REPORT GH 3498

DRAINAGE REGION C-90

PRELIMINARY EVALUATION OF THE GROUND WATER RESOURCES OF THE BARKLY-WEST AREA

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1. INTRODUCTION

The present (1985) source of water supply of the towns along the Vaal River, downstream of the Vaal Dam shows signs of an accelerated deterioration in quality. The average annual electrical conductivity of the river water increased over the period of the past 6 years (1978/79 - 1983/84), from 32 mS/m to 121,6 mS/m at the pump station Vaal-Gamagara and 75,2 to 89,3 mS/m at the Bothaville canal. (Data obtained from Division Hydrology, DWA, Pretoria.)

According to the Directorate: Planning of the Department of Water Affairs this problem can be solved in the future by mixing the river water with that from a better quality source. Groundwater could thus be used provided that its quality as expressed in electrical conductivity is lower than 50 mS/m or approximately 300 mg/ℓ of dissolved solids.

A request from the above-mentioned Directorate: Planning for a ground water study around Parys, Bloemhof, Christiana, Vryburg, Jan Kempdorp, Warrenton, Barkly West and Delportshoop was received by the Directorate: Geohydrology on 11 April 1984. As a first step a desk study of ground water occurrence and quality around the eight towns was completed. The report (GH 3338) was compiled in June 1984 and submitted to the Directorate: Planning. A subsequent request by the Directorate: Planning for a field survey based on the findings and recommendations, of the above-mentioned report but concentrating mainly on water quality was received on 17 July 1984.

The field survey commenced on 2 October 1984 at the town of Parys. Consequently, areas around the other towns with the exception of Vryburg, where a separate geohydrological study is being undertaken by the Institute for Groundwater Studies of UOFS, were surveyed. The field work around the 7 towns was completed on 12 December 1984. Separate reports rather than a single one for all of the 7 towns will be compiled.

During each survey, information on ground water usage, its quality and borehole data was obtained from members of local authorities i.e. Town Clerks and Engineers, Agricultural Extention Officers, as well as from drilling contractors, private ground owners and farmers. priority was given to areas of more prominent ground water occurrence. Representative samples of ground water from boreholes, springs and rivers were taken and submitted to the laboratory of the departmental Hydrological Research Institute at Roodeplaat, near Pretoria.

2. PREVIOUS GEOHYDROLOGICAL INVESTIGATIONS OF THE BARKLY WEST AREA

No geohydrological investigations have in the past been carried out in the area. This can be attributed to the fact that the Vaal River has been able to supply the town with a sufficient quantity of good quality water to meet all its necessary requirements.

3. FIELD WORK AROUND BARKLY WEST

The field work around Barkly West and Delportshoop was done concurrently (4/12/1984 - 11/12/1984). A total of 4 days was spent in the Barkly West area. The survey around the town covered a radius of approximately 15 km (230 km^2).

Aerial photographs (JOB 804, 1978) and topographical maps on a 1:50 000 scale were used but the information on geology was only based on the map 1:1 000 000, North Eastern Section (1970) (geological map of SA) and on a 1:50 000 unpublished map supplied by the Geological Survey.

Data on ground water usage plus borehole data were obtained, and 10 water samples of different aquifers were collected. The electrical conductivity, water temperature and pH were measured in the field for any future reference.

4. PRESENT (1985) EXPLOITATION OF WATER

4.1 Surface water

The town of Barkly West at present relies on the Vaal River for approximately 89% of its total water usage. Present and future water requirements in 10^6 m^3 per annum are:

	1984	1990	2030
Domestic (purified)	0,58	0,69	2,43

Information supplied by municipal authorities and Directorate: Planning (refer to letter B1/300 of 11 April 1984).

4.2 Ground water

An inventory of ground water points was compiled and is presented in a tabulated form in Appendix 1. The location of the boreholes is indicated on GHP 6478 Table I below represents a condensed analysis of the borehole data.

Geological Formation	Borehole yield ℓ/s)	No. of boreholes	Irrigation area (ha)	Usage of boreholes D	S	I	Average depth (m)	Ave field EC (mS/m)
Ventersdorp		1-5	3			)		)
LAVA	5-10	0	25	1	2	1)	88	) 79
	10-20	1				)		)
	TOTAL	4						4 samples
	1-5	4				)		)
Alluvium/						)		)
Dwyka	5-10	0	0	1	3	0)	50	) 221
Dwyka	10-20	0				)		)
	TOTAL	4						3 samples
	1-5	4				)		)
Alluvium	5-10	1	0	3	2	0)	15	) 101
	10-20	0				)		)
	TOTAL	5	25	5	7	1		4 samples

EC = Electrical conductivity
D = Domestic
S = Stock
I = Irrigation

TABLE I: CONDENSED ANALYSES OF BOREHOLE DATA

The majority of the surveyed boreholes are used primarily for stock and domestic supplies. Of the boreholes surveyed, only one tapping the Ventersdorp lava aquifer (HM1) was used for irrigation (25 ha). From the borehole survey and information from the local Agricultural Extension Officer, one can conclude that the usage of ground water for irrigarion in this area is practically not developed.

Ground water accounts for approximately 11% (5 600 m^3/month or 67 000 m^3/a) of the municipal domestic supplies. This water is obtained from borehole BD1 and well BD2 (see GHP 6478) situated in the northern part of the townlands.

The town's ground water resources are most probably not being utilized to its full potential. According to the information supplied, the main part of borehole BD1 has collapsed (gravel section) reducing its yield. BD2 is a very shallow well (± 5-6 m) which is pumped dry in 6 hours, recovery time being only 2 hours. This source could therefore be better utilized by deepening the well.

No sign of exhaustion of these abstraction points is reported.

5. GEOLOGY

Three distinctively different geological formations occur within the area:

(i) lavas of the Supergroup Ventersdorp
(ii) sediments of the Formation Dwyka
(iii) Alluvium.

5.1 Supergroup Ventersdorp

The Supergroup Venterdorp is divided into four main rock groups:

(i) andesitic amygdaloidal lava and quartz porphry,
(ii) volcanic breccia and conglomerate,
(iii) tuff and tuffaceous sedimentary rocks,
(iv) sedimentary rocks consisting of sandstone, quartzite, conglomerate and chert.

At Barkly West the Supergroup Ventersdorp is largely composed of andesitic lavas and related pyroclastics. Sedimentary intercalations which occur within the lavas are usually lenticular in nature (Truswell, 1970).

In the study area the Ventersdorp lava is relatively fresh but in places fractured. The exposures are often in the form of small elongated hills protruding through the alluvium; especially within the town lands area.

5.2 Dwyka Formation

Dwyka consists of shales and tillite, invariably underlain by Ventersdorp lava. The Upper Dwyka shales are usually carbonaceous and rich in iron sulphides such as pyrite and marcasite (Temperley, 1967).

Outcrops of Dwyka occur to the south of Barkly West (see GHP 6478). Borehole data and water chemistry (sample RE 3) confirm that this Formation also underlies the alluvium in the River Bend Estate area. Minor intrusives such as dolerite and kimberlite dykes do occur within the Ventersdorp lavas and the Dwyka sediments.

5.3 Alluvium

Alluvium occur mainly in the vicinity of the Vaal River and its tributaries. Gravels can be found as fillings of the shallow river valley and depressions between outcrops of Ventersdorp lava in and just to the north of Barkly West. These gravels may be described as gully wash gravels which according to Partridge and Brink (1967) are practically undistinguishable from parent primary alluvial gravel. The silty soil forms the top of alluvium.

6. HYDROGEOLOGY

Primary and secondary aquifers are present in the Barkly West area. They represent totally different hydraulic systems and therefore will be discussed separately.

6.1 Primary aquifers

The alluvial deposits which occur along the Vaal River and its tributaries or gullies are shown on GHP 6478. The deposits consist of gravels, sand and silt sometimes overlain by calcrete. From borehole data and field observations it is evident that the alluvial deposits can vary from 3 to 12 m in thickness.

Boreholes tapping the alluvial gravels can yield from 4 to 6 ℓ/s (BD1, BD2). Due to the difficulty of drilling in this formation, and lack of proper borehole development, yields do not always reflect the aquifer's true potential, i.e. BD1 had a yield of ± 12 ℓ/s before collapse (now 4 ℓ/s).

6.2 Secondary aquifers

6.2.1 Ventersdorp Supergroup

The zone of weathering in the lava within the study area is rather thin. Joints in exposed lava just to the north of Barkly West appear well developed, probably due to the intrusion of the Kimberlite dykes (see GHP 6478).

The majority of boreholes drilled in the lava generally yield less than 2 ℓ/s. Exceptions to this occur where boreholes intersect fracture systems either alongside dykes or along fault zones, (e.g. borehole BD4, 18 ℓ/s). Borehole HM1 taps water from a mined section of Kimberlite dyke. Abstraction from this approximately 100 m deep mine which is located in the lava, is in the order of 200 000 m^3/a for irrigation solely. Before pumping starts the water level is at approximately 30 m (June). This drops to ± 65 m by the end December.

6.2.2 The Formation Dwyka

The Dwyka shale has a low permeability and does not usually yield sufficient water to boreholes for them to be used on a larger scale like for municipal supply, (e.g. PL2 yields approximately only 0,6 ℓ/s).

6.3 Ground water levels

6.3.1 Primary aquifers

The water level in the alluvium varies spatially. Borehole BD1 has a water level 9,4 m deep, while in BD2 only 2 m is measured. This borehole overflows after any stronger rainfall.

6.3.2 Secondary aquifers

Water levels within the Formation Dwyka (RE2) and Ventersdorp lava (HM1) can vary from ± 4 up to 50 m from the surface, depending on regional topography. Depth to where the water was first struck in a borehole was usually below the present water levels, indicating semi- to apparently confined aquifer conditions or just certain geometry of the fractures.

6.4 Water quality

A total of 10 ground water samples were taken for detailed chemical analysis (results tabulated in appendix 2). The position of the borehole is indicated on GHP 6478. The representativeness of the ground water samples was ensured by sampling only equipped boreholes after a period of pumping. The conductivity and pH of the ground water was determined in the field. The results compare well with those obtained from laboratory analysis.

The lowest ground water conductivity (63 mS/m) was measured in borehole PL1 within the Ventersdorp lava. Water from borehole RE3 situated within the alluvium and completed within the Formation Dwyka has the highest electrical conductivity (340 mS/m) of the area. Table II below is a comparison of the water quality in different Formations (as determined in the laboratory).

TABLE II

Formation (source)	No. of boreholes	Average water conductivity (mS/m)	Average TDS calculated mg/ℓ	Average pH
Ventersdorp lava	4	83	577	8,2
Dwyka shales	1	237	1 440	7,9
Dwyka/alluvium	1	340	2 623	8,0
Alluvium	4	105	730	8,0
Vaalrivier (6/12/1984)	-	86	573	7,6

Table II reveals that the ground water quality within the survey area is well above the 50 mS/m as required at present for possible mixing with Vaal River water. The Dwyka self and in areas overlain by alluvium have the highest electrical conductivity. The best ground water occurs within the Ventersdorp lava. On average the quality of the ground water within the lavas is slightly better than that of the Vaal River (83 mS/m as opposed to 86 mS/m).

Only one borehole (RE3), of those sampled does not meet the SABS requirements for quality. The macro determinands and electrical conductivity with the specified requirements are listed below:

MACRO DETERMINANDS (mg/ℓ)	MAX ALLOWABLE CONCENTRATION (SABS) mg/ℓ
Na 487	400
Mg 165	100
NO_3 52,7	45
SO_4 1659	600

The above could be due to the mineral composition of Dwyka shale (see paragraph 5.2).

All other boreholes meet the required chemical standard (SABS) for domestic supplies.

7. DISCUSSION OF WATER RESOURCES

With the exception of HM1, the boreholes drilled in the alluvial/Ventersdorp lava areas had on average the highest yield. The kimberlite dyke which passes through a large section of the area north and north east of Barkly West and several faults and lineaments as on the aerial photographs, suggest the existence of a well jointed and fractured area which could be a target area for the ground water detailed exploration.

Using a rainfall figure of 400 mm per annum and an average ground water recharge of 6% of 400 mm (Report GH 3338), the annual recharge to the area of approximately 20 km^2 could be in the order of 500 000 m^3 (20×10^6 m^2 x 0,024). In order to utilize a large percentage of the above, a detailed geophysical investigation and the drilling of exploration boreholes on selected sites would be required.

The Barkly West municipality could probably obtain a large percentage of its supplies from alluvial/Ventersdorp lava source within the municipal boundary. Alternatively the area of Holsdam 229 as a ground water source could be developed and gravity fed to the municipal supply system. The only disadvantage of this source is that (although it borders onto the municipal boundary) it is privately owned.

In the areas south of Barkly West, no boreholes were found with yields exceeding 1-2 ℓ/s, thus no detailed exploration is recommended there.

8. CONCLUSION

1. The area north and north-east of Barkly West has been selected as a favourable target for future geohydrological investigations. Priority would have to be given to the geophysical delineation of the ground water reservoir and the determination of the abstractable water resources.

2. The ground water potential of this area is estimated at 500 000 m^3/a.

3. Although the quality of this water supply source; (alluvium/Ventersdorp lava, north of the town), is only similar to the present river water electrical conductivity, it could, when properly developed, replace a large percentage of the river water from the town supply system.

4. No natural deterioration of water quality of the selected area is expected, thus the present water standards could be maintained.

5. The water quality and borehole yields in the rest of the area seam to be unfavourable for larger scale ground water development.

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APPENDIX 1: BOREHOLE DATA, NOVEMBER 1984

Original farm name and number	Borehole number	Depth (m)	Depth to water level (m)	Geological formation	Equipment	Original pump test (date) l/s	Present delivery l/s	Approximate volume pumped per annum (m^3)	Irrigated area (ha)	Field EC (mS/m)
Barkly West Town Lands	BD1	30	9,4	Alluvium	Mono	8 (1983)	4	35 000	-	88,5
	BD2	9	2,2	Alluvium	Mono	-	6	39 000	-	119,6
	BD3	30	10	Alluvium	Open	-	-	-	-	-
Pniel 281	PL4	-	-	Alluvium	WP	-	-	-	-	94,9
River Bend Estate 291	RE1	9,4	-	Alluvium	SUB	-	-	-	-	105,6
River Bend Estate 291	RE2	63	3,4	ALL/Dwyka	Open	-	-	-	-	-
	RE3			ALL/Dwyka	SUB	-	3	-	-	332,8
Pniel 281	PL2	-	-	Dwyka	WP	-	-	-	-	97,8
	PL6	-	-	Ventersdorp lava	WP	-	-	-	-	235,0
Good Hope 284	GE1	77	16	Ventersdorp lava	Mono	-	0,9	22 000	-	98,0
Hols Dam 229	HM1	100	50	Ventersdorp lava	Mono/T	-	22	200 000	25	107,6
Pniel 281	PL1	-	-	Ventersdorp lava	Mono	-	2	-	1	56,5
	PL3	-	-	Ventersdorp lava	WP	-	-	-	-	64,6
Barkly West Town Land	BD4	60	-		Open	18 (1984)	-	-	-	-

ALL = Alluvium
EC = Electrical conductivity (mS/m, 25°C)
MONO = Monopump
SUB = Submersible pump
T = Turbine
WP = Windpump
l/s = litres per second
TBU = To be used

APPENDIX 2: CHEMICAL ANALYSES OF GROUND WATER (NOVEMBER 1984)

Original farm name and number	Borehole number on map GHP6478		Laboratory reference H number GH84/072	Laboratory EC (mS/m)	Field EC (mS/m)	pH LAB	Total dissolved solids (TDS) (mg/l)	Total alkalinity (TAL) as HCO_3 (mg/l)	Na	Mg	F	Ca	Cl	mg/l NO_3	Si	K	SO_4	P	NH_4	Geological Formation
Barkly West Town Lands	BD1	844	36974	86,0	88,5	8,0	562	286,7	27	54	.7	33	37	24,9	30,5	.9	67	0,004	0,004	Alluvium
Barkly West Town Lands	BD2	844	36982	117,0	119,6	7,9	801	165,9	39	72	.7	99	103	17,5	28,8	1,6	273	0,004	0,004	Alluvium
Pniel 281	PL4	844	36966	105,4	95,0	8,2	780	283,0	74	51	.7	79	103	26,9	17,8	3,2	142	0,004	0,002	Alluvium
River Bend Estate 291	RE1	844	37108	115,0	105,6	7,9	778	168,4	99	31	.2	84	114	40,4	20,6	1,6	219	0,01	0,000	Alluvium
River Bend Estate 291	RE3	844	37116	339,2	332,8	8,0	2 623	79,3	487	165	.5	102	40	11,8	31,1	5,1	1 659	0,02	0,000	Alluvium/ Dwyka
Good Hope 284	GE1	844	36932	90,0	89,0	8,0	626	416,0	38	53	.6	44	19	13,3	19,8	.7	21	0,04	0,003	Ventersdorp lava
Hols Dam 229	HM1	844	36990	113,2	107,6	8,2	787	346,5	124	46	1,1	24	67	14,6	26,4	17,4	120	0,05	0,029	Ventersdorp lava
Pniel 281	PL1	844	36940	63,4	56,5	8,2	431	261,0	27	35	.4	31	19	15,3	15,4	2,6	24	0,13	0,008	Ventersdorp lava
Pniel 281	PL3	844	36958	66,0	64,6	8,4	466	280,6	37	33	.7	24	15	19,7	24,5	1,2	29	0,10	0,006	Ventersdorp lava
Pniel 281	PL6	844	36924	236,8	235,0	7,9	1 443	309,8	166	119	.7	160	387	34,5	14,7	2,1	310	0,01	0,005	Ventersdorp lava

A comparison of the field and laboratory EC measurements reveal a close correlation. The field EC are on average 7% above or below the laboratory one. This could be as a result of the sensitivity of the EC meter.