

TECHNICAL REPORT GH3645

PRELIMINARY EVALUATION OF
AQUIFER TESTS CONDUCTED IN THE
SOUTH EASTERN / BURGERSVILLE
AREAS, SOUTH EAST OF DE AAR

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ABSTRACT

During the period 25/01/89 to 15/08/89, aquifer tests were conducted on twenty boreholes in the South Eastern and Burgerville Areas. This report deals with the evaluation of the aquifer tests and preliminary assessment of the production potential of the boreholes.

Eighteen boreholes are recommended for production purposes. An annual volume of $1.90 \times 10^6 \text{ m}^3$ of groundwater could be abstracted from the boreholes, under the present groundwater conditions. The quality of the groundwater is reasonable, with a bulk electrical conductivity of 158 mS/m.

SAMEVATTING

Gedurende die tydperk 25/01/89 tot 15/08/89, was akwifer toetse op twintig boorgate in die Suid Oostelike en Burgerville gebiede uitgevoer. In die verslag word die akwifer toetse geëvalueer en die voorlopige produksie potensiaal van die boorgate beraam.

Agtien van die boorgate word vir produksie doeleindes aanbeveel. n' Jaarlikse volume van $1.90 \times 10^6 \text{ m}^3$ grondwater kan onder huidige grondwatertoestande van die boorgate onttrek word. Die kwaliteit van die water is redelik, met n' grootmaatse elektriese geleidingsvermoë van 158 mS/m.

TABLE OF CONTENTS

	PAGE
ABSTRACT	i
SAMEVATTING	i
TABLE OF CONTENTS	ii
LIST OF CONTENTS	ii
LIST OF FIGURES	iii
LIST OF TABLES	iii
LIST OF APPENDICES	iii
LIST OF ENCLOSURES	iii
 <u>LIST OF CONTENTS</u>	
1 INTRODUCTION	1
2 THE DE AAR GROUNDWATER INVESTIGATION	1
3 AQUIFER TESTING PROGRAMME	2
3.1 Step Drawdown Tests	4
3.2 Constant Discharge Tests	4
3.3 Discussion of Results	6
4 GROUNDWATER QUALITY	7
5 CONCLUSION AND RECOMMENDATIONS	8
5.1 Conclusions	8
5.2 Recommendations	9
REFERENCES	10

LIST OF FIGURES

- | | | |
|----|---|---|
| 1. | Map indicating existing municipal wellfields and the 1987-89 exploration work, south east of De Aar | 3 |
| 2. | Drawdown curves for aquifer tests (a) G38491 (b) G38478A | 5 |

LIST OF TABLES

- | | | |
|----|---|---|
| 1. | Summary of aquifer testing programme | 2 |
| 2. | Recommended production boreholes and abstraction specifications | 6 |

LIST OF APPENDICES

- A. Borehole Information
- B. Step Drawdown Test Data
- C. Constant Discharge Test Data
- D. Hydrochemical Data

LIST OF ENCLOSURES

- 1. Position of aquifer test sites and existing municipal production boreholes, southeast of De Aar (Ghp 6832).

1 INTRODUCTION

De Aar is solely dependant on groundwater to meet it's water requirements. Groundwater is abstracted from three separate wellfields, which are confined to the Brak River valley and it's tributaries, namely:

- (a) South Western,
- (b) South Eastern, and
- (c) Burgerville/Zewefontein Area.

During 1986/87 the Municipality experienced severe water supply shortages due to the prolonged drought (1982-1987). Early in 1987, the Department of Water Affairs was approached by the De Aar Municipality to help in acquiring additional groundwater supplies to supplement it's existing water resources. The request culminated in an extensive investigation for additional groundwater reserves in a De Aar area. The investigation is expected to be completed early in 1990.

This report deals with a preliminary evaluation of the aquifer tests conducted on boreholes drilled during the so-called "exploration phases 1 and 2" of the investigation. The abstraction potential of the individual production boreholes is assessed.

2 THE DE AAR GROUNDWATER INVESTIGATION

To date two phases of exploration mapping and drilling have been completed, namely:

- (a) Phase 1
This phase of the investigation was aimed at relieving the immediate water supply problems. The exploration work concentrated upon expanding existing groundwater resources in the South Eastern and Burgerville Areas, but was restricted to portions of the cadastral farms Riet Fountain 6 (Riet Fountain), and Zewe Fountain 6 (Sipreshof). Drilling commenced on the 9/11/87 and was completed on the 30/03/88. On request of the Municipality, the exploration work was extended to include the De Aar Allotment area.
- (b) Phase 2
Drilling commenced on the 6/7/88 with the aim of expanding the existing wellfield in the South Eastern Area and to explore the possibilities for additional groundwater in area between the Burger-

ville/Zewe Fountain and South Eastern Schemes. The drilling was completed on the 28/11/88.

The areas investigated during phases 1 and 2 of the project are indicated in Figure 1. A third phase of exploration drilling is presently being conducted on the cadastral farms Houtkraal and Hennopskraal, north of De Aar. This phase is expected to be completed towards the latter half of 1989.

3 AQUIFER TESTING PROGRAMME

The aquifer testing was carried out on contract by Ground-water Practitioners Pty(Ltd) and commenced on the 25/01/88. Eighteen possible production sites were identified from the two phases of exploration drilling. Two production boreholes, G28307 and G28313B, drilled by Von Hoyer (1975) were tested by officials of the Department. The production borehole and testing schedule conducted at each test site are summarised in Table 1.

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BOREHOLE NUMBER	TESTING PROCEDURE (duration minutes)	DATE (1989)
G38478A	ST(520) CT(4320)	25/01-30/01
G38491	ST(360) CT(4320)	31/01-04/02
G38459	ST(300) CT(4320)	05/02-27/02
G38473	ST(360) CT(4320)	28/02-04/03
G38468	ST(280) CT(2880)	05/03-09/03
G38455✓	ST(360) CT(2700)	10/03-13/03
G38517	ST(280) CT(2880)	14/03-17/03
G38520	ST(200) CT(2890)	18/03-01/04
G38531	ST(360) CT(2880)	02/04-05/04
G38537	ST(320) CT(1860)	06/04-08/04
G39024	ST(360) CT(2880)	09/04-12/04
G39025	ST(400) CT(4320)	13/04-18/04
G38269A	ST(300) CT(4320)	19/04-25/04
G39029	ST(360) CT(4320)	26/04-12/05
G38270	ST(360) CT(3060)	13/05-16/05
G38224	ST(360) CT(600)	17/05-19/05
G38507	ST(285) CT(4320)	20/05-25/05
G39037	ST(460) CT(2880)	26/06-09/07
G28307	ST(320) CT(2880)	10/08-13/08
G28313B	ST(320) -	15/08-15/08

CT - Constant Discharge ST - Step Drawdown

TABLE 1 : SUMMARY OF AQUIFER TESTING PROGRAMME

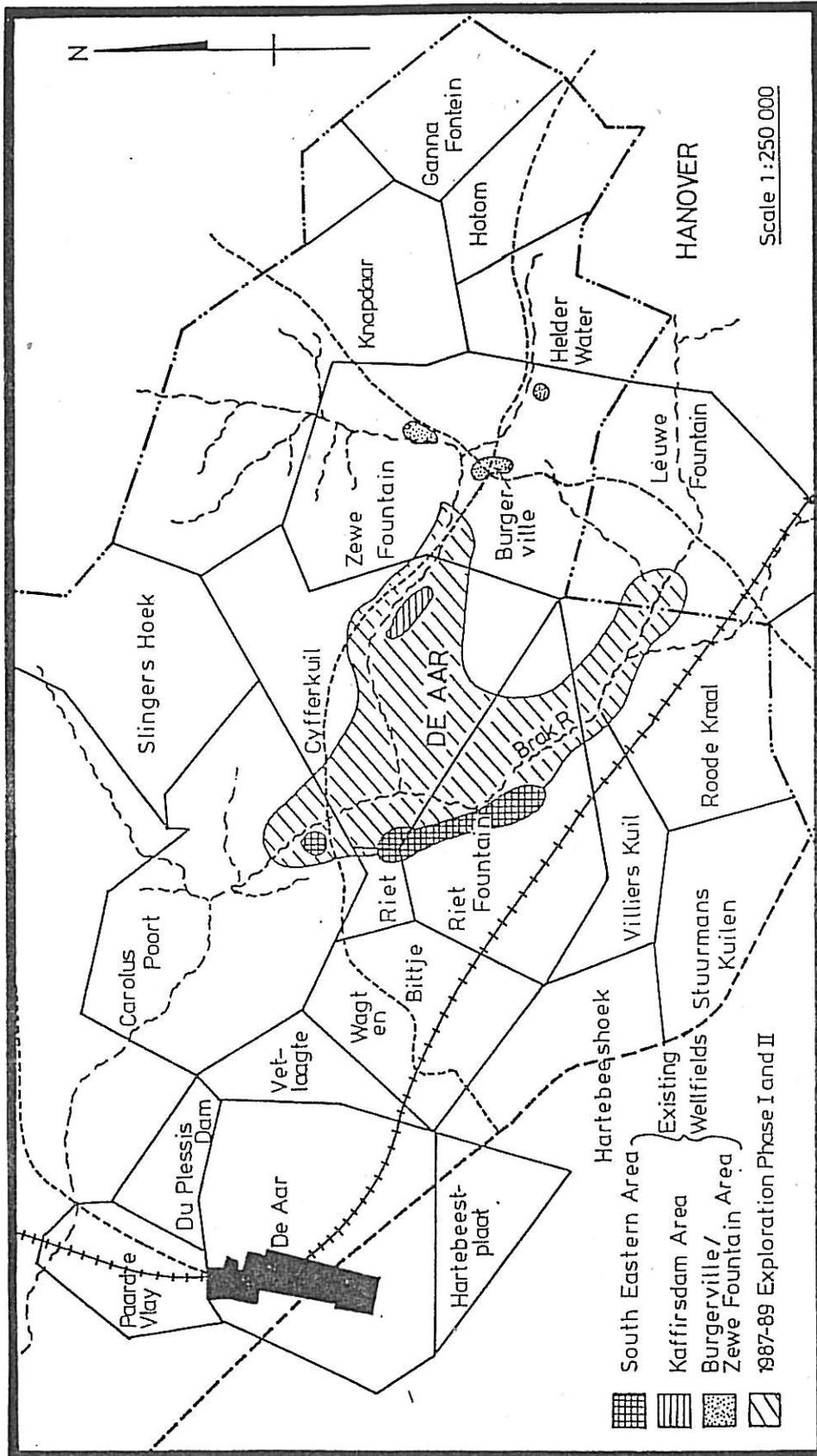


FIGURE 1: MAP INDICATING EXISTING MUNICIPAL WELLFIELDS AND THE 1987-89 EXPLORATION WORK, SOUTH EAST OF DE AAR.

The position of all test sites are indicated in Enclosure 1, while the relevant geohydrological and borehole construction data are contained in Appendix A.

3.1 STEP DRAWDOWN TESTS

The step drawdown tests were conducted primarily to ascertain the yield most suitable for the constant discharge test and provide an indication of the specific capacity of the borehole. The step drawdown test results are summarised in Appendix B.

Relatively high well and formation losses occurred in borehole G38520, partly as a result of the relatively large depth of the major water interception. Similarly, significant well and formations losses in borehole G38224 are attributed to excessive rates of pumping during the step drawdown test and the limited extent of the fracture zone in the aquifer.

3.2 CONSTANT DISCHARGE TESTS

Examination of the test data made it clear that standard methods of interpretation could not be correctly applied, due mainly to the complex nature of the fractured aquifers. Anyway, the hydrological parameters obtained by "force fitting" of the test data to standard curves would be of little practical significance to this report.

A common feature of the test results is a quasi-linear drawdown curve during the latter stages of pumping, when the $\sqrt{\text{time}}$ is plotted against drawdown on arithmetic graphpaper. This feature is illustrated by the drawdown curve of borehole G38478A in Figure 2, described as "linear fracture flow" by Jenkins et al (1982) and Sen (1986).

Where possible regression analysis was applied to the field data exhibiting such linear trends. The linear equations for individual boreholes are contained in Appendix C. The equations were used to simulate drawdown data at large pumping times and at varied rates of abstraction. The optimum discharge of the production borehole was thus estimated, taking into account the major water interception and possible regional water level fluctuations.

The use of such regression techniques to make long term extrapolations should be viewed with the necessary caution. This type of data extrapolation assumes that, as with other standard analytical methods, aquifer conditions remain invariant with time. The hydrological nature and geometry of

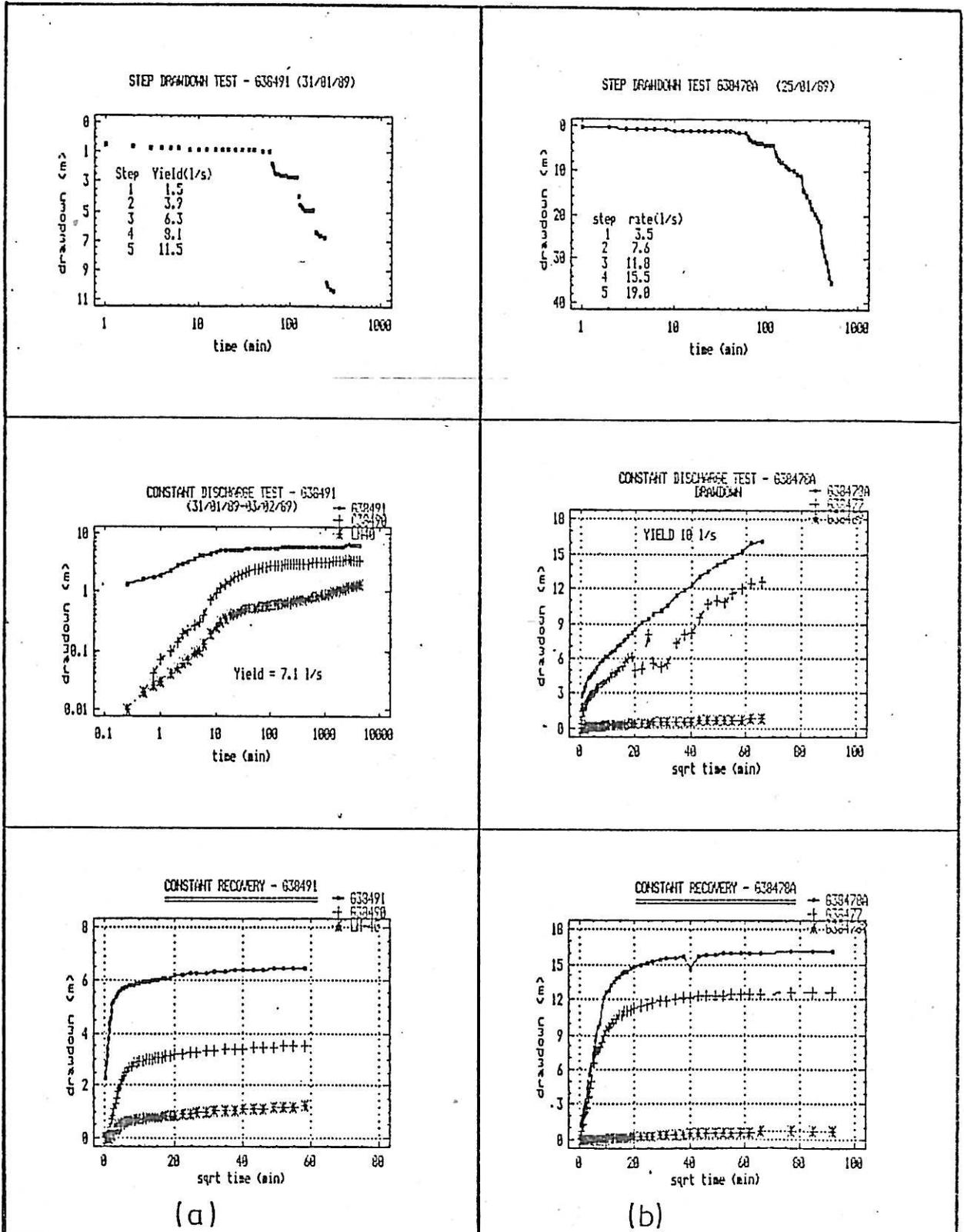


Figure 2 Drawdown Curves for Aquifer Tests (a) G38491 (b) G38478A

the aquifer is assumed to remain constant. However, fractured aquifers commonly exhibit declining storativity with depth and boundary conditions. The equations can therefore only be used to accurately simulate aquifer conditions over that range of drawdowns encountered during testing.

3.3 DISCUSSION OF RESULTS

The boreholes recommended for production purposes are presented in Table 2. The recommended pumping rates are estimated from the results of the aquifer tests (Section 3.2), and the exploration mapping/drilling. It is important to note that the aquifer tests were conducted under very favourable groundwater conditions and that the recommended pumping rates are subject to these groundwater conditions. The maximum volume of groundwater to be abstracted per production site, assumes that the borehole is pumped for 65% of the month.

PRODUCTION BOREHOLE	PUMP RATE (l/s)	MAX. ABSTRACTION (m ³ /mnt)	DEPTH OF PUMP INTAKE (m)	MAX PERMISSIBLE DRAWDOWN BELOW COLLAR (m)
G38478A	8.0	13 500	50.0	16.0
G38491	5.5	9 300	25.0	15.0
G38459	4.0	6 800	25.0	16.0
G38473	5.0	8 400	17.0	12.0
G38468	3.0	5 100	35.0	20.0
G38455	3.5	5 900	18.0	12.0
G38517	3.0	5 100	24.0	13.0
G38531	3.5	5 900	15.0	10.0
G38537	4.0	6 700	24.0	10.0
G39024	10.0	16 800	30.0	18.0
G39025	4.5	7 600	20.0	13.0
G38269A	10.0	16 800	30.0	20.0
G38270	4.0	6 700	25.0	14.0
G39029	5.0	8 400	25.0	8.0
G38507	10.0	16 800	30.0	18.0
G39037	6.0	10 100	12.0	7.0
G28307	4.5	7 600	14.0	7.5
G28313B	3.0	5 100	16.0	9.5
38824		Σ 162 600		

TABLE 2 : RECOMMENDED PRODUCTION BOREHOLES AND ABSTRACTION SPECIFICATIONS.

The production boreholes are capable of yielding approximately $1.90 \times 10^6 \text{ m}^3$ of groundwater per annum. The weighted average electrical conductivity (EC) of the groundwater is in the order of 158 mS/m or 120 mS/m (borehole G39037 excluded).

It must be stressed that the total volume of groundwater available from the production boreholes represents a mere summation of the monthly abstraction maxima and thus does not represent the exploitation potential of the aquifer(s) concerned. The results of this study should be integrated into an overall evaluation of the groundwater potential of the South Eastern and Burgerville Areas, which includes the abstraction from existing production boreholes. This aspect will be covered in a separate report.

More specifically, the following observations should be noted:

(a) Boreholes G38520 and G38224 were found to be unsuitable for production purposes.

(b) Borehole G39024 replaces the existing municipal production borehole CF39, which is not optimally situated in the aquifer. Similarly, boreholes G39025 and G38537 replace existing production borehole CF31. The new boreholes will facilitate that larger volumes of groundwater could be abstracted from the aquifer.

(c) Borehole G39041, situated 12m from G39037, should be utilised for production purposes. The borehole is equipped with Preussag PVC screens and casing. The information quoted for borehole G39037 is equally applicable to G39041.

(d) The abstraction specifications for borehole G38269A (Table 2), do not include simultaneous pumping of municipal production borehole ZN26. Should both boreholes be used it is recommended that their combined yield should not exceed 16 l/s ($27\ 000 \text{ m}^3/\text{mth}$).

(e) Production boreholes G38468 and G38473 are only 250m apart and hence a combined yield not exceeding 8 l/s is recommended.

4 WATER QUALITY

The conductivity of the groundwater abstracted during the aquifer tests was continually monitored. No significant changes in the EC of the groundwater could be detected during the aquifer tests. This however, does not exclude qual-

ity changes in the long term. Parsons (1989) indicated a general increase in total dissolved solids over the period 1974 to 1989.

The chemical analysis of the production boreholes are tabulated in Appendix D. The individual elements exceeding the maximum allowable limits (Kempster et al, 1985), are highlighted. The boreholes yield groundwater of acceptable quality, when considered in terms of a bulk supply. Individual boreholes do yield water in which certain elements are in excess of the allowable limits, notably the element F.

The quality of groundwater in the vicinity of borehole G39037 is not fit for direct human consumption. It should be noted that the quality of the groundwater, as tabulated in Appendix D, has improved since the date of sampling. The EC of groundwater declined from 1018 mS/m (25/11/1988) to 710 mS/m (5/7/1989). This is attributed to dilution of the groundwater by fresh recharge water following the heavy rainfalls of February/March 1989. With prolonged abstraction the quality of the groundwater is expected to improve to that more typical of aquifer (ie. 300 - 500 mS/m).

The quality of the groundwater abstracted from existing production boreholes in the South Eastern and Burgerville Areas is highly variable. The bulk EC of the water varies between 60 and 280 mS/m, depending on combination of boreholes and/or fountains utilised. During dryer periods, when fountain flow is at it's lowest, the average EC of the groundwater varies between 140 and 220 mS/m. The incorporation of the new production boreholes into the existing scheme would yield a more consistent quality of groundwater, with an EC range in the order of 120 to 190 mS/m.

5 CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSIONS

Aquifer tests were performed on twenty boreholes in the South Eastern and Burgerville Area during the period 25/01/89 to 15/08/89. Eighteen boreholes were found to be suitable for production purposes, of which three boreholes replace two existing municipal production boreholes. An annual volume of $1.90 \times 10^6 \text{ m}^3$ of groundwater could be abstracted from the boreholes, under present groundwater conditions. The quality of the groundwater is reasonable, with a bulk electrical conductivity of 158 mS/m.

5.2 RECOMMENDATIONS

(i) Production boreholes should be pumped according to the guidelines recommended. Volumes of groundwater abstracted from individual boreholes should be carefully monitored.

(ii) To prevent overpumping of the boreholes they should be equipped with electrical pump-cutoff mechanisms, set at the recommended maximum depths to which waterlevels may be drawn down.

(iii) The results of this report should be integrated into an overall evaluation of the groundwater potential of the South Eastern and Burgerville Areas.

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APPENDIX A

BOREHOLE INFORMATION

BORE-HOLE NUMBER	GEOLOGICAL CODE	DEPTH (m) TO WATER INTERCEPTION BELOW COLLAR LEVEL (blowields 1/s bracketed)					CONDUCTIVITY mS/m
		1	2	3	4	5	
G38478A	DS	6(0.1)	18-20(9)	46.5(15)	-	-	87
G38491	DS	8(0.1)	13.5(1.5)	14-16(6)	23(7)	-	126
G38459	DD	10(0.1)	18-25(9)	-	-	-	110
G38473	DD	9(0.1)	11.5(0.8)	13-16(7)	-	-	165
G38468	DD	12(0.1)	18(0.2)	30-34(5)	-	-	244
G38455	DD	14(1.0)	16(3.5)	-	-	-	269
G38517	DD	9(0.2)	13-14(3)	22-23(7)	-	-	332
G38520	DS	37-42(5)	-	-	-	-	204
G38531	DS	8(0.5)	11-13(4)	-	-	-	133
G38537	AL/DS	6(0.1)	10-12(2)	18(2.4)	22(6.7)	-	75
G39024	DS	8(0.1)	16(0.2)	20(6.9)	28(8.5)	-	141
G39025	DD	9(0.1)	11(0.5)	13(2)	15(5.5)	18(6.5)	104
G39029	DS	9-12(10)	23-25(14)	-	-	-	107
G38269A	DS/DC	7(0.1)	12(0.6)	22(21.5)	-	-	76
G38224	AL/DS	6(0.1)	10(1)	12(4)	34(5)	42(6)	140
G38507	DS	6(0.1)	9.5(2.5)	17(3.4)	28-30(15)	36(18.5)	84
G38270	DD	12(0.5)	15(3.5)	22(4.5)	-	-	76
G39037	AL	5(1.3)	8-10(22)	-	-	-	1091
G28307	DS	3.2(?)	8-11(9)	19(?)	-	-	81
G39313B	DS	6.4(?)	10-12(6)	16.5(?)	-	-	73

DD - Dolerite Dyke Contact DS - Dolerite Sheet Contact AL - Alluvium

BOREHOLE NUMBER	CADASTRAL FARM NAME	BOREHOLE CONSTRUCTION			
		DEPTH (m)	CASING		
			PLAIN (m)	SLOT. (m)	DIAM (mm)
G38478A	Leuwe Fountain 27	60	0-12	-	165
G38491	Leuwe Fountain 27	42	0-12	-	165
G38459	Riet Fountain 6	36	0-12	-	165
G38473	Riet Fountain 6	24	0-6	-	165
G38468	Riet Fountain 6	48	0-6	-	165
G38455	Bloemhof 145	30	0-11	-	165
G38517	Bloemhof 145	36	0-13	-	165
G38520	Bloemhof 145	54	0-5	-	165
G38531	Bloemhof 145	90	0-2	-	165
G38537	Cyfferkuil 7	66	0-6	6-24	165
G39024	Cyfferkuil 7	36	0-6	-	165
G39025	Cyfferkuil 7	72	0-9	9-23	165
G38269A	Zewe Fountain 6	48	0-18	18-34	165
G39029	Wagt-en-Bittje 5	48	0-7	7-13	165
G38270	Zewe Fountain 6	48	0-6	-	165
G38224	Riet Fountain 6	60	0-9.6	-	165
G38507	Roode Kraal 28	42	0-12	18-36	165
G39037	Carolus Poort	18	0-8	8-14	165
G39041 **	Carolus Poort	13.5	0-8	8-12	165
G28307	Riet Fountain 6	22	0-6	6-20	165
G28313B	Riet Fountain 6	21	0-3	3-7.6	165

Boreholes case steel casing, flame slotted, slot width 4-10mm length 300mm, staggered, 5-8 slots per diameter.
 ** Preussag K200 screen, 1.5mm slot, PVC (165mm) casing.

APPENDIX B

STEP DRAWDOWN TEST DATA

BOREHOLE NUMBER	STEP	YIELD (l/s)	DRAWDOWN END STEP (m)	SPECIFIC CAPACITY ($\times 10^{-3}$)	WELL LOSSES (C)	FORMATION LOSSES (B)
G38478A	1	3.5	4.54	4.70	8.98×10^{-6}	1.2×10^{-3}
	2	7.7	7.51	7.63		
	3	11.6	14.39	16.50		
	4	15.5	25.66	24.90		
	5	18.0	38.49	-		
G38491	1	1.5	0.94	7.25	4.90×10^{-6}	6.60×10^{-3}
	2	3.8	2.73	8.76		
	3	6.0	4.99	11.60		
	4	7.8	6.75	10.50		
	5	10.9	10.35	12.60		
	6	15.0	22.54	-		
G38459	1	3.7	3.25	10.20	1.42×10^{-7}	5.35×10^{-3}
	2	6.3	7.07	16.20		
	3	8.2	11.78	21.90		
	4	9.8	18.31	32.40		
	5	12.8	25.72	-		
G38473	1	1.8	6.56	1.35	-4.68×10^{-7}	1.37×10^{-3}
	2	3.2	6.68	0.91		
	3	5.2	6.91	1.22		
	4	7.1	7.16	0.98		
	5	10.4	7.62	1.37		
G38468	1	1.5	7.75	11.73	4.82×10^{-5}	6.20×10^{-3}
	2	3.1	11.92	30.00		
	3	4.5	18.09	49.80		
	4	6.5	30.42	68.30		
	5	7.8	40.96	-		
G38455	1	1.6	8.19	1.74	7.27×10^{-6}	0.40×10^{-3}
	2	3.1	8.59	3.01		
	3	4.2	9.14	5.36		
	4	6.2	10.39	6.89		
	5	9.2	13.13	10.54		
G38517	1	2.7	9.02	4.84	6.82×10^{-6}	3.29×10^{-3}
	2	4.1	9.95	7.69		
	3	6.1	11.46	8.45		
	4	9.1	15.94	16.86		
	5	11.0	21.30	-		
G38520	1	1.5	12.41	39.60	1.54×10^{-4}	1.65×10^{-2}
	2	3.0	21.46	67.50		
	3	4.6	35.29	131.00		
	4	6.2	47.71	-		

BOREHOLE NUMBER	STEP	YIELD (l/s)	DRAWDOWN END STEP (m)	SPECIFIC CAPACITY ($\times 10^{-3}$)	WELL LOSSES (C)	FORMATION LOSSES (B)
G38531	1	1.5	3.56	2.86	1.04×10^{-6}	2.62×10^{-3}
	2	3.0	3.91	2.78		
	3	5.1	4.57	3.14		
	4	8.0	5.66	3.55		
	5	13.1	8.08	5.02		
G38537	1	2.6	4.71	3.65	3.00×10^{-6}	3.05×10^{-3}
	2	4.0	5.37	5.12		
	3	6.3	6.52	5.44		
	4	9.8	10.29	12.20		
	5	14.8	56.89	-		
G39024	1	2.6	3.57	2.76	1.96×10^{-6}	1.17×10^{-3}
	2	4.0	4.19	1.77		
	3	6.2	5.16	1.85		
	4	9.8	7.42	2.58		
	5	14.5	10.93	2.75		
	6	20.0	15.36	-		
	7	25.6	23.75	-		
G39025	1	2.2	5.75	1.26	1.81×10^{-6}	9.80×10^{-4}
	2	4.3	6.16	2.32		
	3	6.3	6.70	2.43		
	4	9.2	7.66	3.07		
	5	15.2	9.86	3.82		
	6	20.7	13.27	-		
G38269A	1	4.1	5.01	1.21	8.32×10^{-7}	9.10×10^{-4}
	2	8.2	5.64	1.78		
	3	12.2	6.52	2.37		
	4	16.8	7.86	2.82		
	5	21.8	9.34	3.10		
G39029	1	3.2	2.81	1.34	1.15×10^{-7}	1.13×10^{-3}
	2	6.0	3.43	2.44		
	3	9.2	4.17	2.35		
	4	14.2	5.75	3.19		
	5	18.7	7.41	4.73		
G38270	1	1.4	2.81	1.40	6.72×10^{-6}	2.00×10^{-4}
	2	3.1	3.43	1.77		
	3	4.6	4.17	6.17		
	4	6.4	5.75	5.33		
	5	11.0	7.41	10.72		

BOREHOLE NUMBER	STEP	YIELD (l/s)	DRAWDOWN END STEP (m)	SPECIFIC CAPACITY ($\times 10^{-3}$)	WELL LOSSES (C)	FORMATION LOSSES (B)
G38224	1	1.7	3.96	13.94	2.11×10^{-5}	1.09×10^{-2}
	2	3.2	4.22	19.80		
	3	4.2	5.14	12.10		
	4	6.2	6.03	-		
	5	8.2	10.45	-		
G38507	1	2.9	3.30	0.88	3.33×10^{-7}	9.50×10^{-4}
	2	7.9	3.77	1.02		
	3	11.0	4.14	1.23		
	4	16.2	4.82	1.47		
	5	22.0	5.76	-		
G39037	1	9.1	1.99	2.52	7.91×10^{-7}	2.21×10^{-3}
	2	10.7	2.68	2.80		
	3	13.6	3.72	0.96		
	4	15.7	4.40	3.02		
	5	19.5	6.55	3.61		
G28307	1	6.6	1.34	2.35	4.17×10^{-6}	6.00×10^{-5}
	2	8.8	2.40	3.14		
	3	12.0	5.01	4.55		
	4	14.7	7.78	5.47		
G28313B	1	6.5	2.77	4.93	3.43×10^{-6}	3.85×10^{-3}
	2	8.2	4.36	5.96		
	3	9.8	6.89	7.58		
	4	11.9	11.97	-		

APPENDIX C

CONSTANT DISCHARGE TEST DATA

BOREHOLE NUMBER	REGRESSION EQUATION	RECOVERY SLOPE	Yield (1/s)
3024CD 6 G38478A (P) G38477 G38489	$s = (Q \times \sqrt{t} \times 5.27 \times 10^{-3}) + 4.18$ $s = (Q \times \sqrt{t} \times 6.40 \times 10^{-3}) + 1.08$ $s = (Q \times \sqrt{t} \times 3.64 \times 10^{-4}) + 0.33$	4.74×10^{-4} 3.64×10^{-4} 7.36×10^{-5}	10.0
3024CD 8 G38491 (P) G38490 LN40	$s = (Q \times \sqrt{t} \times 3.43 \times 10^{-4}) + 5.42$ $s = (Q \times \sqrt{t} \times 3.43 \times 10^{-4}) + 2.74$ $s = (Q \times \sqrt{t} \times 3.80 \times 10^{-4}) + 0.45$	1.56×10^{-3} 3.43×10^{-3} 2.40×10^{-4}	7.0
3024CA 387 3024CA 392 G38459 (P) G38460 G38465	$s = (Q \times \sqrt{t} \times 1.64 \times 10^{-3}) + 11.34$ $s = (Q \times \sqrt{t} \times 6.61 \times 10^{-4}) + 9.43$ $s = (Q \times \sqrt{t} \times 6.11 \times 10^{-4}) + 8.79$	2.13×10^{-4} 4.43×10^{-4} 1.54×10^{-4}	7.1
G38473 (P) G38472 G38474 G38468	$s = (Q \times \sqrt{t} \times 1.21 \times 10^{-4}) + 1.48$ $s = (Q \times \sqrt{t} \times 1.52 \times 10^{-4}) + 1.10$ $s = (Q \times \sqrt{t} \times 1.72 \times 10^{-4}) + 1.01$ $s = (Q \times \sqrt{t} \times 1.09 \times 10^{-4}) + 0.09$	1.01×10^{-4} 1.38×10^{-4} 2.63×10^{-3} -	10.4
3024CA 394 G38468 (P) G38467 G38469	$s = (Q \times \sqrt{t} \times 1.05 \times 10^{-3}) + 16.43$ $s = (Q \times \sqrt{t} \times 2.40 \times 10^{-4}) + 1.38$ $s = (Q \times \sqrt{t} \times 1.25 \times 10^{-4}) + 0.22$	2.38×10^{-4} 1.47×10^{-4} 2.96×10^{-5}	5.1
3024CA 384 G38455 (P) G38457 G38456	$s = (Q \times \sqrt{t} \times 9.25 \times 10^{-5}) + 2.27$ $s = (Q \times \sqrt{t} \times 1.56 \times 10^{-4}) + 0.04$ $s = (Q \times \sqrt{t} \times 1.24 \times 10^{-4}) + 0.73$	5.06×10^{-5} 7.54×10^{-5} 4.85×10^{-5}	6.1
3024CA 406 G38517 (P) G38518 G38516	$s = (Q \times \sqrt{t} \times 3.93 \times 10^{-3}) + 4.16$ $s = (Q \times \sqrt{t} \times 3.87 \times 10^{-4}) + 3.95$ $s = (Q \times \sqrt{t} \times 3.50 \times 10^{-4}) + 2.92$	1.52×10^{-4} 1.72×10^{-4} 1.93×10^{-4}	7.1
G38520 (P)	non-linear		3.1
G38531 (P)	$s = (Q \times t \times 1.26 \times 10^{-3}) + 6.51$	3.22×10^{-3}	16.1
3024CB 100 3024CB 101 G38537 (P) G38538 G39021 G39022	$s = (Q \times \sqrt{t} \times 3.48 \times 10^{-3}) + 2.97$ $s = (Q \times \sqrt{t} \times 2.15 \times 10^{-3}) + 1.35$ $s = (Q \times \sqrt{t} \times 1.20 \times 10^{-4}) - 0.05$ $s = (Q \times \sqrt{t} \times 3.43 \times 10^{-4}) + 0.21$	5.19×10^{-4} 4.80×10^{-4} - 1.45×10^{-5}	8.2
G39024 (P) CF39 CF38	$s = (Q \times \sqrt{t} \times 3.66 \times 10^{-4}) + 7.14$ $s = (Q \times \sqrt{t} \times 2.33 \times 10^{-4}) + 0.33$ $s = (Q \times \sqrt{t} \times 1.46 \times 10^{-4}) + 0.03$	1.95×10^{-4} 1.50×10^{-4} 1.09×10^{-4}	15.4
3024CB 105 3024 CB 106 G39025 (P) G39026 G39027 CF26	$s = (Q \times \sqrt{t} \times 4.64 \times 10^{-4}) + 3.31$ $s = (Q \times \sqrt{t} \times 5.40 \times 10^{-4}) + 2.40$ $s = (Q \times \sqrt{t} \times 1.77 \times 10^{-4}) + 0.19$ $s = (Q \times \sqrt{t} \times 2.35 \times 10^{-4}) + 0.11$	2.85×10^{-4} 2.77×10^{-4} - 2.13×10^{-4}	10.4
G39037 (P) G39041	$s = (Q \times \sqrt{t} \times 1.42 \times 10^{-3}) + 2.69$ $s = (Q \times \sqrt{t} \times 9.22 \times 10^{-4}) + 1.07$	4.48×10^{-4} 5.01×10^{-4}	16.1

(P) - Production Borehole

BOREHOLE NUMBER	REGRESSION EQUATION	RECOVERY SLOPE	Yield (l/s)
G38269A (P)	$s = (Q \times \sqrt{t} \times 8.35 \times 10^{-4}) + 2.57$	3.03×10^{-4}	15.2
G38267	$s = (Q \times \sqrt{t} \times 8.43 \times 10^{-4}) + 1.23$	3.16×10^{-4}	
G38269	$s = (Q \times \sqrt{t} \times 3.16 \times 10^{-4}) + 1.55$	-	
ZN26	$s = (Q \times \sqrt{t} \times 1.31 \times 10^{-4}) - 0.14$	6.96×10^{-5}	
G28397G	$s = (Q \times \sqrt{t} \times 1.88 \times 10^{-4}) - 0.17$	-	
G39029 (P)	$s = (Q \times \sqrt{t} \times 7.67 \times 10^{-4}) + 2.90$	4.35×10^{-4}	12.5
G39030	$s = (Q \times \sqrt{t} \times 7.83 \times 10^{-4}) + 2.07$	3.32×10^{-4}	
G39031	$s = (Q \times \sqrt{t} \times 1.65 \times 10^{-4}) - 0.02$	6.19×10^{-5}	
G39032	$s = (Q \times \sqrt{t} \times 9.22 \times 10^{-4}) + 1.71$	3.35×10^{-4}	
G38270 (P)	$s = (Q \times \sqrt{t} \times 6.48 \times 10^{-4}) + 4.05$	1.28×10^{-4}	8.7
G38272	$s = (Q \times \sqrt{t} \times 6.03 \times 10^{-4}) + 3.20$	1.48×10^{-4}	
G38273	$s = (Q \times \sqrt{t} \times 5.56 \times 10^{-4}) + 3.28$	1.84×10^{-4}	
ZN15	$s = (Q \times \sqrt{t} \times 2.03 \times 10^{-4}) - 0.11$	-	
G38224 (P)	$s = (Q \times \sqrt{t} \times 3.82 \times 10^{-3}) + 4.44$	-	3.3
G38225	$s = (Q \times \sqrt{t} \times 4.48 \times 10^{-3}) + 4.10$	-	
G38226	$s = (Q \times \sqrt{t} \times 4.11 \times 10^{-3}) + 3.27$	-	
G38227	$s = (Q \times \sqrt{t} \times 4.14 \times 10^{-3}) + 3.31$	-	
G38507 (P)	$s = (Q \times \sqrt{t} \times 1.33 \times 10^{-3}) + 2.11$	1.12×10^{-4}	19.1
G38505	$s = (Q \times \sqrt{t} \times 2.14 \times 10^{-4}) + 0.75$	8.69×10^{-5}	
RL3A	$s = (Q \times \sqrt{t} \times 2.01 \times 10^{-4}) + 0.26$	1.05×10^{-4}	
G28307 (P)	$s = (Q \times \sqrt{t} \times 4.01 \times 10^{-3}) + 2.91$	7.64×10^{-4}	13.0
G28307D	$s = (Q \times \sqrt{t} \times 1.16 \times 10^{-3}) + 0.27$	6.75×10^{-4}	

(P) - Production Borehole

PRODUCTION BOREHOLE	RADIAL DISTANCE TO OBSERVATION BOREHOLE (m)
G38478A	G38477=7.2 G38489=37.2 G38476=52.8 LN39±170
G38491	G38490=14.0 LN40=29.5
G38459	G38460=9.7 G38465=7.0
G38473	G38472=2.8 G38474=3.6 G38468±174
G38468	G38467=6.1 G38469=16 G38473±174
G38455	G38456=25.6 G38457=24.7
G38517	G38518=33.8 G38516=2.2
G38520	G38519=6.3 G38525=70.8 G38524=94.6
G38531	G38532±243
G38537	G38538=11.7 G39022=16.2 G39021=103
G39029	CF38±450 CF39±208
G39025	G39027=120 G39026=5.3 CF26±600
G38269A	G38267=26.9 G38269=1.5 G28397B±560 ZN26±620
G39029	G39030=66.5 G39031=53.5 G39032=48.3
G38270	G38272=14.2 G38273=3.0 ZN15±340
G38224	G38225=1.9 G38226=7.72 G38227=11.6
G38507	G38505=44.4 G38509=64.5 RL3A=238
G39037	G39041=12.2 G39036=150
G28307	G28307D=6.1 G28313B=±250

38490 - 3024CD 8

38460 - 3024CB 87

3024CC 19

22213B

BORE-HOLE NUMBER	STEP DRAWDOWN				CONSTANT DISCHARGE			
	REST	WATERLEVEL (m)		VOL. (m ³)	REST	WATERLEVEL (m)		VOL. (m ³)
		RECOVERY	DEFICITE			RECOVERY	DEFICITE	
G38478A	3.12	3.38 (520)	-0.26	402	3.28	3.41 (4320)	-0.13	2592
G38491	3.46	3.57 (360)	-0.11	162	3.15	3.14 (3400)	+0.01	1840
G38459	2.94	3.45 (300)	-0.51	143	3.30	3.30 (4320)	0.00*	1814
G38473	6.35	6.42 (360)	-0.07	133	6.39	6.38 (3000)	-0.01	2696
G38468	6.23	6.25 (280)	-0.02	74	6.23	6.21 (2880)	+0.02	869
G38455	7.95	7.97 (360)	-0.02	118	7.95	8.05 (2700)	-0.10	991
G38517	7.89	7.91 (280)	-0.02	94	7.89	8.03 (2880)	-0.14	1204
G38520	6.94	9.45 (200)	-2.51	38	6.86	7.54 (2890)	-0.68	531
G38531	3.19	3.29 (360)	-0.10	148	3.23	3.83 (2880)	-0.60	2754
G38537	3.89	4.01 (320)	-0.12	137	3.89	4.08 (1860)	-0.21	897
G39024	2.95	2.99 (360)	-0.04	229	2.95	2.96 (2880)	-0.01	2674
G39025	5.51	5.74 (400)	-0.23	218	5.60	5.59 (4320)	+0.01*	2709
G38269A	4.58	4.46 (300)	+0.12	222	4.58	4.91 (4320)	-0.33*	3938
G39029	2.44	2.58 (360)	-0.14	246	2.45	2.81 (4320)	-0.36	3190
G38270	3.79	3.82 (360)	-0.03	131	3.82	3.93 (3065)	-0.11	1600
G38224	3.41	6.65 (300)	-3.24	78	3.77	4.54 (600)	-0.77	115
G38507	3.08	3.12 (285)	-0.04	163	3.08	3.33 (4320)	-0.25	4914
G39037	1.12	1.01 (460)	-0.01	394	1.41	1.65 (2880)	-0.24	2782
G28307	2.60	- (320)	-0.20	211	2.80	3.27 (2880)	-0.47	2052
G28313B	3.00	- (320)	-	152	-	-	-	-

* Rainfall during aquifer test.

BOREHOLE NUMBER	TDS mg/l	Na	Mg	Ca	F	Cl	NO ₃	SO ₄	PO ₄	TAL	Si	K	NH ₄	pH	
3024CD6 3024CD9 3024CA 76 CP 50 3024CA 395 3024CA 382 3024CA 405 3024CA 408 3024CB 74 3024CB 99 3024CB 113 3024CB 114 3024CB 115 3024CA 419 3024CD 22 CC 32 CC 17 3024CA 78	G38478A	602	106	14	44	<u>1.5</u>	63	3.9	60	0.04	227	10	10	0.04	7.70
	G38491	868	116	55	61	1.2	137	3.1	153	0.03	255	13	7	0.04	7.70
	G38459	767	192	21	22	<u>3.2</u>	157	0.3	108	0.02	207	10	1	0.01	7.20
	G38473 a	1026	114	69	100	1.0	224	3.6	178	0.04	246	11	13	0.07	8.50
	G38468	1496	164	<u>117</u>	141	1.0	385	3.2	400	0.05	212	11	6	0.06	8.10
	G38455 b	1629	278	<u>106</u>	94	1.0	412	2.1	333	0.02	310	16	2	0.02	6.90
	G38517 c	1914	<u>480</u>	77	43	<u>1.5</u>	458	1.0	510	0.06	265	9	8	0.07	7.20
	G38520	1125	274	15	58	1.0	274	0.0	298	0.04	147	6	20	0.10	7.50
	G38531	773	114	38	38	1.3	32	0.9	76	0.03	373	13	2	0.02	7.70
	G38537	636	107	31	30	<u>1.8</u>	52	0.2	43	0.12	299	12	6	0.17	7.76
	G39024	928	141	52	60	0.9	119	0.2	132	0.09	342	12	6	0.11	7.47
	G39025	702	109	39	34	0.9	50	0.1	89	0.04	305	11	8	0.06	7.56
	G38269A	584	49	30	67	1.2	32	6.4	61	0.01	244	12	6	0.01	7.80
	G39029	672	125	30	35	<u>3.8</u>	103	1.9	75	0.11	234	11	5	0.17	7.36
	G38270	553	50	24	60	0.9	27	4.5	25	0.02	273	10	13	0.05	8.01
	G38224	881	220	18	35	<u>2.3</u>	202	0.0	125	0.02	218	9	4	0.01	7.90
	G38507 d	514	44	31	47	1.1	36	4.1	46	0.02	235	13	4	0.04	7.40
	G39037	<u>7196</u>	<u>1605</u>	<u>495</u>	132	0.7	<u>2123</u>	0.0	<u>2222</u>	0.04	479	19	16	0.01	8.20

567 - Exceeds S.A.B.S maximum allowable limits. No results for G28307

Samples from observation boreholes: a - G38471 G28313B

b - G38454

c - G38518

d - G38505

ION	RECOMMENDED LIMIT	MAX. ALLOWABLE LIMIT	CRISIS LIMIT
EC (mS/m)	70	300	400
Na (mg/l)	100	400	800
Mg	70	100	200
Ca	150	200	400
F	1.0	1.5	3.0
Cl	250	600	1200
NO ₃	6	10	20
SO ₄	200	600	1200
TAL	300	650	1300
K	200	400	800
NH ₄	1.0	2.0	4.0

(Kempster et al, 1985)

APPENDIX D

HYDROCHEMICAL DATA