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A: SOURCE DESCRIPTION

District Municipality:

Amatole		Chris Hani		O.R Tambo	
Ukhahlamba		Cacadu	x	Alfred Nzo	

Local Municipality: NELSON MANDELA

Institution where Information is held: KHULANI VSA GROUNDWATER CONSULTANTS

Branch of Institution: DEPARTMENT OF GEOHYDROLOGY

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B: TYPE OF INFORMATION

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Report / Info Title: A DESKTOP STUDY FOR AN EMEGERNCY BOREHOLE FOR THE KLEINPOORT COMMUNITY

Report Nr: WE 02075 7-Apr-03

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Author's Qualification:

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Engineer		Technician		Other	
Specify Other:					

Captured by: NOMSA NKOMO Date: 18-Mar-04 Signed: [signature]

C: GEOHYDROLOGICAL CATEGORIZATION

Project Type

Source development		Feasibility Study	x	Sanitation Study:	
Specify Other:					

Reference Co-ordinate:

Latitude	Longitude
S 33.32362	E 24.89917

	Yes	No	Complete	Incomplete
Lithological & Construction Logs		X		
Hydrocensus Data	X		X	
Pump Testing Data		X		
Chemical Water Analysis Data	X		X	
Geohydrological Data	X		X	
Spring Data		X		
Remote Sensing Data		X		
Map Data	X			X

Comments:

Reviewed by: EUNICE GOOSSENS Date: 25/3/2004 Signed: [signature]

DESK STUDY FOR AN EMERGENCY BOREHOLE FOR THE KLEINPOORT COMMUNITY

Prepared for

MASUKU DUBE TIFFLIN

by

Etienne Mouton Pr.Sci.Nat

WE 02075 **MAY 2002**

WSM CIVIL ENGINEERS HYDROGEOLOGISTS PROJECT MANAGERS

1. INTRODUCTION AND TERMS OF REFERENCE

The Kleinpoort community has an insufficient basic water supply. This situation has become exacerbated by low-rainfall which has resulted in diminished yields from the existing Mono pump-equipped borehole. To alleviate the problem, the Cacadu District Municipality has approached Masuku Dube Tifflin (Consulting Engineers) to implement an emergency borehole supply scheme to augment the current supply. ***WSM* (Pty) Ltd** were approached for their hydrogeological input and to undertake a Desk Study ahead of a drilling programme. The Desk Study is based on existing information and data available for the Kleinpoort area and is a critical foundation for preliminary groundwater resource assessment and target delineation for borehole siting.

The Desk Study provides extensive information on the hydrogeological conditions in the Kleinpoort area and entails completion of the following:

- Existing Borehole Information
- Maps
- Water Quality Analyses
- Existing Reports
- Aerial Photograph Review (not included in this report)
- Test Pumping Data (not included in this report).

A recommended schedule of tasks and deliverables leading up to commissioning of a successful production borehole for the Kleinpoort community should include:

- Desk Study (initiated 15 May 2002)
- Reconnaissance/Hydrogeological Survey
- Remote Sensing/Geophysical Borehole Siting
- Borehole Drilling
- Pump Testing
- Installation
- Final Report
- Community Training
- Transfer Ownership
- Registration of borehole

2. INVESTIGATION AREA

WSM were provided with a locality map of the Kleinpoort community, which occurs approximately midway between Uitenhage and Klipplaat on the R75 national road in the Steytlerville district (Figure 1). The general area conforms to the southern-most foothills of the great Karoo of the Eastern Cape, characterised by relatively small, low-income, rural/agricultural communities.

The Kleinpoort community numbers around 70 individuals, whose main source of income involves farm labour. Assuming 5 persons per household (entitled to a free 6 000 ℓ of basic water per month), places the absolute minimum monthly requirement at around 84 000 ℓ. A borehole yielding 2 ℓ/s and being pumped on a 12-hour rotation will be able to provide for the community.

Topographic elevations vary between 600 and 800 m above mean sea level. The area has a semi-desert climate of hot summers and cold winters and receives ~ 300 mm rain/annum.

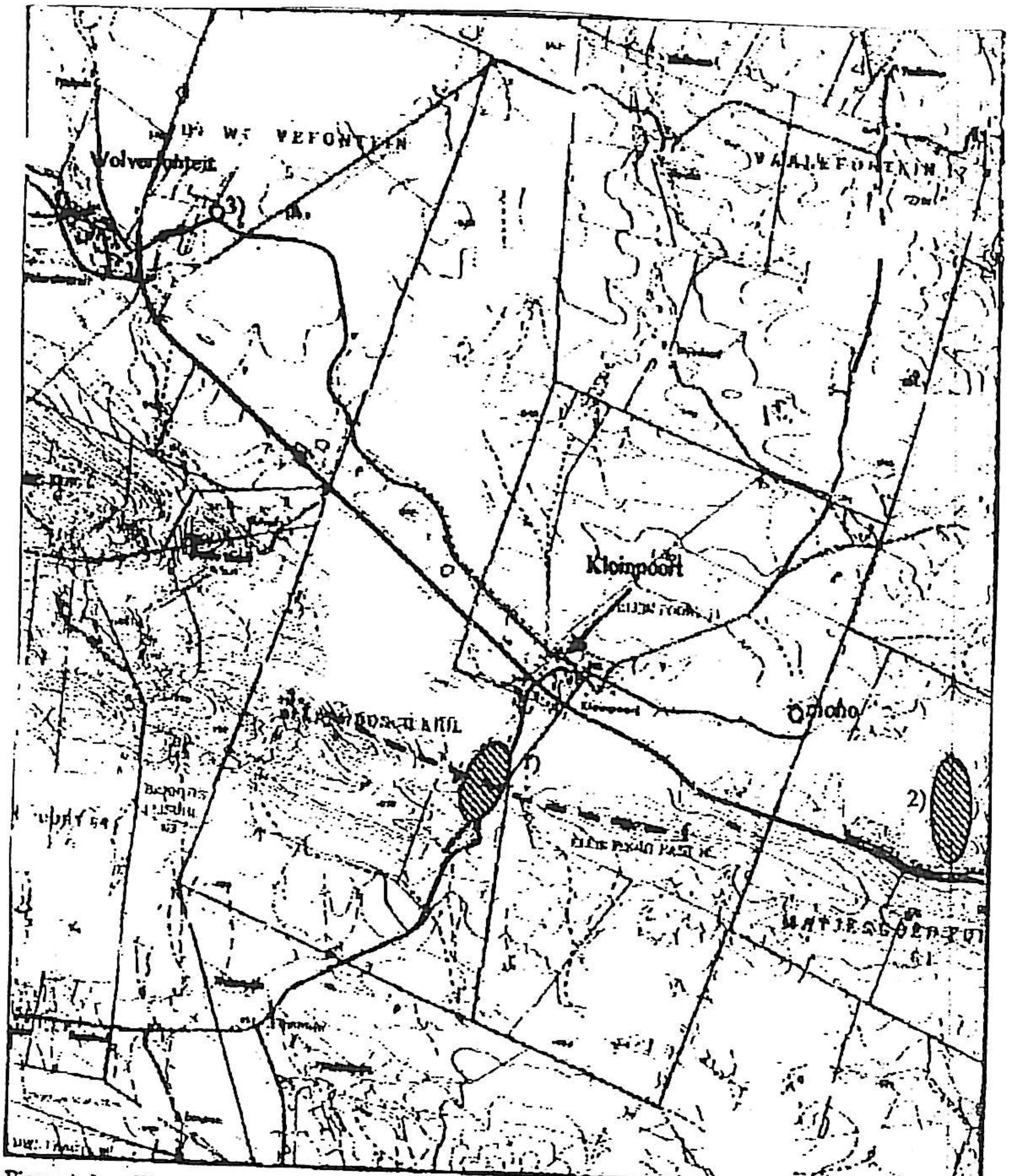


Figure 1: Locality map of Klenpoort indicating position of existing supply borehole (mono) and options 1), 2) and 3) for augmenting groundwater supply. There are several windmills in the vicinity of Kleinpoort not shown in this figure.

Most of groundwater

Groundwater is scant in the general area and the lack of potable groundwater seriously restricts development. A sparse distribution of windmills and motorised boreholes are used mainly for stock watering and domestic purposes.

3. METHODOLOGY

3.1 Existing Information

Existing information was obtained from a variety of sources including DWAF's (Port Elizabeth Office) National Groundwater Database, relevant technical publications of the Water Research Commission as well as interviewing drilling and pump testing contractors who are familiar with the area. Survey and Mapping (Cape Town) were approached to supply the relevant 1:50 000 Topographic Sheets and 1:60 000 Aerial Photographs (on order).

3.2 Geology

Geological information was gleaned primarily from the 1:250 000 Port Elizabeth 3324 sheet and the accompanying geological explanation compiled by Toerien and Hill (1989). Other references include SACS (1980) and Tankard et al., (1982).

3.3 Hydrogeology

Hydrogeological information was drawn largely from the 1:500 000 Port Elizabeth 3324 General Hydrogeological Map and accompanying explanation compiled by Meyer (1998). Other references include the Standards and Guidelines for the Groundwater Development in the SADC Region (2000).

3.4 Preliminary Target Identification and Groundwater Potential

Processing the available groundwater data will develop the hydrogeological character of the Kleinpoort village. This will provide an insight as to the pattern of productive boreholes, anticipated hydrochemistry's as well as yield estimates.

4. RESULTS

4.1 Existing Information

A general summary of information obtained during the data collection is presented. The location of the village of Kleinpoort is shown in Figure 1. Hydrogeological and hydrochemical data is presented in Appendix 1 and 2 respectively. The red and black squares have dimensions of 2 and 10 km respectively and are centred over the village of Kleinpoort.

4.2 Geology

Intensely folded and partly faulted rocks of the Cape Supergroup (408 – 360 My) and Karoo Supergroup (360 – 286 My) dominate the area. (Figure 2). The more competent beds of the Cape

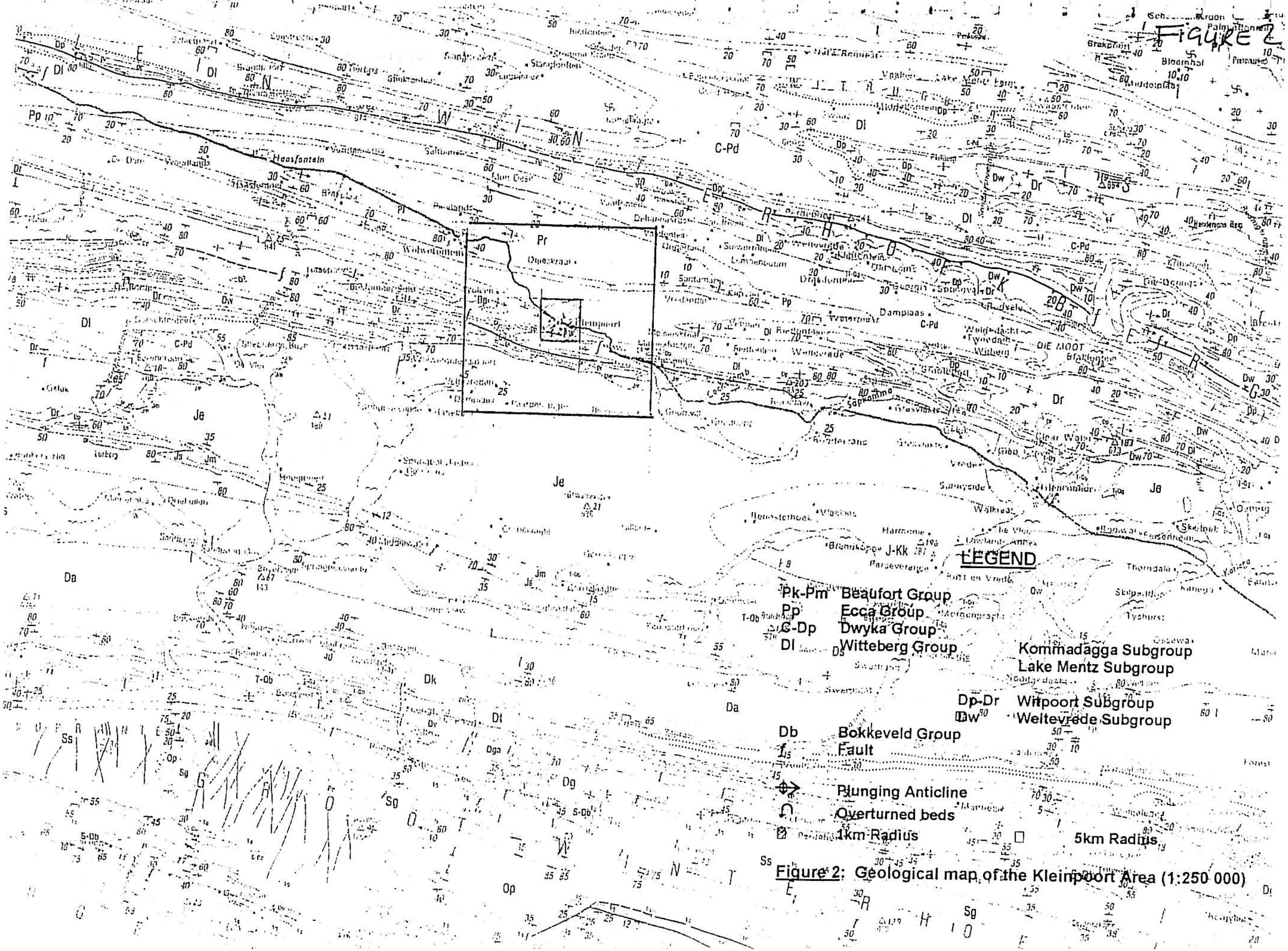


Figure 2: Geological map of the Kleinpoort Area (1:250 000)

Supergroup form the high ground of the Groot and Klein Winterhoekberge whereas the younger, less competent beds of the Karoo Supergroup tend to form the valley floors.

The Cape Supergroup is represented by the Witteberg Group, which is in turn subdivided into the basal Weltevrede (800 m thick) and Witpoort (850 m thick) Formations, the Lake Mentz (620 m) and the topmost Kommadagga (380 m) Subgroups. The Weltevrede Formation is composed largely of shale, siltstone and lesser sandstone. Two prominent sandstone horizons (50 and 120 m thick) occur within the Weltevreden Formation. The argillaceous : arenaceous ratio for the unit as a whole is 30 : 70. The Witpoort Formation is essentially an arenaceous unit and consists of siliceous ultra-quartzose with subordinate mudrock. The arenaceous : argillaceous ratio for the unit as a whole is about 94 : 6. The Lake Mentz Subgroup consists largely of shale, except the middle portion which consists of shale and interbedded sandstone. The Kommadagga Subgroup consists of an 8 m thick basal diamictite, followed by 10 m thick sandstone, 170 m thick shale and terminating in 110 m thick sandstone.

The Karoo Supergroup is represented by the 600 m thick Dwyka Formation, which comprises a glacial diamictite with subordinate shale and sandstone layers. Regionally the contact with underlying Cape Supergroup rocks is a disconformable one, with sharp contacts. Due to their dense, impervious nature, the rocks of the Dwyka Formation generally offer limited groundwater potential.

The Dwyka is followed by the argillaceous Ecca Formation, which occurs outside and to the north of the area.

The east west trending Winterhoek mountain ranges formed as a result of compressive stress directed from the south during the break up of Godwanaland some 65 My ago. Younger igneous intrusions are conspicuously absent in the general vicinity of the village. Subsequent tensional stresses during the Jurrassic (213 – 144 My) resulted in southward dipping normal faults and the development of half-grabens. The tensional forces culminated in the Cretaceous Period (144 – 65 My) with several large, partly reactivated, strike faults.

The sedimentary rocks have been folded into a series of east plunging anticlines and synclines, whose limbs may be locally overturned and/or overthrusted. The intensity of the deformation diminishes to the north.

4.3 Hydrogeology

Consolidated rocks dominate the general area and as a consequence, *rocks with a significant intergranular porosity (or transmissivity) are not found in the study area* (Figure 3). Aquifers associated with sedimentary rocks (not influenced by faulting) typically yield less than 1 ℓ/s. Higher yields are rarely obtained.

Aquifers associated with faulting/thrusting also have a secondary intergranular aquifer component in the zone of dislocation due to jointing and subsequent weathering of juxtaposed rock units. Yields associated with highly weathered fault/thrust zones tend to be erratic, and occasionally high. The many faults could probably be used advantageously for groundwater development (Figure 3).

The Witteberg Group as a whole is a lot more arenaceous than the older Bokkeveld Group and therefore topographically more prominent. Most units of the Witteberg Group are remarkably continuous in an east-west direction. The largely argillaceous components of the Witteberg Group seldom yield more than 2 ℓ/s in boreholes (Appendix 1a). The yield potential of the arenaceous components are noticeably better, especially in the Witpoort Formation, with borehole yields exceeding 2 ℓ/s not uncommon (Appendix 1a).

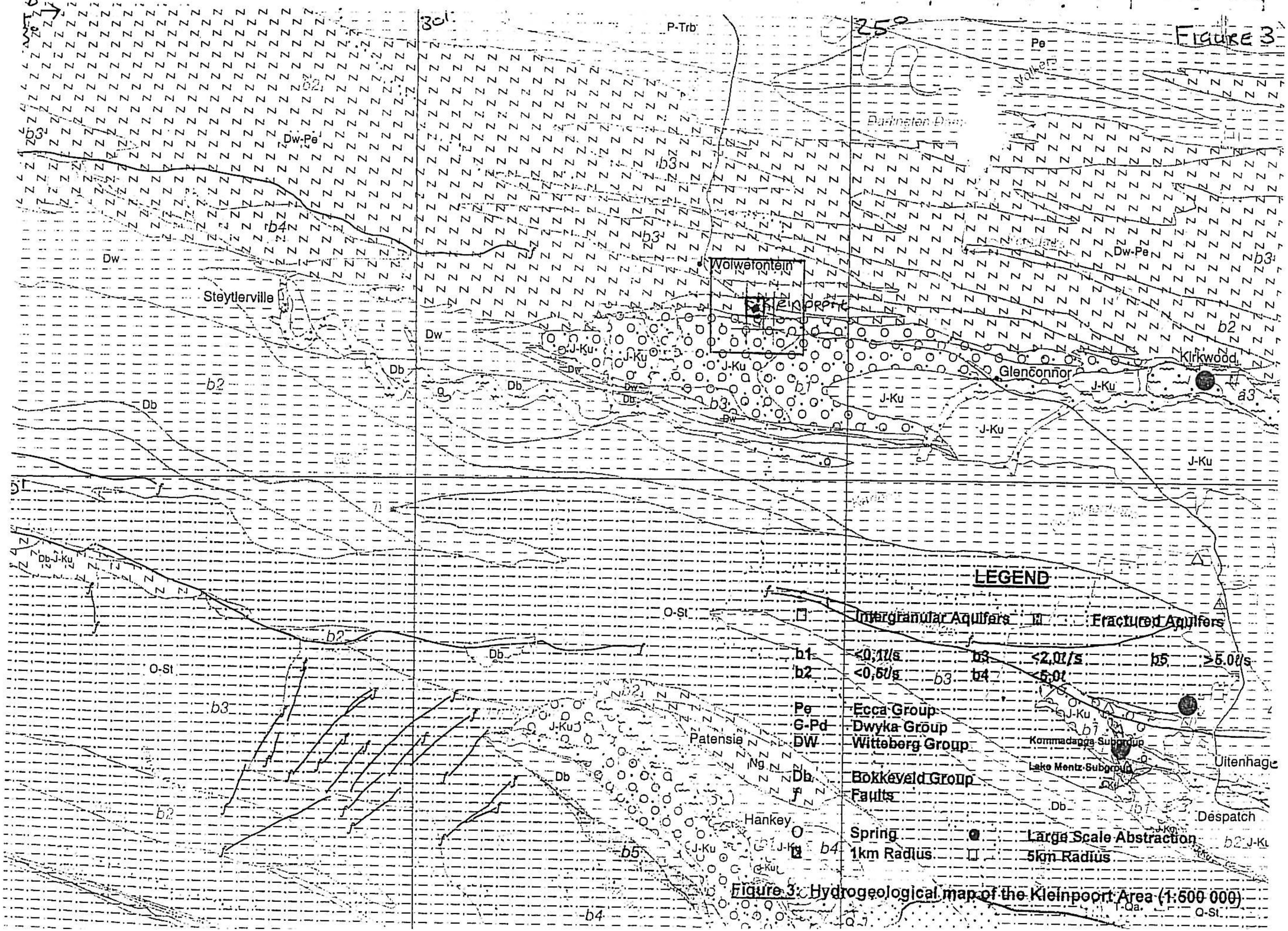


Figure 3: Hydrogeological map of the Kleinpoort Area (1:500 000)

Electrical Conductivity's (EC's) ranging between 200 to 700 mS/m can be expected in the shale components. Sodium, magnesium, chloride and sulphate often exceed maximum allowable limits in the shales (Appendix 2a) and the water is generally of a sodium – chloride nature.

EC's of groundwater from the sandstone units are generally less than 100 mS/m (Appendix 2a). Determinants seldom exceed the recommended limits.

Positioning of boreholes on fractures in the sandstone units close to shale units often poses the danger of poor quality groundwater being drawn in from the shale units.

A borehole analysis of the Dwyka Formation indicates that 45 % of boreholes drilled, yield less than 0,5 ℓ/s. Borehole yields exceed 2 ℓ/s only where occasional fault or joint structures, backed by favourable recharge conditions, occur (Appendix 1b).

EC's of groundwater from the Dwyka rocks often exceed 300mS/m (Appendix 2b). The following determinants often exceed maximum recommended or even allowable limits: sodium, calcium, magnesium, chloride, and sulphate. Groundwater obtained in relatively massive Dwyka rocks generally portrays a sodium-chloride-sulphate nature. In boreholes drilled in fracture and joint structures where significant groundwater movement and recharge takes place, EC's of less than 200 mS/m can be expected (Appendix 2b).

Appendix 3 is hydrogeological data (ex-DWAF) taken from a 5 km radius around the village of Kleinpoort. These boreholes (n=19) have an average yield of 0,57 ℓ/s and an average depth of 82 m. Eliminating the 9 unsuccessful boreholes increases the yield to 1,1 ℓ/s. This is somewhat less than the regional data suggests and may be attributed to unscientifically sited boreholes.

4.4 Preliminary Target Identification and Groundwater Potential

Taking all the formations into account, an analysis of the available data indicates that the highest percentage of water levels occur at a depth of >30 m in the Cape and Karoo Supergroup rocks, which can be ascribed to:

- High relief conditions in the sandstone units of the Witteberg Group.
- Imperviousness of and the lack of groundwater recharge in the shale units of the Witteberg Group and/or Dwyka Formation

Excluding areas of major groundwater abstraction, seasonal fluctuations of water commonly vary between 1 and 5 m. Groundwater recharge during the during the rainy season is usually sufficient for water levels to recover to pre-dry levels. Exceptions can occur in the very dry area around Steytlerville and Jansenville.

In and around the village of Kleinpoort, geophysical methods of siting boreholes are limited in their application and are used as an aid only when deeper structures are totally obscured. As fracture, joint and fold structures are generally the principal features to focus on when siting boreholes; the use of aerial photographs is crucial. A thorough field reconnaissance of the geology, topography and climate, together with the interpretation of hydrocensus data is essential. Once a broad picture of conditions on the ground has taken form, obscured features can be traced geophysically, applying the electrical resistivity and electromagnetic methods.

To a limited extent, interbedded sandstone, alluvium and/or weathered zones may be targeted for the siting of boreholes.

The necessity of using trained personnel to site boreholes cannot be over-emphasised.

For the optimum development of a community borehole, management practices are essential in order to prevent exhaustion and/or pollution of the source. Groundwater management by means of a water level monitoring, evaluation with regard to volumes abstracted, and suitable water quality monitoring should be applied where bulk abstraction takes place or where pollution of groundwater sources is likely, or where groundwater sources are generally vulnerable.

5. CONCLUSIONS

Ideally boreholes should be sited in sandstone rather than shale units, especially when the former have been dislocated by fractures, joints and fold structures. Water-bearing fractures and joints are detectable via electrical resistivity and electromagnetic methods. To a lesser extent saturated interfaces within sandstone units, alluvium or weathered are also detectable.

The complex, highly folded and faulted siliceous ultra-quartzose of the Witpoort Formation is the most attractive proposition from a groundwater perspective. Average yields of 2 ℓ/s at an average depth of 80 m can be anticipated. This yield will be sufficient to supply basic water needs for the community. The Witpoort Formation outcrops a short distance from Kleinpoort on the Steytlerville road and generally corresponds to Option 1 for augmenting groundwater supply. Determinants seldom exceed maximum recommended limits.

The Dwyka Formation is significantly less conducive for groundwater development with yields often averaging less than 0,5 ℓ/s. Sodium, calcium, magnesium, chloride and sulphate often exceed maximum recommended or even allowable limits. Kleinpoort's existing borehole, equipped with a Mono pump, appears to be tapping the Dwyka aquifer. Option 2 for augmenting groundwater supply also appears to have sited on Dwyka Formation. Dwyka rock-types invariably offer limited groundwater potential.

6. RECOMMENDATIONS

Hydrogeological and infrastructural criteria, along with the unique needs of the Kleinpoort community need to be assessed during a reconnaissance/hydrogeological survey, before commencing with remote sensing and geophysical siting of boreholes. This fieldwork will determine unambiguously the needs of the community as well as the hydrological character of the village. Ideally borehole targets should be sited within a maximum distance of 1 000 m from the centre of gravity of the community. The general area coinciding with Option 1 appears to be hydrogeologically the most attractive.

Water samples taken during the hydrogeological survey will indicate whether there are contaminants as a result of point pollution sources.

Upon completion of the reconnaissance/hydrogeological survey, tenders should be requested from drilling, pump testing and installation contractors.

7. REFERENCES

MEYER, P (1989). An Explanation of the 1:500 000 General Hydrological Map 3324, Port Elizabeth. DWAF.

SACS (1980). Stratigraphy of South Africa. Handbook 8. Compiled by Kent, L E.

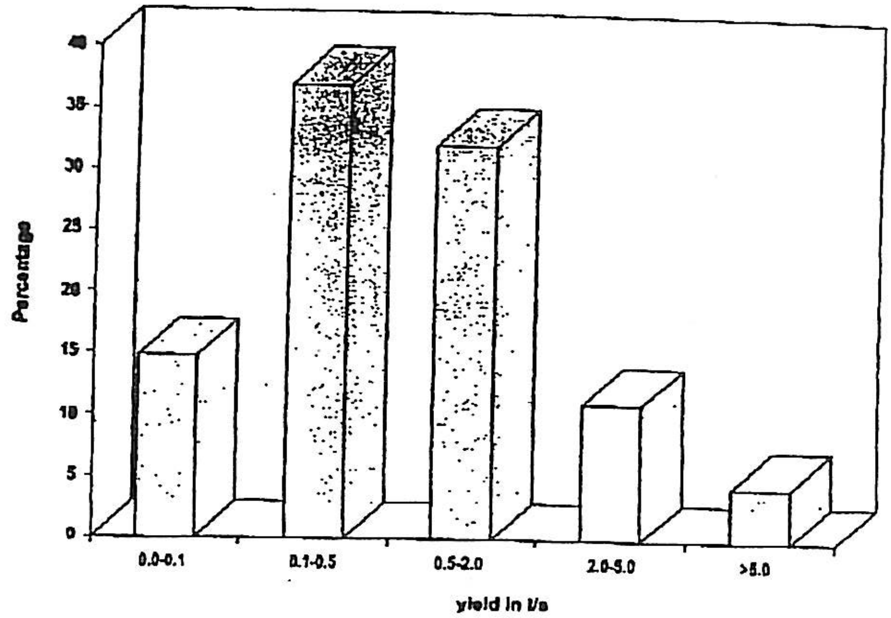
TANKARD, A J; HOBDAY, D K; JACKSON, M P A; HUNTER, D R; ERIKSON, K A; MINTER, W E L (1982). Crustal Evolution of Southern Africa. 3,8 billion Years of Earth History. Springer- Verlag, New York.

TOERIEN, D K; HILL, R S (1989). The Geology of the Port Elizabeth Area –Explanation Sheet 3324 (1:250 000). Geological Survey.

APPENDIX 1A & 1B

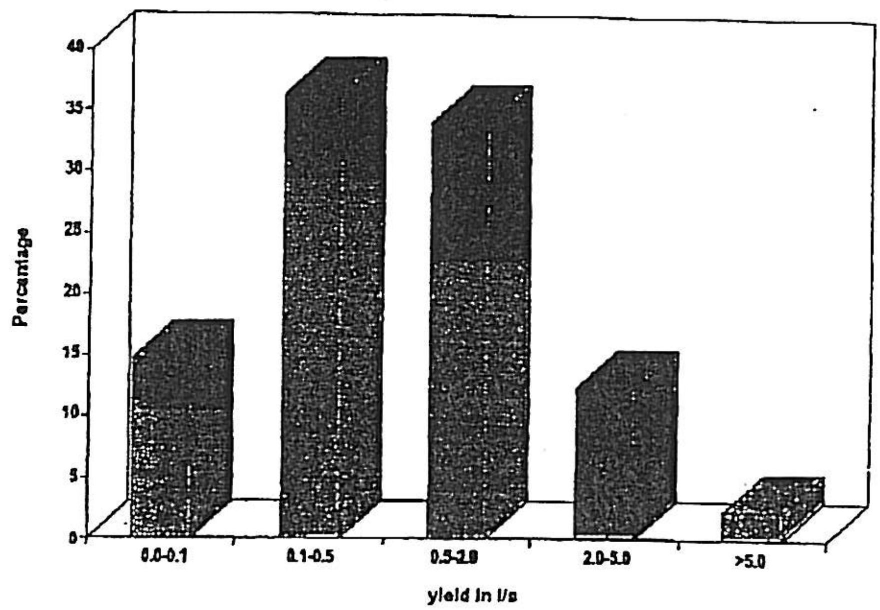
YIELD FREQUENCIES OF BOREHOLES IN THE WITTEBERG GROUP

(776 BOREHOLES ANALYSED)



YIELD FREQUENCIES OF BOREHOLES IN THE DWYKA GROUP

(88 BOREHOLES ANALYSED)



CHEMICAL ANALYSES FROM DIFFERENT BOREHOLES IN THE WITTEBERG GROUP

(ANALYSED BY THE IWQS)

		A	B	C	D
EC	(mS/m)	385,0	70,8	70,0	300,0
TDS	(mg/ℓ)	2 717,0	394,0	1 200,0	2 000,0
pH		8,2	7,1	6 - 9	5,5 - 9,5
Na	(mg/ℓ)	621,0	100,0	100,0	400,0
K	(mg/ℓ)	4,9	3,0	200,0	400,0
Ca	(mg/ℓ)	140,0	18,0	150,0	200,0
Mg	(mg/ℓ)	111,0	13,0	70,0	100,0
Cl	(mg/ℓ)	917,0	171,0	250,0	600,0
SO_4	(mg/ℓ)	425,0	29,0	200,0	600,0
TAL (as $CaCO_3$)	(mg/ℓ)	408,0	49,0	20 - 300	650,0
F	(mg/ℓ)	0,8	0,2	1,0	1,5
$NO_3 + NO_2$ (as N)	(mg/ℓ)	0,04	0,07	6,0	10,0
PO_4 (as P)	(mg/ℓ)	0,01	0,012	-	-
Si	(mg/ℓ)	9,7	6,1	-	-
NH_4 (as N)	(mg/ℓ)	0,06	0,04	6,0	10,0
Fe	(mg/ℓ)	*	*	0,1	1,0

* = Not determined

A = Borehole in a shale component of the Lake Mentz Subgroup (Witteberg Group); farm Allemanskraal northwest of Steytlerville; yield 0,2 ℓ/s.

B = Borehole in the Witpoort Sandstone Formation of the Witteberg Group; farm Woodbury southeast of Paterson; yield 0,4 ℓ/s.

C = Drinking Water Quality Criteria: Maximum Recommended limit.
D = Drinking Water Quality Criteria: Maximum Allowable limit.

CHEMICAL ANALYSES FROM DIFFERENT BOREHOLES IN THE DWYKA GROUP

(A WAS ANALYSED BY THE IWOS AND B WAS ANALYSED BY THE CSIR)

		A	B	C	D
EC	(mS/m)	419,0	255,0	70,0	300,0
TDS	(mg/ℓ)	2 477,0	1632,0	1 200,0	2 000,0
pH		7,9	7,8	6 - 9	5,5 - 9,5
Na	(mg/ℓ)	520,0	352,0	100,0	400,0
K	(mg/ℓ)	3,7	3,8	200,0	400,0
Ca	(mg/ℓ)	173,0	79,0	150,0	200,0
Mg	(mg/ℓ)	127,0	69,0	70,0	100,0
Cl	(mg/ℓ)	1 057,0	638,0	250,0	600,0
SO_4	(mg/ℓ)	343,0	77,0	200,0	600,0
TAL (as $CaCO_3$)	(mg/ℓ)	207,0	254,0	20 - 300	650,0
F	(mg/ℓ)	0,5	1,0	1,0	1,5
$NO_3 + NO_2$ (as N)	(mg/ℓ)	0,06	0,1	6,0	10,0
PO_4 (as P)	(mg/ℓ)	0,026	*	-	-
Si	(mg/ℓ)	8,8	*	-	-
NH_4 (as N)	(mg/ℓ)	0,04	*	6,0	10,0
Fe	(mg/ℓ)	*	1,10	0,1	1,0

* = Not determined

A = Borehole; farm Wilger Fontein south of Riebeek East; relatively massive tillite; yield 1 ℓ/s.

B = Borehole; farm Salisbury Plain near Great Fish River Mouth; fractured rock related: yield 5 ℓ/s (courtesy of Toens and Partners).

C = Drinking Water Quality Criteria: Maximum Recommended limit.
D = Drinking Water Quality Criteria: Maximum Allowable limit.

APPENDIX 3

KLEINPOORT HYDROSENSUS (DATA EX-DWAF's NGDB)

SITE ID	LAT	LONG	ALTITUDE	BH NO.	FARM NAME	DEPTH	YIELD
3324 BD 00147	-33.28612	24.76944	9999.99	160634	Boschfontein Ptn	96.00	0.00
3324 BD 00146	-33.28611	24.76944	9999.99	160633	Boschfontein Ptn	102.00	0.00
3324 BD 00141	-33.32361	24.89917	9999.99	158847	Kleinpoort	90.00	0.00
3324 BD 00140	-33.32362	24.89917	9999.99	158848	Kleinpoort	108.00	0.00
3324 BD 00131	-33.26833	24.78472	9999.99	152915	Boschfontein G20	90.00	1.00
3324 BD 00125	-33.28500	24.90917	605.00		Vaalefontein	76.20	3.80
3324 BD 00110	-33.33944	24.80250	427.00		Wolve Fontein	61.00	0.82
3324 BD 00109	-33.33917	24.80611	427.00		Wolve Fonteins	30.50	0.22
3324 BD 00090	-33.32194	24.83333	503.00		Wolve Fonteins	20.70	0.37
3324 BD 00089	-33.32333	24.81333	473.00		Wolve Fonteins	999.99	0.00
3324 BD 00088	-33.31944	24.81583	479.00		Wolve Fonteins	45.70	0.37
3324 BD 00057	-33.29305	24.79166	579.12	158842	Boschfontein Ged.	102.00	0.00
3324 BD 00056	-33.29166	24.77500	546.64	158843	Boschfontein Ged.	66.00	1.66
3324 BD 00055	-33.29027	24.79166	594.36	158844	Boschfontein Ged.	90.00	0.00
3324 BD 00054	-33.26111	24.81250	609.60	158845	Boschfontein Ged.	90.00	0.00
3324 BD 00053	-33.25833	24.77223	594.36	158846	Boschfontein Ged.	60.00	0.00
3324 BD 00025	-33.33333	24.81667	609.60	158833	Wolve Fonbtein	108.00	1.50
3324 BD 00024	-33.34027	24.83333	502.92	158834	Brandts Leisure	120.00	0.83
3324 BD 00018	-33.33333	24.77500	457.20	158290	Haas Poort	120.00	0.24
n = 19						x = 82m	X = 0.57ℓ/s
							X = 1.1ℓ/s (n = 10)

NOTE: Hydrogeological data taken from a ~ 5km radius around the village of Kleinpoort