to groundwater in RUK

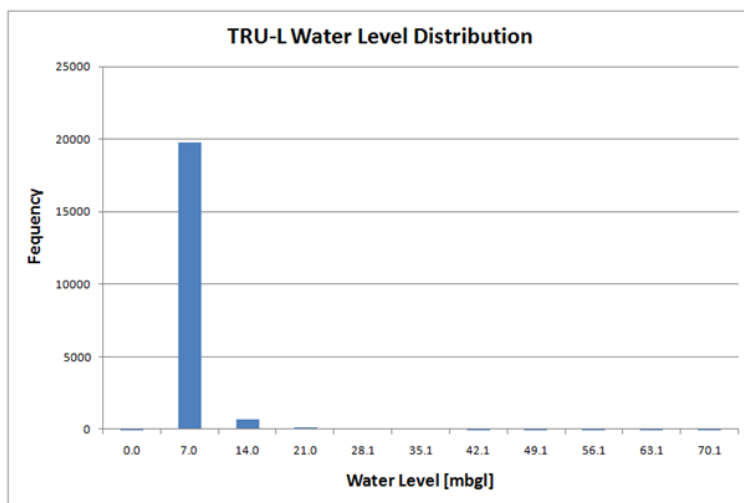


Figure A 13: Depth to groundwater in RUL

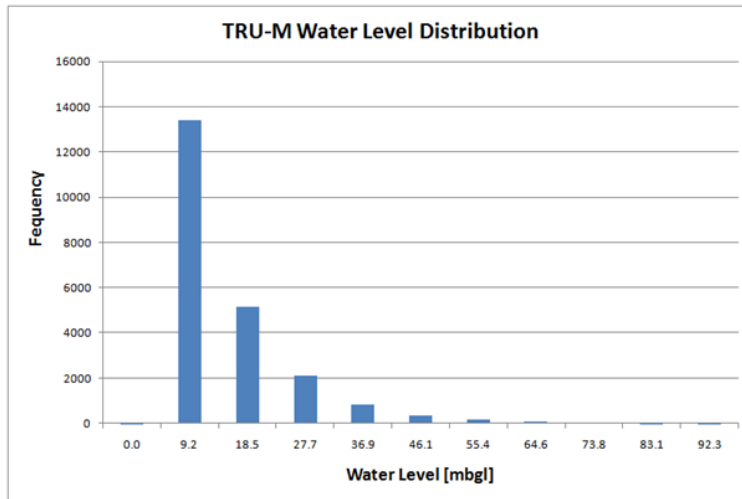


Figure A 14: Depth to groundwater in RUM

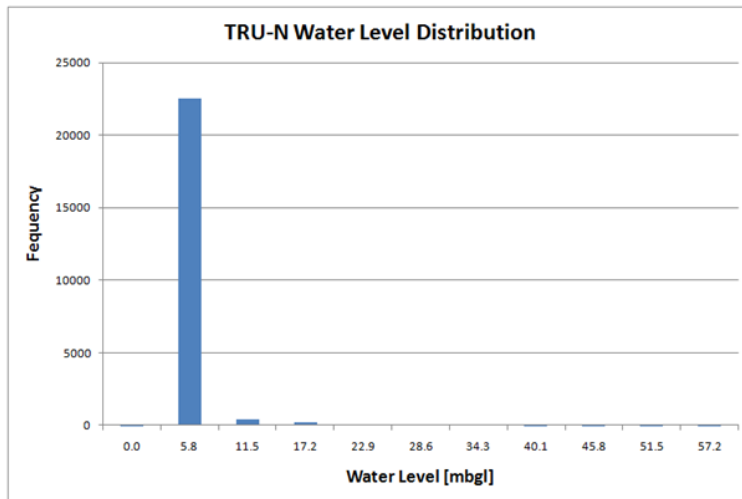


Figure A 15: Depth to groundwater in RUN

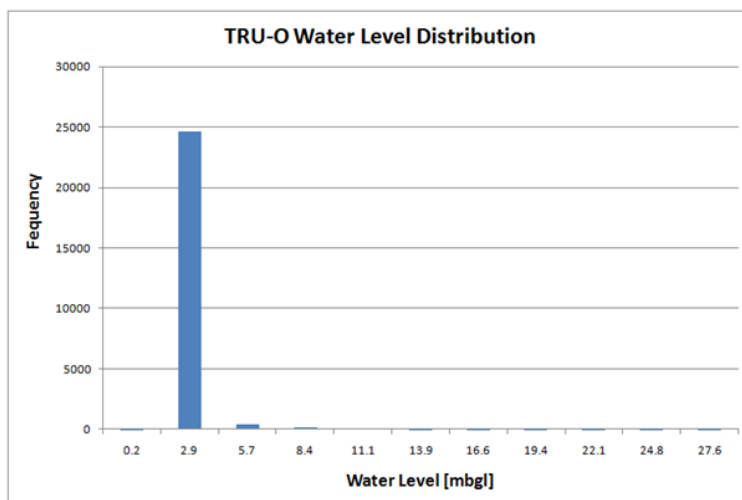


Figure A 16: Depth to groundwater in RUO

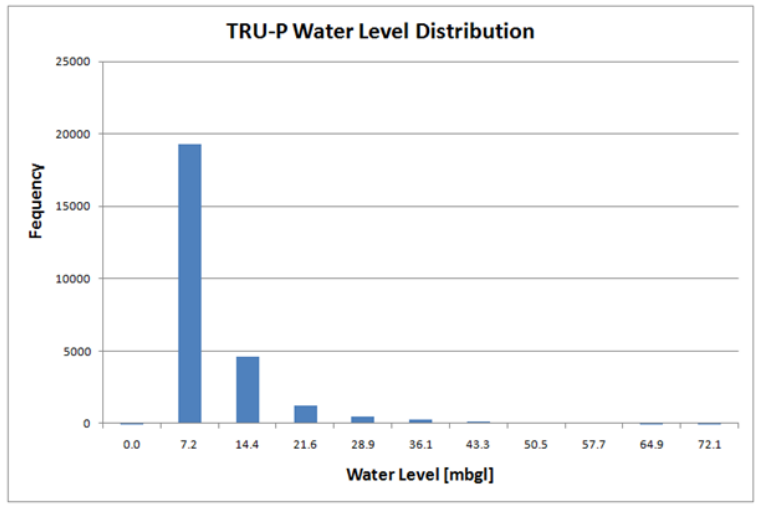


Figure A 17: Depth to groundwater in RUP

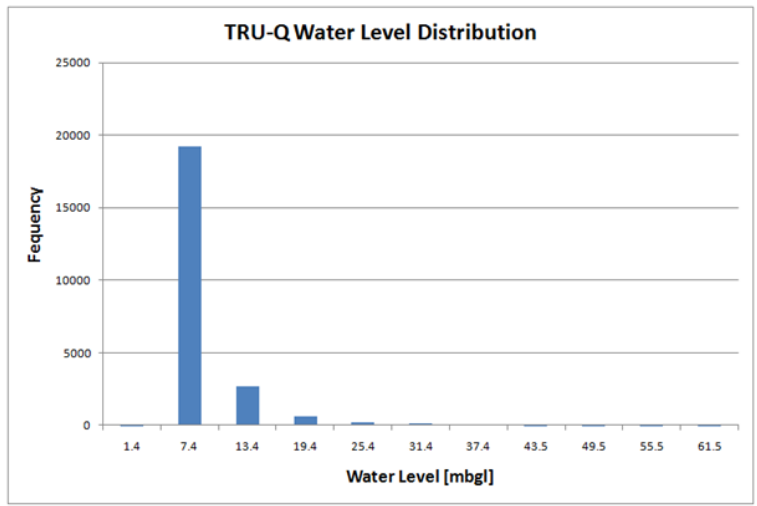


Figure A 18: Depth to groundwater in RUQ

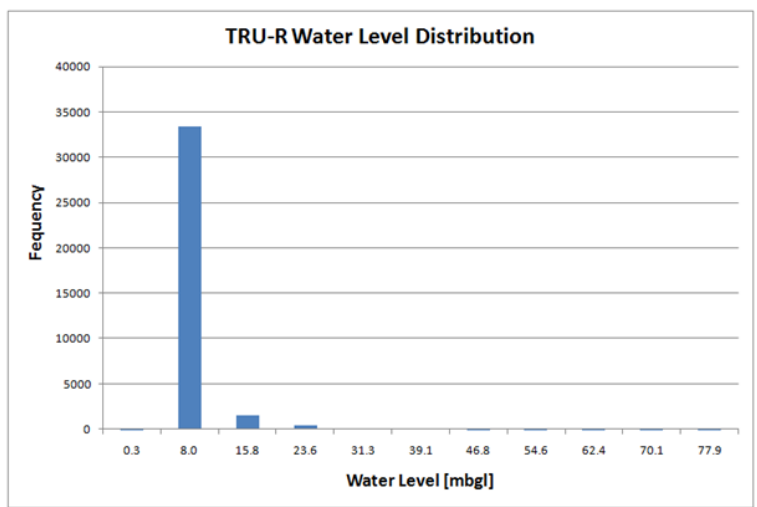


Figure A 19: Depth to groundwater in RUR

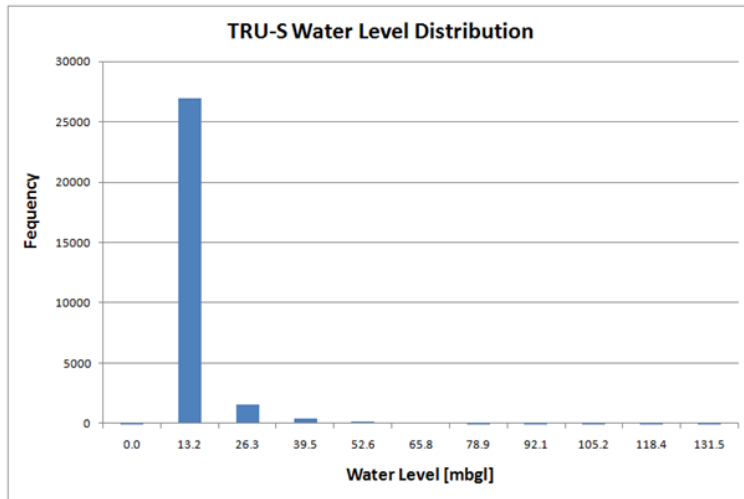


Figure A 20: Depth to groundwater in RUS

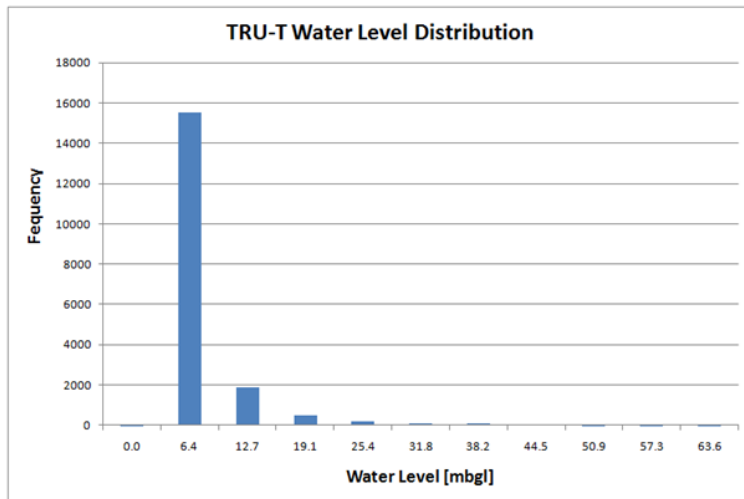


Figure A 21: Depth to groundwater in RUT

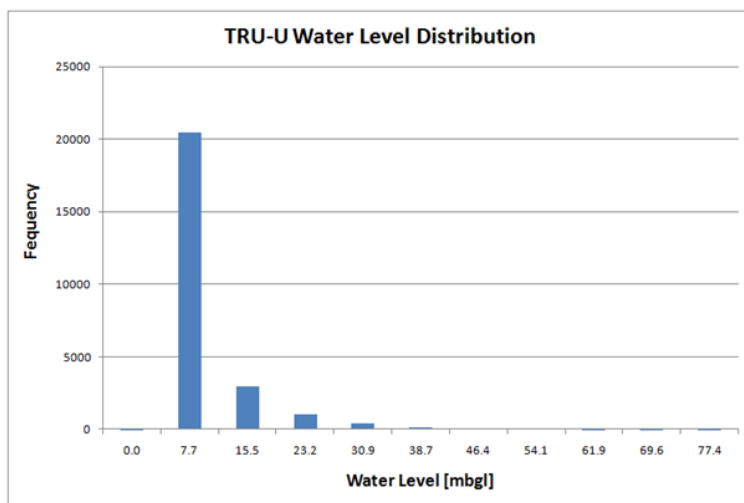


Figure A 22: Depth to groundwater in RUU

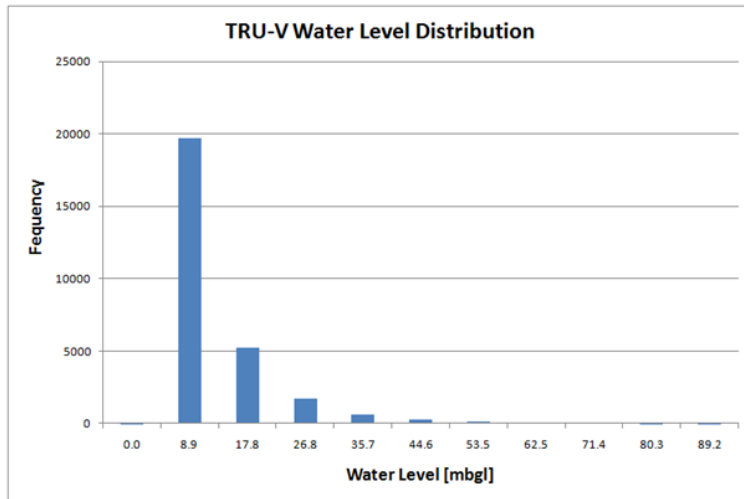


Figure A 23: Depth to groundwater in RUV

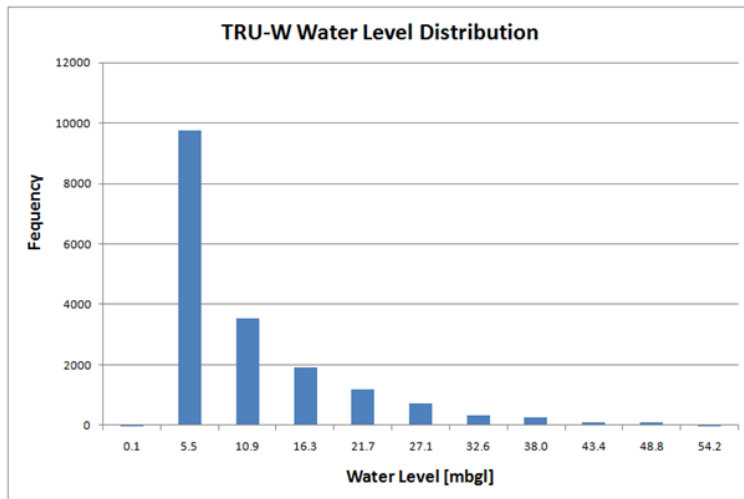


Figure A 24: Depth to groundwater in RUW

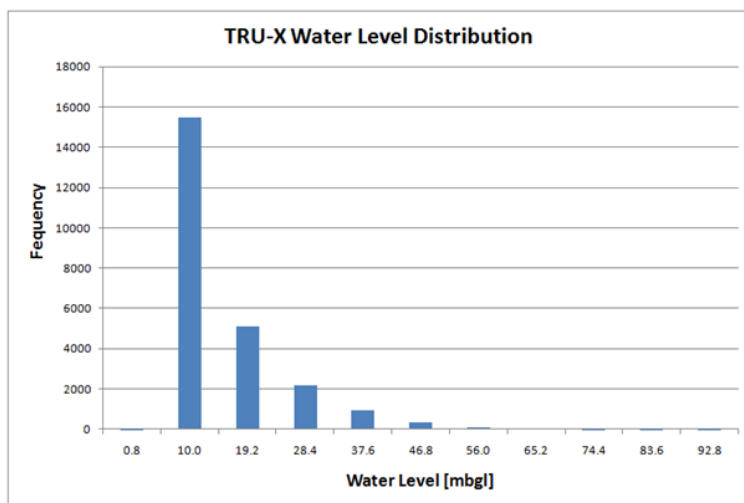


Figure A 25: Depth to groundwater in RUX

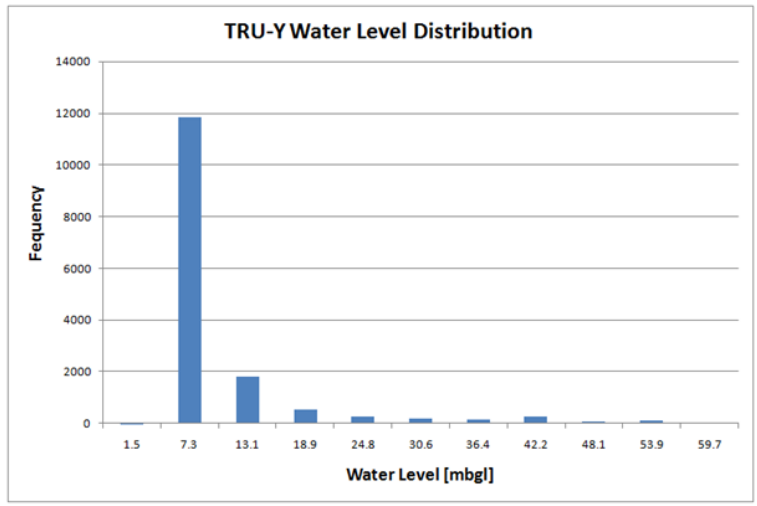


Figure A 26: Depth to groundwater in RUY

# Appendix B: Slope Histograms

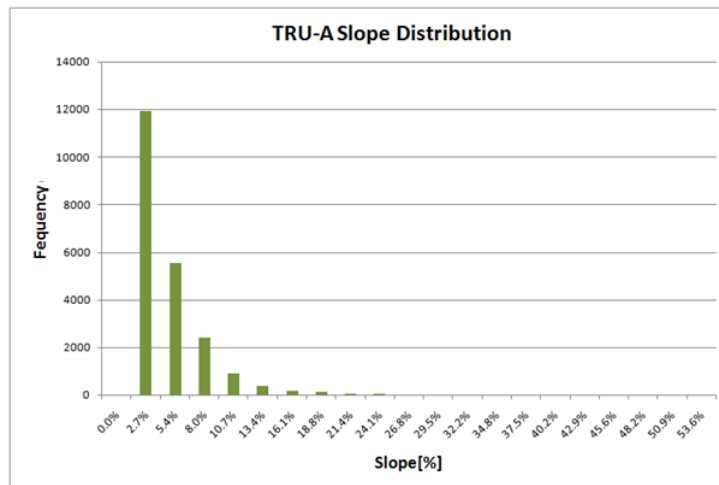


Figure B 1: Slope histogram for RUA

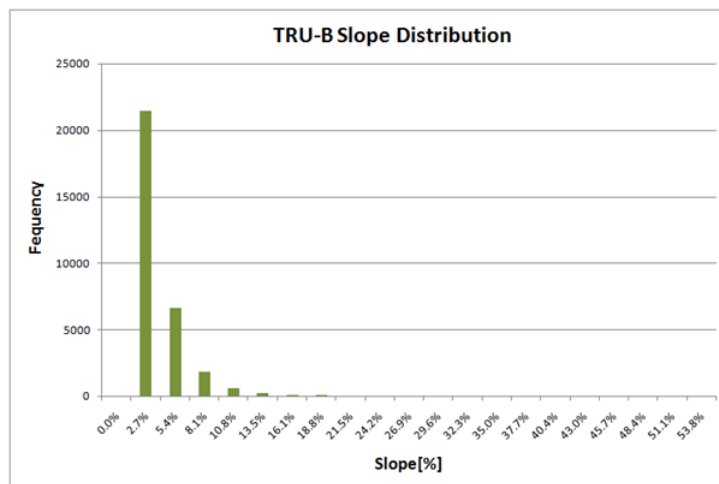


Figure B 2: Slope histogram for RUB

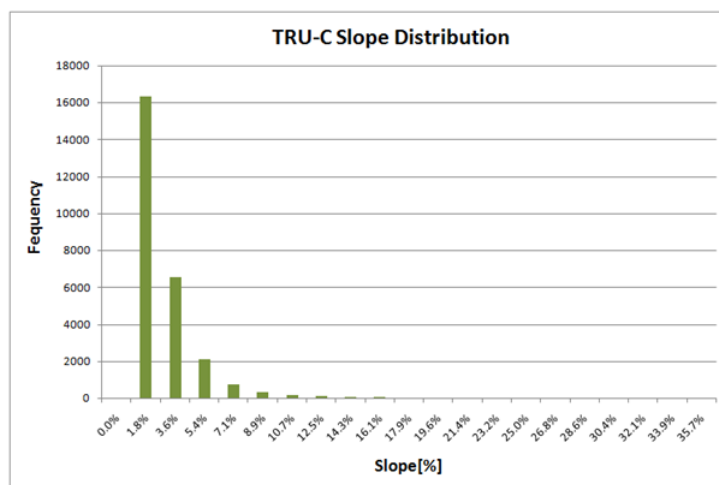


Figure B 3: Slope histogram for RUC

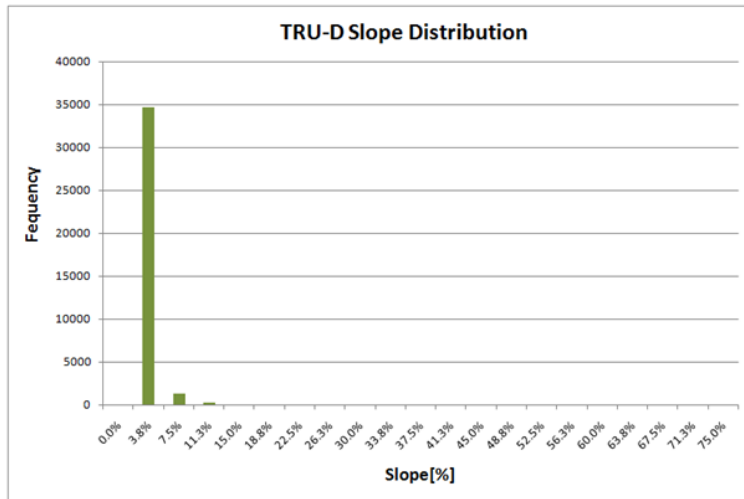


Figure B 4: Slope histogram for RUD

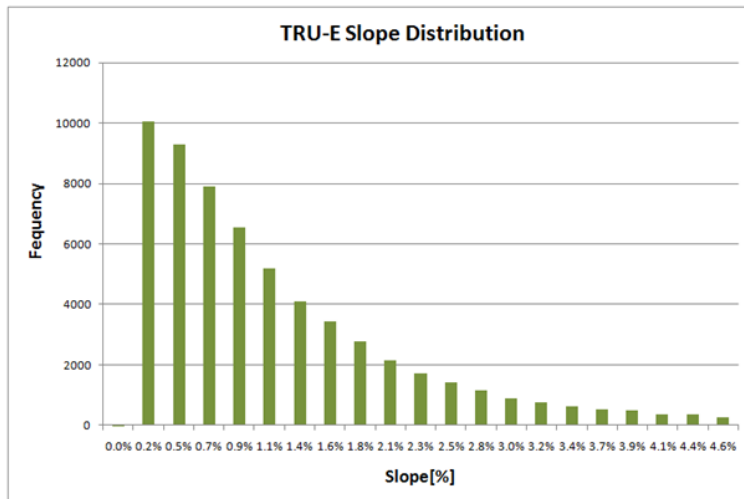


Figure B 5: Slope histogram for RUE

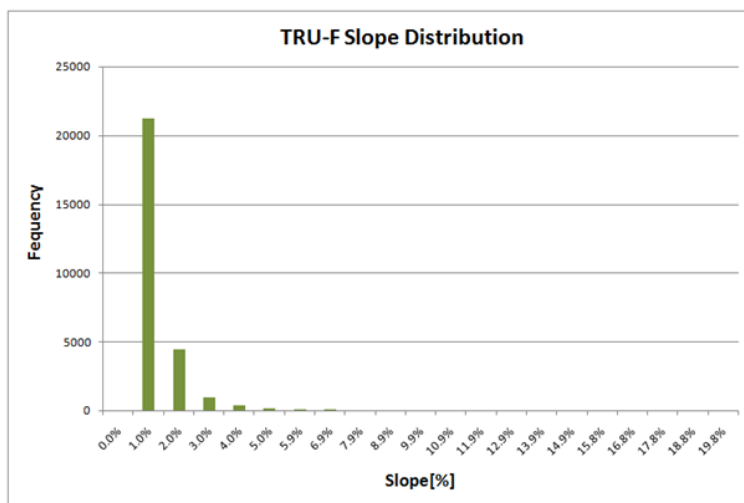


Figure B 6: Slope histogram for RUF

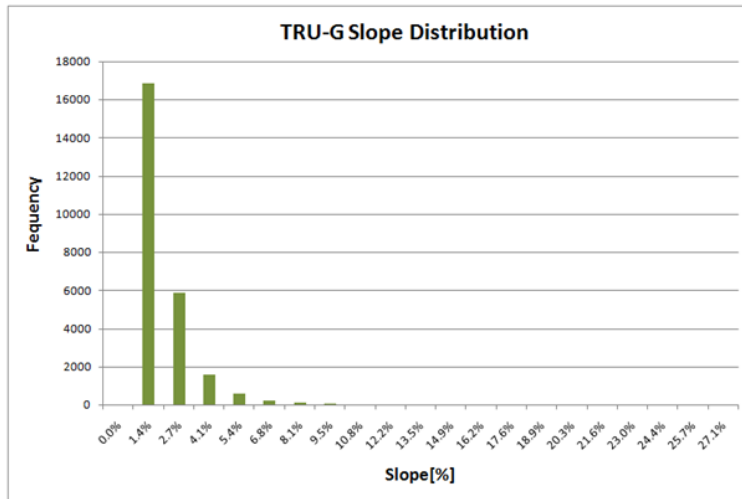


Figure B 7: Slope histogram for RUG

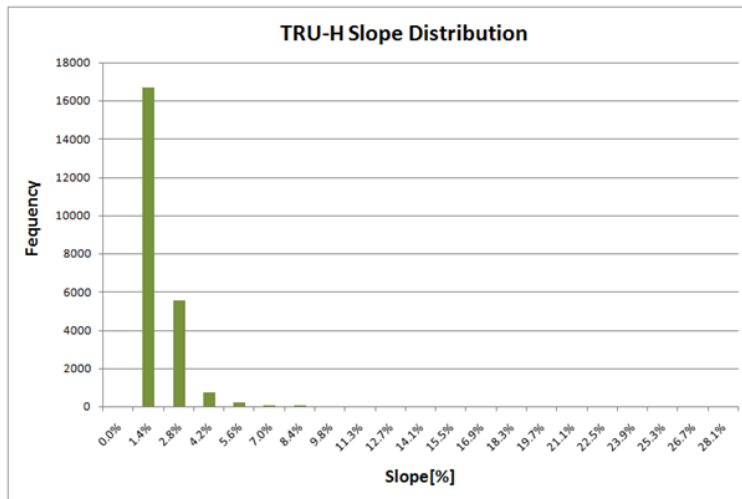


Figure B 8: Slope histogram for RUH

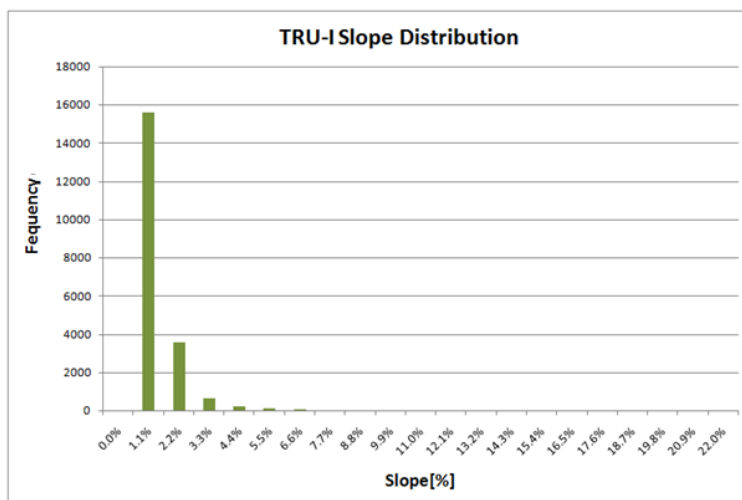


Figure B 9: Slope histogram for RUI

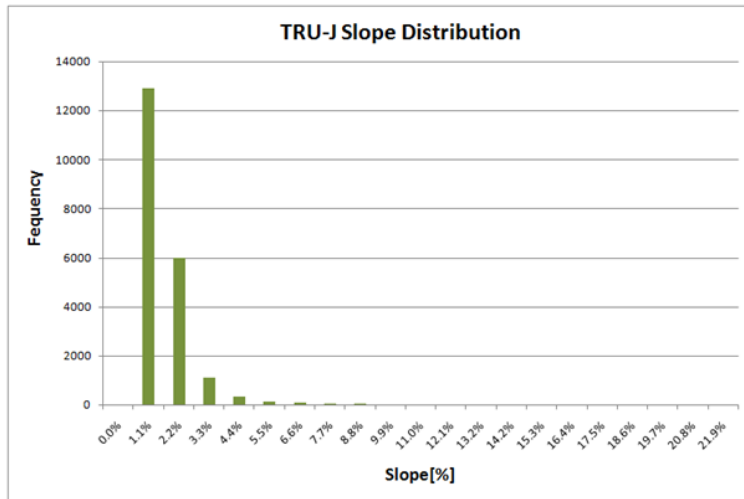


Figure B 10: Slope histogram for RUJ

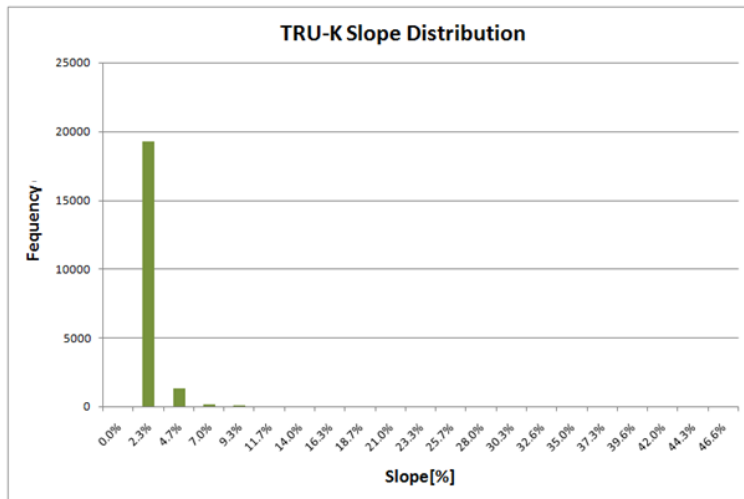


Figure B 11: Slope histogram for RUK

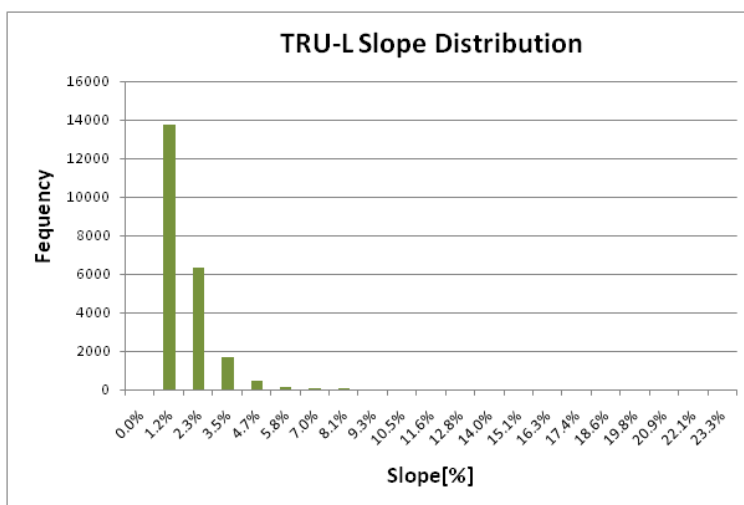


Figure B 12: Slope histogram for RUL

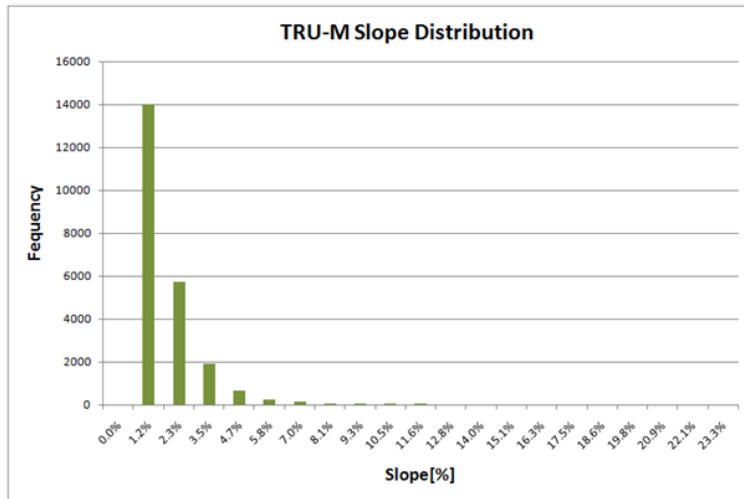


Figure B 13: Slope histogram for RUM

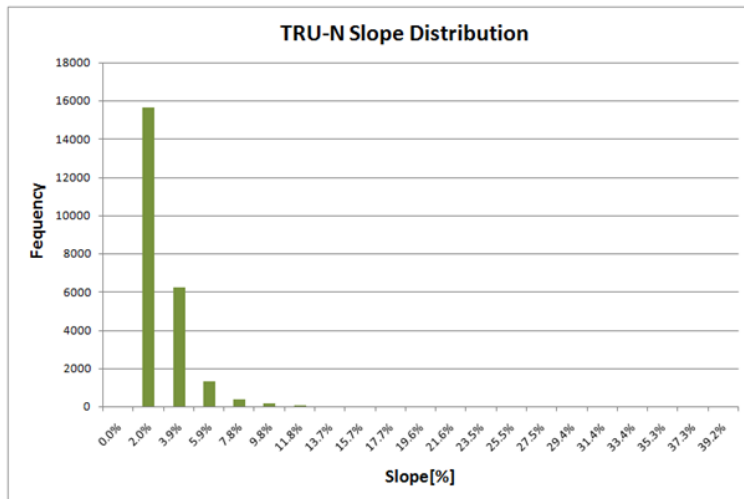


Figure B 14: Slope histogram for RUN

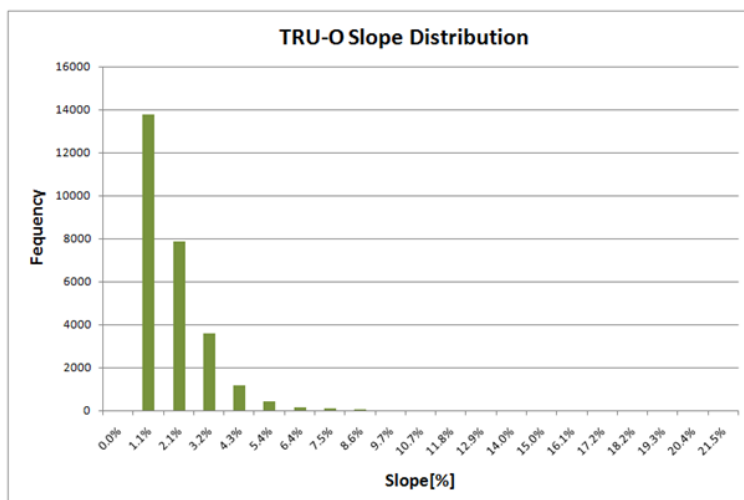


Figure B 15: Slope histogram for RUO

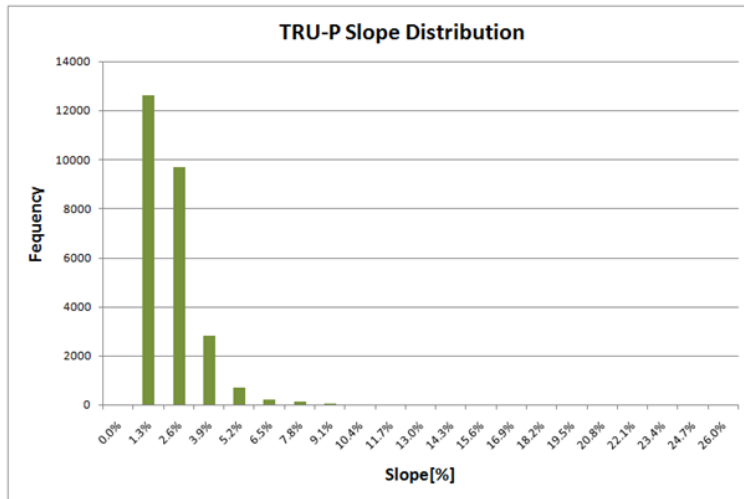


Figure B 16: Slope histogram for RUP

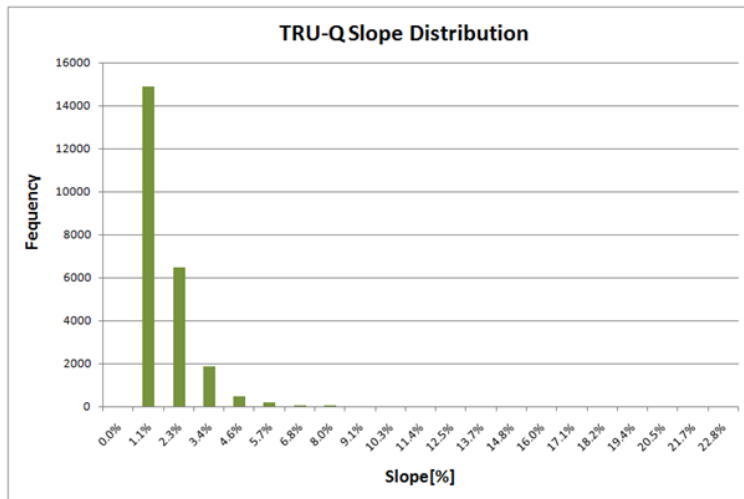


Figure B 17: Slope histogram for RUQ

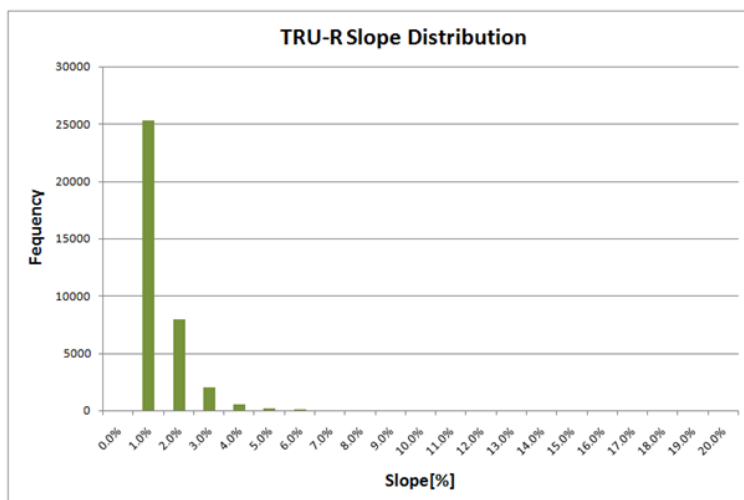


Figure B 18: Slope histogram for RUR



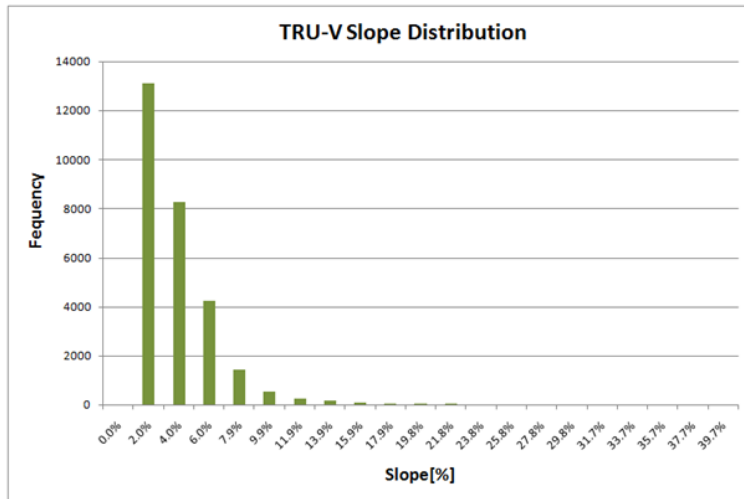


Figure B 22: Slope histogram for RUV

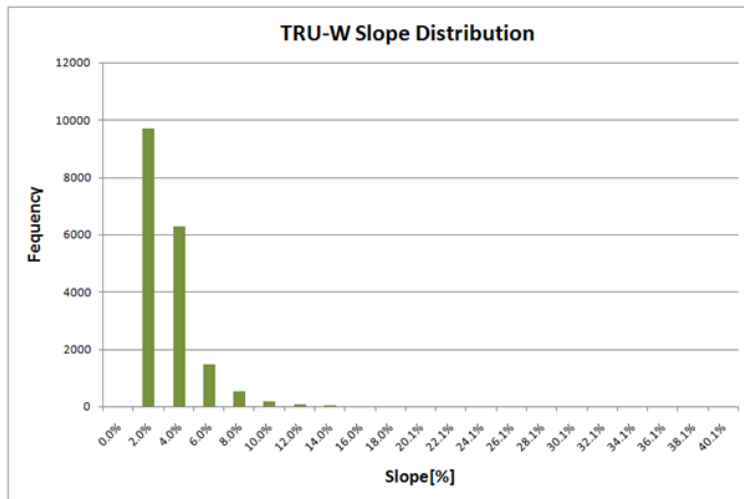


Figure B 23: Slope histogram for RUW

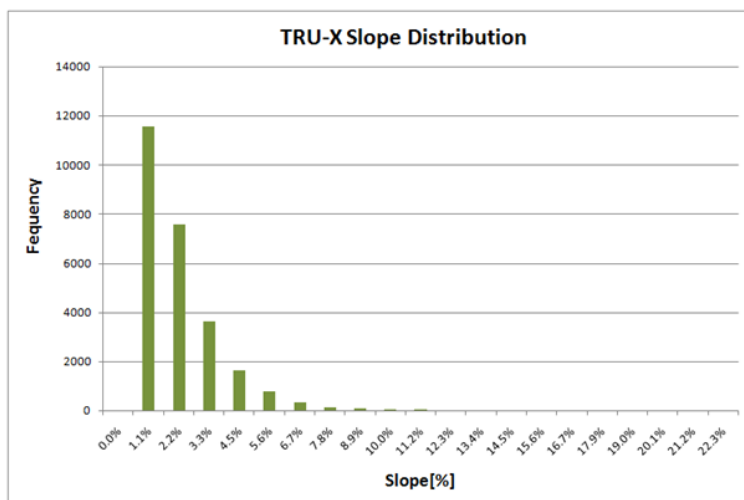


Figure B 24: Slope histogram for RUX

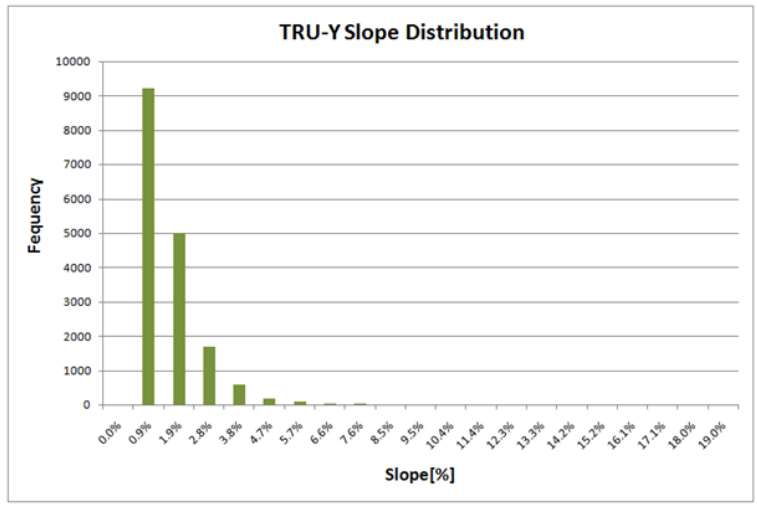


Figure B 25: Slope histogram for RUY

# CAPACITY BUILDING



## Introduction

The capacity building on this Reserve Determination included the following activities:

- GRDM training course
- Training of post-graduate students
- Two field trips

Each of these will be discussed in more detail in the following Sections.

## GRDM Training Course

A GRDM training course held in Durban on 17 & 18 April 2008. The attendance list is documented in Table 9.

Table 9: List of Delegates


Name	Company	Email address	Cell	Telephone
Hanco Roux	Geotech	hanco@geotech.co.za	0826511892	0397274108
Thanda Zulu	DWAF	zuluth@dwaf.gov.za	0828805817	0313362843
JK Mukumba	125	katsindi@telkomsa.net	0823913563	0333431516
Taryn Swales	Geomeasure	taryn@geomeasuregroup.co.za	0837873794	0317681103
Clinton Mandew	Geomeasure	clinton@geomeasuregroup.co.za	0828253748	0317681103
Robert Schapers	Terratest	schapersr@terratest.co.za	0829249141	0312755515
Nandi Madlala	DWAF	madlalan@dwaf.gov.za	0828805514	0313362907
Tenoayi Makombe	DWAF	makombet@dwaf.gov.za	0836621413	0213368503
Sylvester Noodra	BMA Geoservices	sndoora@bmageoservices.co.za	0723061764	0333433410
Douglas Mbata	Terratest	mbatad@terratest.co.za	0829050879	0312755500



The course was presented by Roger Parsons, Ingrid Dennis and Rainier Dennis. All delegates received training on the GRDM process and the associated software. Day 2 focuses on the WMA and more specifically Nottingham Road.

## Training of post-graduate students

All honours and MSc students at the Institute for Groundwater Studies received training on the GRDM software using information from the WMA. The role of three students on the project are highlighted in Table 10.

Table 10: Training of students

	<p><b>Molly Ntwaeaborwa</b></p> <p>Molly was an honours student at the IGS in 2008. DWAF sponsored her studies and she has just joined DWAF's learning academy. She was assigned a Groundwater Reserve Determination as an honours project. The focus of the project was Nottingham Road because of the concerns regarding over-abstraction.</p>
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	<p><b><i>Jana Brits</i></b>  Jana is currently still registered as an honours student at the IGS. DWAF is sponsoring her studies and she will join DWAF's learning academy once she is finished. She was assigned a Groundwater Reserve Determination as an honours project. The focus of the project was a rapid to intermediate Reserve for the whole Thukela WMA.</p>
	<p><b><i>Sakhile Mdaweni</i></b>  Sakhile was a MSc student at the IGS during 2007 &amp; 2008. He was responsible for all field work on the project.</p>

### ***Field trip (17 - 18 June 2008)***

A field trip was arranged for DWAF officials. The aim of the field trip was to familiarize DWAF officials with the site and the issues related to the Groundwater Reserve within the WMA. The two day field trip was attended by:

- Sakhile Mndaweni (IGS)
- Yasmin Rajkumar (DWAF)
- Nandi Madlala (DWAF)
- Molly Ntwaeaborwa (IGS student)
- Jana Brits (IGS student)
- Zee Mbotho (IGS student)
- Puleng Moche (DWAF)
- Ndivhwo Netshiendeulu (DWAF)

A summary of the issues are highlighted below:

#### **1. Nottingham Road (Day 1)**

- The town is wholly dependent on groundwater.
- New developments are targeted on the North East part of the town.
- There have been complains received by DWAF on the usage of groundwater.
- Nottingham Road must be delineated as a hot spot, since the whole quaternary Catchment has areas that are not high groundwater users (e.g., Balgowan and Rosetta - schedule 1 users).
- All the developments in the area use septic tanks.
- Tree plantations are visible in the northwest of the town.

#### **2. Ladysmith (Day 1)**

- Meet Sabo Mthethwa and Mbuyiseni Buthelezi from the uThukela District Municipality (WSA and WSP for the region).

- They visited the Driefontein area
  - ✓ Water scheme dependent on only one borehole.
  - ✓ The scheme pumps water from the borehole to the huge reservoir and is pumped for 24 hours.
  - ✓ No monitoring of water levels and water quality.
  - ✓ During draught they experience problems like cholera
  - ✓ The area uses pit latrine and in immediate vicinity of the borehole there is a pit latrine
  - ✓ There are other hand pump boreholes in the area
  - ✓ No estimate on the size of the population the scheme supplies.
  
- They visited Peace Town
  - ✓ Three boreholes were initially used for the scheme, but only two are currently operational.
  - ✓ They are being pumped for 24 hours.
  - ✓ There is a small tree plantation near the boreholes and also the cattle kraal.
  - ✓
  
- 3. Newcastle – Dundee (Day 1)**
  - Springlake colliery: A coal washing plant and the mine were visited and only photos were obtained. No comments on the reserve.
  - Dundee Town
    - ✓ There are 20 mine sites have been identified to be decanting and six have prioritized needing immediate attention
    - ✓ Boreholes have been drilled on that mine sites
    - ✓ The town does not dependent on groundwater but the streams in the area are polluted with sulphates.
  
- 4. Newcastle (Day 2)**
  - Meet Kallie DeHaas from Uthukela Water (PTY) LTD the WSP from the Amajuba and Umzinyathi District Municipalities and gave a brief explanation of the problems they encounter with groundwater in terms of quality and quantity in the area.
    - ✓ They have problems with their groundwater dependent schemes due to over abstractions. Areas mentioned is: Ngome, Muden, Amantungwa, Hemnansburg.
    - ✓ Berouw (Utrecht) - there are old mines in the area, groundwater is highly contaminated.
  
  - They visited Amantungwa
    - ✓ There is water scheme dependent on 7 boreholes, with three of them are already dry. Each borehole is abstracting about 10000 l/day
    - ✓ The solution is to get water from nearby balkscheme
    - ✓ The schemes supply about 30000 people

- They visited Pomeroy
  - ✓ There are four boreholes and they are pumping about 32000 l/ day for the scheme, sometimes they are drying up
  - ✓ For augmentation they are constructing a weir in nearby river to support the scheme

Below are some photos of the field trip.





Below is a summary of the documentation provided on the trip.

# The Thukela Groundwater Reserve Determination

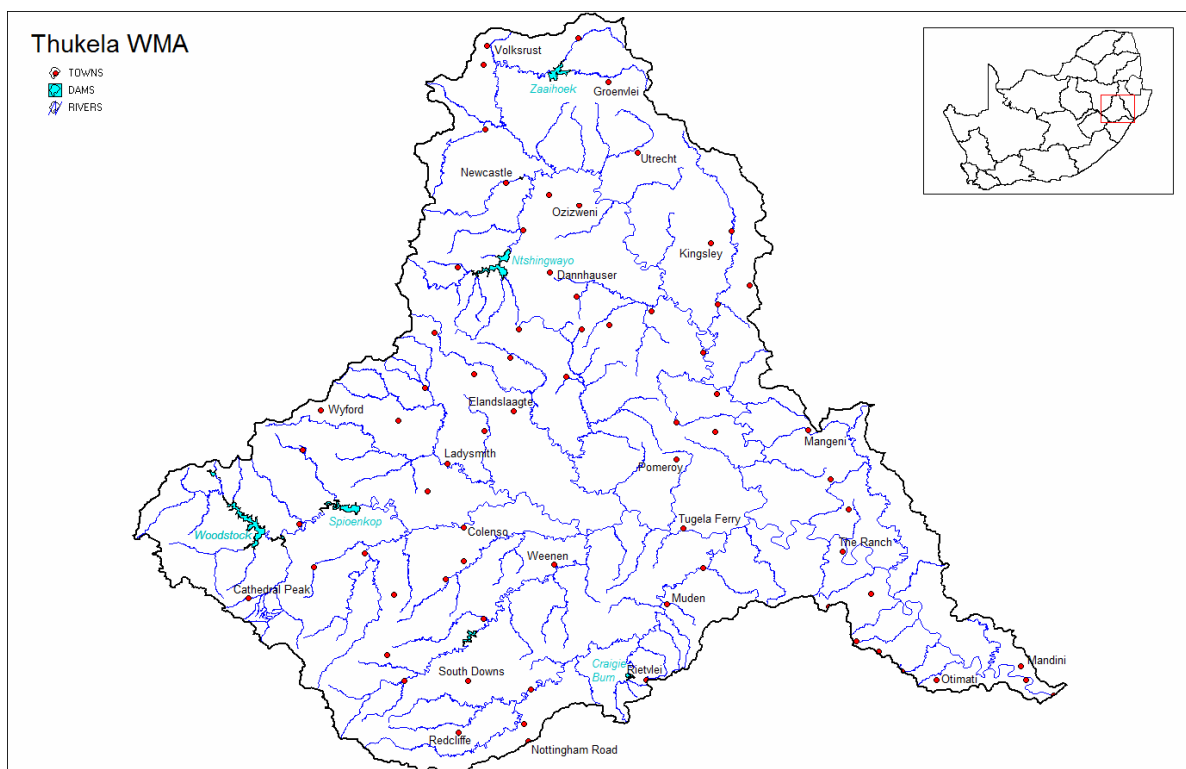


Field trip  
17 & 18 June 2008

# Introduction

The Thukela River is the third largest river in South Africa. It is a physiographically, climatologically, hydro-logically and socioeconomically diverse and complex catchment.

The Thukela Water Management Area (WMA) consists of the entire catchment of the Thukela River, also referred to as the 'V' Hydrological Drainage Region (Midgeley *et al.*, 1994). The WMA contains 88 quaternary catchments. The River rises in the Drakensberg mountains very close to the Lesotho border, and meanders through central KwaZulu-Natal. The Thukela River mouth lies midway between Durban and Richards Bay, 10 km to the east of the national road bridge, 14 km to the southeast of the town Mandini and 104 km from Durban.



Major tributaries flowing into the Thukela River from the north are as follows:

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

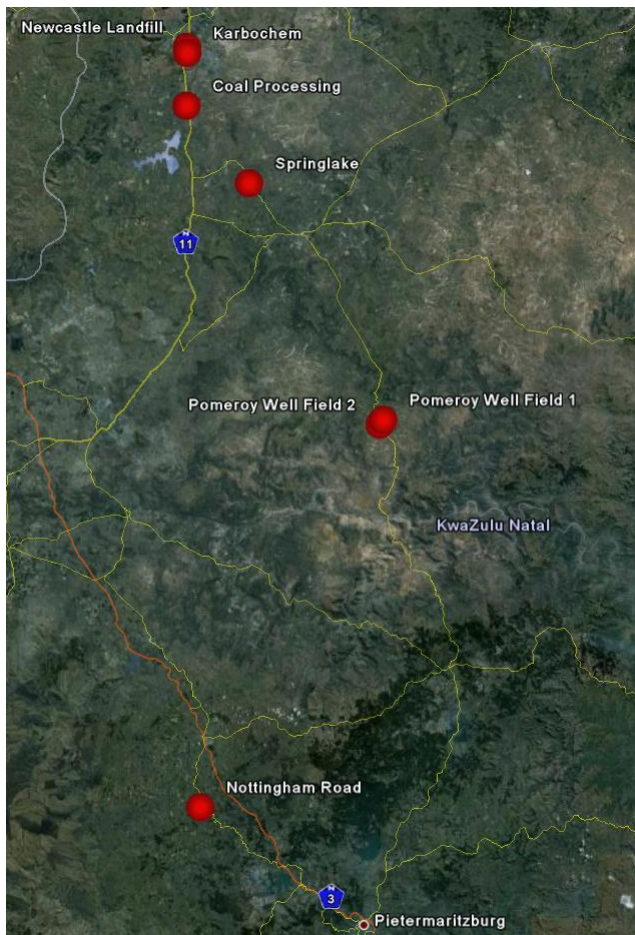
Major tributaries into the Thukela River from the south are as follows:

- The Little Thukela River
- The Bloukrans River
- The Bushmans River, passing through Estcourt
- The Mooi River

The Department of Water Affairs and Forestry have requested a Groundwater Reserve determination for the Thukela River catchments. The Thukela River urgently requires compulsory licensing due to stressed conditions and water quality problems. Groundwater issues identified within the Water Management area include:

- Over abstraction
- Groundwater contamination due to:
  - industry,
  - urbanisation,
  - mining,
  - agriculture and
  - in rural areas pit latrines

The aim of this field trip is to familiarise interested parties with the study area and highlight some of the issues to be addressed in the reserve determination. The route to be followed over the next 2 days is shown below. The field trip will end at Thukela Ferry. This document is a summary of the field trip providing details of the areas to be visited.



As you drive through the area discussing the issues – classify the sites and suggest resource quality objectives.

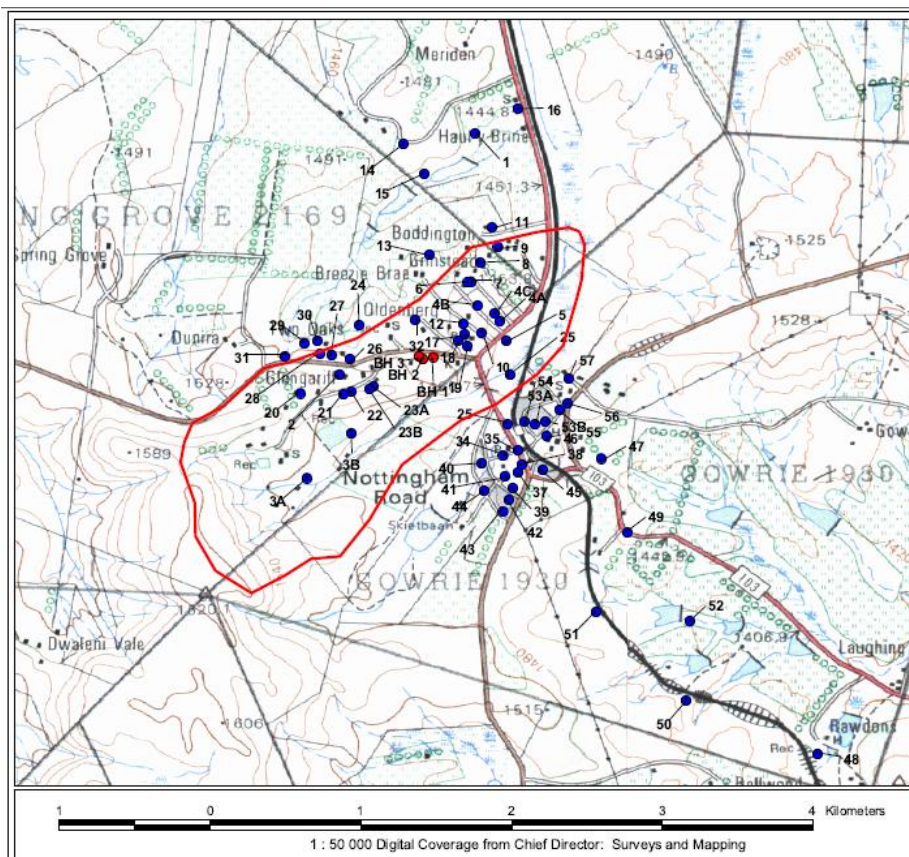
# Nottingham Road

Nottingham Road is a small town that falls on the southern boundary of the study area. The town and surrounding area is heavily dependent on groundwater. Groundwater over abstraction is a concern.

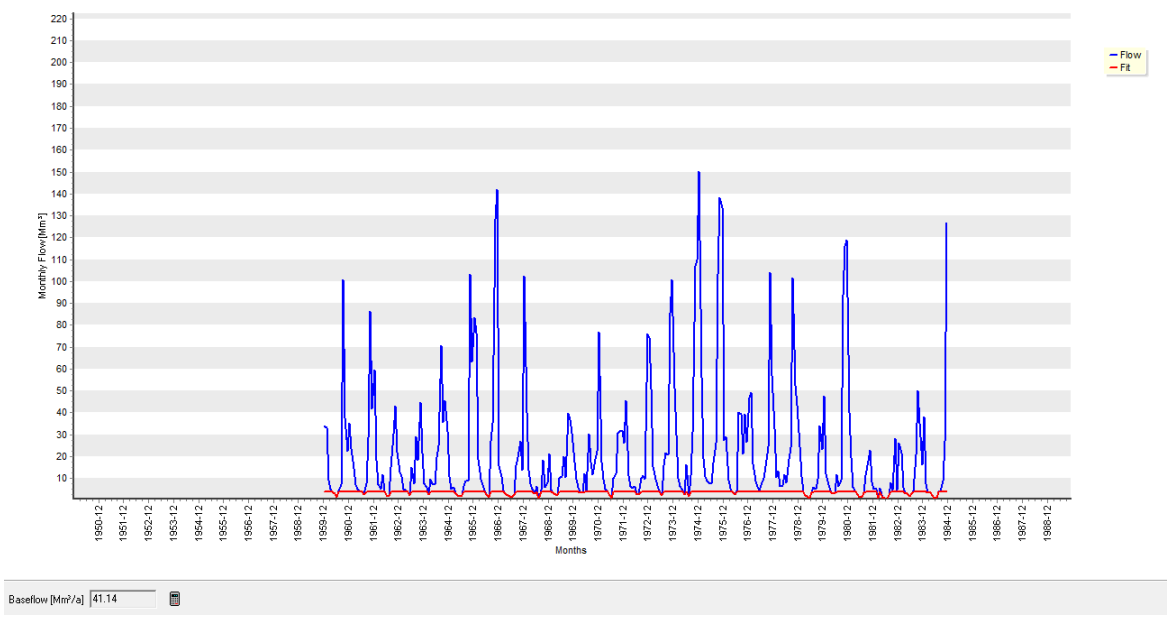
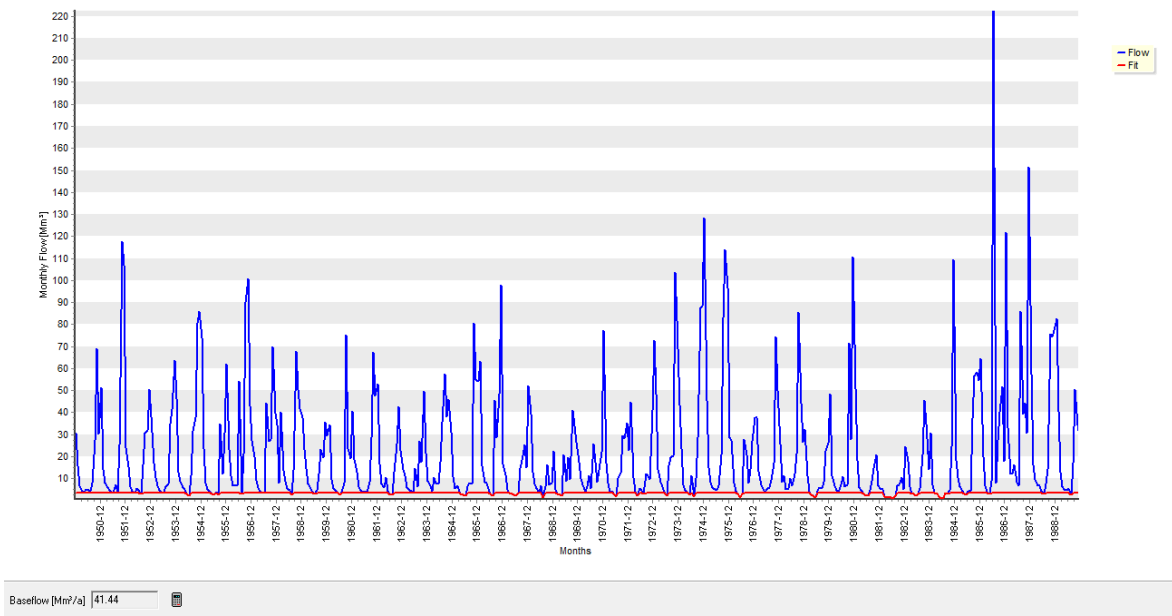
Basic information for the town includes the following:

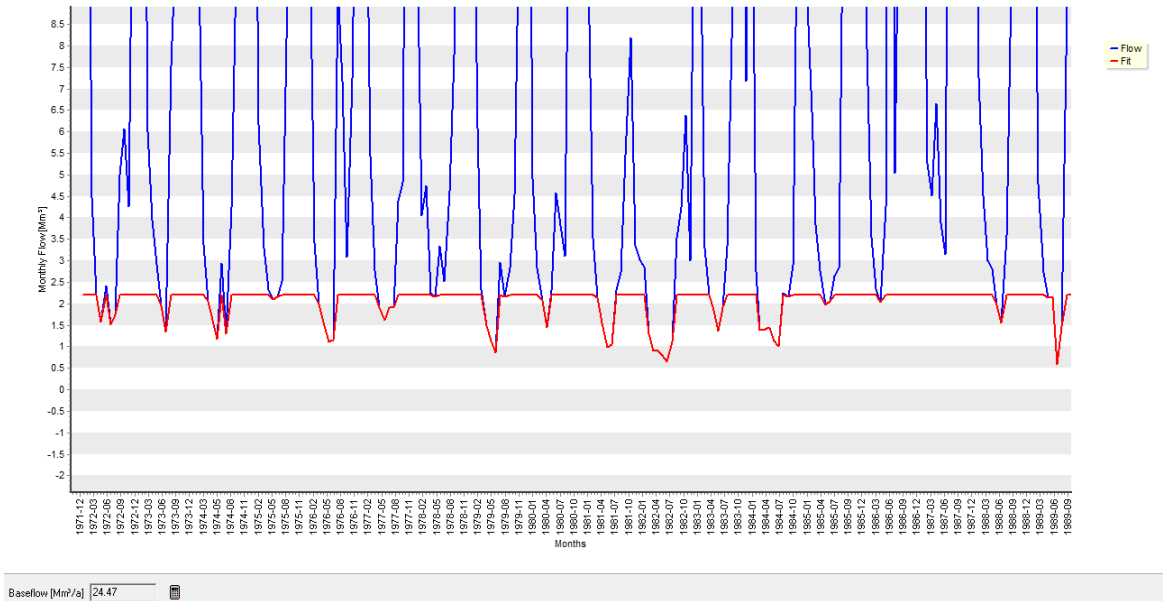
Parameter	Value
Quaternary catchment	V20D
Area	300 km <sup>2</sup>
Geology	Beaufort
Rainfall	857 mm/a
Recharge	49.5 mm/a (5% of rainfall) = 14.8 Mm <sup>3</sup> /a
Population	2994
Groundwater use	0.12 Mm <sup>3</sup> /a (From GeoMeasure hydrocensus)
Baseflow	35.6 Mm <sup>3</sup> /a
Problem	Negative water balance
Solution	??
Classification	?
Resource quality objectives (RQOs)	

The boreholes are shown in the sketch below:



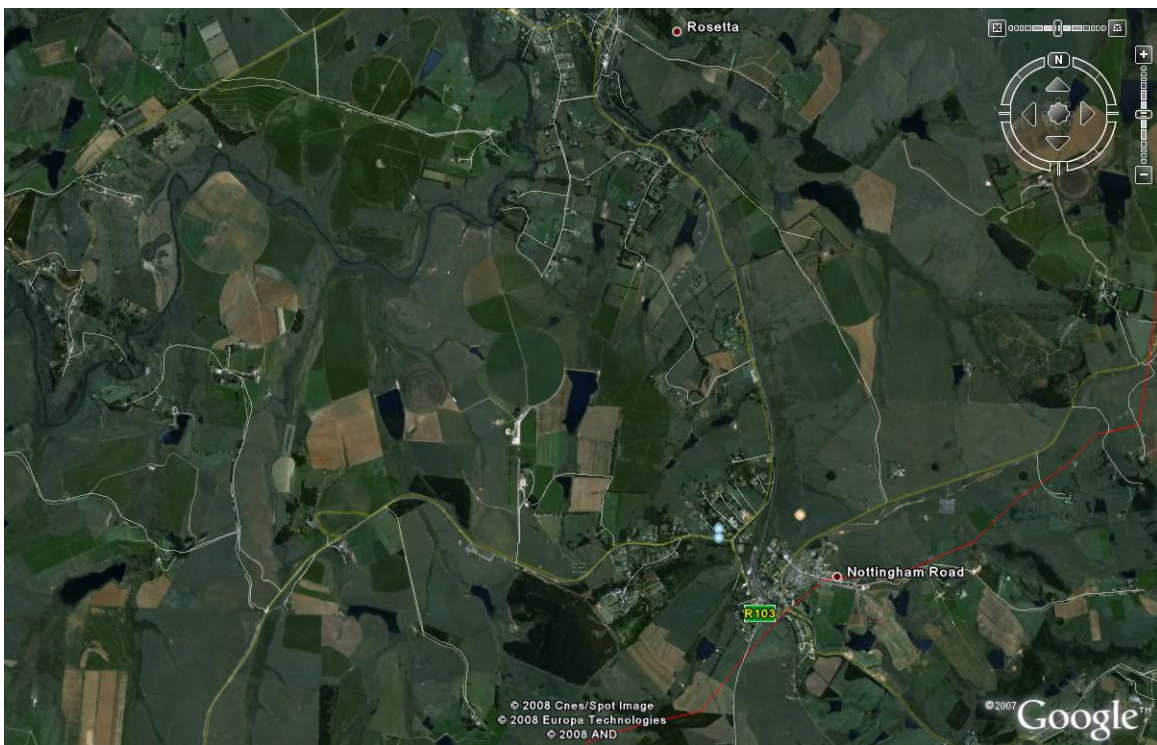
Baseflow calculations (using data from 3 flow stations in the catchment):





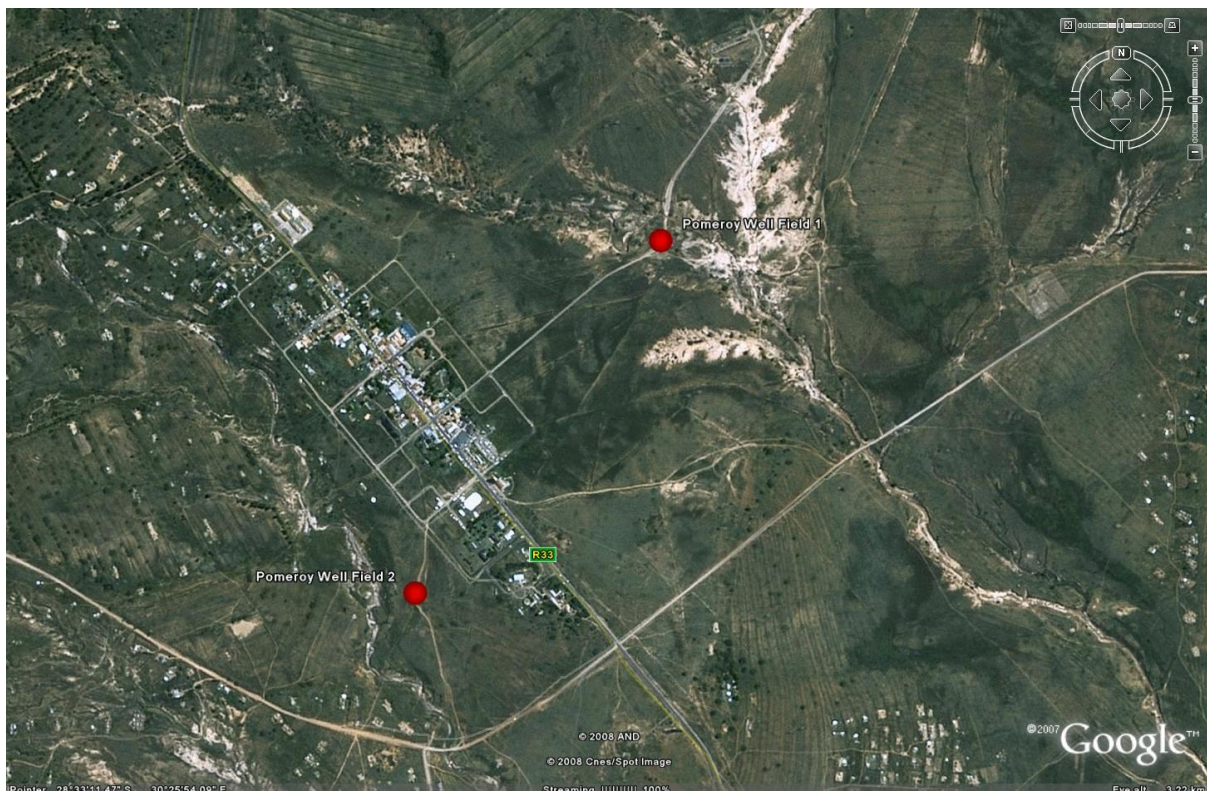
Other issues to consider in the study area:

- Agriculture close to river impacting on riparian zone and baseflow (see Figure below).
- Agriculture can cause groundwater contamination (from example high nitrates).
- Pivots form of artificial recharge.



# Pomeroy (& Thukela Ferry)

Three major rivers flow through the area namely, the Tugela River which flows from west to east, the Buffalo River which forms the eastern boundary between Msinga and Nqutu, Nkandla and Umvoti and the Sundays River to the west. The Mooi River also flows through Keates Drift, and joins the Tugela River approximately 11 km east of Tugela Ferry. Currently, the majority of the population are dependent on water abstracted from natural systems, being springs or the rivers mentioned above. Pomeroy also has 2 wellfields supplying the area with water. Agriculture is one of the most important economic sectors although it is still largely practiced for subsistence. Despite the large irrigation potential linked to the Tugela and Mooi Rivers, the area is subjected to water shortages during dry seasons, high soil erosion and low land carrying capacity.



Groundwater pollution is occurring in the urban areas of Pomeroy and Tugela Ferry as a consequence of poorly controlled industrial and commercial practices. This is not yet a major issue due to the small scale of industrial and commercial activities, but it needs to be addressed through appropriate building regulations (inclusive of storm water controls).

Pit latrines are common in the area.

Encroachment of invasive plants primarily on the banks of watercourses needs to be addressed.

These alien plants can have a negative impact on water flow and availability thereof.

Basic information for the area includes the following:

Parameter	Value
Quaternary catchment	V60H
Area	355 km <sup>2</sup>
Geology	Vryheid
Rainfall	702 mm/a
Recharge	38 mm/a (5% of rainfall) = 13.4 Mm <sup>3</sup> /a
Population	20000
Groundwater use	0.11 Mm <sup>3</sup> /a (average person in area 15 l/d)
Baseflow	4 Mm <sup>3</sup> /a (Issue alien vegetation)
Available	9 Mm <sup>3</sup> /a
Classification	??
RQOs	??

# Springlake Colliery

Springlake Colliery is one of the many collieries found in the study area. Springlake, which has been in operation for 30 years, is South Africa's largest producer of anthracite. The underground operation consists of one incline shaft and one vertical shaft with the deepest mining taking place 120 metres below surface. The opencast operation comprises two pits which are mined to an average depth of 30 metres. Here groundwater concerns are quality and quantity. Groundwater quantity concerns are the cone of depression due to dewatering for underground mining. Once mining has ceased the mine will flood and most likely decant (contaminating surface water bodies). Contamination issues include sources such as the opencast pits and underground, discard dumps, pollution control dams and treatment plants. Acid mine drainage is always a concern at coal mines.

Borehole and stream sampling and analysis are conducted on an ongoing basis in terms of the mine's water monitoring system.



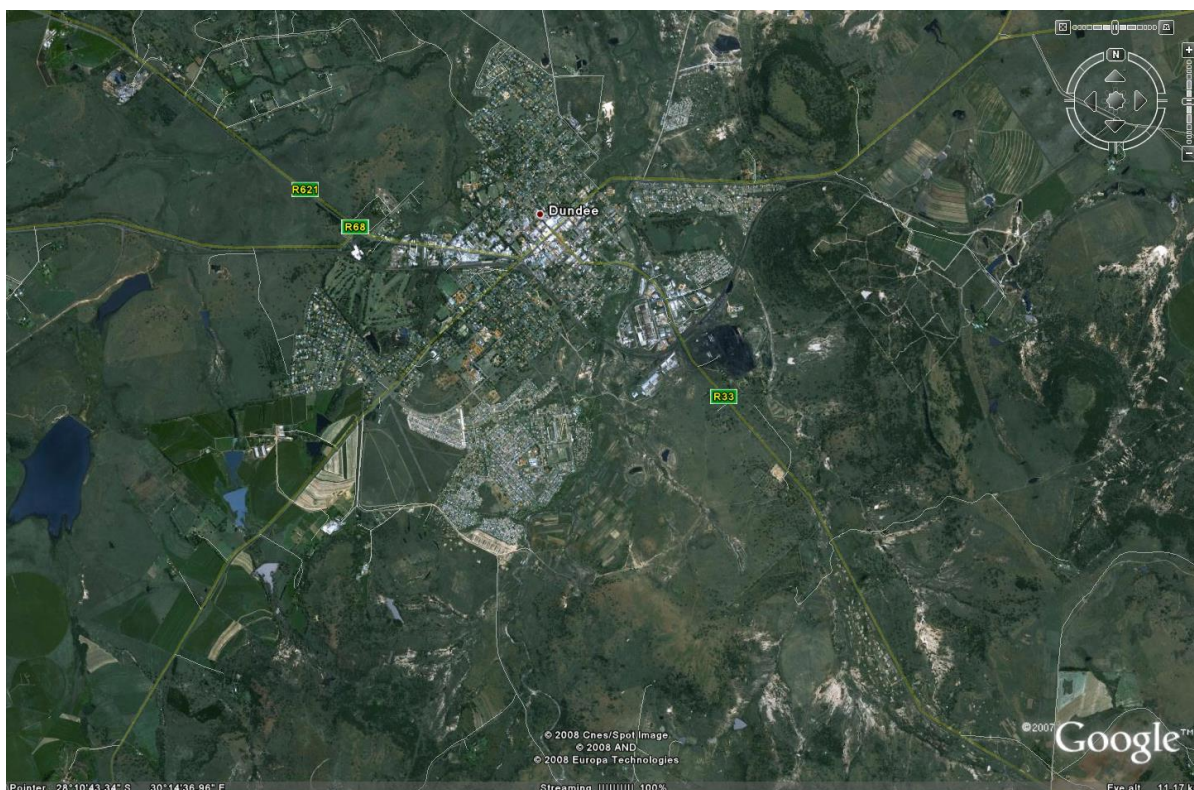


Basic information for the area includes the following:

Parameter	Value
Quaternary catchment	V32E
Area	783 km <sup>2</sup>
Geology	Vryheid with dolerite intrusions
Rainfall	776 mm/a
Recharge	42 mm/a (5% of rainfall) = 32.8 Mm <sup>3</sup> /a
Population	44500
Groundwater use	?? (Waiting for municipality to provide values)
Baseflow	11 Mm <sup>3</sup> /a (How much is contaminated?)
Available	??
Classification	??
RQOs	??

# Dundee

One of the main manufacturing plants of animal feeds is found in Dundee. The stock feeds are usually formulated from maize or sugarcane bagasse as the staple commodities with the addition of cake oil, fishmeal, bone meal, molasses, wheaten bran, feed urea and a range of trace elements. Mining is also a concern in the quaternary catchment (see Springlake Colliery).



Basic information for the area includes the following:

Parameter	Value
Quaternary catchment	V32E
Area	783 km <sup>2</sup>
Geology	Vryheid with dolerite intrusions
Rainfall	776 mm/a
Recharge	42 mm/a (5% of rainfall) = 32.8 Mm <sup>3</sup> /a
Population	44500
Groundwater use	?? (Waiting for municipality to provide values)
Baseflow	11 Mm <sup>3</sup> /a (How much is contaminated?)
Available	??
Classification	??
RQOs	??

# Newcastle

---

Newcastle is an industrial and mining town. Here the following sites will be discussed:

- Landfill site



- Karbochem synthetic rubbers are found in products produced by a number of international tyre, industrial and sporting goods companies. Karbochem also produces a speciality product (3,4 Polyisoprene) known as Isogrip, which is used to enhance wet grip in high performance tyres.



Basic information for the area includes the following:

Parameter	Value
Quaternary catchment	V31J
Area	358 km <sup>2</sup>
Geology	Vryheid
Rainfall	874 mm/a
Recharge	54 mm/a (6% of rainfall) = 19.3 Mm <sup>3</sup> /a
Population	46000
Groundwater use	0.01 Mm <sup>3</sup> /a (value obtained from municipality)
Baseflow	7 Mm <sup>3</sup> /a (How much is contaminated?)
Available	12 Mm <sup>3</sup> /a
Classification	??
RQOs	??

# Geology

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## Beaufort Formation

The main sediment source area for the Beaufort rocks lay along the high-lying, southern margin of the Basin. The coarser grained rocks are, therefore, found near the Cape Fold Belt (alluvial fan and braided stream environments), while mudstone, shale and fine-grained sandstones dominate the more distal central and northern portion (meandering river and floodplain environment) of the Basin. The sedimentary units in the Group therefore usually have very low primary permeabilities. The geometry of these aquifers is complicated by the lateral migration of meandering streams over a floodplain. Aquifers in the Beaufort Group will thus not only be multi-layered, but also multi-porous with variable thicknesses.

The contact plane between two different sedimentary layers will cause a discontinuity in the hydraulic properties of the composite aquifer. The pumping of a multi-layered aquifer will thus cause the piezometric pressure in the more permeable layers to drop faster than in the less permeable layers. It is therefore possible to completely extract the more permeable layers of the multi-layered Beaufort aquifers, without materially affecting the piezometric pressure in the less permeable layers. This complex behaviour of aquifers in the Beaufort Group is further complicated by the fact that many of the coarser, and thus more permeable, sedimentary bodies are lens-shaped. The life-span of a high-yielding borehole in the Beaufort Group may therefore be limited, if the aquifer is not recharged frequently.

## Vryheid Formation (part of the Ecca Formation)

The Ecca Group consists mainly of shales. Since the shales are very dense, they are often overlooked as significant sources of groundwater. One should thus not neglect the Ecca rocks as possible sources for groundwater, especially the deltaic sandstone facies. The deltaic sandstones represent a facies of the Ecca sediments in which one would expect to find high-yielding boreholes. Unfortunately, Rowsell and De Swardt (1976) have found that the permeabilities of these sandstones are also usually very low. The main reason for this is that the sandstones are usually poorly sorted, and that their primary porosities have been lowered considerably by diagenesis. However, the Vryheid Formation sandstones in KwaZulu-Natal (west of Pietermaritzburg) appear to be more permeable, with a median borehole yield of 0.33 l/s and 62% yielding greater than 1 l/s (KwaZulu-Natal project, 1995, unit 8).

# Issues of concern

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- Rural communities highly dependent on groundwater (handpumps)
- Rural communities make use of pit latrines – microbial contamination
- Surface water in some instances (mining areas) contaminating groundwater
- Where groundwater is shallow cemeteries are also a source of contamination
- Forestry uses high volumes of groundwater for example
  - Pine – approximately 25 l/d
  - Eucalyptus - approximately 25 l/d
  - Wattle – approximately 50 l/d
- Huge feedlots in the area also form part of the contamination problem
- Quantification of baseflow is important! In general the default baseflow values are found to be too high in the GRDM software. Current revision of the GRAII data sets in progress. Baseflow has to be estimated using Darcys Law, Herolds Method and water quality data.
- Accurate abstraction rates is also a concern as data sets are incomplete.



### *Field trip (2 – 3 October 2008)*

A field trip was arranged for DWAF officials. The aim of the field trip was to familiarize DWAF officials with the site and the issues related to the Groundwater Reserve within the WMA. The two day field trip was attended by:

- Rainier Dennis (IGS)
- Nomalizo Mvimbi (DWAF)
- Puleng Moche (DWAF)
- Ndivhwo Netshiendeulu (DWAF)
- Amukelani Shibambo (DWAF)
- Tichatonga Gouah (DWAF)

The second trip started in Harrismith at the eastern edge of the ended in the Drakensberg mountains at Little Switzerland. Some of the photos from the trip are shown below:





The documentation provided for the field trip is provided in the following section.

# The Thukela Groundwater Reserve Determination



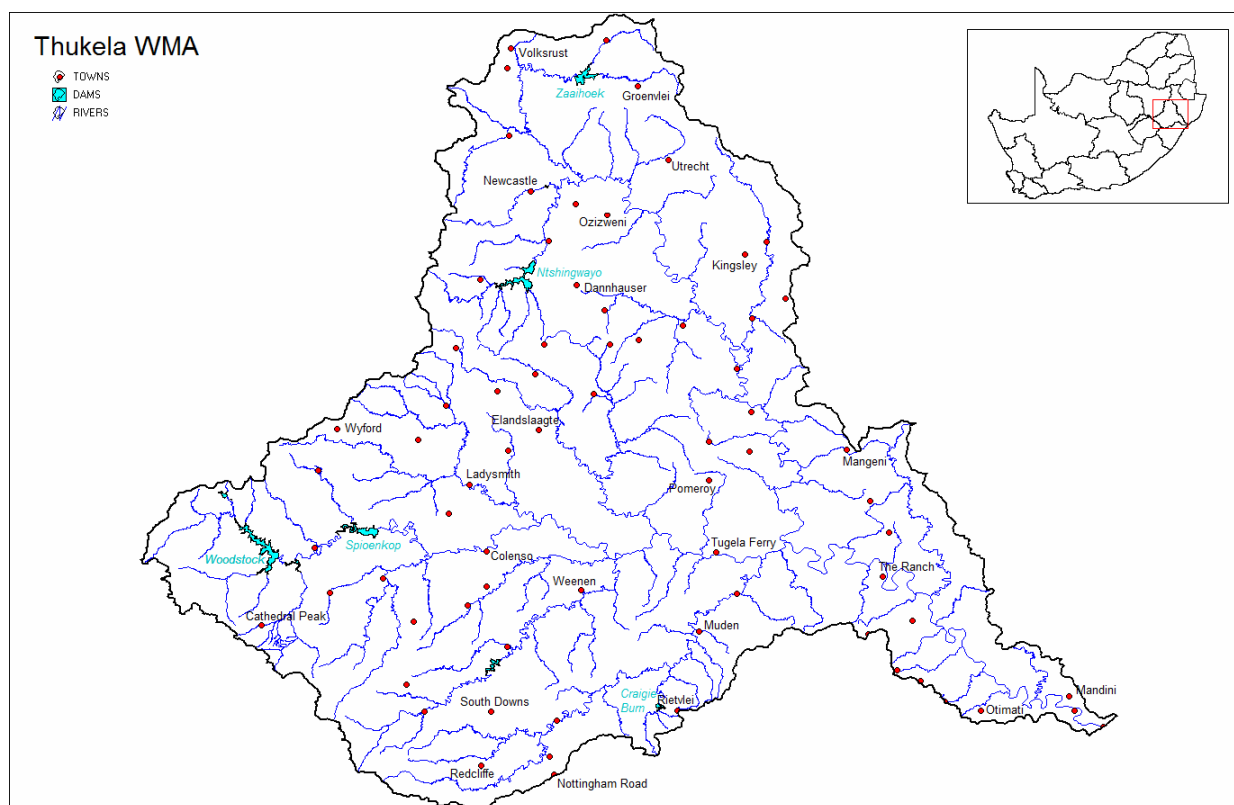
Field trip

2 & 3 October 2008

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- The Buffalo River, which rises above Newcastle

Major tributaries into the Thukela River from the south are as follows:

- The Little Thukela River
- The Bloukrans River

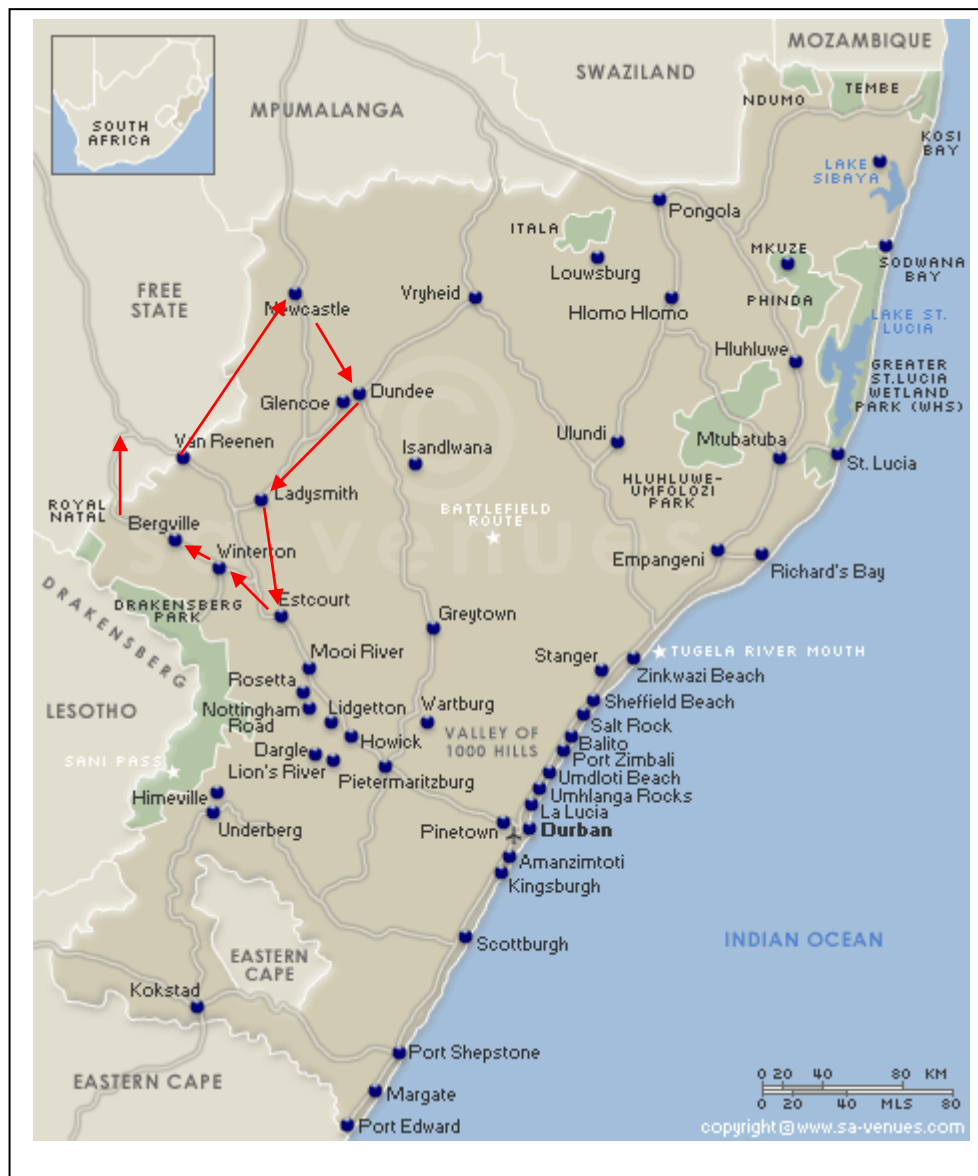
- The Bushmans River, passing through Estcourt
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- Over abstraction
- Groundwater contamination due to:
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  - urbanisation,
  - mining,
  - agriculture and
  - in rural areas pit latrines

# Aim

The aim of this field trip is to familiarise interested parties with the study area and highlight some of the issues to be addressed in the reserve determination. The route to be followed over the next 2 days is shown below. The field trip will end at Thukela Ferry. This document is a summary of the field trip providing details of the areas to be visited.



As you drive through the area discuss the issues – classify the sites and suggest resource quality objectives.

# New Castle

---

Newcastle is an industrial and mining town. It is a “HOT SPOT” in the study area.

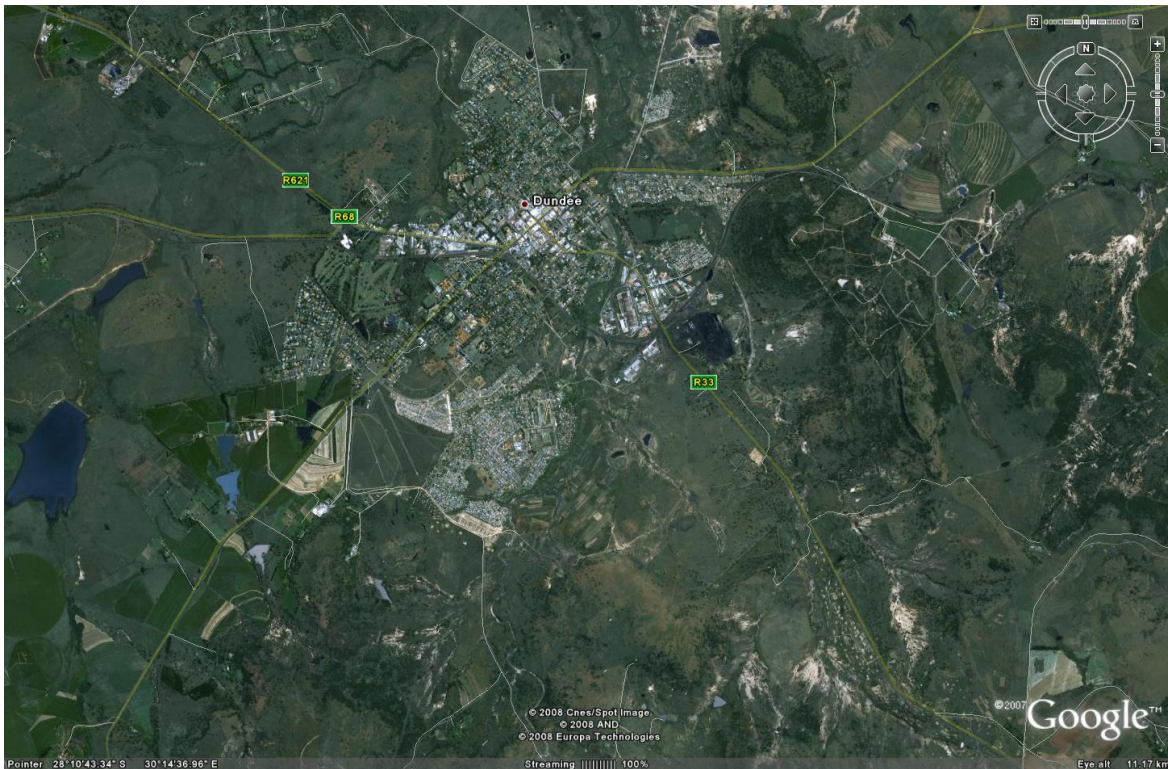
Basic information for the area includes the following:

Parameter	Value
<b>Quaternary catchment</b>	V31J
<b>Area</b>	358 km <sup>2</sup>
<b>Geology</b>	Vryheid
<b>Rainfall</b>	874 mm/a
<b>Recharge</b>	54 mm/a (6% of rainfall) = 19.3 Mm <sup>3</sup> /a
<b>Population</b>	46000
<b>Groundwater use</b>	0.01 Mm <sup>3</sup> /a (value obtained from municipality)
<b>Baseflow</b>	7 Mm <sup>3</sup> /a (How much is contaminated?)
<b>Available</b>	12 Mm <sup>3</sup> /a
<b>Classification</b>	??
<b>RQOs</b>	??



# Dundee

One of the main manufacturing plants of animal feeds is found in Dundee. The stock feeds are usually formulated from maize or sugarcane bagasse as the staple commodities with the addition of cake oil, fishmeal, bone meal, molasses, wheaten bran, feed urea and a range of trace elements. Mining is also a concern in the quaternary catchment.



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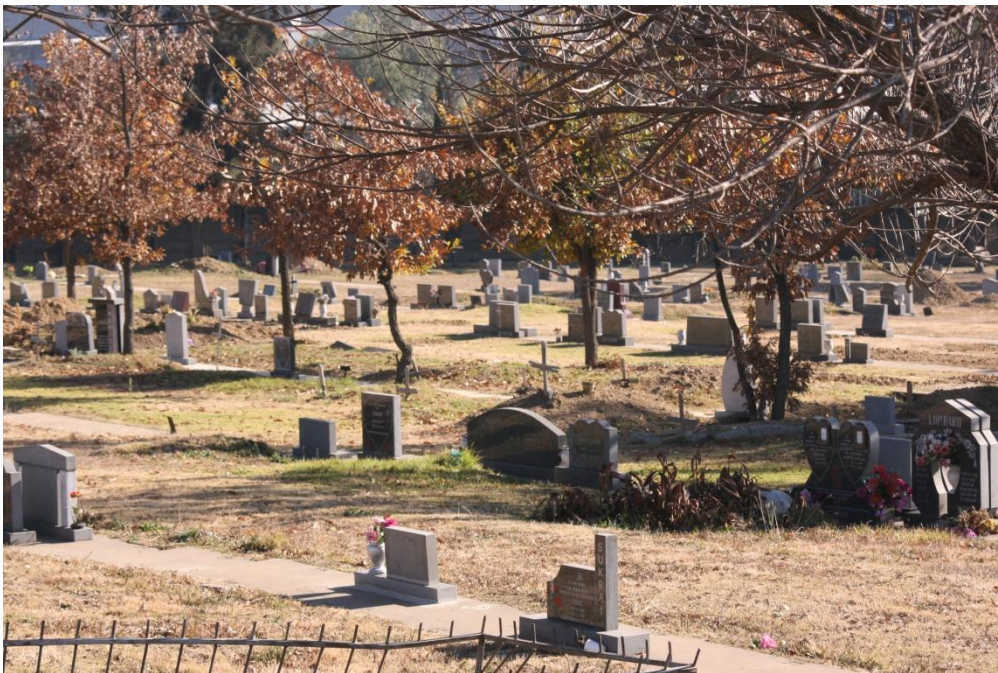
Parameter	Value
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<b>Rainfall</b>	776 mm/a
<b>Recharge</b>	42 mm/a (5% of rainfall) = 32.8 Mm <sup>3</sup> /a
<b>Population</b>	44500
<b>Groundwater use</b>	?? (Waiting for municipality to provide values)
<b>Baseflow</b>	11 Mm <sup>3</sup> /a (How much is contaminated?)
<b>Available</b>	??
<b>Classification</b>	??
<b>RQOs</b>	??



# Escourt

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Escourt is an industrial town set on the Bushmans River. There are numerous industrial sites along the river together with cemeteries etc. Groundwater will be shallow in these areas.



# Winterton and Bergville

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Winterton and Bergville fall into the high recharge area of the WMA. Farming is the main activity in this area that can impact on groundwater. Most irrigation is occurring from tributaries of the Thukela River.

## Geology

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### Beaufort Formation

The main sediment source area for the Beaufort rocks lay along the high-lying, southern margin of the Basin. The coarser grained rocks are, therefore, found near the Cape Fold Belt (alluvial fan and braided stream environments), while mudstone, shale and fine-grained sandstones dominate the more distal central and northern portion (meandering river and floodplain environment) of the Basin. The sedimentary units in the Group therefore usually have very low primary permeabilities. The geometry of these aquifers is complicated by the lateral migration of meandering streams over a floodplain. Aquifers in the Beaufort Group will thus not only be multi-layered, but also multi-porous with variable thicknesses.

The contact plane between two different sedimentary layers will cause a discontinuity in the hydraulic properties of the composite aquifer. The pumping of a multi-layered aquifer will thus cause the piezometric pressure in the more permeable layers to drop faster than in the less permeable layers. It is therefore possible to completely extract the more permeable layers of the multi-layered Beaufort aquifers, without materially affecting the piezometric pressure in the less permeable layers. This complex behaviour of aquifers in the Beaufort Group is further complicated by the fact that many of the coarser, and thus more permeable, sedimentary bodies are lens-shaped. The life-span of a high-yielding borehole in the Beaufort Group may therefore be limited, if the aquifer is not recharged frequently.

### Vryheid Formation (part of the Ecca Formation)

The Ecca Group consists mainly of shales. Since the shales are very dense, they are often overlooked as significant sources of groundwater. One should thus not neglect the Ecca rocks as possible sources for groundwater, especially the deltaic sandstone facies. The deltaic sandstones represent a facies of the Ecca sediments in which one would expect to find high-yielding boreholes. Unfortunately, Rowsell and De Swardt (1976) have found that the permeabilities of these sandstones are also usually very low. The main reason for this is that the sandstones are usually poorly sorted, and that their primary porosities have been lowered considerably by diagenesis.

However, the Vryheid Formation sandstones in KwaZulu-Natal (west of Pietermaritzburg) appear to be more permeable, with a median borehole yield of 0.33 l/s and 62% yielding greater than 1 l/s (KwaZulu-Natal project, 1995, unit 8).

## Issues of concern

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- Rural communities highly dependent on groundwater (handpumps)
- Rural communities make use of pit latrines – microbial contamination
- Surface water in some instances (mining areas) contaminating groundwater
- Where groundwater is shallow cemeteries are also a source of contamination
- Forestry uses high volumes of groundwater for example
  - Pine – approximately 25 l/d
  - Eucalyptus - approximately 25 l/d
  - Wattle – approximately 50 l/d
- Huge feedlots in the area also form part of the contamination problem
- Quantification of baseflow is important! In general the default baseflow values are found to be too high in the GRDM software. Current revision of the GRAII data sets in progress. Baseflow has to be estimated using Darcys Law, Herolds Method and water quality data.
- Accurate abstraction rates is also a concern as data sets are incomplete.

