Years of Water & Environmental Science

GROUNDWATER ABSTRACTION ASSESSMENT

FOR

DEVELOPMENT ON THE FARM VLAKFONTEIN 523 JR PORTION 25

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Compiled for:

JCJ DEVELOPMENTS

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LIST OF ABBREVIATIONS

Abbreviation	**Explanation**
ARD	Acid Rock Drainage
BPG	Best Practice Guidelines
CMS	Catchment Management Strategy
CSM	Conceptual Site Model
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
IWRMP	Integrated Water Resources Management Plan
IWRM	Integrated Water Resources Management
Km^2	Square Kilometre
L/s	Litres per second
mamsl	Metres above mean sea level
Ml/d	Megalitres per day
m	meter
mm	Millimetre
mm/a	Millimetres per annum
mS/m	Millisiemens per metre
m^3	Cubic metre
MAP	Mean Annual Precipitation
MPRDA	Mining and Petroleum Resources Development Act (Act No. 73 of 2002) 1989)
NEMA	National Environmental Management Act (Act No. 107 of 1998)
NWA	National Water Act (Act No. 36 of 1998)
ppm	Parts per million
RDM	Resource Directed Measures
RQO	Resource Quality Objective
RWQO	Resource Water Quality Objective
TDS	Total Dissolved Solids
WMA	Water Management Area
WMP	Water Management Plan

DEFINITIONS

Definition	Explanation
Aquiclude	A geologic formation, group of formations, or part of formation through which virtually no water moves
Aquifer	A geological formation which has structures or textures that hold water or permit appreciable water movement through them. Source: National Water Act (Act No. 36 of 1998).
Borehole	Includes a well, excavation, or any other artificially constructed or improved underground cavity which can be used for the purpose of intercepting, collecting or storing water in or removing water from an aquifer; observing and collecting data and information on water in an aquifer; or recharging an aquifer. Source: National Water Act (Act No. 36 of 1998).
Boundary	An aquifer-system boundary represented by a rock mass (e.g. an intruding dolerite dyke) that is not a source of water, and resulting in the formation of compartments in aquifers.
Cone of Depression	The depression of hydraulic head around a pumping borehole caused by the withdrawal of water.
Confining Layer	A body of material of low hydraulic conductivity that is stratigraphically adjacent to one or more aquifers; it may lie above or below the aquifer.
Dolomite Aquifer	See “Karst” Aquifer
Drawdown	The distance between the static water level and the surface of the cone of depression.
Fractured Aquifer	An aquifer that owes its water-bearing properties to fracturing.
Groundwater	Water found in the subsurface in the saturated zone below the water table.
Groundwater Divide or Groundwater Watershed	The boundary between two groundwater basins which is represented by a high point in the water table or piezometric surface.
Groundwater Flow	The movement of water through openings in sediment and rock; occurs in the zone of saturation in the direction of the hydraulic gradient.
Hydraulic Conductivity	Measure of the ease with which water will pass through the earth's 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 (m/d).
Hydraulic Gradient	The rate of change in the total hydraulic head per unit distance of flow in a given direction.
Infiltration	The downward movement of water from the atmosphere into the ground.
Intergranular Aquifer	A term used in the South African map series referring to aquifers in which groundwater flows in openings and void spaces between grains and weathered rock.

Definition	Explanation
Karst (Karstic)	The type of geomorphological terrain underlain by carbonate rocks where significant solution of the rock has occurred due to flowing groundwater.
Karst (Karstic) Aquifer	A body of soluble rock that conducts water principally via enhanced (conduit or tertiary) porosity formed by the dissolution of the rock. The aquifers are commonly structured as a branching network of tributary conduits, which connect together to drain a groundwater basin and discharge to a perennial spring.
Monitoring	The regular or routine collection of groundwater data (e.g. water levels, water quality and water use) to provide a record of the aquifer response over time.
Observation Borehole	A borehole used to measure the response of the groundwater system to an aquifer test.
Phreatic Surface	The surface at which the water level is in contact with the atmosphere: the water table.
Piezometric Surface	An imaginary or hypothetical surface of 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.
Porosity	Porosity is the ratio of the volume of void space to the total volume of the rock or earth material.
Production Borehole	A borehole specifically designed to be pumped as a source of water supply.
Recharge	The addition of water to the saturated zone, either by the downward percolation of precipitation or surface water and/or the lateral migration of groundwater from adjacent aquifers.
Recharge Borehole	A borehole specifically designed so that water can be pumped into an aquifer in order to recharge the ground-water reservoir.
Saturated Zone	The subsurface zone below the water table where interstices are filled with water under pressure greater than that of the atmosphere.
Specific Capacity	The rate of discharge from a borehole per unit of drawdown, usually expressed as m3/d•m.
Specific Yield	The ratio of the volume of water that drains by gravity to that of the total volume of the saturated porous medium.
Storativity	The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head.
Transmissivity	Transmissivity is the rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. It is expressed as the product of the average hydraulic conductivity and thickness of the saturated portion of an aquifer.
Unsaturated Zone (Also Termed Vadose Zone)	That part of the geological stratum above the water table where interstices and voids contain a combination of air and water.
Watershed (Also Termed Catchment)	Catchment in relation to watercourse or watercourses or part of a watercourse means the area from which any rainfall will drain into the watercourses or part of a watercourse through surface flow to a common point or points. Source: National Water Act (Act No. 36 of 1998).
Water Table	The upper surface of the saturated zone of an unconfined aquifer at which pore pressure is equal to that of the atmosphere.

1 INTRODUCTION

Geo Pollution Technologies (Pty) Ltd (GPT) was appointed by JCJ developments to conduct a groundwater abstraction assessment for development of the Rainbow Filling Station on the farm Vlakfontein 523 JR near Bronkhorstspruit, Gauteng Province. The study was undertaken in support of the basic assessment.

1.1 Requirements for water use licence applications (Groundwater abstraction)

As per the requirements for water use license applications: Groundwater abstraction. Section 21 (a), an initial regional assessment is required to determine the amount of information necessary for each new Water Use licence application. This is based on the amount of recharge that is used by the applicant in relation to the property.

1.2 Initial assessment

The initial assessment is detailed in Table 1 below:

Table 1: Initial assessment

Area of property	Area (m2)	Rainfall (mm)	Rainfall (m)	Recharge m (@3% of rainfall)	Recharge on area (m3/a)
	111550	730	0,73	0,0219	2442,9
Abstraction (Abs)	Existing (m3/a)	New (m3/a)	Total (ABStotal)		
	1800	0	1800		
Abstraction scale as % of recharge	Small scale abstraction	Medium scale abstraction	Large scale abstraction		
74	Category A (<60%)	Category B (60-100%)	Category C (> 100%)		

Using conservative assumptions[1] on rainfall and recharge the proposed development is deemed to be a medium-scale abstraction (Cat B) development and requires the following:

- Geology of the area, including structures
- Borehole census within a 1 km radius around the property
- Aquifer description
- Effective annual recharge on the property and safe yield of the aquifer
- Volume and purpose of use
- Impact of abstraction on existing water users and surface water discharges
- Monitoring programme

[1] Limpopo region directorate water regulation and use status report on groundwater levels 30 April 2010 – 30 April 2011

2 GEOGRAPHICAL SETTING

2.1 Regional Water Management Setting and Sensitivity

The site is located in the Olifants Water Management Area downstream (north) of the Bronkhorstspruit Dam, 350 m from the Bronkhorstspruit which flows north in the quaternary catchment B20D. The Bronkhorstspruit in this area flows permanently throughout the whole year. The site is located at an elevation of 1410 mamsl. Surface drainage is easterly towards the Bronkhorstspruit. Groundwater flow is expected to follow topography flowing towards a discharge point, i.e. the Bronkhorstspruit. (see Figure 1 below).

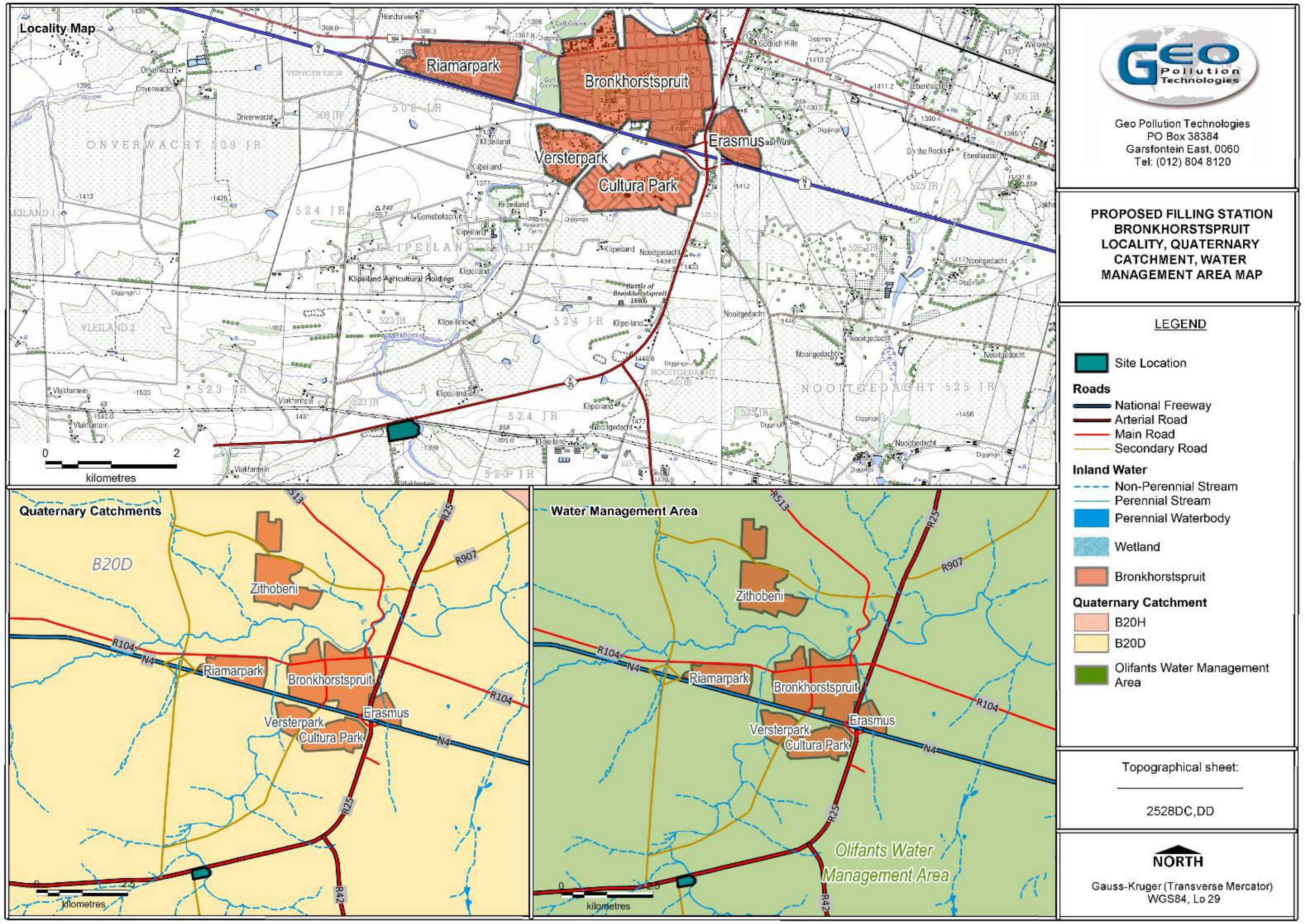

Figure 1: Site Location and Quaternary Catchment Boundaries

2.2 Climate

Climatic data was obtained from the DWA weather station Groenfontein at Bronkhorstspruit Dam (rainfall data and evaporation data) for the Bronkhorstspruit area (Table 2)[2]. The proposed site is located in the summer rainfall region of Southern Africa with precipitation usually occurring in the form of convectional thunderstorms. The average annual rainfall (measured over a period of 47 years) is approximately 726.6 mm, with the high rainfall months between October to March.

Table 2: Climatic Data

Month	Average monthly rainfall (mm)	Mean monthly evaporation
January	138.8625	164.875
February	84.26666667	144.22
March	93.58085106	135.3404255
April	43.09361702	104.0744681
May	14.43191489	84.9893617
June	7.014893617	65.40212766
July	2.543478261	73.65
August	7.542553191	103.4553191
September	22.53111111	141.5711111
October	76.76086957	165.9340426
November	112.306383	163.7543478
December	123.6319149	175.6446809
Annual	726.5667533	1522.910884

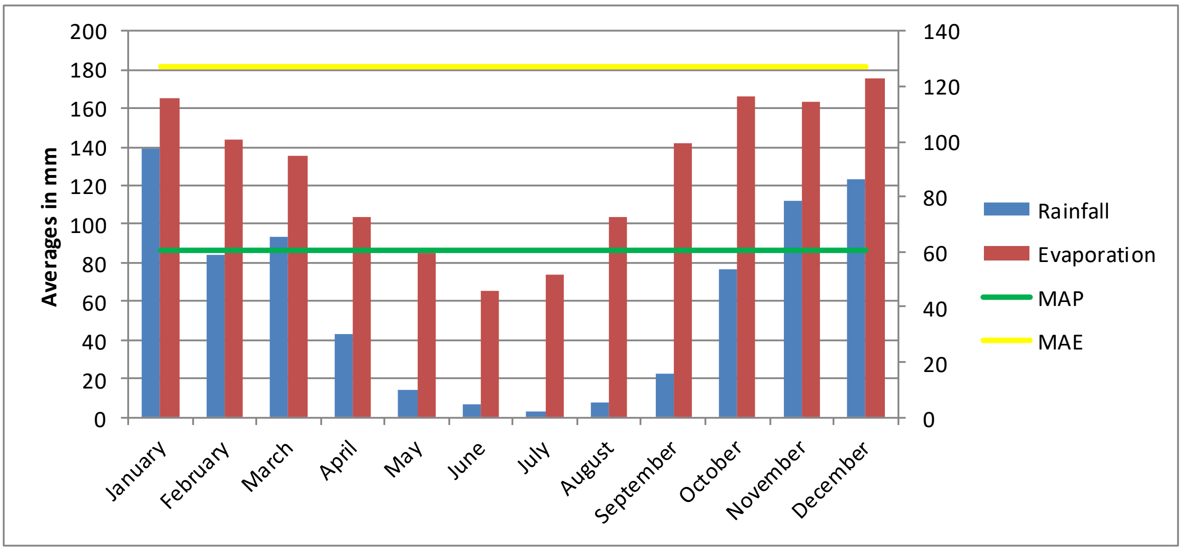

Figure 2: Climatic data representation

2 Department of Water Affairs (DWA): www.dwa.gov.za

3 FINDINGS

3.1 Hydrocensus

A hydrocensus survey was conducted within a one km radius of the site of development to identify groundwater users and natural drainage features. Three privately-owned abstraction boreholes were identified in the surrounding area. One abstraction borehole was found at the proposed filling station site. The dominant groundwater use in the area is human consumption, with minor livestock watering. The average depth to water table across the area is 8.5 mbgl. The hydrocensus positions are shown on the locality map in Figure 3 below. The hydrocensus data sheet for each borehole is attached under Appendix II.

The hydrocensus information is summarised in Table 1.

3.2 Groundwater depth and flow direction

It can generally be assumed that the groundwater table emulates the surface topography. Groundwater flow is therefore inferred to take place in an westerly direction. The average depth to the water table in the area is 8.5 mbgl.

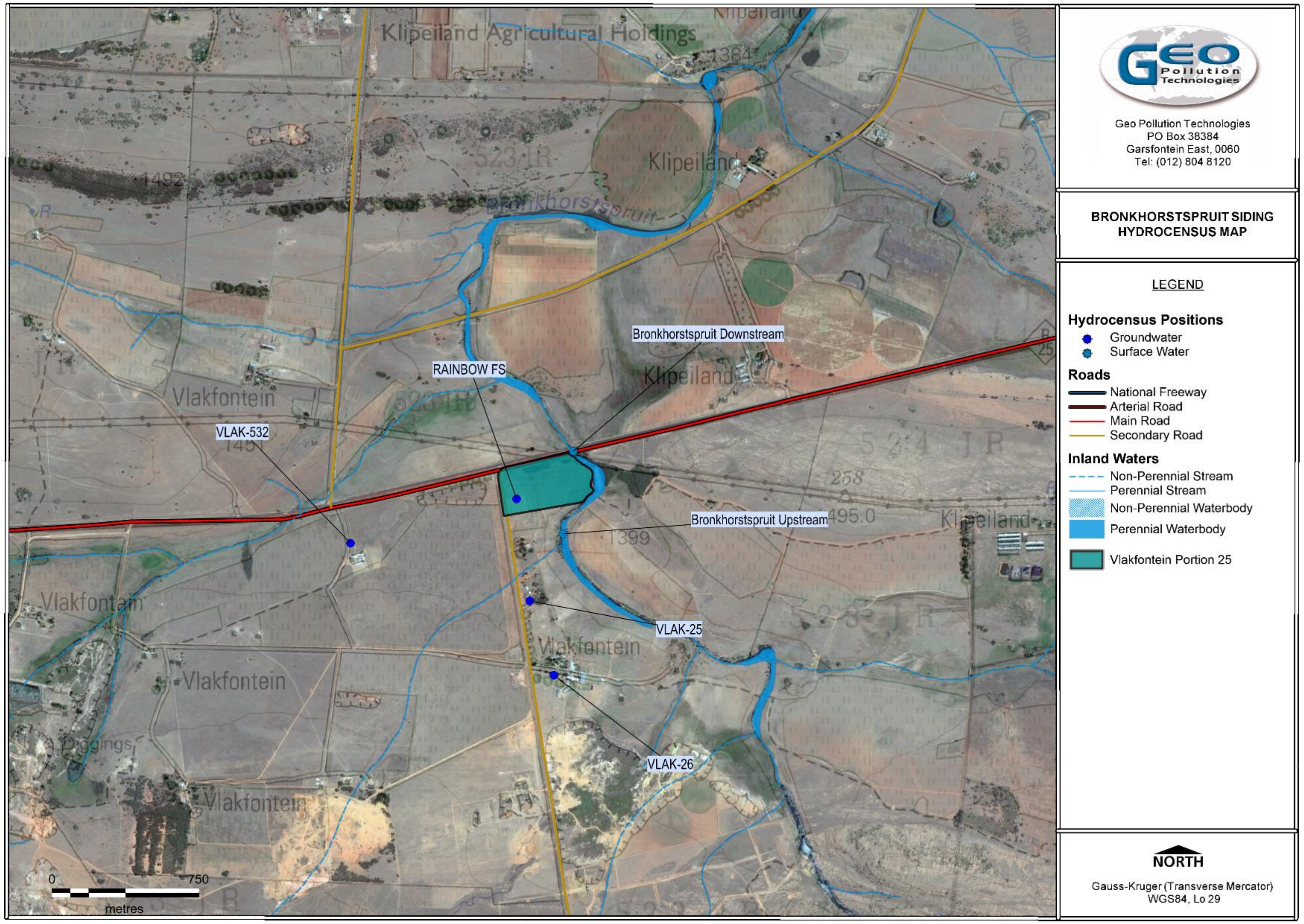

Figure 3: Hydrocensus map

Table 3:Hydrocensus information

No.	ID	Latitude	Longitude	Elevation (mamsl)	Owner	Property	Casing height	Static water level (mbgl)	Static water level (mamsl)	Sampled (Y/N)	Use
Groundwater											
1	RAINBOW FS	-25.85852	28.70007	1413	J. J. Erasmus	Rainbow Filling Station	0.025	-	-	Yes	Domestic
2	VLAK-25	-25.86319	28.70074	1419	Mr. Tinus Strydom	Unit 25 Vlakfontein	0.024	11.5	1407.5	Yes	Domestic
3	VLAK-26	-25.8666	28.70198	1427	Mr. Tinus Strydom	Unit 26 Vlakfontein	0.000	7.1	1419.9	Yes	Domestic and Livestock
4	VLAK-532	-25.86054	28.69161	1411	Vlakfontein Trust	Unit 532 Vlakfontein	0.000	6.9	1404.1	Yes	Domestic
Surface water											
1	Bronkhorstspruit Upstream	-25.86012	28.70244	1392	NA	*Bronkhorstspruit*	0.000	0	1392	Yes	NA
2	Bronkhorstspruit Downstream	-25.85633	28.70295	1388		*Bronkhorstspruit*	0.000	0	1388	Yes	

3.3 Aquifer Classification

The site of the planned development is underlain by quartzite with interlayers of shale and sub-greywacke of the Rayton Formation of the Pretoria Group, Transvaal Supergroup. Around the site outcrops dolerite dykes or sills.

Pretoria Group quartzites are extensive and competent; they reach up to 300 m in thickness at places. The Transvaal Supergroup rocks are of Vaalian age and underwent deformation related to the intrusion of the BIC and granitic provinces resulting in small-scale folding and faulting. The average dip of the quartzite layers is 18° north-east.

3.3.1 Hydrogeology

As discussed, the site is underlain by the Rayton Formation. At outcrop areas and if weathered, the Pretoria Group quartzites tend to form extensive aquitards with improved porosity and permeability.

The potential for groundwater occurrence will depend on the presence of joints and fractures in the quartzites. Weathering and fracturing may increase the aquifer potential, thus zones of weathering and fracturing within the quartzites will act as targets for potential groundwater exploration. The thickness of Pretoria Group quartzites may reach up to 300 m but the depth of weathering is thin (up to 15 m), it can be concluded that groundwater users in the area tap their water from this weathered/fractured quartzitic aquifer.

3.3.2 Shallow weathered aquifer

Quartzite/shale and sandstone complexes are found to generally have low transmissivities, except if weathered and form extensive aquitards in outcrop areas. The sandy soil horizon is expected to allow for rapid infiltration into the vadose zone during precipitation events at recharge. High runoff rates are expected on the steep slopes to the east towards the *Bronkhorstspruit*. Streams that converge at right angles are common in jointed, folding or faulted quartzites. Folding leads to a high degree of fracturing and the shallow weathered aquifer is thought to have developed a high fracture density due to folding.

The main source of recharge into the shallow alluvial aquifer is rainfall that infiltrates the aquifer through the unsaturated zone. Vertical movement of water is faster than lateral movement in this system as water moves predominantly under the influence of gravity. Groundwater recharge was estimated to be an average of 10% of mean annual precipitation. The commonly expected values of porosity and hydraulic conductivity are 0.05 and 0.1 m/day, respectively. This aquifer is thought to be the main productive aquifer in the area.

3.3.3 Fractured aquifer

At depth, Pretoria Group quartzites are generally competent rock and tend to develop good jointing systems. Primary porosity is virtually inexistent and the presence of water is generally limited to secondary structures, i.e. joints and fractures.

Both the porosity and the hydraulic conductivity of these aquifers are known to be low. The commonly expected values of porosity and hydraulic conductivity are 0.035 and 0.01 m/day, respectively. Movement of groundwater in this aquifer occurs primarily in secondary structures such as faults and fractures. The Pretoria Group quartzites are low-yielding aquifers, with a low groundwater development potential at depths greater than 40 m below the surface.

3.4 Recharge Estimation

Recharge in the shallow regolith aquifer is estimated at approximately 3 to 5%. A higher proportion of infiltration may occur in areas where the natural permeability is increased.

Table 4: Recharge calculation for the shallow unconfined aquifer

Recharge Estimation			
Method	**mm/a**	**% of rainfall**	**Certainty (Very High = 5 ; Low = 1)**
Soil	59.0	8.1	3
Geology	42.6	5.9	3
Vegter	65.0	9.0	3
Acru	10.0	1.4	3
Harvest Potential	15.0	2.1	3

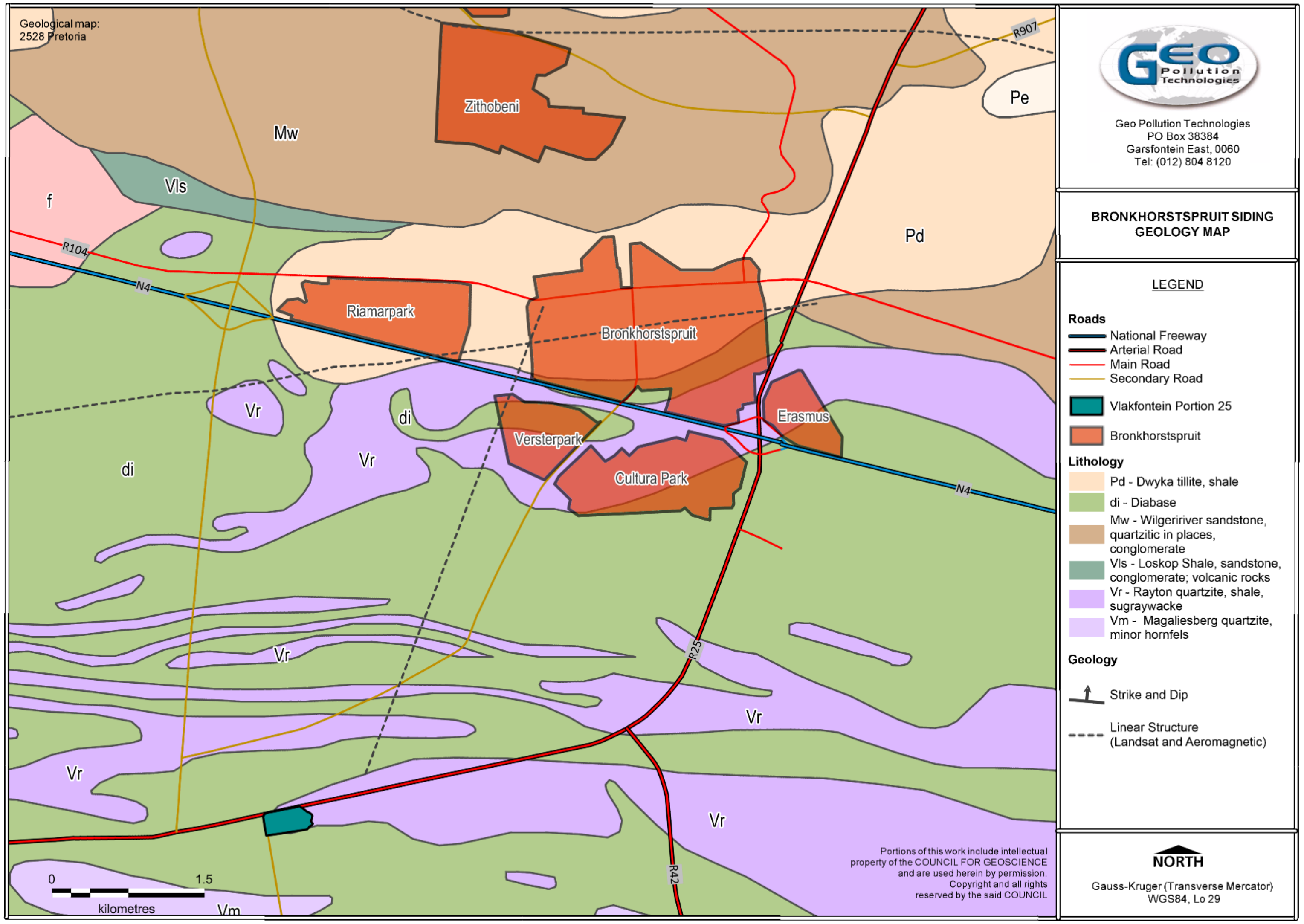

Figure 4: Geology map

3.5 Aquifer Testing

Two aquifer tests were conducted on boreholes Rainbow FS and Vlak 25 (see Figure 3). The data shown in Appendix I was interpreted using the flow characteristic (FC) method developed by the Institute for Groundwater Studies. The following recommendations are put forward for Rainbow FS:

- Sustainable pumping rate: 0.75 l/s
- Pumping cycle: On 8 hours/day, Off 16 hours/day

The following recommendations are put forward for VLAK 25:

- Sustainable pumping rate: 0.1 l/s
- Pumping cycle: On - 8 hours/day, Off 16 hours/day

Applying the above recommendations, the aquifer is able to supply 21 m^3/day or 7776m^3.

Table 5: Pump test summary

Borehole Name	Starting Water Level (mbgl)	Borehole depth (mbgl)	Available drawdown m	Pump Installation (mbgl)	Q pump tested (l/s)	Drawdown (mbgl)	Time Constant Discharged Tested			Recovery Time		
							Hours	Minutes	Seconds	Hours	Minutes	Seconds
Rainbow FS	8,4	30	20	28	0,75	11,1	6	360	21600	0,5	30	1800
Vlak 25	8,05	unknown	_	_	0,1	15	2	120	7200	>3	> 180	>10800
Averages	8,225	30	20	28	0,425	13,05	4	240	14400	0,5	30	1800

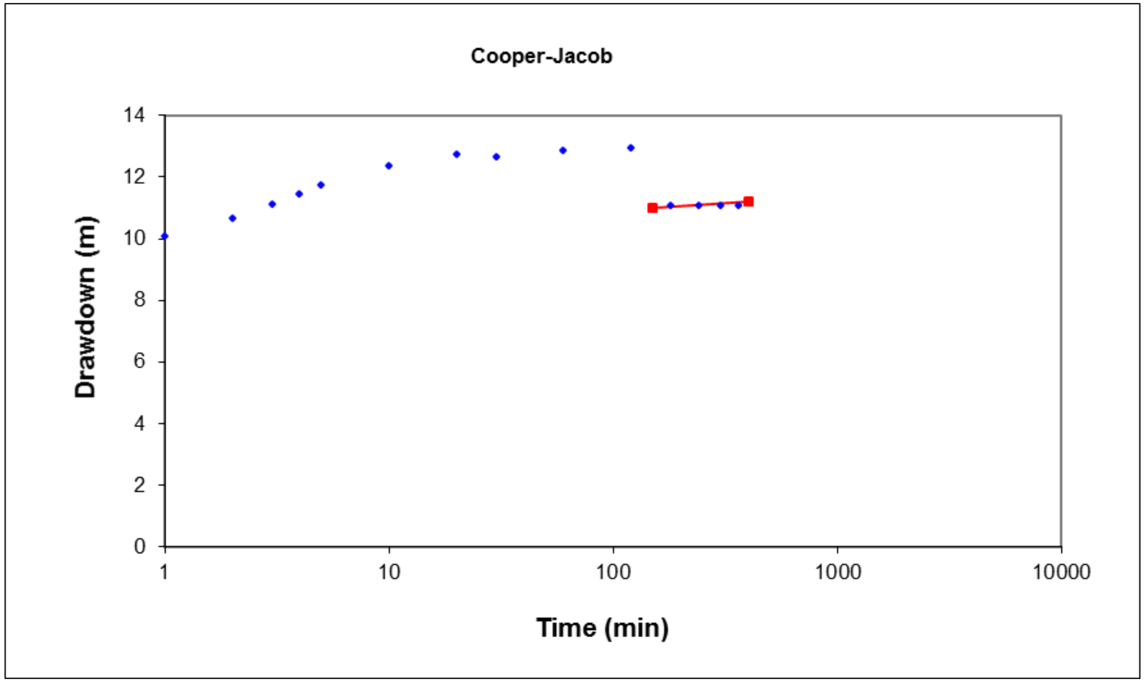

Figure 5: Late time using the Cooper-Jacob method (Rainbow FS)

Table 6: Recommended pumping rates and yields

Recommended pumping rates and yield							
Borehole Name	**Pumping rate (L/s)**	**Pumping rate (L/hr)**	**Pump cycle (hours)**	**Yield (L/day)**	**Yield (m^3/day)**	**Yield (m^3/month)**	**Yield (m^3/per annum)**
Rainbow FS	0,7500	2700,0000	8,0	21600,0	21,6000	648,0000	7776,0000
Vlak 25	0,1000	360,0000	4,0	1440,0	1,4400	43,2000	518,4000
Total	**0,8500**	**3060,0000**	**NA**		**23,0400**	**691,2000**	**8294,4000**

3.6 Impact of abstraction

The cone of depression is limited to 200 m surrounding the borehole, thus no impact is expected on any privately-owned boreholes. The bottom of the borehole is also above the Bronkhorstspruit, thus flow loss is not expected on the Spruit.

4 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions are drawn:

- The main waterstrikes originate from the weathered/fractured quartzitic aquifer.
- Recharge is expected to be between 3 and 5% across the property
- No impact on other boreholes or the Bronkhorstspruit are foreseen if the recommended pumping rates and pump cycle are adhered too

The following recommendations are put forward:

- Only borehole Rainbow FS should be used to supply the development
- Sustainable pumping rate: 0,75 l/s
- Pumping cycle: On 8 hours/day, Off 16 hours/day. This will allow recovery of the borehole ensuring the fractured (water flow) is not closed.
- A float switch on the tanks should be considered. This will ensure that when the tanks are filled to capacity pumping is stopped.

APPENDIX I: PUMP TEST INFORMATION