Exxaro

BELFAST RELOCATION PROJECT:

GROUNDWATER EXPLORATION

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TABLE OF CONTENTS

1	INTRODUCTION	. 1
2	METHODOLGY	. 1
2.1	Phase 1: Desk study & Reconnaissance trip	. 1
2.2	PHASE 2: AEROMAGNETIC DATA INTERPRETATION, TARGET IDENTIFICATION AND GROUND GEOPHYSICAL	
SUR	/EYS FOR BOREHOLE SITING	. 1
2.3	Phase 3: Drilling	. 1
2.4	PHASE 4: PUMPTESTING	. 2
2.5	PHASE 5: REPORTING	. 2
3	DESK STUDY	. 2
3.1	PHYSIOGRAPHY	. 2
3.1.	1 Location	2
3.1.2	2 Geology & Geohydrology	2
3.1.3	3 Groundwater Recharge	4
4	GEOPHYSICAL SURVEYS	. 4
4.1	INTERPRETATION OF AEROMAGNETIC SURVEY DATA	. 4
4.2	RECOMMENDED EXPLORATION TARGETS	. 5
5	BOREHOLE DRILLING	. 8
6	PUMP TESTING OF SUCCESFULL BOREHOLES	. 9
6.1	DESCRIPTION OF A PUMPTEST	. 9
6.1.	1 Stepped Discharge Test	9
6.1.2	2 Constant Discharge Test	10
6.1.3	3 Recovery Monitoring	10
7	CALCULATING THE SUSTAINABLE YIELD OF THE BOREHOLES	10
8	GROUNDWATER QUALITY	10
9	MANAGEMENT RECOMMENDATIONS	12
10	REFERENCES	14

LIST OF FIGURES

Figure 1. High resolution aeromagnetic coverage of the relocation site.	. 6
Figure 2: Aeromag data overlain over the aerial image of the site	. 6
Figure 3: Aerial image of the site with the interpreted structures overlain as well as the proposed groun geophysical traverses.	nd . 7
Figure 4: EDRS drilling rig established on borehole BRBH2.	. 9

LIST OF TABLES

Table 1. Rainfall & Recharge in Quaternary Catchment B41A	4
Table 2: Coordinates of the start and end points of the proposed geophysical traverses (Decimal de WGS 84).	egrees, 5
Table 3: Details of actual ground geophysical traverses conducted.	7
Table 4. Summary of the newly drilled boreholes at the Belfast Relocation Project	8
Table 5. Results of the sustainable yield calculations	10
Table 6. Chemical parameters compared to SANS 241-1:2015 (edition 2) drinking water standards	11
Table 7. Management recommendations for newly drilled boreholes	13

LIST OF APPENDICES

- Appendix A: Locality Maps Showing Borehole Locations
- Appendix B: Ground Geophysical Profiles
- Appendix C: Borehole Logs
- Appendix D: Calculation of Sustainable Yield (FC Solutions)
- Appendix E: Laboratory Reports
- Appendix F: Pumptesting Field Sheets

1 INTRODUCTION

As part of the "Belfast Relocation Project", a groundwater exploration study was required to provide the project of potable water.

The Scope of Work consisted of the following:

- 1. Desk study & target identification by means of interpreting an existing high resolution aerial magnetic survey of the area.
- 2. Borehole Siting by means of a ground geophysical survey.
- 3. Supervising the drilling of the boreholes.
- 4. Supervising the pumptesting of successful boreholes.
- 5. Report on the findings and management recommendations.

This report is not intended to be an exhaustive description of the exploration program, but rather a summary of the most important findings & management recommendations which should be used for the equipping of the newly drilled boreholes.

2 METHODOLGY

A phased approach was followed consisting of the following 4 phases:

2.1 Phase 1: Desk study & Reconnaissance trip

A desk study of all available geohydrological reports and data pertaining to the project area was done. A reconnaissance trip was undertaken to familiarize the project team with the area.

2.2 Phase 2: Aeromagnetic data interpretation, target identification and ground geophysical surveys for borehole siting

On completion of the desk study, a structural interpretation of existing aeromagnetic data provided by Exxaro were done by Dr Edgar Stettler from Nadir Geophysics, with the aim of identifying prospective groundwater targets.

Selected target structures picked from the airborne magnetic data was followed up on the ground by a combination of magnetic & electromagnetic techniques.

Not all of the targets picked from the airborne magnetic surveys were explored, but can be investigated during subsequent phases, should the need arise. The criteria used for selecting specific targets during this project consisted of the following:

- 1. Potential for yielding significant volumes of groundwater;
- 2. Location of targets in relation to property boundaries.

2.3 Phase 3: Drilling

After interpretation of the ground geophysical data, drilling targets were selected. Drilling was done according to the Department of Water Affairs (DWA) Guidelines for Community Water Supply. Drilling of boreholes was supervised by a qualified geohydrologist/geotechnician from Aurecon, and details such as waterstrikes, meters of casing installed, the geological profile and blow yields was recorded. Drilling supervision ensured that the boreholes was constructed and delivered according to specification.

2.4 Phase 4: Pumptesting

A first estimate of a borehole yield can be deduced from the blow yield of the borehole. This does however not represent the sustainable yield at which the borehole can be pumped. DWA Guidelines for Rural Water Supply stipulates a 48 to 72 hour constant discharge test when a borehole has a potential to yield more than 0.5 l/s and will operate for a period in excess of 8 hours per day. Forty Eight hour constant discharge tests was conducted on successful boreholes and supervised by a qualified geohydrologist/geotechnician from Aurecon to ensure that testing takes place according to the DWA Guidelines for Community Water Supply. Groundwater samples were collected towards the end of each test and submitted for a SANS 241:2006 chemical analysis to assess the water quality.

2.5 Phase 5: Reporting

A Technical Report was compiled after completion of Phases 1 - 4. This report discussed all the relevant information such as geophysical interpretations, borehole logs, pumptest and water quality interpretation and management recommendations.

3 DESK STUDY

3.1 Physiography

3.1.1 Location

The project area is located ~20km west south west of Belfast in the Mpumalanga Province on the farm Paardeplaats 425, with coordinates (S 25.760667° E 29.965690°). The site can be accessed via the unpaved road leading to Sunbury station from the N4 leading to Belfast (Map 1 - Appendix A).

3.1.2 Geology & Geohydrology

According to the 1:250 000 geological map (2528 Pretoria) (Map 2-Appendix A), the study area is underlain by sedimentary rocks of the Vryheid Formation, Karoo Supergroup. The rocks consist of sandstone, shale, gritstone, conglomerate with coal seams in places near the base and top. No geological structures (dykes, faults) are indicated on the project area.

The deposition of the Vryheid Formation sediments is largely controlled by the irregular pre-Karoo platform on which they were deposited. The pre-Karoo rocks, consisting mainly of felsites of the Bushveld Igneous Complex, have been glacially sculpted to give rise to uneven basement topography. The thin veneer sediments of the Dwyka Formation, which overlies the pre-Karoo, are generally not thick enough to ameliorate the irregularities in the placated surface, which therefore affected the deposition of the younger Vryheid Formation sediments.

The Ecca sediments consist predominantly of sandstone, siltstone, shale and coal. Combinations of these rock types are found in the form of interbedded siltstone, mudstone and coarse grained sandstone.

Dolerite/Diabase intrusions in the form of dykes and sills are present within the Ecca Group. The sills usually precede the dykes, with the latter being emplaced during a later period of tensional forces within the earth's crust. Tectonically, the Karoo sediments are practically undisturbed. Faults are rare. However, fractures are common in competent rocks such as sandstone and coal.

According to Barnard (2000), the groundwater yield potential is classed as low since 83% of boreholes on record produce less than 2 l/s. The general suitability of the groundwater for any use is indicated by the average EC value of 57 mS/m and a mean pH value of 7.5. The groundwater rest level is generally encountered between 5 and 25m below surface. This was confirmed on site where the measured average static water level was 12.41mbgl.

It can be assumed that the regional groundwater flow direction will emulate to local topography. Due to the fact that the site is situated on a water divide, groundwater flow will be in two directions, namely in a north westerly and a north easterly direction towards the intermittent stream that both flow into the Steelpoort River downstream as well as a southern direction towards the intermittent stream flowing into the Klein-Komati River.

According to Hodgson et al. (1998), three distinct superimposed groundwater systems are present within the occurring geology. They can be classified as the upper weathered Ecca aquifer, the fractured aquifers within the unweathered Ecca sediments and the aquifer below the Ecca sediments.

3.1.2.1 Ecca Weathered Aquifer

The Ecca sediments are weathered to depths between 5 - 12 meters below surface and often form a perched aquifer. This aquifer is recharged by rainfall and estimated to be between 1-3 % of the annual rainfall. Rainfall that infiltrates into the weathered rock soon reaches an impermeable layer of shale underneath the weathered zone. The movement of groundwater on top of this shale is lateral and in the direction of the surface slope. The water discharges at surface in the forms of fountains and springs where the flow paths are obstructed by a barrier, such as a dolerite dyke, paleo-topographic highs in the bedrock, or where the surface topography cuts below the groundwater table at streams. It is suggested that less than 60% of the water recharged to the weathered zone eventually emanates in streams while the remaining water is evapo-transpirated or drained by some other means.

This aquifer is generally low-yielding $(100 - 2000 \ell//h)$ because of its insignificant thickness. Wells or trenches dug into this aquifer are often sufficient to secure a constant water supply of excellent quality. The excellent water quality can be attributed to the many years of dynamic groundwater flow through the weathered sediments. Leachable salts have been dissolved and it is only the slow decomposition of clay particles which presently releases salts into the water.

3.1.2.2 Fractured Ecca Aquifer

The pores within the Ecca sediments are too well cemented to allow any significant permeation of water. Groundwater movement is therefore along secondary structures, such as fractures, cracks and joints in the sediments. These structures are better developed in competent rocks such as sandstone, hence the better water yielding properties of the latter rock type. It should, however, be emphasised that not all secondary structures are water bearing. Many of these structures are constricted because of compressional forces that act within the earth's crust. The chance of intersecting a water-bearing fracture by drilling decreases rapidly with depth. At depths deeper than 30 m, water-bearing fractures with significant yield were observed to be spaced at 100 m or greater. Scientific siting of production boreholes is necessary to intersect these fractures. The mean yield of this aquifer is ~1250 ℓ//h.

In terms of water quality, the fractured Ecca aquifer always contains higher salt loads than the upper weathered aquifer. Although the sulphate, magnesium and calcium concentrations in the Ecca fractured aquifer are higher than that in the weathered zone, they are well within expected

limits. The higher concentrations can be attributed to the longer exposure time of the water to the rock. The occasional elevated chloride and sodium levels can be attributed to boreholes in the vicinity of areas where salts naturally accumulate on surface, such as pans and some of the fountains.

3.1.2.3 Pre-Karoo Aquifer

Drilling in only a few instances has intersected the basement of the Karoo Supergroup which can be regarded as an insignificant aquifer due to:

- The great depth,
- Low yielding fractures,
- Inferior water quality with elevated concentrations of fluoride associated with the granitic rocks,
- Low recharge characteristics of this aquifer because of the overlying impermeable Dwyka tillite.

3.1.3 Groundwater Recharge

The study area falls within quaternary catchment B41A. The mean annual precipitation and annual recharge figures for this quaternary catchment is presented in Table 1. The values used were derived from the WR90 data set as contained in the GRDM Software (DWA and WRC).

 Table 1. Rainfall & Recharge in Quaternary Catchment B41A

	B41A
Mean Annual Rainfall (mm)	715
Annual Recharge (mm)	51.88
Annual Recharge (%)	7.25

4 GEOPHYSICAL SURVEYS

Borehole siting is primarily concerned with the location of geological discontinuities, as higher borehole yields are generally associated with such features. Apart from direct geological observation, which is the most satisfactory method of borehole location where it can be practised, potential groundwater bearing discontinuities can be located either by remote sensing methods or surface geophysical methods. Both methods were used for the exploration program.

4.1 Interpretation of aeromagnetic survey data

The aeromagnetic data used in this study as the criterion to determine the measure of optimum placement of drilling targets, was flown by Exxaro as part of their geophysical survey for the Belfast coal mine.

Figure 1 depicts total magnetic field (TMF) coverage of the survey area. Increases in the magnetic field strength or 'magnetic highs' are portrayed as ridges or hills coloured in a (warm), reddish hue and decreases in the field strength appear as valleys or troughs and are coloured in a (cold) bluish hue.

In Figure 2 the magnetic data was overlain on an aerial image of the site. Because the exact location and dip of the identified structures was not known, it was recommended that ground

geophysical surveys be conducted. In Figure 3, the interpreted structures as well as the recommended geophysical traverses are overlain on the aerial image of the site.

4.2 Recommended Exploration Targets

Below are given the coordinates of the start and end points of the proposed traverses and the location of the traverses can be seen in Figure 2 below.

Table 2:	Coordinates	of the	start a	nd end	points	of the	proposed	geophysical	traverses
(Decimal	degrees, WG	S 84).							

Trav. ID	Lat/Long Start	Lat/Long End	Length (m)
A-A'	S25.76080 E29.97278	S25.75980 E29.97440	160
B-B'	S25.75922 E29.97075	S25.75833 E29.97328	270
C-C'	S25.75985 E29.96490	S25.76115 E29.96685	250
D-D'	S25.75759 E29.96794	S25.75911 E29.96922	200
E-E'	S25.75709 E29.97678	S25.75616 E29.97920	260
F-F'	S25.75549 E29.98121	S25.75472 E29.98346	240
G-G'	S25.75948 E29.96276	S25.76033 E29.96378	130
H-H'	S25.75764 E29.96419	S25.75857 E29.96549	150
I-I'	S25.75531 E29.96597	S25.75653 E29.96737	190



Figure 1. High resolution aeromagnetic coverage of the relocation site.



Figure 2: Aeromag data overlain over the aerial image of the site.



Figure 3: Aerial image of the site with the interpreted structures overlain as well as the proposed ground geophysical traverses.

After the interpretation of the aeromagnetic data of the relocation area, priority areas were selected for ground geophysical surveys. It must be stated that not all of the priority areas were investigated.

The traverses were conducted using the magnetic (Geotron G5) and electro-magnetic (Geonics EM34-3) methods. The station spacing was 10m and a coil spacing of 20 and 40m was utilised.

A total of five geophysical traverses were conducted. Data for the geophysical profiles are presented in Appendix B. After interpretation of the data, 7 drilling targets were identified of which three were drilled (Map 1 - 4 in Appendix A). The details of the ground geophysical traverses conducted are given in Table 4.

Line No	Start Coordinate (WGS84)	End Coordinate (WGS84)	Drilling Targets
Line A	S25.76082 E29.97277	S25.75918 E29.97494	~
Line B	S25.75723 E29.97228	S25.75857 E29.96996	~
Line C	S25.76044 E29.96668	S25.75881 E29.96443	Target 2 (163m); Target 7 (180m)
Line DI	S25.75913 E29.96919	S25.75607 E29.96599	Target 4 (55m); Target 5 (440m); Target 6 (480m)

Table 3: Details of actual ground	d geophysical traverses conducted.
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Line G	S25.75949 E29.96326	S25.76146 E29.96398	~
Line H	S25.75850 E29.96541	S25.75787 E29.96452	Target 3 (53m)

5 BOREHOLE DRILLING

After completion of the geophysical survey and interpretation of the results, 6 boreholes were drilled within the allocated budget by Environmental Drilling and Remediation Services (EDRS) from Lanseria during March 2016 using an air percussion drilling rig.

All of the boreholes were drilled to a final depth of 80m. The boreholes were fitted with 3mm solid steel casing in the weathered zone and perforated where waterstrikes were encountered. The boreholes were delivered with a concrete plinth and a tamper proof cap. As requested by Exxaro, all boreholes were delivered with a concrete plinth and lockable cap to act as future monitoring boreholes.

A summary of the newly drilled boreholes are presented in Table 4 and the location of the boreholes are presented in Map 4 - Appendix A. Detailed borehole logs are presented in Appendix C.

BH No.	S (WGS84)	E (WGS84)	Target on Geophysical Traverse	Depth (m)	Diameter (mm)	Water strikes (m)	Blow Yield (I/h)
BRBH1	25.76156	29.96534	Redrilled Existing Borehole	80	165	22	Seepage
BRBH2	25.75937	29.96526	C-180m	80	165	19	7200
BRBH3	25.75619	29.96611	DI-480m	80	165	13	7200
BRBH4	25.75947	29.96539	C-163	80	165	70	Seepage
BRBH5	25.75881	29.96888	DI-55m	80	165	9, 71	7200
BRBH6	25.75829	29.96506	H-53	80	165	21	4680

 Table 4. Summary of the newly drilled boreholes.





Figure 4: EDRS drilling rig established on borehole BRBH2.

6 PUMP TESTING OF SUCCESFULL BOREHOLES

Upon completion of the drilling, *AB Pumps* from East London conducted pump tests on the 3 successful boreholes. Aurecon supervised the testing to ensure that the "DWAF Standard Guidelines for Pump Testing" were adhered to.

A Step Test followed by 48 hour Constant Discharge Test & Recovery Monitoring was performed on the boreholes. Pump test data sheets are presented in Appendix F. Background information on the details of pumptesting is presented in the following paragraphs.

6.1 Description of a pumptest

The efficient operation and utilisation of a borehole requires insight into and an awareness of its productivity and that of the groundwater resource from which it draws water. This activity, which is also known as test pumping, provides a means of identifying potential constraints on the performance of a borehole and on the exploitation of the groundwater resource. It also provides data to calculate aquifer parameters such as Transmissivity (T) values.

The following tests were performed on the boreholes: (1) Stepped Discharge Test; (2) Constant Discharge Test and (3) Recovery Monitoring.

6.1.1 Stepped Discharge Test

Also known as a step drawdown test, it is performed to assess the productivity of a borehole. It also serves to more clearly define the optimum yield at which the borehole can be subjected to constant discharge testing. The test involves pumping the borehole at three or more sequentially higher pumping rates each maintained for an equal length of time, generally not less than 60 minutes. The magnitude of the water level drawdown in the borehole in response to each of these pumping rates is measured and recorded in accordance with a prescribed time schedule.

A constant discharge test is performed to assess the productivity of the aquifer according to its response to the abstraction of water. This test entails pumping the borehole at a single pumping rate which is kept constant for an extended period of time. The test duration is usually between 24 and 74 hours. In this instance, 48 hour tests were conducted.

6.1.3 Recovery Monitoring

This test provides an indication of the ability of a borehole and groundwater system to recover from the stress of abstraction. This ability can again be analysed to provide information with regards to the hydraulic properties of the groundwater system and arrive at an optimum yield for the medium to long term utilisation of the borehole.

7 CALCULATING THE SUSTAINABLE YIELD OF THE BOREHOLES

Data acquired during pumptesting of the boreholes was used to calculate the sustainable yield of the tested boreholes. The sustainable yield of a borehole can be defined as the discharge rate that will not cause the water level to drop below the major fracture network supplying water to the borehole. The distance between the static water level and this position is also generally referred to as the available drawdown (AD). The major water strike is obtained through observation during drilling supervision or can be more accurately detected from diagnostic plots compiled from the pumping test data. The water level in the borehole should never drop below the position of the main fracture.

The Flow Characterisation Method (more commonly referred to as the "FC-Method") developed by the Institute of Groundwater Studies at the University of the Free State was used to calculate the sustainable yield of the boreholes. The FC-Method calculates the sustainable yield of a borehole by using recharge, derivatives, boundary information and error propagation. The results of the calculation of the sustainable yield are presented in Table 5 and the FC-Solutions in Appendix D.

Borehole nr.	Depth (m)	Static Water Level (m)	Available Drawdown (m)	Sustainable Yield (I/h) Pumping 24 hours/day	Volume/day (m³)
BRBH2	80	7.98	10.2	900	21.6
BRBH5	80	13.62	57.38	1 800	43.2
BRBH6	80	15.98	5.02	3 600	86.4
			TOTAL VOL	<u>151.2</u>	

Table 5.	Results	of the	sustainable	yield	calculations
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Based on the available data, it can be concluded that a total volume of <u>**151.2**</u> m^3/day can be abstracted from the tested boreholes.

8 GROUNDWATER QUALITY

A pumped water sample was collected from the tested borehole towards the end of the pump test and submitted to Aquatico Scientific (SANAS accredited laboratory) in Pretoria for a major cation/anion analysis. The samples were filtered and preserved and bacteriological samples were taken using sterile made-for-purpose sample bottles. Laboratory reports of the chemical and bacteriological analysis are presented Appendix E. The analytical results were compared with the SABS drinking water standards (SANS 241-1:2015, edition 2) (Table 6). Water is classified unfit for human consumption if the Standard Limits are exceeded.

Table 6.	Chemical	parameters	compared	to	SANS	241-1:2015	(edition	2)	drinking	water
standards	5									

Sample Nr.	BRBH2	BRBH5	BRBH6		Standard Limits
Са	23.50	19.90	14.70		~
Mg	8.20	6.10	5.41		~
Na	9.28	8.60	7.47		200
K	5.39	4.40	4.19		~
Mn	0.02	0	0		0.1
Fe	2.43	0	0		0.3
F	0	0.27	0.16		1.5
NO ₃ -N	0.37	0.24	0.29		11
NH ₄ -N	0.09	0.01	0.07		1.5
AI	0	0	0		0.3
PO ₄	0.04	0.06	0.096		-
CI	4.8	2.7	1.2		300
SO ₄	31.3	5.7	4.2		250
TDS	131	106	88		1200
T-Alk	76	95	81		~
рН	8.23	8.06	8.25		5.0 - 9.7
EC	20	18	17		170
E.Coli Count	0	0	0		0
Total Coli.					
Count	0	0	4		≤10
Faecal					
Coliform.	0	0	0		0
Notes					
Yellow = Accepta	ble				
Exceeds standar	rd limits				
0 = below detect	ion limit of	analytical te	chnique		

EC measurements in mS/m, other parameters in mg/l.

From Table 6 it can be concluded that with the exception of BRBH2 (elevated Fe concentrations) the water quality of the tested boreholes falls within the Drinking Water Standard Limits.

The occurring Iron concentrations within BRBH2 will have a pronounced aesthetic (taste and staining) effects as well as result in problems with plumbing. Slight health effects may be expected in young children and sensitive adults. High iron concentrations may result in haemachromatosis, where tissue damage occurs as a consequence of iron accumulation. Treatment includes aerating the water. Aeration results in oxygenation of the water aiding in the precipitation of iron as iron oxide.

9 MANAGEMENT RECOMMENDATIONS

Based on the desk study, field work and interpretation of available and newly acquired data, Table 7 was compiled which summarises management recommendations for the newly tested boreholes. This data should be used by the relevant engineer who is responsible for the equipping of the boreholes.

Furthermore, the following recommendations are made with regards to the management of boreholes at the Belfast Relocation Site:

- Boreholes should not be pumped at a pumping rate exceeding the calculated sustainable yield.
- Water samples for chemical analysis should be taken on a three monthly basis and water levels should be measured on a monthly basis. This would act as an early warning system. Should a sudden decrease in water levels occur, borehole yields should be adapted accordingly. Automatic borehole loggers could also be installed.
- Care must be taken not to develop and build potential pollution sources (french drains, septic tanks, pit latrines, etc.) close to and upstream from production boreholes.
- If necessary, the drilling targets not drilled during this phase can be drilled in a subsequent phase.

Table 7. Management recommendations for newly drilled boreholes

	Coordinat	es (WGS84)			٨L	(mr	Sustainable	ay	Proposed		
Borehole nr.	S	E	Depth (m)	Static Water Level (m)	*Dynamic \ (m)	Diameter (n	Yield (I/h) Pumping 24 hours/day	Volume/da (m³)	depth of pump installation (m)	Water Quality (SANS 241)	Comments
BRBH2	25.75937	29.96526	80	7.98	10	165	900	21.6	30	Exceeds Standard Limits (Fe)	Borehole ready to be equipped. Treatment required
BRBH5	25.75881	29.96888	80	13.68	20	165	1800	43.2	30	Suitable for Human Use	Borehole ready to be equipped
BRBH6	25.75829	29.96506	80	15.98	20	165	3600	86.4	30	Suitable for Human Use	Borehole ready to be equipped
	-	-			Total Vo	olume/Da	ay (m³)	151.2		-	

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APPENDIX A

LOCALITY MAPS SHOWING GEOLOGY, GEOPHYSICAL LINES & BOREHOLE LOCATIONS









APPENDIX B

GROUND GEOPHYSICAL PROFILES













APPENDIX C

BOREHOLE LOGS



aurec	on	PROJECT LOCATION CLIENT	: Exxaro Belfast Relocation Project I: Belfast, Mpumalanga : Exxaro	HOLE NO : BRBH2 FILE / JOB NO : 112407
CONTRACTOR : EDRS DRILLER : J Oosthuyze	RIG TYPE : Supe LOGGED BY : MI	rrock	ANGLE FROM HORIZONTAL : 90° HOLE DIA : 165 mm	LATITUDE : 25.75937° LONGITUDE : 29.96526°
DATE STARTED : 16/03/15	DATE LOGGED :	16/03/15	HOLE DEPTH : 80 m	ELEVATION :
DATE COMPLETED : 16/03/25		s	COLLAR HEIGHT : 0.5 m	GRID & DATUM : WGS84
			INATENAL	
Penetratio	GROUND WATE GROUND WATE SAMPLES FIELD TEST DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRI	PTION
	0.0 1.0	1.00m		- 7
	2.0 - 3.0 -		SAND: Clayey sand, cream	
	4.0 - 5.0 -			
	6.0-			
177	8.0 −			
	. <u>4</u> . <u>10.0</u>			
2 <u>15</u>	8 11.0 12.0	12.00m	SHALE: Grey	
	13.0-	•••••	SANDSTONE: Grey	
	14.0 -	•••••		
	16.0 -	17.00m		
	18.0	18.00m	SHALE: Brown	Z
177	20.0 -	· · · · · · · · · · · · · · · · · · ·	SANDSTONE: Grey	Z
	21.0 - 22.0 -	••••• •••••	SANDSTONE. BIOWII, weathered	
	23.0	24.00m		
	25.0	· · · · · · · ·	SANDSTONE: Grey	
	26.0 - 27.0 -	27.00m		
	28.0 – 29.0 –	• • • • • •		
	30.0-	· · · · · · · · · · · · · · · · · · ·	GANDOTONE. GIEY	
	32.0 -	•••••		
	33.0 <u>-</u> 34.0 -	· · · · · · · ·		
	35.0	••••• •••••		
	37.0	• • • • • •		
	38.0 - 39.0 -	•••••• •••••		
	40.0 <u>–</u> 41.0 –	41.00m		
	42.0	•••••	SANDSTONE: White	
	44.0 -	• • • • •		
	45.0 - 46.0 -	•••••		
	47.0-	•••••		
	49.0-	••••		
165	51.0 -	52 00m		
	52.0 - 53.0 -	•••••	SANDSTONE: Dark grey	
	54.0-	••••		
	56.0	•••••		-
	57.0 <u>-</u> 58.0 -	•••••		
	59.0 - 60.0 -	•••••		
	61.0	· · · · · · · ·		
	63.0 -	•••••		
	64.0 <u>-</u> 65.0 -	• • • • • • • • • • • • • • • • • • •		
	66.0	· · · · · ·		
	68.0	68.00m	COAL · Coal	-
	69.0 - 70.0 -	70.00m		
	71.0 - 72.0 -	•••••	SANDS I UNE. Dark grey	
	73.0-	· · · · · · ·		
	75.0	· · · · · · · · · · · ·		
	76.0 - 77.0 -	77.00m		
	78.0 - 79.0 -	•••••	SANDSTONE: Dark grev	Z
	80.0	80.00m	BOREHOLE BRBH2 TERMINATED AT 80.	 00 m
Hole				
Casing (plain / perforated)				
Casing diamater (mm)				

aure	con	PROJECT LOCATION CLIENT	: Exxaro Belfast Relocation Project : Belfast, Mpumalanga : Exxaro	HOLE NO : BRBH3 FILE / JOB NO : 112407 SHEET : 1 OF 1
	RIG TYPE : Supe	rrock	ANGLE FROM HORIZONTAL : 90°	LATITUDE : 25.75619°
DATE STAPTED : 16/03/15		16/03/16		
DATE COMPLETED · 16/03/16	CHECKED BY · I	S		GRID & DATUM · WGS84
CONSTRUCTION	DRILLING		MATERIAL	
	uû u u u u u u u u u u u u u u u u u u			
	 Penetrati(Rate (min/ Rate (min/	GRAPHIC LOG	MATERIAL DESCRIF	TION
	0.0 1.0 2.0 2.0	25 25 25 2 27 37 35 36 36 36 3 300m	TOPSOIL: Red sandy soil	
215	3.0 4.0- 5.0 6.0 7.0 0	••••• ••••• ••••• ••••• ••••• ••••• ••••	SANDSTONE: Highly weathered, cream	
	8.0 9.0 10.0 11.0 12.0 13.0 14.0 16.0 17.0 18.0 19.0 20.0 21.0 22.0 23.0 24.0 22.0 23.0 24.0 25.0 26.0 26.0 27.0 27.0 27.0 28.0 29.0 30.0 24.0 25.0 26.0 27.0 27.0 27.0 28.0 29.0 30.0 30.0 31.0 30.0 30.0 30.0 30.0 30	36.00m	SANDSTONE: Slightly weathered, grey	
	42.0 - 43.0 -	44.00m	SHALE: Carbonasceous	-
165	44.0 45.0 46.0 47.0 48.0 49.0 50.0 51.0 52.0 53.0 53.0 55.0 55.0 55.0 56.0 56.0 56.0 56.0 56	56.00m	SANDSTONE: Grey	
	57.0	58.00m		
	59.0 60.0 61.0	62.00m	SHALE: Dark grey	
	63.0	64.00m	COAL: Coal	
	64.0 - 65.0 -	·····	SANDSTONE: Grey	=
	66.0	66.00m	SHALE: Carbonaceous. coal in places	
	67.0	68.00m		
	69.0 - 70 0 -	•••••• 70.00m	SAINDS I UNE: GREY	
	710 720 730 740 750 760 750 760 770 780 780 790 790 790	80.00m	SANDSTONE: Light Grey	
			BOREHOLE BRBH3 TERMINATED AT 80.0	00 m
Hole ————————————————————————————————————	ated)			
L			F :1-	

aure		Dr			LO CL	CATION	EARING Benast Relocation Project Belfast, Mpumalanga Exxaro	FILE / JOB NO : 112407 SHEET : 1 OF 1
NTRACTOR:EDRS ILLER:J Oosthuyze		RIG LOG	TYPE: GED BY	Super ′: MT	rrock -		ANGLE FROM HORIZONTAL : 90° HOLE DIA : 165 mm	LATITUDE : 25.75947° LONGITUDE : 29.96539°
TE STARTED : 16/03/16		DAT	E LOGG	ED :	16/03/1	6	HOLE DEPTH : 80 m	ELEVATION :
TE COMPLETED : 16/03	/16	CHE	CKED B	SY : L:	S		COLLAR HEIGHT : 0.5 m	GRID & DATUM : WGS84
CONSTRUCTION		DRILLIN	G o				MATERIAL	
	 Penetration Rate (min/m 	GROUND WATEI LEVELS	SAMPLES & FIELD TEST	DEPTH (m)	GRAPHIC LOG		MATERIAL DESCR	PTION
				0.0 - 1.0 -	र स्टब्स् स्टब्स् इ.स. इ.स. इ.स.	2 00m	TOPSOIL: Red sandy soil	
2 <u>15</u>				2.0 - 3.0 - 4.0 - 5.0 - 6.0 -		2.0011	SANDSTONE: Completely weathered, yello	W
				8.0 9.0 10.0 11.0	· · · · · · · · · · · · · · · · · · ·	8.00m	SANDSTONE: Highly weathered, cream	
				12.0 - 13.0 - 14.0 - 15.0 - 16.0 - 17.0 -		18.00m	SANDSTONE: Slightly weathered, light gree	у
				18.0 - 19.0 - 20.0 - 21.0 - 22.0 - 23.0 - 24.0 - 25.0 -			SANDSTONE: Slightly weathered, dark gre	у
				26.0		26.00m 27.00m		
				27.0 -			SANDSTONE: Slightly weathered, light gre	V
				29.0 - 30.0 -	••••	30.00m		
				31.0		31.00m	_ COAL: Coal	
				33.0 - 34.0 - 35.0 -	· · · · · · · · · · · · · · · · · · ·	36.00m	SANDS I ONE: Light grey	
				36.0 - 37.0 - 38.0 - 39.0 - 40.0 -		41 00m	SHALE: Alternating between coal and carbo	onaceous shale.
1 <u>65</u>				41.0 42.0 43.0 44.0 45.0 45.0 46.0 47.0 47.0 50.0 51.0 52.0 52.0		41.0011	SANDSTONE: White	
				53.0 <u>-</u> 54.0 <u>-</u>				
				55.0 - 56.0 -	•••••	56.00m		
				57.0 58.0 59.0	· · · · · · · · · · · · · · · · · · ·		SANDSTONE: Grey	
				61.0		61.00m 62.00m	COAL Coal	
				o∠.0 _ 63.0 _			SANDSTONE: Grey	
				64.0	• • • • • • • • • • • • • • • • • • •			
				69.0	••••			
				70.0 – 71.0 –		71.00m		
				72.0		73.00m	COAL: Coal	
				74.0 - 75.0 - 76.0 -	· · · · · · · · · · · · · · · · · · ·		SANDSTONE: Grey grading to white.	
				77.0 -	· · · · · · · ·			
				80.0	•••••	80.00m	BOREHOLE BRBH4 TERMINATED AT 80.	00 m
Hole	arforated)							
Casing (plain / n								

aure	2C	Dr	1		PR LO CLI	OJECT CATION IENT	: Exxaro Belfast Relocation Project : Belfast, Mpumalanga : Exxaro	HOLE NO : BRBH5 FILE / JOB NO : 112407 SHEET : 1 OF 1
CONTRACTOR : EDRS DRILLER : J Oosthuyze DATE STARTED : 16/03/16	3	Rig Log Dat	TYPE : GED BY E LOGGI	Super : MT ED :	тоск 16/03/1	7	ANGLE FROM HORIZONTAL : 90° HOLE DIA : 165 mm HOLE DEPTH : 80 m	LATITUDE : 25.75881° LONGITUDE : 29.96888° ELEVATION :
DATE COMPLETED : 16/0)3/17	CHE	CKED B	Y : L	S		COLLAR HEIGHT : 0.5 m	GRID & DATUM : WGS84
CONSTRUCTION	- ^		IG				MATERIAL	
	 Penetration Rate (min/m 	GROUND WATEF LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG		MATERIAL DESCR	IPTION
				0.0 1.0	1 12 12 12 11 12 12 12	2 00m	TOPSOIL: Red sandy soil and Ferricrete	
2 <u>15</u>				2.0 - 3.0 - 4.0 - 5.0 - 6.0 -	:16:.16::16 	7.00m	SANDSTONE: Competely weathered, yello	w brown
				7.0 8.0 9.0 10.0 11.0 12.0		13.00m	SANDSTONE: Grey. Fractured @ 11m. 52	00l/h
		<u> </u>		13.0 – 14.0 –		13.0011	SHALE: Carbonaceous and coal, alternatin	g.
		/04/16		15.0 - 16.0 -		16.00m		
		13		17.0 - 18.0 - 19.0 - 20.0 - 21.0 - 22.0 - 23.0 - 23.0 -			SANDSTONE: Light grey	
				25.0	· · · · · ·	25.00m	SHALE: Carbonaceous and coal alternation	n
				26.0 - 27.0 - 28.0 - 29.0 -		30.00m		y.
BELFAST.GPJ <507awingFile> 20042016 10:38				0.0.0 32.0 32.0 33.0 35.0 35.0 36.0 37.0 38.0 39.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 40.0 50.0		51.00m	SANDSTONE: Light grey SANDSTONE: Dark grey	
			-	58.0 - 59.0 -	••••	58.00m	COAL: Coal	
			1	60.0 - 61.0 - 62.0 - 63.0 -		64 00m		
				64.0 <u>–</u> 65.0 –		66.00m	SHALE: Carbonaceous	
				66.0 <u>-</u> 67.0 -	•••••	68.00	SANDSTONE: Dark Grey	
				68.0 - 69.0 - 70.0 -	$\begin{array}{c} + + + + + + + + + + + + + + + + + + +$	00.UUM	CARBONACEOUS: Fracture @ 71m, 1800	l/h
				71.0 72.0 73.0 74.0 75.0 76.0 77.0 78.0 78.0		71.00m	SANDSTONE: Grey	
TATA 				80.0	•••••	80.00m	BOREHOLE BRBH5 TERMINATED AT 80	.00 m
Hole Hole	perforated) (mm) er (mm)							
<								

File: 112407 BRBH5 Page 1 OF 1

DNTRACTOR : EDRS RILLER : J Oosthuyze ATE STARTED : 16/03/17		RIG LOG	TYPE : GGED BY	Supe ′:M1 ¡ED:	PR LO CL rrock - 16/03/1	OJECT CATION IENT 17	: Exxaro Belfast Relocation Project : Belfast, Mpumalanga : Exxaro ANGLE FROM HORIZONTAL : 90° HOLE DIA : 165 mm HOLE DEPTH : 80 m	HOLE NO : BRBH6 FILE / JOB NO : 112407 SHEET : 1 OF 1 LATITUDE : 25.75829° LONGITUDE : 29.96506° ELEVATION :
ATE COMPLETED : 16/03	/17	CHE	ECKED B	Y : L	s		COLLAR HEIGHT : 0.5 m	GRID & DATUM : WGS84
CONSTRUCTION		DRILLIN	١G				MATERIA	L
	 Penetration € Rate (min/m) 	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG		MATERIAL DESC	CRIPTION
2 <u>15</u>				0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1		1.00m 8.00m	TOPSOIL: Red sandy soil and ferricrete SANDSTONE: Completely weathered, ye SANDSTONE: Moderately weathered, ye	Ilow brown
		08/04/16 1		10.0 11.0 12.0 13.0 14.0 15.0 16.0 17.0 18.0 19.0 20.0		14.00m	SANDSTONE: Grey. Waterstrike @ 21m	, 4680l/h.
				21.0 - 22.0 - 23.0 - 24.0 - 25.0 - 26.0 - 27.0 - 28.0 -	· · · · · ·	21.00m 27.00m	SHALE: Carbonaceous and coal, alternat	ing.
				29.0 - 30.0 - 31.0 - 32.0 - 33.0 - 34.0 - 35.0 -		33.00m	SHALE: Carbonaceous and coal, alternat	ing.
1 <u>65</u>				36.0 - 36.0 - 37.0 - 38.0 - 39.0 - 39.0 - 40.0 - 40.0 - 40.0 - 40.0 - 40.0 - 40.0 - 40.0 - 40.0 - 40.0 - 40.0 - 40.0 - 40.0 - 40.0 - 50		38.00m	SANDSTONE: Light grey	
				54.0 55.0 56.0 57.0 57.0 58.0 59.0 60.0 61.0 61.0 62.0 63.0		55.00m 63.00m	SANDSTONE: Dark grey	
				64.0			SHALE: Carbonaceous and coal, alternat	ing.
				78.0 - 70 0 -		78.00m	SANDSTONE: Grev	
				79.0 80.0		80.00m		20.00
────────────────────────────────────	erforated) nm)						DUKETULE DKBHO I EKMINATED AT 8	JU. UU III

APPENDIX D

CALCULATION OF SUSTAINABLE YIELD (FC - SOLUTIONS)

FC-METHOD : Estimation of the sustainable	e yield of a	borehole		
BRBH2				
Extrapolation time in years = (enter)	2	1051200	Extrapol.time in	minutes
Effective borehole radius $(r_e) = (enter)$	40.46 🗲	40.46	– Est. r _e	From r(e) sheet
Q (l/s) from pumping test =	0.25	4.05E-04	- S-late	Change r _e
s _a (available drawdown), sigma_s = (enter)	10.2	0.2 🗲	Sigma_s from	m risk
Annual effective recharge (mm) =	15	25.20	s_available work	awdown of tost
Average maximum derivative = (enter)	37	2.74	Estimate of aver	awdown of test
Average second derivative = (enter)	0.0	- 0.0	Estimate of aver	age second deriv
Derivative at radial flow period = (enter)	0.46	- 0.46	Read from derivation	ative graph
	T-early[m ² /d] =	8.66	Aqui. thick (m)	20
T and S estimates from derivatives	T-late [m ² /d] =	1.08	<u>Est. S-late =</u>	1.10E-03
(To obtain correct S-value, use program RPTSOLV)	S-late =	1.10E-03	S-estimate coul	d be wrong
BASIC SOLUTION				
(Using derivatives + subjective information about boundaries)		Maximum influ	uence of boundari	ies at long time
(No values of T and S are necessary)	No boundaries	1 no-flow	2 no-flow	Closed no-flow
sWell (Extrapol.time) =	12.02	21.39	30.77	58.90
Q_sust (I/s) =	0.52	0.29	0.20	0.11
	Best case			Worst case
Average Q_sust (I/s) =	0.24			
with standard deviation=	0.18			
(If no information exists about boundaries skip advanced solution	n and go to final i	recommendatio	n)	
ADVANCED SOLUTION				
(Using derivatives+ knowledge on boundaries and other boreho	les)			
(Late T-and S-values a priori + distance to boundary)				
T-late [m2/d] = (enter)	1.08	1		
S-late = (enter)	1.00E-03			
1. BOUNDARY INFORMATION (choose a or b)	1.002 00	(Code =9999 =	- dummy value if i	est seelisship)
		10000 -0000 -	- aanning value in i	not applicable)
(a) Barrier (no-flow) boundaries	Closed Square	Single Barrier	Intersect. 90°	2 Parallel Barriers
(a) Barrier (no-flow) boundaries → Bound. distance a[meter] : (enter)	Closed Square 9999	Single Barrier	Intersect. 90° 9999	2 Parallel Barriers 9999
(a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter)	Closed Square 9999	Single Barrier 1000	Intersect. 90° 9999 9999	2 Parallel Barriers 9999 9999
(a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] =	Closed Square 9999 0.00	Single Barrier 1000 0.23	Intersect. 90° 9999 9999 0.00	2 Parallel Barriers 9999 9999 #NUM!
(a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] =	Closed Square 9999 0.00	Single Barrier 1000 0.23	Intersect. 90° 9999 9999 0.00	2 Parallel Barriers 9999 9999 #NUM!
 (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow 	Closed Square 9999 0.00 Closed Fix	Single Barrier 1000 0.23 Single Fix	Intersect. 90° 9999 9999 0.00 90°Fix+no-flow	2 Parallel Barriers 9999 9999 #NUM!
 (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) 	Closed Square 9999 0.00 Closed Fix 9999	Single Barrier 1000 0.23 Single Fix 9999	Intersect. 90° 9999 9999 0.00 90°Fix+no-flow 9999	2 Parallel Barriers 9999 9999 #NUM! // Fix+no-flow 9999
 (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) 	Closed Square 9999 0.00 Closed Fix 9999	Single Barrier 1000 0.23 Single Fix 9999	Intersect. 90° 9999 9999 0.00 90°Fix+no-flow 9999 0.00	2 Parallel Barriers 9999 9999 #NUM! // Fix+no-flow 9999 9999
 (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] =	Closed Square 9999 0.00 Closed Fix 9999 0.00	Single Barrier 1000 0.23 Single Fix 9999 0.00	Intersect. 90° 9999 9999 0.00 90°Fix+no-flow 9999 0.00	2 Parallel Barriers 9999 9999 #NUM! // Fix+no-flow 9999 9999 #NUM!
 (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) S_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES → 	Closed Square 9999 0.00 Closed Fix 9999 0.00	Single Barrier 1000 0.23 Single Fix 9999 0.00 r (m)	Intersect. 90° 9999 9999 0.00 90°Fix+no-flow 9999 0.00	2 Parallel Barriers 9999 9999 #NUM! // Fix+no-flow 9999 9999 #NUM!
 (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES BH1 	Closed Square 9999 0.00 Closed Fix 9999 0.00 0.00 Q (l/s)	Single Barrier 1000 0.23 Single Fix 9999 0.00 r (m)	Intersect. 90° 9999 9999 0.00 90°Fix+no-flow 9999 9999 0.00 90°Fix+no-flow 9999 0.00 0.00	2 Parallel Barriers 9999 9999 #NUM! // Fix+no-flow 9999 9999 #NUM! W(u,r) #NUM!
 (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES → BH1 	Closed Square 9999 0.00 Closed Fix 9999 0.00 0.00 Q (l/s)	Single Barrier 1000 0.23 Single Fix 9999 0.00 r (m)	Intersect. 90° 9999 9999 0.00 90°Fix+no-flow 9999 0.00 u_r 0.00E+00 0.00E+00	2 Parallel Barriers 9999 9999 #NUM! // Fix+no-flow 9999 9999 #NUM! W(u,r) #NUM!
 (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES → BH1 BH2 s_(influence of BH1,BH2) = 	Closed Square 9999 0.00 Closed Fix 9999 0.00 Q (l/s) Q (l/s)	Single Barrier 1000 0.23 Single Fix 9999 0.00 r (m) 0.00	Untersect. 90° 9999 9999 0.00 90°Fix+no-flow 9999 9999 0.00 0 u_r 0.00E+00 0.00E+00 5.19E-04	2 Parallel Barriers 9999 9999 #NUM! // Fix+no-flow 9999 9999 #NUM! W(u,r) #NUM! #NUM! 6.99
 (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES BH1 BH2 S_(influence of BH1,BH2) = 	Closed Square 9999 0.00 Closed Fix 9999 0.00 Q (l/s) Q (l/s) 0.00	Single Barrier 1000 0.23 Single Fix 9999 0.00 r (m) 0.00	untersect. 90° 9999 9999 0.00 90°Fix+no-flow 9999 0.00 u_r 0.00E+00 0.00E+00 5.19E-04	2 Parallel Barriers 9999 9999 #NUM! // Fix+no-flow 9999 9999 #NUM! W(u,r) #NUM! #NUM! 6.99
 (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES BH1 BH2 Solution INCLUDING BOUNDS AND BH's Fix head + No-flow : Q_sust (I/s) = 	Closed Square 9999 0.00 Closed Fix 9999 0.00 Q (l/s) 0.00 9999.00	Single Barrier 1000 0.23 Single Fix 9999 0.00 r (m) 0.00 9999.00	Intersect. 90° 9999 9999 0.00 90°Fix+no-flow 9999 9999 0.00 u_r 0.00E+00 0.00E+00 5.19E-04	2 Parallel Barriers 9999 9999 #NUM! // Fix+no-flow 9999 9999 #NUM! W(u,r) #NUM! W(u,r) #NUM! 6.99
 (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES BH1 BH2 SOLUTION INCLUDING BOUNDS AND BH's Fix head + No-flow : Q_sust (I/s) = No-flow : Q_sust (I/s) =	Closed Square 9999 0.00 Closed Fix 9999 0.00 Q (l/s) Q (l/s) 0.00 9999.00	Single Barrier 1000 0.23 Single Fix 9999 0.00 r (m) 0.00 9999.00 0.20	Intersect. 90° 9999 9999 0.00 90°Fix+no-flow 9999 0.00 9999 0.00 u_r 0.00E+00 5.19E-04 9999.00 9999.00	2 Parallel Barriers 9999 9999 #NUM! // Fix+no-flow 9999 9999 #NUM! W(u,r) #NUM! #NUM! 6.99 9999.00 9999.00
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 (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES BH1 BH2 s_(influence of BH1,BH2) = SOLUTION INCLUDING BOUNDS AND BH's Fix head + No-flow : Q_sust (I/s) = No-flow : Q_sust (I/s) = No-flow : Q_sust (I/s) = Enter selected Q for risk analysis = (enter) → (Go to Risk sheet and perform risk analysis from which sigma_ FINAL RECOMMENDED ABSTRACTION RATE Abstraction rate (I/s) for 24 hr/d = (enter) Total amount of water allowed to be bound distance (I/s) for 24 hr/d = (enter) Solution in the sigma and perform the sigma and performs the sigma and perfor	Closed Square 9999 0.00 Closed Fix 9999 0.00 Q (l/s) 0.00 9999.00 9999.00 0.20 s will be estimat	Single Barrier 1000 0.23 Single Fix 9999 0.00 r (m) 0.00 Single Fix 9999 0.00 r (m) 0.00 Single Sector Sigma_s = ed : only for bar	Intersect. 90° 9999 9999 0.00 90°Fix+no-flow 9999 0.00 u_r 0.00E+00 5.19E-04 9999.00 1.396 rrier boundaries)	2 Parallel Barriers 9999 9999 #NUM! // Fix+no-flow 9999 9999 #NUM! W(u,r) #NUM! #NUM! 6.99 9999.00 9999.00
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 (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES BH1 BH2 s_(influence of BH1,BH2) = SOLUTION INCLUDING BOUNDS AND BH's Fix head + No-flow : Q_sust (I/s) = No-flow : Q_sust (I/s) = No-flow : Q_sust (I/s) = Inter selected Q for risk analysis = (enter) → (Go to Risk sheet and perform risk analysis from which sigma_ FINAL RECOMMENDED ABSTRACTION RATE Abstraction rate (I/s) for 24 hr/d = (enter) Total amount of water allowed to be abstracted per month (m³) = Abstraction rate (I/s) for 24 hr/d = (mather) Sound Abstracted per month (m³) = Abstracted per month (m³) Substracted per month (m³) Substracted per month (m³) Abstracted per month (m³) Abstracte	Closed Square 9999 0.00 Closed Fix 9999 0.00 Q (l/s) 0.00 9999.00 9999.00 0.20 s will be estimat 0.25 648	Single Barrier 1000 0.23 Single Fix 9999 0.00 r (m) 0.00 9999.00 0.20 Sigma_s = ed : only for bar	Intersect. 90° 9999 9999 0.00 90°Fix+no-flow 9999 0.00 u_r 0.00E+00 0.00E+00 5.19E-04 9999.00 1.396 rrier boundaries)	2 Parallel Barriers 9999 9999 #NUM! // Fix+no-flow 9999 9999 #NUM! W(u,r) #NUM! 6.99 9999.00 9999.00
 (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES BH1 BH2 Solution INCLUDING BOUNDS AND BH's Fix head + No-flow : Q_sust (I/s) = No-flow : Q_sust (I/s) = Inter selected Q for risk analysis = (enter) → (Go to Risk sheet and perform risk analysis from which sigma_ FINAL RECOMMENDED ABSTRACTION RATE Abstraction rate (I/s) for 24 hr/d = (enter) Total amount of water allowed to be abstracted per month (m³) = COMMENTS Solution Abstraction rate (mathematical action for the selected of the selected	Closed Square 9999 0.00 Closed Fix 9999 0.00 Q (l/s) 0.00 99999.00 99999.00 99999.00 0.20 s will be estimat 0.25 648	Single Barrier 1000 0.23 Single Fix 9999 0.00 r (m) 0.00 9999.00 0.20 Sigma_s = ed : only for bar	Intersect. 90° 9999 9999 0.00 90°Fix+no-flow 9999 9090 0.00 u_r 0.00E+00 0.00E+00 5.19E-04 9999.00 1.396 rrier boundaries)	2 Parallel Barriers 9999 9999 #NUM! // Fix+no-flow 9999 9999 #NUM! W(u,r) #NUM! 6.99 9999.00 9999.00
 (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES BH1 BH2 s_(influence of BH1,BH2) = SOLUTION INCLUDING BOUNDS AND BH's Fix head + No-flow : Q_sust (I/s) = No-flow : Q_sust (I/s) = No-flow : Q_sust (I/s) = Enter selected Q for risk analysis = (enter) → (Go to Risk sheet and perform risk analysis from which sigma_ FINAL RECOMMENDED ABSTRACTION RATE Abstraction rate (I/s) for 24 hr/d = (enter) Total amount of water allowed to be abstracted per month (m³) = COMMENTS Q sust with 68% safety = Action Abstraction rate (I/s) for 24 hr/d = (enter) Total amount of water allowed to be abstracted per month (m³) = Action Action Action Action Abstraction Abstraction Abstracted Abstracted Action Abstracted Abstracted Abstracted Action Abstracted Abstrac	Closed Square 9999 0.00 Closed Fix 9999 0.00 Q (I/s) 0.00 9999.00 9999.00 0.20 s will be estimat 0.25 648	Single Barrier 1000 0.23 Single Fix 9999 0.00 r (m) 0.00 9999.00 0.20 Sigma_s = ed : only for ball	Untersect. 90° 9999 9999 90°Fix+no-flow 9999 90°Fix+no-flow 9999 90°E 0.00 u_r 0.00E+00 0.00E+00 5.19E-04 9999.00 1.396 rrier boundaries) 1.396	2 Parallel Barriers 9999 9999 #NUM! // Fix+no-flow 9999 9999 #NUM! W(u,r) #NUM! 6.99 9999.00 9999.00
 (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES BH1 BH2 s_(influence of BH1,BH2) = SOLUTION INCLUDING BOUNDS AND BH's Fix head + No-flow : Q_sust (I/s) = No-flow : Q_sust (I/s) = No-flow : Q_sust (I/s) = Inter selected Q for risk analysis = (enter) → (Go to Risk sheet and perform risk analysis from which sigma_ FINAL RECOMMENDED ABSTRACTION RATE Abstraction rate (I/s) for 24 hr/d = (enter) Total amount of water allowed to be abstracted per month (m³) = COMMENTS Q_sust with 68% safety = Q sust with 95% safety = Q sust with 95% safety = Q Sust with 95% safety = Q Sust with 95% safety = Q Sust with 95% safety = Q Sust with 95% safety = Q Sust with 95% safety = Q Sust with 95% safety = Q Sust with 95% safety = Q Sust with 95% safety = Q Sust with 95% safety = Q Sust with 95% safety = Q Sust with 95% safety = Sust with 95% Safety = Q Sust with 95% Safety = Commentation Safety = Safety = Safety = Safety = Safety = Safety = Safety =	Closed Square 9999 0.00 Closed Fix 9999 0.00 Q (l/s) 0.00 9999.00 9999.00 0.20 s will be estimat 0.25 648	Single Barrier 1000 0.23 Single Fix 9999 0.00 r (m) 0.00 Sigma_s = ed : only for ball	Intersect. 90° 9999 9999 0.00 90°Fix+no-flow 9999 0.00 u_r 0.00E+00 5.19E-04 9999.00 1.396 rrier boundaries)	2 Parallel Barriers 9999 9999 #NUM! // Fix+no-flow 9999 9999 #NUM! W(u,r) #NUM! 6.99 9999.00 9999.00

FC-METHOD : Estimation of the sustainabl	e yield of a	borehole		
BRBH5				
Extrapolation time in years = (enter)	2	1051200	Extrapol.time in	minutes
Effective borehole radius $(r_e) = (enter)$	52.85 🗲	52.85	Est. r _e	From r(e) sheet
Q (l/s) from pumping test =	1.6	7.39E-05	S-late	Change r _e
S _a (available drawdown), sigma_s = (enter)	56.8	0.34	Sigma_s froi	m risk
t(end) and s(end) of numping test –	1560	/1.03	S_available work	awdown of test
Average maximum derivative = (enter)	78.3	- 78.3	Estimate of aver	age of max deriv
Average second derivative = (enter)	0.1	- 0.1	Estimate of aver	age second deriv
Derivative at radial flow period = (enter)	1.91 🗲	- 1.91	Read from derivation	ative graph
	T-early[m ² /d] =	13.24	Aqui. thick (m)	20
T and S estimates from derivatives	T-late $[m^2/d] =$	0.32	<u>Est. S-late =</u>	1.10E-03
(To obtain correct S-value, use program RPTSOLV)	S-late =	1.10E-03	S-estimate coul	d be wrong
BASIC SOLUTION				
(Using derivatives + subjective information about boundaries)		Maximum influ	uence of boundari	es at long time
(No values of T and S are necessary)	No boundaries	1 no-flow	2 no-flow	Closed no-flow
sWell (Extrapol.time) =	269.86	491.32	712.78	1377.18
Q_sust (I/s) =	0.43	0.23	0.16	0.08
	Best case		•	Worst case
Average Q_sust (I/s) =	0.19			
with standard deviation=	0.15			
(If no information exists about boundaries skip advanced solution	n and go to final i	recommendatio	n)	
ADVANCED SOLUTION				
(Using derivatives+ knowledge on houndaries and other horebo				
(Using derivatives+ knowledge on boundaries and other bolence (Late T and S values a priori L distance to boundary)	<i>hes)</i>			
(Late 1-and 5-values a prior + distance to boundary) $T_{\text{late}} [m^2/d] = (\text{onter})$	0.22	1		
	0.32			
S-late = (enter)	1.00E-03	(Codo 0000	dummy value if	not annliaghla)
(a) Barrier (no-flow) boundaries	Closed Square	Code =9999 =	Intersect 90°	2 Parallel Barriers
				2 I alaliel Dalliels
Bound distance almeterl · (enter)	yyyy	1000	qqqq	9999
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter)	9999	1000	9999 9999	9999 9999
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] =	9999 #NUM!	0.10	9999 9999 #NUM!	9999 9999 #NUM!
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] =	9999 #NUM!	0.10	9999 9999 #NUM!	9999 9999 #NUM!
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow	#NUM!	0.10 Single Fix	9999 9999 #NUM! 90°Fix+no-flow	9999 9999 #NUM! // Fix+no-flow
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter)	#NUM! Closed Fix 9999	1000 0.10 Single Fix 9999	9999 9999 #NUM! 90°Fix+no-flow 9999	9999 9999 #NUM! // Fix+no-flow 9999
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter)	#NUM! Closed Fix 9999	0.10 Single Fix 9999	9999 9999 #NUM! 90°Fix+no-flow 9999 9999	9999 9999 #NUM! // Fix+no-flow 9999 9999
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] =	9999 #NUM! Closed Fix 9999 #NUM!	0.10 0.10 Single Fix 9999 0.00	9999 9999 #NUM! 90°Fix+no-flow 9999 9999 #NUM!	9999 9999 #NUM! // Fix+no-flow 9999 9999 #NUM!
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] =	9999 #NUM! Closed Fix 9999 #NUM!	0.10 0.10 Single Fix 9999 0.00	9999 9999 #NUM! 90°Fix+no-flow 9999 9999 #NUM!	9999 9999 #NUM! // Fix+no-flow 9999 9999 #NUM!
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES	9999 #NUM! Closed Fix 9999 #NUM! Q (l/s)	0.10 Single Fix 9999 0.00 r (m)	9999 9999 #NUM! 90°Fix+no-flow 9999 9999 #NUM! r	9999 9999 #NUM! // Fix+no-flow 9999 9999 #NUM! W(u,r)
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES BH1	9999 #NUM! Closed Fix 9999 #NUM! Q (l/s)	1000 0.10 Single Fix 9999 0.00 r (m)	9999 9999 #NUM! 90°Fix+no-flow 9999 9999 #NUM! 	9999 9999 #NUM! // Fix+no-flow 9999 9999 #NUM! W(u,r) #NUM!
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES BH1 BH2	9999 #NUM! Closed Fix 9999 #NUM! Q (I/s)	1000 0.10 Single Fix 9999 0.00 r (m)	9999 9999 #NUM! 90°Fix+no-flow 9999 9999 #NUM! u_r 0.00E+00 0.00E+00	9999 9999 #NUM! // Fix+no-flow 9999 9999 #NUM! W(u,r) #NUM! #NUM!
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES BH1 BH2 s_(influence of BH1,BH2) =	9999 #NUM! Closed Fix 9999 #NUM! Q (I/s) 0.00	1000 0.10 Single Fix 9999 0.00 r (m) 0.00	9999 9999 #NUM! 90°Fix+no-flow 99999 9999 #NUM! u_r 0.00E+00 0.00E+00 2.96E-03	9999 9999 #NUM! // Fix+no-flow 9999 9999 #NUM! W(u,r) #NUM! #NUM! 5.25
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES BH1 BH2 S_(influence of BH1,BH2) = SOLUTION INCLUDING BOUNDS AND BH's	9999 #NUM! Closed Fix 9999 #NUM! Q (I/s) 0.00	1000 0.10 Single Fix 9999 0.00 r (m) 0.00	9999 9999 #NUM! 90°Fix+no-flow 9999 9999 #NUM! u_r 0.00E+00 0.00E+00 2.96E-03	9999 9999 #NUM! 9999 9999 9999 #NUM! W(u,r) #NUM! \$.25
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES BH1 BH2 S_(influence of BH1,BH2) = SOLUTION INCLUDING BOUNDS AND BH's Fix head + No-flow : Q_sust (I/s) = No flow : Q_sust (I/s) =	9999 #NUM! Closed Fix 9999 #NUM! Q (I/s) 0.00 9999.00	1000 0.10 Single Fix 9999 0.00 r (m) 0.00 9999.00	9999 9999 #NUM! 90°Fix+no-flow 9999 9999 #NUM! u_r 0.00E+00 0.00E+00 2.96E-03 9999.00	9999 9999 #NUM! 9999 9999 #NUM! W(u,r) #NUM! \$.25 9999.00
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES BH1 BH2 s_(influence of BH1,BH2) = SOLUTION INCLUDING BOUNDS AND BH's Fix head + No-flow : Q_sust (I/s) = No-flow : Q_sust (I/s) = Enter selected O for risk applysic = (onter)	9999 #NUM! Closed Fix 9999 #NUM! Q (l/s) 0.00 9999.00 9999.00	0.10 0.10 Single Fix 9999 0.00 r (m) 0.00 9999.00 0.33 Sigma o	9999 9999 #NUM! 90°Fix+no-flow 9999 9999 #NUM! u_r 0.00E+00 0.00E+00 2.96E-03 99990.00 99990.00	9999 9999 #NUM! 9999 9999 #NUM! W(u,r) #NUM! #NUM! 5.25 9999.00 9999.00
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES BH1 BH2 s_(influence of BH1,BH2) = SOLUTION INCLUDING BOUNDS AND BH's Fix head + No-flow : Q_sust (I/s) = No-flow : Q_sust (I/s) = Enter selected Q for risk analysis = (enter) →	9999 #NUM! Closed Fix 9999 #NUM! Q (l/s) 0.00 99999.00 9999.00 0.34	1000 0.10 Single Fix 9999 0.00 r (m) 0.00 9999.00 0.33 Sigma_s =	9999 9999 #NUM! 90°Fix+no-flow 99999 9999 #NUM! u_r 0.00E+00 0.00E+00 2.96E-03 99999.00 9999.00 6.003	9999 9999 #NUM! // Fix+no-flow 9999 9999 #NUM! W(u,r) #NUM! \$.25 9999.00 9999.00
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES → BH1 BH2 s_(influence of BH1,BH2) = SOLUTION INCLUDING BOUNDS AND BH's Fix head + No-flow : Q_sust (I/s) = No-flow : Q_sust (I/s) = Enter selected Q for risk analysis = (enter) → (Go to Risk sheet and perform risk analysis from which sigma_	9999 #NUM! Closed Fix 9999 #NUM! Q (I/s) 0.00 9999.00 9999.00 0.34 s will be estimat	1000 0.10 Single Fix 9999 0.00 r (m) 0.00 9999.00 0.33 Sigma_s = ed : only for bat	9999 9999 #NUM! 90°Fix+no-flow 9999 9999 #NUM! u_r 0.00E+00 0.00E+00 2.96E-03 9999.00 9999.00 6.003	9999 9999 #NUM! 9999 9999 9999 #NUM! W(u,r) #NUM! 5.25 99999.00 9999.00
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES → BH1 BH2 S_(influence of BH1,BH2) = SOLUTION INCLUDING BOUNDS AND BH's Fix head + No-flow : Q_sust (I/s) = No-flow : Q_sust (I/s) = Enter selected Q for risk analysis = (enter) → (Go to Risk sheet and perform risk analysis from which sigma_	9999 #NUM! Closed Fix 9999 #NUM! Q (I/s) 0.00 9999.00 9999.00 0.34 s will be estimat	1000 0.10 Single Fix 9999 0.00 r (m) 0.00 9999.00 0.33 Sigma_s = ed : only for bar	9999 9999 #NUM! 90°Fix+no-flow 9999 9999 #NUM! u_r 0.00E+00 0.00E+00 2.96E-03 9999.00 9999.00 6.003 rrier boundaries)	9999 9999 #NUM! 9999 9999 #NUM! W(u,r) #NUM! #NUM! 5.25 9999.00 9999.00
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES BH1 BH2 s_(influence of BH1,BH2) = SOLUTION INCLUDING BOUNDS AND BH's Fix head + No-flow : Q_sust (I/s) = No-flow : Q_sust (I/s) = Enter selected Q for risk analysis = (enter) → (Go to Risk sheet and perform risk analysis from which sigma_ FINAL RECOMMENDED ABSTRACTION RATE Abstraction rate (I/s) for 24 hr/d = (enter)	9999 #NUM! Closed Fix 9999 #NUM! Q (I/s) 0.00 9999.00 9999.00 0.34 s will be estimat	1000 0.10 Single Fix 9999 0.00 r (m) 0.00 9999.00 0.33 Sigma_s = ed : only for bar	9999 9999 #NUM! 90°Fix+no-flow 9999 9999 #NUM! u_r 0.00E+00 0.00E+00 2.96E-03 9999.00 9999.00 6.003 rrier boundaries)	9999 9999 #NUM! 9999 9999 #NUM! W(u,r) #NUM! \$.25 9999.00 9999.00
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES BH1 BH2 s_(influence of BH1,BH2) = SOLUTION INCLUDING BOUNDS AND BH's Fix head + No-flow : Q_sust (I/s) = No-flow : Q_sust (I/s) = Enter selected Q for risk analysis = (enter) → (Go to Risk sheet and perform risk analysis from which sigma_ FINAL RECOMMENDED ABSTRACTION RATE Abstraction rate (I/s) for 24 hr/d = (enter) Total amount of water allowed to be	9999 #NUM! Closed Fix 9999 #NUM! Q (l/s) 0.00 9999.00 9999.00 0.34 s will be estimat 0.50	0.10 0.10 Single Fix 9999 0.00 r (m) 0.00 9999.00 0.33 Sigma_s = ed : only for bar	9999 9999 #NUM! 90°Fix+no-flow 9999 9999 #NUM! u_r 0.00E+00 0.00E+00 2.96E-03 9999.00 9999.00 6.003 rrier boundaries)	9999 9999 #NUM! 9999 9999 #NUM! W(u,r) #NUM! \$.25 9999.00 9999.00
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES → BH1 BH2 S_(influence of BH1,BH2) = SOLUTION INCLUDING BOUNDS AND BH's Fix head + No-flow : Q_sust (I/s) = No-flow : Q_sust (I/s) = Enter selected Q for risk analysis = (enter) → (Go to Risk sheet and perform risk analysis from which sigma_ FINAL RECOMMENDED ABSTRACTION RATE Abstraction rate (I/s) for 24 hr/d = (enter) Total amount of water allowed to be abstracted per month (m ³) =	9999 #NUM! Closed Fix 9999 #NUM! Q (I/s) 0.00 9999.00 9999.00 0.34 s will be estimat 0.50 1296	1000 0.10 Single Fix 9999 0.00 r (m) 0.00 9999.00 0.33 Sigma_s = ed : only for bar	9999 9999 #NUM! 90°Fix+no-flow 9999 9999 #NUM! u_r 0.00E+00 0.00E+00 2.96E-03 9999.00 9999.00 6.003 rrier boundaries)	9999 9999 #NUM! 9999 9999 #NUM! W(u,r) #NUM! \$.25 99999.00 9999.00
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES → BH1 BH2 s_(influence of BH1,BH2) = SOLUTION INCLUDING BOUNDS AND BH's Fix head + No-flow : Q_sust (I/s) = No-flow : Q_sust (I/s) = Enter selected Q for risk analysis = (enter) → (Go to Risk sheet and perform risk analysis from which sigma_ FINAL RECOMMENDED ABSTRACTION RATE Abstraction rate (I/s) for 24 hr/d = (enter) Total amount of water allowed to be abstracted per month (m ³) =	9999 #NUM! Closed Fix 9999 #NUM! Q (I/s) 0.00 99999.00 9999.00 0.34 s will be estimat 0.50 1296	1000 0.10 Single Fix 9999 0.00 r (m) 0.00 9999.00 0.33 Sigma_s = ed : only for bar	9999 9999 #NUM! 90°Fix+no-flow 9999 9999 #NUM! u_r 0.00E+00 0.00E+00 2.96E-03 99999.00 9999.00 6.003	9999 9999 #NUM! 9999 9999 #NUM! W(u,r) #NUM! \$.25 9999.00 9999.00
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES BH1 BH2 s_(influence of BH1,BH2) = SOLUTION INCLUDING BOUNDS AND BH's Fix head + No-flow : Q_sust (I/s) = No-flow : Q_sust (I/s) = Enter selected Q for risk analysis = (enter) → (Go to Risk sheet and perform risk analysis from which sigma_ FINAL RECOMMENDED ABSTRACTION RATE Abstraction rate (I/s) for 24 hr/d = (enter) Total amount of water allowed to be abstracted per month (m ³) =	9999 #NUM! Closed Fix 9999 #NUM! Q (I/s) 0.00 9999.00 9999.00 0.34 s will be estimat 0.50 1296	1000 0.10 Single Fix 9999 0.00 r (m) 0.00 9999.00 0.33 Sigma_s = ed : only for bai	9999 9999 #NUM! 90°Fix+no-flow 9999 9999 #NUM! u_r 0.00E+00 0.00E+00 2.96E-03 9999.00 9999.00 6.003 rrier boundaries)	9999 9999 #NUM! 9999 9999 #NUM! W(u,r) #NUM! 5.25 99999.00 9999.00
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES BH1 BH2 s_(influence of BH1,BH2) = SOLUTION INCLUDING BOUNDS AND BH's Fix head + No-flow : Q_sust (I/s) = No-flow : Q_sust (I/s) = Enter selected Q for risk analysis = (enter) → (Go to Risk sheet and perform risk analysis from which sigma_ FINAL RECOMMENDED ABSTRACTION RATE Abstraction rate (I/s) for 24 hr/d = (enter) Total amount of water allowed to be abstracted per month (m ³) =	9999 #NUM! Closed Fix 9999 #NUM! Q (I/s) 0.00 9999.00 9999.00 0.34 s will be estimat 0.50 1296	1000 0.10 Single Fix 9999 0.00 r (m) 0.00 9999.00 0.33 Sigma_s = ed : only for bai	9999 9999 #NUM! 90°Fix+no-flow 9999 9999 #NUM! u_r 0.00E+00 0.00E+00 2.96E-03 9999.00 6.003 rrier boundaries)	9999 9999 #NUM! 9999 9999 #NUM! W(u,r) #NUM! 5.25 99999.00 9999.00
Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES → BH1 BH2 s_(influence of BH1,BH2) = SOLUTION INCLUDING BOUNDS AND BH's Fix head + No-flow : Q_sust (I/s) = No-flow : Q_sust (I/s) = Enter selected Q for risk analysis = (enter) → (Go to Risk sheet and perform risk analysis from which sigma_ FINAL RECOMMENDED ABSTRACTION RATE Abstraction rate (I/s) for 24 hr/d = (enter) Total amount of water allowed to be abstracted per month (m ³) = COMMENTS Q_sust with 68% safety = Q_sust with 95% safety =	9999 #NUM! Closed Fix 9999 #NUM! Q (l/s) 0.00 9999.00 0.34 s will be estimat 0.50 1296	0.10 0.10 Single Fix 9999 0.00 r (m) 0.00 9999.00 0.33 Sigma_s = ed : only for bar	9999 9999 #NUM! 9999 9999 #NUM! u_r 0.00E+00 0.00E+00 2.96E-03 9999.00 9999.00 6.003 rrier boundaries)	9999 9999 #NUM! 9999 9999 #NUM! W(u,r) #NUM! 5.25 99999.00 9999.00

FC-METHOD : Estimation of the sustainabl	e yield of a	borehole		
BRBH6				
Extrapolation time in years = (enter)	2	1051200	Extrapol.time in	minutes
Effective borehole radius $(r_e) = (enter)$	43.89	43.89	Est. r _e	From r(e) sheet
Q (I/s) from pumping test =	1.55	3.00E-06	S-late	Change r _e
S_a (available drawdowii), sigma_s = (enter)	5.3 0	5.30	s available work	ing drawdown(m)
t(end) and s(end) of pumping test =	2880	4.47	End time and dra	awdown of test
Average maximum derivative = (enter)	0.6 🗲	- 0.6	Estimate of aver	age of max deriv
Average second derivative = (enter)	-0.2 🗲	-0.2	Estimate of aver	age second deriv
Derivative at radial flow period = (enter)	1.07 🗲	- 1.07	Read from deriva	ative graph
	$T-early[m^2/d] =$	22.91	Aqui. thick (m)	20
T and S estimates from derivatives	I-late [m ⁻ /d] =	43.67	Est. S-late =	1.10E-03
	S-late =	1.10E-03	S-estimate cour	a be wrong
BASIC SOLUTION				
(Using derivatives + subjective information about boundaries)		Maximum influ	lence of boundari	es at long time
(No values of T and S are necessary)	No boundaries	1 no-flow	2 no-flow	Closed no-flow
sWell (Extrapol.time) =	5.12	6.56	8.00	12.31
Q_SUST (I/S) =	1.60	1.25	1.03	0.67
	Best case	1		worst case
Average Q_Sust (I/S) =	0.30			
(If no information exists about boundaries skip advanced solutio	n and go to final i	l recommendatio	n)	
	in and go to final f		•••	
ADVANCED SOLUTION				
(Using derivatives+ knowledge on boundaries and other boreho	oles)			
(Late T-and S-values a priori + distance to boundary)				
T-late $[m^2/d] = (enter)$	43.67			
S-late = (enter)	1.00E-03			
1. BOUNDARY INFORMATION (choose a or b)		(Code =9999 =	dummy value if i	not applicable)
1. BOUNDARY INFORMATION (choose a or b) (a) Barrier (no-flow) boundaries	Closed Square	(Code =9999 = Single Barrier	dummy value if r	not applicable) 2 Parallel Barriers
1. BOUNDARY INFORMATION (choose a or b) (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound_distance b[meter] : (enter)	Closed Square 9999	(Code =9999 = Single Barrier 1000	dummy value if r Intersect. 90° 9999	not applicable) 2 Parallel Barriers 9999 9999
1. BOUNDARY INFORMATION (choose a or b) (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s Bound(t = Extrapol.time) [m] =	Closed Square 9999	(Code =9999 = Single Barrier 1000 0.71	dummy value if r Intersect. 90° 9999 9999 0.01	not applicable) 2 Parallel Barriers 9999 9999 0.01
1. BOUNDARY INFORMATION (choose a or b) (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] =	Closed Square 9999	(Code =9999 = Single Barrier 1000 0.71	e dummy value if r Intersect. 90° 9999 9999 0.01	not applicable) 2 Parallel Barriers 9999 9999 0.01
 1. BOUNDARY INFORMATION (choose a or b) (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow 	Closed Square 9999 0.01 Closed Fix	(Code =9999 = Single Barrier 1000 0.71 Single Fix	e dummy value if i Intersect. 90° 9999 0999 0.01 90°Fix+no-flow	not applicable) 2 Parallel Barriers 9999 9999 0.01 // Fix+no-flow
 1. BOUNDARY INFORMATION (choose a or b) (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) 	Closed Square 9999 0.01 Closed Fix 9999	(Code =9999 = Single Barrier 1000 0.71 Single Fix 9999	e dummy value if 1 Intersect. 90° 9999 0.01 90°Fix+no-flow 9999	not applicable) 2 Parallel Barriers 9999 9999 0.01 // Fix+no-flow 9999
 1. BOUNDARY INFORMATION (choose a or b) (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) 	Closed Square 9999 0.01 Closed Fix 9999	(Code =9999 = Single Barrier 1000 0.71 Single Fix 9999	e dummy value if r Intersect. 90° 9999 9999 0.01 90°Fix+no-flow 9999 9999	not applicable) 2 Parallel Barriers 9999 9999 0.01 // Fix+no-flow 9999 9999
1. BOUNDARY INFORMATION (choose a or b) (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] =	Closed Square 9999 0.01 Closed Fix 9999 -0.01	(Code =9999 = Single Barrier 1000 0.71 Single Fix 9999 0.00	dummy value if i Intersect. 90° 9999 0.01 00°Fix+no-flow 9999 9999 0.00	not applicable) 2 Parallel Barriers 9999 9999 0.01 // Fix+no-flow 9999 9999 0.00
1. BOUNDARY INFORMATION (choose a or b) (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] =	Closed Square 9999 0.01 Closed Fix 9999 -0.01	(Code =9999 = Single Barrier 1000 0.71 Single Fix 9999 0.00	e dummy value if i Intersect. 90° 9999 0.01 90°Fix+no-flow 9999 9999 0.00	not applicable) 2 Parallel Barriers 9999 9999 0.01 // Fix+no-flow 9999 9999 0.00
 1. BOUNDARY INFORMATION (choose a or b) (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES	Closed Square 9999 0.01 Closed Fix 9999 -0.01 Q (l/s)	(Code =9999 = Single Barrier 1000 0.71 Single Fix 9999 0.00 0.00	e dummy value if i Intersect. 90° 9999 0.01 90°Fix+no-flow 9999 0.00 0.00 u_r	not applicable) 2 Parallel Barriers 9999 9999 0.01 // Fix+no-flow 9999 9999 0.00 W(u,r)
 1. BOUNDARY INFORMATION (choose a or b) (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES BH1 	Closed Square 99999 0.01 Closed Fix 99999 -0.01 Q (l/s)	(Code =9999 = Single Barrier 1000 0.71 Single Fix 9999 0.00 r (m)	e dummy value if i Intersect. 90° 9999 0.01 90°Fix+no-flow 9999 0.00 0.00 U_r 0.00E+00	not applicable) 2 Parallel Barriers 9999 9999 0.01 // Fix+no-flow 9999 9999 0.00 W(u,r) #NUM!
 1. BOUNDARY INFORMATION (choose a or b) (a) Barrier (no-flow) boundaries Bound. distance a[meter] : (enter) Bound. distance b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = (b) Fix head boundary + no-flow Bound. distance to fix head a[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) Bound. distance to no-flow b[meter] : (enter) s_Bound(t = Extrapol.time) [m] = 2. INFLUENCE OF OTHER BOREHOLES BH1 BH2 	Closed Square 9999 0.01 Closed Fix 9999 -0.01 Q (l/s)	(Code =9999 = Single Barrier 1000 0.71 Single Fix 9999 0.00 r (m)	e dummy value if i Intersect. 90° 9999 9999 0.01 90°Fix+no-flow 9999 9999 0.00 u_r 0.00E+00 0.00E+00 0.00E+00	not applicable) 2 Parallel Barriers 9999 9999 0.01 // Fix+no-flow 9999 9999 0.00 W(u,r) #NUM! #NUM!
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APPENDIX E

LABORATORY REPORTS





Page 1 of 1

Test Report

Client:	Aurecon	Date of certificate:	12 April 2016
Address:	Lynwood Bridge Office Park, No. 4 Daventry str., Pretoria, 0081	Date accepted:	05 April 2016
Report no:	30228	Date completed:	12 April 2016
Project:	Aurecon	Revision:	0

Lal	b no:			253348
Da	te sampled:			05-Apr-16
Sa	mple type:			Water
Lo	cality description:			BRBH2
	Analyses	Unit	Method	
A	pH @ 25°C	рН	ALM 20	8.23
A	Electrical conductivity (EC) @ 25°C	mS/m	ALM 20	20.2
A	Total dissolved solids (TDS)	mg/l	ALM 26	131
A	Total alkalinity	mg CaCO₃/l	ALM 01	75.8
A	Chloride (Cl)	mg/l	ALM 02	4.78
A	Sulphate (SO₄)	mg/l	ALM 03	31.3
A	Nitrate (NO₃) as N	mg/l	ALM 06	0.368
A	Ammonium (NH₄) as N	mg/l	ALM 05	0.093
A	Orthophosphate (PO₄) as P	mg/l	ALM 04	0.035
A	Fluoride (F)	mg/l	ALM 08	<0.142
A	Calcium (Ca)	mg/l	ALM 30	23.5
A	Magnesium (Mg)	mg/l	ALM 30	8.20
A	Sodium (Na)	mg/l	ALM 30	9.28
A	Potassium (K)	mg/l	ALM 30	5.39
A	Aluminium (Al)	mg/l	ALM 31	<0.002
A	Iron (Fe)	mg/l	ALM 31	2.43
A	Manganese (Mn)	mg/l	ALM 31	0.021
A	E.coli	CFU/100ml	ALM 40	<1
Ν	Faecal coliform	CFU/100ml	ALM 42	<1
A	Total coliform	CFU/100ml	ALM 40	<1
А	Total hardness	mg CaCO₃/I	ALM 26	92

A = Accredited N = Non accredited O = Outsourced S = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine The results relates only to the test item tested.

Results reported against the limit of detection.

Results marked 'Not SANAS Accredited' in this report are not included in the SANAS Schedule of Accreditation for this laboratory. Uncertainty of measurement available on request for all methods included in the SANAS Schedule of Accreditation.





Page 1 of 1

Test Report

Client:	Aurecon	Date of certificate:	15 April 2016
Address:	Lynwood Bridge Office Park, No. 4 Daventry str., Pretoria, 0081	Date accepted:	11 April 2016
Report no:	30343	Date completed:	15 April 2016
Project:	Aurecon	Revision:	0

La	b no:			254252
Da	te sampled:			11-Apr-16
Sa	mple type:			Water
Lo	cality description:	Unit	Mathad	BRBH6
٨	лн @ 25°С	nH		8 25
Δ	Electrical conductivity (EC) @ 25°C	mS/m		16.9
Δ	Total dissolved solids (TDS)	mg/l	ALM 26	88
Δ	Total alkalinity	mg CaCO ₂ /l	ALM 01	81.1
Δ	Chloride (CI)	mg/l	ALM 02	1 18
Δ	Sulphate (SQ4)	mg/l	ALM 02	4 16
Α	Nitrate (NO ₂) as N	mg/l	ALM 06	0.288
A	Ammonium (NH4) as N	mg/l	ALM 05	0.066
A	Orthophosphate (PO_4) as P	mg/l	ALM 04	0.096
A	Fluoride (F)	mg/l	ALM 08	0.160
A	Calcium (Ca)	mg/l	ALM 30	14.7
A	Magnesium (Mg)	mg/l	ALM 30	5.41
A	Sodium (Na)	mg/l	ALM 30	7.47
A	Potassium (K)	mg/l	ALM 30	4.19
A	Aluminium (Al)	mg/l	ALM 31	<0.002
A	Iron (Fe)	mg/l	ALM 31	<0.004
А	Manganese (Mn)	mg/l	ALM 31	<0.001
A	E.coli	CFU/100ml	ALM 40	<1
N	Faecal coliform	CFU/100ml	ALM 42	<1
A	Total coliform	CFU/100ml	ALM 40	4
А	Total hardness	mg CaCO₃/I	ALM 26	59

A = Accredited N = Non accredited O = Outsourced S = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine The results relates only to the test item tested.

Results reported against the limit of detection.

Results marked 'Not SANAS Accredited' in this report are not included in the SANAS Schedule of Accreditation for this laboratory. Uncertainty of measurement available on request for all methods included in the SANAS Schedule of Accreditation.





Page 1 of 1

Test Report

Client:	Aurecon	Date of certificate:	21 April 2016
Address:	Lynwood Bridge Office Park, No. 4 Daventry str., Pretoria, 0081	Date accepted:	15 April 2016
Report no:	30480	Date completed:	21 April 2016
Project:	Aurecon	Revision:	0

La	b no:			255208
Da	te sampled:			15-Apr-16
Sa	mple type:			Water
Lo	cality description:			BRBH5
	Analyses	Unit	Method	
A	pH @ 25°C	рН	ALM 20	8.06
A	Electrical conductivity (EC) @ 25°C	mS/m	ALM 20	18.1
A	Total dissolved solids (TDS)	mg/l	ALM 26	106
A	Total alkalinity	mg CaCO₃/l	ALM 01	94.7
A	Chloride (Cl)	mg/l	ALM 02	2.71
A	Sulphate (SO₄)	mg/l	ALM 03	5.66
A	Nitrate (NO₃) as N	mg/l	ALM 06	0.237
A	Ammonium (NH₄) as N	mg/l	ALM 05	0.011
A	Orthophosphate (PO₄) as P	mg/l	ALM 04	0.063
A	Fluoride (F)	mg/l	ALM 08	0.268
A	Calcium (Ca)	mg/l	ALM 30	19.9
A	Magnesium (Mg)	mg/l	ALM 30	6.10
A	Sodium (Na)	mg/l	ALM 30	8.60
A	Potassium (K)	mg/l	ALM 30	4.40
A	Aluminium (Al)	mg/l	ALM 31	<0.002
A	Iron (Fe)	mg/l	ALM 31	<0.004
A	Manganese (Mn)	mg/l	ALM 31	<0.001
A	E.coli	CFU/100ml	ALM 40	<1
N	Faecal coliform	CFU/100ml	ALM 42	<1
A	Total coliform	CFU/100ml	ALM 40	<1
А	Total hardness	mg CaCO₃/l	ALM 26	75

A = Accredited N = Non accredited O = Outsourced S = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine The results relates only to the test item tested.

Results reported against the limit of detection.

Results marked 'Not SANAS Accredited' in this report are not included in the SANAS Schedule of Accreditation for this laboratory. Uncertainty of measurement available on request for all methods included in the SANAS Schedule of Accreditation.

APPENDIX F

PUMPTESTING FIELD SHEETS

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Telephone: 043-732 1211 Fax no: 043-732 1422 Fax to e-mail: 0866 717 732 E mail: office@abpumps.co.za

	Abbreviations
c	Electrical conductivity
nbgl	Meters below ground level
nbch	Meters below casing height
mbdl	Meters below datum level
magl	Meters above ground level
L/S	Litres per second
RPM	Rates per minute
s/w/L	Static water level
μS/cm	Microsiemens per centimeter



Ground water solutions t/a AB Pumps CC

								PR0JECT #	P1582
								BBR	CHRISTOPHER
CONSULTANT:	SRK EL								
DISTRICT:	BELFAST						-		SAMUEL
PROVINCE:	MPUMALANGA						-	PRODUCTION BONUS:	
FARM / VILLAGE NAME ·	BELEAST						-		
	DELIAOT						-		-
DATE TESTED:	02/04/2016						-	EC meter number	UNMARKED BLUE
IAP REFERENCE:									
CO-ORDINATES:									
FORMAT ON G	PS: hddd	°mm '	SS.S	"		hddd	°mm.mmm	•	hddd.ddddd
	ne.	• •		"			0	•	25.7594
	DE:	• •		"	– OR		0	OR	29.9653
					_				
OREHOLE NO:	BR BH 2				_				
RANSMISSIVITY VALUE:					-				
YPE INSTALLATION:	NEW BOREHOL	.E			_				
OREHOLE DEPTH: (mbgl)	79.25				_				
AMPLE INSTRUCTIONS :	Yes	No		Test for:		macro	bacterio-logical	DATA CAPTURED BY:	AVN
AMPLE INSTRUCTIONS : Vater sample taken	Yes	No	If co	Test for: posultant took sample, give i	name:	macro	bacterio-logical	DATA CAPTURED BY: DATA CHECKED BY:	AVN
AMPLE INSTRUCTIONS : //ater sample taken ate sample taken ime sample taken	Yes	No	If co	Test for: onsultant took sample, give	name:	macro	bacterio-logical	DATA CAPTURED BY: DATA CHECKED BY:	AVN AVN
AMPLE INSTRUCTIONS : Vater sample taken inte sample taken ime sample taken	Yes	No	If co	Test for: onsultant took sample, give i	name:	macro	bacterio-logical	DATA CAPTURED BY: DATA CHECKED BY:	AVN AVN
AMPLE INSTRUCTIONS : Vater sample taken iate sample taken ime sample taken ONSULTANT GUIDELINES OREHOLE DEPTH:	Yes	No	If co	Test for: onsultant took sample, give r	name:	macro	bacterio-logical	DATA CAPTURED BY: DATA CHECKED BY:	AVN AVN
AMPLE INSTRUCTIONS : Vater sample taken Vater sample taken Vater sample taken Vater sample taken ONSULTANT GUIDELINES OREHOLE DEPTH: LOW YIELD:	Yes m m	No STE STE	======================================	Test for: onsultant took sample, give r 0.50 1.00	name:	macro WATER STRIKE 1: WATER STRIKE 2:	bacterio-logical	DATA CAPTURED BY: DATA CHECKED BY:	AVN AVN m
AMPLE INSTRUCTIONS : Vater sample taken Vates sample taken Vates sample taken VORSULTANT GUIDELINES OREHOLE DEPTH: LOW YIELD: TATIC WATER LEVEL:	Yes m m m_	No STE STE	EP 1: EP 2: EP 3:	Test for: onsultant took sample, give i 0.50 1.00 2.00	name:	macro WATER STRIKE 1: WATER STRIKE 2: WATER STRIKE 3:	bacterio-logical	DATA CAPTURED BY: DATA CHECKED BY:	AVN AVN m m
AMPLE INSTRUCTIONS : /ater sample taken ate sample taken onsultant guidelines OREHOLE DEPTH: LOW YIELD: TATIC WATER LEVEL: UMP INSTALLATION DEPTH:	Yes m m m m	No STE STE STE	EP 1: EP 2: EP 3: EP 4:	Test for: Disultant took sample, give i 0.50 1.00 2.00 4.00	name:	macro WATER STRIKE 1: WATER STRIKE 2: WATER STRIKE 3: COMMENTS:	bacterio-logical	DATA CAPTURED BY: DATA CHECKED BY:	AVN AVN m m
AMPLE INSTRUCTIONS : /ater sample taken /ate sample taken /onsultant guidelines OREHOLE DEPTH: LOW YIELD: TATIC WATER LEVEL: ////////////////////////////////////	Yes m m m m m	No STE STE STE STE	If or EP 1: EP 2: EP 3: EP 4: EP 5:	Test for: Disultant took sample, give i 0.50 1.00 2.00 4.00	name:	Macro WATER STRIKE 1: WATER STRIKE 2: WATER STRIKE 3: COMMENTS:	bacterio-logical	DATA CAPTURED BY: DATA CHECKED BY:	AVN AVN m m
SAMPLE INSTRUCTIONS : Vater sample taken Vater sample taken Time sample taken CONSULTANT GUIDELINES SOREHOLE DEPTH: STATIC WATER LEVEL: PUMP INSTALLATION DEPTH: RECOVERY: AFTER STEPS:	Mes	No STE STE STE STE STE	If a	Test for: onsultant took sample, give i 0.50 1.00 2.00 4.00	name:	Macro WATER STRIKE 1: WATER STRIKE 2: WATER STRIKE 3: COMMENTS: TELEPHONE NUMB	ERS PHONE : (NAME &	DATA CAPTURED BY: DATA CHECKED BY:	AVN AVN m m
AMPLE INSTRUCTIONS : Vater sample taken ine sample taken CONSULTANT GUIDELINES OREHOLE DEPTH: LOW YIELD: TATIC WATER LEVEL: UMP INSTALLATION DEPTH: ECOVERY: AFTER STEPS: AFTER CONSTANT:	Mes	No STE STE STE STE STEP DI	If cc IF 1: IF 2: IF 3: IF 4: IF 5: IF 6: IF 6: IF ATION:	Test for: onsultant took sample, give i 0.50 1.00 2.00 4.00	name: Vs Vs Vs Vs Vs Vs Vs Vs Vs Vs	macro WATER STRIKE 1: WATER STRIKE 2: WATER STRIKE 3: COMMENTS: TELEPHONE NUMB	ERS PHONE : (NAME &	DATA CAPTURED BY: DATA CHECKED BY:	AVN AVN m m
AMPLE INSTRUCTIONS : /ater sample taken ime sample taken ONSULTANT GUIDELINES OREHOLE DEPTH: LOW YIELD: TATIC WATER LEVEL: UMP INSTALLATION DEPTH: ECOVERY: AFTER STEPS: AFTER CONSTANT: ESCEIDTON:	Yes m m m m h h	No STE STE STE STE STE STEP DO	EP 1: EP 2: EP 3: EP 4: EP 5: EP 6: JRATION:	Test for: Dissultant took sample, give i 0.50 1.00 2.00 4.00	name: Vs Vs Vs Vs Vs Vs Vs Ms Min	Macro WATER STRIKE 1: WATER STRIKE 2: WATER STRIKE 3: COMMENTS: TELEPHONE NUMB	ERS PHONE : (NAME &	DATA CAPTURED BY: DATA CHECKED BY: DATA CHECKED BY: TEL)	AVN AVN m m m
AMPLE INSTRUCTIONS : /ater sample taken ine sample taken ONSULTANT GUIDELINES OREHOLE DEPTH: LOW YIELD: TATIC WATER LEVEL: UMP INSTALLATION DEPTH: ECOVERY: AFTER STEPS: AFTER CONSTANT: ESCRIPTION: TRAIGHTNESS TEST:	Yes m m m m m h h	No STE STE STE STEP DI UNIT NO	EP 1: EP 2: EP 3: EP 4: EP 5: EP 6: URATION: QTY 0	Test for: Disultant took sample, give i 0.50 1.00 2.00 4.00 BOREHOLE DEPTH AFTER T	name: Us Us Us Us Us Us Us EST	Macro WATER STRIKE 1: WATER STRIKE 2: WATER STRIKE 3: COMMENTS: TELEPHONE NUMB	ERS PHONE : (NAME &	DATA CAPTURED BY: DATA CHECKED BY: DATA CHECKED BY: TEL)	AVN AVN m m m
AMPLE INSTRUCTIONS : Vater sample taken Vater sample taken Vater sample taken ONSULTANT GUIDELINES OREHOLE DEPTH: LOW YIELD: TATIC WATER LEVEL: UMP INSTALLATION DEPTH: ECOVERY: AFTER STEPS: AFTER STEPS: AFTER CONSTANT: ESCRIPTION: TRAIGHTNESS TEST: EPTICALLY TEST:	Yes m m m m h h	No STE STE STE STE DUNIT NO	EP 1: EP 2: EP 3: EP 4: EP 5: EP 6: JRATION: QTY 0 0	Test for: Disultant took sample, give i 0.50 1.00 2.00 4.00 BOREHOLE DEPTH AFTER TI BOREHOLE DEPTH AFTER TI	name: //s //s //s //s //s min EST: ETER TEST:	Macro	ERS PHONE : (NAME &	TEL)	AVN AVN m m m d f f f f f f f f f f f f f f f f
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AMPLE INSTRUCTIONS : Jater sample taken ate sample taken ime sample taken ONSULTANT GUIDELINES OREHOLE DEPTH: LOW YIELD: LOW YIELD: TATIC WATER LEVEL: UMP INSTALLATION DEPTH: ECOVERY: AFTER STEPS: AFTER CONSTANT: ESCRIPTION: TRAIGHTINESS TEST: ERTICALLY TEST: ASING DETECTION:	Yes 	No STE STE STE STE STE DI UNIT NO NO NO	If cc EP 1: EP 2: EP 3: EP 4: EP 5: EP 6: JRATION: 0 0 1 0 1 0	Test for: DISUITANT took sample, give I 0.50 1.00 2.00 4.00 BOREHOLE DEPTH AFTER TI BOREHOLE DEPTH AFTER TI BOREHOLE WATER LEVEL A SAND/GRAVEL/SILT PUMPED	name: //s //s //s //s //s //s //s /s	macro WATER STRIKE 1: WATER STRIKE 2: WATER STRIKE 3: COMMENTS: TELEPHONE NUMB	ERS PHONE : (NAME &	DATA CAPTURED BY: DATA CHECKED BY: DATA CHECKED BY: Image: Comparison of the second seco	AVN AVN m m m d m f f f f f f f f f f f f f f f
AMPLE INSTRUCTIONS : Vater sample taken Vater sample taken Vater sample taken Vater sample taken VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIIII VIIIII VIIIII VIIII VIIII VIIII VIIII VIIII VIIIII VIIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIIII VIIII VIIII VIIII VIIIII VIIII VIIIII VIIIII VIIII VIIII VIIII VIIII VIIIII VIIIII VIIII VIIII VIIIII VIIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIIII VIIII VIIII VIIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIIII VIIII VIIII VIIII VIIIII VIIII VIIIII VIIII VIIII VIIII VIIIII VIIIII VIIIII VIIII VIIII VIIII VIIIII VIIII VIIII VIIII VIIII VIIII VIIIII VIIII VIIII VIIII VIIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIII VIIII VIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIII VIIIII VIIII VIIII VIIII VIIII VIIIII VIIII VIIII VIIIII VIIII VIIII VIIIII VIIII VIIII VIIII VIIIII VIIII VIIII VIIII VIIII VIIII VIIIII VIIII VIIIII VIIII VIIII VIIII VIIIII VIIII VIIIII VIIII VIIII VIIIII VIIII VIIII VIIIII VIIIII VIIIII	Yes 	No STE STE STE STE STE DI UNIT NO NO NO	If or EP 1: EP 2: EP 3: EP 4: EP 5: EP 6: JRATION: 0 0 0 1 0 0	Test for: DISUITANT took sample, give i 0.50 1.00 2.00 4.00 BOREHOLE DEPTH AFTER TI BOREHOLE WATER LEVEL A SAND/GRAVEL/SILT PUMPER DATA REPORTING AND REC	name: Us Us Us Us Us Us EST: FTER TEST: P ORDING	MATER STRIKE 1: WATER STRIKE 1: WATER STRIKE 2: WATER STRIKE 3: COMMENTS: TELEPHONE NUMB	ERS PHONE : (NAME &	DATA CAPTURED BY: DATA CHECKED BY: DATA CHECKED BY:	AVN AVN m m m 63.18 7.98 0 1
AMPLE INSTRUCTIONS : Vater sample taken Vater sample taken Vater sample taken ONSULTANT GUIDELINES OREHOLE DEPTH: LOW YIELD: TATIC WATER LEVEL: UMP INSTALLATION DEPTH: LECOVERY: AFTER STEPS: AFTER CONSTANT: ESCRIPTION: TRAIGHTNESS TEST: ERTICALLY TEST: ASING DETECTION: UPPLIED NEW STEEL BOREHOLI OREHOLE MARKING	Yes 	No STE STE STE STE UNIT NO	If or EP 1: EP 2: EP 3: EP 4: EP 5: EP 6: JRATION: QTY 0 0 0 1 0 0 0	Test for: DISUITANT took sample, give i 0.50 1.00 2.00 4.00 BOREHOLE DEPTH AFTER TI BOREHOLE WATER LEVEL A SAND/GRAVEL/SILT PUMPEE DATA REPORTING AND REC SLUG TEST:	name: Us Us Us Us Us Us Us EST: FTER TEST: ORDING	macro WATER STRIKE 1: WATER STRIKE 2: WATER STRIKE 3: COMMENTS: TELEPHONE NUMB	ERS PHONE : (NAME &	DATA CAPTURED BY: DATA CHECKED BY: DATA CHECKED BY: Image: I	AVN AVN m m m 63.18 7.98 0 1 1 0
AMPLE INSTRUCTIONS : Vater sample taken Vater sample taken Vate sample taken Vate sample taken VORSULTANT GUIDELINES VOREHOLE DEPTH: VIMP INSTALLATION DEPTH: ECOVERY: AFTER STEPS: AFTER CONSTANT: VESCRIPTION: ITRAIGHTNESS TEST: VESCRIPTION: ITRAIGHTNESS TEST: VESCRIPTION: IDPPLIED NEW STEEL BOREHOL OREHOLE MARKING ITE CLEANING & FINISHING	Yes 	No STE STE STE UNIT NO NO	If cc EP 1: EP 2: EP 3: EP 4: EP 5: EP 6: JRATION: QTY 0 0 0 1 0 0 1 0 0 1	Test for: DISUITANT took sample, give i 0.50 1.00 2.00 4.00 BOREHOLE DEPTH AFTER TI BOREHOLE WATER LEVEL A SAND/GRAVEL/SILT PUMPER DATA REPORTING AND REC SLUG TEST: LAYFLAT (M):	name: //s //s //s //s //s //s //s /s	macro WATER STRIKE 1: WATER STRIKE 2: WATER STRIKE 3: COMMENTS: TELEPHONE NUMB	ERS PHONE : (NAME &	DATA CAPTURED BY: DATA CHECKED BY: DATA CHECKED BY: Image: I	AVN AVN m m m 63.18 7.98 0 1 1 0 50

ig the site, all existing equipment is in an acceptable cond

NAME:

SIGNATURE: DATE:

DESIGNATION:

				STEPPED I	DISCHARG	FO E TEST & F	RM 5 E RECOVI	ERY						
BOREHOLE PROJ NO : BOREHOLE N	OF	P1582	:ET	MAP REFER	ENCE:	0								
ALT BH NO: ALT BH NO:	0.	0 0	2							SITE N/	AME:	BELFAS	ST	
BOREHOLE DI WATER LEVEI	EPTH (m) L (mbdl):		79.25 8.44		DATUM LE CASING H	EVEL ABOVE EIGHT: (magi	CASING	i (m):	0.47 0.56		NG PUMP: ACTOR:	0 AB PUN	1PS	
DEPTHOPPO	MP (m).		03.10	S	TEPPED C		TEST (& RECC	DVERY	PUIVIP	TPE.	DVV 240	Z	
DISCHARGE R	RATE 1		RPM		DISCHARC	GE RATE 2		RPM		DISCHA	ARGE RATE	3	RPM	
DATE:	02/04/2016	TIME:	09H30		DATE:	02/04/2016	TIME:	10H30		DATE:		TIME:		
TIME	DRAW	YIELD	TIME	RECOVERY	TIME	DRAW	YIELD	TIME	RECOVERY	TIME	DRAW	YIELD	TIME	RECOVERY
(MIN)	DOWN (M)	(L/S)	(MIN)	(M)	(MIN)	DOWN (M)	(L/S)	(MIN)	(M)	(MIN)	DOWN (M)	(L/S)	(MIN)	(M)
1	0.61		1		1	3.90		1	51.36	1 ว			1 ว	
2	0.89		2		2	5.13		2	49.10	2			2	
5	1.13	0.54	5		5 5	6.00	1.09	5 5	40.92	5 5			5 5	
3 7	1.25	0.54	3 7		3 7	7 35	1.05	5 7	42.20	3 7			J 7	
10	1.40	0.55	, 10		, 10	8.03	1.07	, 10	41.02	, 10			, 10	
15	2.14	0.00	15		13	16.60	1.07	15	39.67	15			15	
20	2.50	0.56	20		14	37.80	1.09	20	38.50	20			20	
30	2.73		30		15	44.90		30	37.43	30			30	
40	2.85	0.53	40		20	54.74		40	36.14	40			40	
50	3.05		50		25	54.74	0.51	50	35.03	50			50	
60	3.21	0.54	60		30	54.74	0.48	60	33.64	60			60	
70			70		40	54.74	0.45	70	31.44	70			70	
80			80					80		80			80	
90			90					90		90			90	
100			100					100		100			100	
110			110					110		110			110	
120			120					120		120			120	
рН			150		рН			150		рН			150	
ТЕМР	21.50	°C	180		TEMP	20.90	°C	180		TEMP		°C	180	
EC	193.00	µS/cm	210		EC	206.00	µS/cm	210		EC		µS/cm	210	
	RATE 4		RPM		DISCHARC	GE RATE 5	I	RPM		DISCHA	ARGE RATE	6	RPM	
DATE:		TIME:	TIN 4 5		DATE:	BB 444	TIME:	TIN 4 5		DATE:	DD 111	TIME:	TIN 1 5	
		YIELD					YIELD		(M)			YIELD		
(101113)		(Ľ/Ŭ)	(101114)	(101)	(IVIII N)		(L/O)	(IVIII 1)	(101)	(IVIIIN) 1		(L/O)	(IVIII \)	(101)
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3			3		3			3		3			3	
5			5		5			5		5			5	
7		1	7		7		1	7		7			7	
10		1	10		10			10		10			10	
15			15		15			15		15			15	
20			20		20			20		20			20	
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90			90		90 1			90		90			90	<u> </u>
100			100		100			100		100			100	
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12V mH	1	1	120		12 0		I	120		120 mL!			120	
рп теме		°C	130		рп темв		°C	100		рп темо		°C	100	
			210					210					10U 210	
20		µ3/cm	210		20		µ3/cm	210		<u> </u>		µ3/cm	210	
			300					300					300	
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	I	1		1		1			I		1	1		<u> </u>
S/W/L:(mbch)	7.98													

BORE	HOLE TEST RE	ECORD S	CONSTAN SHEET	FORM 5 F	: GE TESI	& RECOV	ERY					
PROJ N BOREH ALT BH ALT BH	NO : IOLE NO: I NO: I NO:	P1582 BRBH 2 0 0		MAP REFER	ENCE:	25.7514 29.96563			PROVINCE DISTRICT: SITE NAME	:	MPUMA BELFAS BELFAS	LANGA ST ST
BOREH WATEF DEPTH	IOLE DEPTH: R LEVEL (mbdl): OF PUMP (m):	79.25 8.80 0.00		DATUM LEVE CASING HEE DIAM PUMP	EL ABOV IGHT: (m INLET(mi	E CASING (n agl): m):	n):	0.47 0.50 165	EXISTING F CONTRACT PUMP TYPI	PUMP: "OR: =:	0 AB PUN 0	IPS
CONST	ANT DISCHARC	GE TEST	& RECOVER									
DATE			071100			04/04/0040		071100				2
DATE:	04/04/2016	TIME:	07H33		DATE: OBSER\	04/04/2016 /ATION HOL	E 1	07H33 OBSERV	ATION HOLE	0MP: 2	OBSER	U VATION HOLE 3
			-		NR:	BRBH 2	15.0	NR:	BRBH6		NR:	
TIME	DISCHARGE B		E ITIME	RECOVERY	Distance	(m); Drawdown	15.8 Recovery	Distance(m); Drawdown	Recovery	Distance TIME ·	e(m); Drawdown
(MIN)	DOWN (M)	(L/S)	MIN	(M)	(min)	m	(m)	(min)	(m)	Recovery	(min)	(m)
1	0.48		1	2.37	1			1			1	
2	0.51		2	2.19	2			2			2	
з 5	0.55	0.25	5	2.14	з 5			5			3 5	
7	0.62		7	2.16	7			7			7	
10	0.67	0.27	10	2.04	10			10			10	
15 20	0.71	0.26	15	1.97	15 20			15			15 20	
20 30	0.74	0.26	30	1.90	20 30	0.00		30	0.00		30	
40	0.97	0.27	40	1.77	40	0.00		40	0.00		40	
60	1.04		60	1.68	60	0.00		60	0.00		60	
90 4 20	1.20	0.25	90	1.57	90 120	0.00		90	0.00		90	
120 150	1.24	0.27	120	1.45	120	0.01		120	0.00		120	
180	1.38	0.21	180	1.34	180	0.04		180	0.00		180	
210	1.43	0.26	210	1.30	210	0.06		210	0.00		210	
240	1.46	0.05	240	1.27	240	0.09		240	0.01		240	
300 360	1.50	0.25	300	1.19	300 360	0.12		300	0.03		300	
420	1.65	0.27	420	1.08	420	0.19		420	0.00		420	
480	1.70		480	1.04	480	0.23		480	0.09		480	
540 600	1.74	0.25	540	1.01	540	0.27		540	0.09		540	
600 720	1.77	0.25	600 720	0.97	600 720	0.32		600 720	0.09		600 720	
840	1.87	0.20	840	0.90	840	0.43		840	0.09		840	
960	1.91	0.27	960	0.84	960	0.47		960	0.09		960	
1080	1.94	0.05	1080	0.79	1080	0.52		1080	0.09		1080	
1200 1320	1.98	0.25	1200	0.75	1200	0.57		1200	0.09		1200	
1440	2.02	0.27	1440	0.70	1440	0.65		1440	0.09		1440	
1560	2.20		1560	0.69	1560	0.67		1560	0.09		1560	
1680	2.32	0.25	1680	0.66	1680	0.69		1680	0.09		1680	
1800 1920	2.50	0.27	1800	0.65	1800 1920	0.73		1800	0.09		1800 1920	
2040	2.55	0.21	2040	0.61	2040	0.76		2040	0.09		2040	
2160	2.61	0.25	2160	0.59	2160	0.77		2160	0.09		2160	
2280	2.63	0.07	2280	0.58	2280	0.78		2280	0.09		2280	
2400 2520	2.04	0.27	2400	0.57	2400 2520	0.79		2400	0.09		2400 2520	
2640	2.68	0.26	2640	0.55	2640	0.82		2640	0.09		2640	
2760	2.70		2760	0.53	2760	0.83		2760	0.09		2760	
2880	2.74	0.28	2880	0.50	2880	0.85		2880	0.09		2880	
3000 3120			3000		3000 3120			3000			3000	
3240			3240		3240			3240			3240	
3360			3360		3360			3360			3360	
3480			3480		3480			3480			3480	
3600 3720		+	3000		3600 3720			3000		ļ	3000	L
3840			3840		3840			3840			3840	
3960			3960		3960			3960			3960	
4080			4080		4080			4080			4080	
4200 4320			4200		4200 4320			4200		ļ	4200	
HJ20 Total tin	ne pumped(min)	:	4320	2880	4320	W/L	9.86	4320	W/L	13.95	+320	W/L
Average	e yield (l/s):	-		0.27								

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	Abbreviations
c	Electrical conductivity
nbgl	Meters below ground level
nbch	Meters below casing height
mbdl	Meters below datum level
magl	Meters above ground level
L/S	Litres per second
RPM	Rates per minute
s/w/L	Static water level
μS/cm	Microsiemens per centimeter



Ground water solutions t/a AB Pumps CC

P1586 CHRISTOPHER THANDO SAMUEL

hddd.ddddd

•

PR0JECT #

								BBR
CONSULTANT:		AURECON					_	
DISTRICT:		BELFAST					_	
PROVINCE:		MPUMALANGA					_	PRODUCTION BONUS
FARM / VILLAGE NA	ME:	BELFAST					_	
							_	
DATE TESTED:		13/04/2016					_	EC meter number
MAP REFERENCE:								
CO-ORDINATES:			_	_				
F	ORMAT ON GPS:	hddd	°mm	ˈss.s		hddd	°mm.mmm '	

LATITUDE: LONGITUDE:	0 0	•	"	 OR	0 0	 - OR	_	25.75330 ° 29.96888 °
BOREHOLE NO:	BRBH5							
TRANSMISSIVITY VALUE:								
TYPE INSTALLATION:	NEW BOREHOLE							
BOREHOLE DEPTH: (mbgl)	80.30							

COMMENTS:

SAMPLE INSTRUCTIONS :									
Water sample taken	Yes	No		Test for:		macro	bacterio-logical	DATA CAPTURED BY:	AVN
Date sample taken	14/04/2	.016	If C ⁱ	onsultant took sample, give n	iame:			DATA CHECKED BY:	AVN
Time sample taken	08H30					*		·	
CONSULTANT GUIDELINES						<u>. </u>			
BOREHOLE DEPTH:	BOREHOLE DEPTH: I/s WATER STRIKE 1:							_	m
BLOW YIELD:	m	STI	EP 2:		WATER STRIKE 2:		_	m	
STATIC WATER LEVEL:	m	STI	EP 3:		WATER STRIKE 3:			m	
PUMP INSTALLATION DEPTH:	m	STI	EP 4:		COMMENTS:				
RECOVERY:		STI	EP 5:		l/s				
AFTER STEPS:	h	STI	EP 6:		l/s	TELEPHONE NUMBE	RS PHONE : (NAME & T	TEL)	
AFTER CONSTANT:	h	STEP DI	URATION:						
DESCRIPTION:		UNIT	QTY					UNIT	QTY
STRAIGHTNESS TEST:		NO	0	BOREHOLE DEPTH AFTER TE	ST:			м	80.30
VERTICALLY TEST:		NO	0	BOREHOLE WATER LEVEL AF	FTER TEST: (I	mbch)		м	16.44
CASING DETECTION:		NO	1	SAND/GRAVEL/SILT PUMPED	?			YES/NO	0
SUPPLIED NEW STEEL BOREHOLE C	OVER:	NO	0	DATA REPORTING AND RECC	ORDING			NO	1
BOREHOLE MARKING		NO	0	SLUG TEST:				NO	0
SITE CLEANING & FINISHING		NO	1	LAYFLAT (M):				м	50
LOGGERS FOR WATERLEVEL MONIT	ORING	NO	0	LOGGERS FOR pH AND EC:				NO	0
It is hereby acknowledged that upc	n leaving the si	ite, all existing	j equipment	is in an acceptable condition	1.				
NAME:				s					
DESIGNATION:		-		-	DATE	:	-		
		-				·	-		

FORM 5 E STEPPED DISCHARGE TEST & RECOVERY														
BOREHOLE	TEST RECO		IEET			0								
PROJ NO : BOREHOLE N	0.	P1586 BRBH5		MAP REFER	ENCE:	0				DISTRI	NCE: CT·	MPUMA BELEAS	LANGA	
ALT BH NO:	0.	0								SITE NA	AME:		от.	
ALT BH NO:		0						.				DELFAS		
	EPTH (m)		80.30					G (m):	0.15					
DEPTH OF PU	MP (m):		61.87		DIAM PUM	IP INLET (mi	yı). m):		165.00	PUMP 1	YPE:	BP10		
	()			S	STEPPED DISCHARGE TEST & RECOVERY									
DISCHARGE R	RATE 1		RPM		DISCHARGE RATE 2 RPM				DISCHARGE RATE 3 RPM					
DATE:	13/04/2016	TIME:	12H00		DATE:	13/04/2016	TIME:	13H00		DATE:	13/04/2016	TIME:	14H00	
TIME	DRAW	YIELD	TIME	RECOVERY	TIME	DRAW	YIELD	TIME	RECOVERY	TIME	DRAW	YIELD	TIME	RECOVERY
(MIN)	DOWN (M)	(L/S)	(MIN)	(M)	(MIN)	DOWN (M)	(L/S)	(MIN)	(M)	(MIN)	DOWN (M)	(L/S)	(MIN)	(M)
1	0.08		1		1	0.79		1		1	1.61		1	
2	0.08		2		2	0.85		2		2	1.69		2	
3	0.09		3		3	1.05	0.80	3		3	2.00		3	
5	0.09	0.42	5		5	1.08		5		5	2.68	1.61	5	
7	0.22		7		7	1.10	0.81	7		7	3.07		7	
10	0.34	0.42	10		10	1.14	0.00	10		10	3.39	1.60	10	
15	0.39	0.40	15		15	1.23	0.82	15 20		15 20	3.85	1.01	15	
20	0.43	0.43	20		20	1.26	0.04	20		20	4.02	1.61	20	
3U 40	0.50	0.40	3U 40		30 40	1.33	0.81	3U 40		30 40	4.26	1.60	3U 40	
40 50	0.55	0.42	40 50		40 50	1.40	0.91	40 50		40 50	4.45	1.62	40 50	
50	0.59	0.42	50 60		50 60	1.40	0.01	50 60		50 60	4.00	1.61	50 60	
70	0.02	0.42	70		00 70	1.02		00 70		00 70	4.07	1.01	70	
80			70 80		20 80			70 80		20 20			70 80	
90			90		90 90			90 90		90 90			90	
100			100		30 100			100		100			100	
110			110		110			110		110			110	
120			120		120			120		120			120	
рН			150		рН			150		рН			150	
ТЕМР	20.70	°C	180		ТЕМР	19.40	°C	180		ТЕМР	21.50	°C	180	
EC	153.00	µS/cm	210		EC	157.00	µS/cm	210		EC	167.00	µS/cm	210	
DISCHARGE F	RATE 4		RPM		DISCHARC	GE RATE 5		RPM		DISCHA	RGE RATE	6	RPM	
DATE:	13/04/2016	TIME:	15H00		DATE:		TIME:			DATE:		TIME:		
TIME	DRAW	YIELD	TIME	RECOVERY	TIME	DRAW	YIELD	TIME	RECOVERY	TIME	DRAW	YIELD	TIME	RECOVERY
(MIN)	DOWN (M)	(L/S)	(MIN)	(M)	(MIN)	DOWN (M)	(L/S)	(MIN)	(M)	(MIN)	DOWN (M)	(L/S)	(MIN)	(M)
1	5.60		1	46.13	1			1		1			1	
2	10.18		2	40.34	2			2		2			2	
3	13.45	3.50	3	32.40	3			3		3			3	
5	21.88		5	16.90	5			5		5			5	
7	30.02	3.51	7	5.33	7			7		7			7	
10	43.10		10	1.65	10			10		10			10	
12	48.00	3.51	15	1.53	15			15		15			15	
13	48.00	1.65	20	1.39	20			20		20			20	
14	48.00	1.50	30 40	1.25	30			30 40		30 40			30	
15	48.00	1.48	40 50	1.20	40 50			40 50		40 50			40 50	
			5U 60	1.14	5U 60			50 60		50 60			00 60	
			0U 70	1.10	00 70			0U 70		00 70			0U 70	
			/U 00	1.04	/U 80			/U 00		/U 00			/U 00	
			0U 00	1.00	80 90			0U 00		00 00			00 00	
			90 100	0.90	90 100			90 100		90 100			90 100	
			100	0.92	100			110		110			110	
			120	0.04	120			120		120			120	
рН			150	0.73	nH			150		nH			150	
TEMP		°C	180	0.74	г ТЕМР		°C	180		ТЕМР		ംറ	180	
EC		uS/cm	210	0.10	EC		uS/cm	210		EC		uS/cm	210	
		10,011	240				HO/OIII	240					240	
			300					300		l –			300	
			360					360					360	
						•					•	•		
S/W/L:(mbch)														
, ,	13.68													
~ /	13.68													

BORE	FORM 5 F CONSTANT DISCHARGE TEST & RECOVERY 3OREHOLE TEST RECORD SHEET											
PROJ N BOREH ALT BH ALT BH	IO : OLE NO: NO: NO:	P1586 BRBH5 0 0		MAP REFERI	ENCE:	25.7533 29.96888			PROVINCE DISTRICT: SITE NAME	:	MPUMA BELFAS BELFAS	NLANGA ST ST
BOREH WATER DEPTH	OLE DEPTH: LEVEL (mbdl): OF PUMP (m):	80.30 14.17 61.87		DATUM LEVE CASING HEI DIAM PUMP	EL ABOV GHT: (m INLET(mi	E CASING (n agl): m):	n):	0.15 0.30 165	EXISTING PUMP: 0 CONTRACTOR: AB PUMPS PUMP TYPE: BP10			
CONST	ANT DISCHARG	E TEST	& RECOVER		ETED				I			
DATE			001140									
DATE:	14/04/2016	TIME:	06H40		DATE: OBSER\	ATION HOL	E 1	OBSERV	ATION HOLE	0MP: 2	OBSER	VATION HOLE 3
			_		NR:			NR:			NR:	
TIME			E		Distance	(m); Drawdown	Recovery	Distance(m); Drawdown	Recovery	Distance	e(m); Drawdown
(MIN)	DOWN (M)	(L/S)	MIN	(M)	(min)	m	(m)	(min)	(m)	Recovery	(min)	(m)
1	0.88	· /	1	45.56	1		. ,	1			1	× ,
2	1.08		2	39.18	2			2			2	
3 5	1.66	1.48	3	31.78	3 5			3			3 5	
5 7	3.10	1.01	7	20.92	5 7			5 7			3 7	
10	3.35	1.62	10	16.66	10			10			10	
15	3.53		15	5.17	15			15			15	
20 30	3.63	1.61	20 30	4.53	20 30			20 30			20 30	
30 40	3.98	1.62	40	4.47	30 40			30 40			30 40	
60	4.20		60	4.27	60			60			60	
90	4.53	1.60	90	4.21	90			90			90	
120	4.82	1.61	120	4.13	120			120			120	
150	5.16	1.01	180	4.08	180			180			180	
210	5.34	1.60	210	3.94	210			210			210	
240	5.46		240	3.83	240			240			240	
300	12.48	1.61	300	3.77	300			300			300	
360 420	21.46	1.62	420	3.53	360 420			360 420			360 420	
480	25.18		480	3.34	480			480			480	
540	26.05	1.60	540	3.25	540			540			540	
600 720	29.32	1.61	600 720	3.18	600 720			600 720			600 720	
720 840	31.74	1.01	720 840	3.13	720 840			720			720 840	
960	35.60	1.62	960	3.02	960			960			960	
1080	38.12		1080	2.94	1080			1080			1080	
1200	40.10	1.60	1200	2.81	1200			1200			1200	
1320	41.89	1.62	1320	2.73	1320			1320			1320	
1554	47.86	1.02	1560	2.41	1560			1560			1560	
1556	47.86	1.12	1680		1680			1680			1680	
1558	47.86	1.10	1800		1800 1020			1800			1800	
2040	47.86	1.00	2040		1920 2040			2040			1920 2040	
2160			2160		2160			2160			2160	
2280			2280		2280			2280			2280	
2400			2400		2400 2520			2400			2400	
2520			2520		2520			2520			2520	
2760			2760		2760			2760			2760	
2880			2880		2880			2880			2880	
3000			3000		3000			3000			3000	
3120			3120		3120 3240			3120			3120	
3360			3360		3360			3360			3360	
3480			3480		3480			3480			3480	
3600			3600		3600			3600			3600	
3720 3840			3720		3720 3840			3720			3720 3840	
3960			3960		3960			3960			3960	
4080			4080		4080			4080			4080	
4200			4200		4200			4200			4200	
4320			4320	1560	4320	\\//I		4320	W//I		4320	W//I
Average	vield (I/s).			1.62		VV/L			VV/L			VV/L
, woraye	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,							1				

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LONGITUDE:

BRBH6

NEW BOREHOLE

79.60

	Abbreviations
с	Electrical conductivity
nbgl	Meters below ground level
nbch	Meters below casing height
mbdl	Meters below datum level
magl	Meters above ground level
L/S	Litres per second
RPM	Rates per minute
s/w/L	Static water level
μS/cm	Microsiemens per centimeter



Ground water solutions t/a AB Pumps CC

P1582 CHRISTOPHER THANDO SAMUEL

•

25.75992 °

29.96480 °

PR0JECT #

								BBR	CHRISTOPHE
CONSULTANT:	AURECON								THANDO
DISTRICT:	BELFAST								SAMUEL
PROVINCE:	MPUMALANG	A						PRODUCTION BONUS:	
FARM / VILLAGE NAME :	BELFAST								
DATE TESTED:	08/04/2016							EC meter number	
MAP REFERENCE:									
CO-ORDINATES:									
FORMAT ON GPS	ու hddd	°mm	ˈss.s	"		hddd	°mm.mmm	•	hddd.ddddd
LATITUDE	E:	•	•	"	0.0		0	•	25
		0			OR		0	- OR	20

COMMENTS:

BOREHOLE NO: TRANSMISSIVITY VALUE: TYPE INSTALLATION:

BOREHOLE DEPTH: (mbgl)

SAMPLE INSTRUCTIONS :											
Water sample taken	Yes	No		Test for:		macro	bacterio-logical	DATA CAPTURED BY:	AVN		
Date sample taken	11/04/20	016	If co	onsultant took sample, give n	iame:			DATA CHECKED BY:	AVN		
Time sample taken	07H50					*	•	·			
CONSULTANT GUIDELINES			·		1	· · · · · · · · · · · · · · · · · · ·		· · · · · · · · · · · · · · · · · · ·			
BOREHOLE DEPTH:	m	STE	EP 1:		l/s	WATER STRIKE 1:			m		
BLOW YIELD:	m	STE	EP 2:		l/s	WATER STRIKE 2:			m		
STATIC WATER LEVEL:	m	STE	EP 3:		WATER STRIKE 3:			m			
PUMP INSTALLATION DEPTH:	m	STE	EP 4:		l/s	COMMENTS:					
RECOVERY:		STE	EP 5:		l/s						
AFTER STEPS:	h	STE	EP 6:		l/s	TELEPHONE NUMBE	ERS PHONE : (NAME & 1	ſEL)			
AFTER CONSTANT:	h	STEP DL	STEP DURATION: min								
DESCRIPTION:		UNIT	QTY					UNIT	QTY		
STRAIGHTNESS TEST:		NO	0	BOREHOLE DEPTH AFTER TE	ST:		м	79.60			
VERTICALLY TEST:		NO	0	BOREHOLE WATER LEVEL AF	TER TEST: (r	mbch)		м	15.92		
CASING DETECTION:		NO	1	SAND/GRAVEL/SILT PUMPED	?			YES/NO	0		
SUPPLIED NEW STEEL BOREHOLE CO	OVER:	NO	0	DATA REPORTING AND RECO	RDING			NO	1		
BOREHOLE MARKING		NO	0	SLUG TEST:				NO	0		
SITE CLEANING & FINISHING		NO	1	LAYFLAT (M):				м	100		
LOGGERS FOR WATERLEVEL MONITO	ORING	NO	0	LOGGERS FOR pH AND EC:				NO	0		
It is hereby acknowledged that upor	t is hereby acknowledged that upon leaving the site, all existing equipment is in an acceptable condition.										
NAME:				s	IGNATURE:	:					
DESIGNATION:		-			DATE	:	-				

				STEPPED	DISCHARG	FO	RM 5	E /FRY						
BOREHOLE	TEST RECO	ORD SH	IEET				NE001							
PROJ NO : BOREHOLE NO	0:	P1582 BRBH6		MAP REFER	ENCE:	0				PROVIN	NCE: CT:	MPUMA BELFAS	ALANGA ST	
ALT BH NO:		0								SITE NA	AME:	BELFAS	ST	
BOREHOLE DI	EPTH (m)	0	79.60		DATUM LE	VEL ABOVE	E CASIN	G (m):	0.27	EXISTING PUMP:		0		
WATER LEVEL	_ (mbdl): MP (m):		14.95 61.87		CASING H	CASING HEIGHT: (magl): 0.43 DIAM PUMP INLET (mm): 165.00					AB PUN BP10	/IPS		
DEI III OI I O	wii (iii).		01.07	STEPPED DISCHARGE TEST & RECOVERY										
DISCHARGE R	RATE 1		RPM		DISCHARC	GE RATE 2		RPM DISCHARGE RATE 3				3	RPM	
DATE:	08/04/2016	TIME:	12H20		DATE:	08/04/2016	TIME:	13H20		DATE:	08/04/2016	TIME:	14H20	
(MIN)	DOWN (M)	(L/S)	(MIN)	(M)	(MIN)	DRAW DOWN (M)	(L/S)	(MIN)	(M)	(MIN)	DRAW DOWN (M)	(L/S)	(MIN)	(M)
1	0.17		1		1	0.79		1		1	1.27		1	
2	0.18		2		2	0.83	0.52	2		2	1.50	1.47	2	
3	0.18	0.27	3		3	0.85		3		3	1.69	1.50	3	
5 7	0.19	0.34	5 7		5 7	0.87	0.52	5 7		5 7	2.05	1 5 1	5 7	
/ 10	0.20	0.34	, 10		, 10	0.89	0.53	, 10		, 10	2.40	1.51	, 10	
15	0.22	0.01	15		15	0.95	0.00	15		15	3.18	1.52	15	
20	0.24	0.35	20		20	0.99	0.53	20		20	3.25		20	
30	0.36		30		30	1.05		30		30	3.47	1.52	30	
40	0.52	0.35	40		40	1.12	0.52	40		40	3.69		40	
50 C0	0.59	0.04	50 CO		50 C0	1.17	0.50	50 CO		50 C0	3.80	1.50	50 CO	
60 70	0.64	0.34	60 70		60 70	1.22	0.52	60 70		60 70	3.97		60 70	
80			80		80			80		80			80	
90			90		90			90		90			90	
100			100		100			100		100			100	
110			110		110			110		110			110	
120			120		120			120		120			120	
рН темр	20.20	°C	150		рН темр	20.40	°C	150		рН темр	21.00	°C	150	
EC	159.00	uS/cm	210		EC	160.00	uS/cm	210			159.00	uS/cm	210	
DISCHARGE R	DISCHARGE RATE 4 RPM			DISCHARC	GE RATE 5		RPM		DISCHA	ARGE RATE	6	RPM		
DATE:	08/04/2016	TIME:	15H20		DATE:		TIME:		-	DATE:		TIME:		
TIME	DRAW	YIELD	TIME	RECOVERY	TIME	DRAW	YIELD	TIME	RECOVERY	TIME	DRAW	YIELD	TIME	RECOVERY
(MIN)	DOWN (M)	(L/S)	(MIN)	(M)	(MIN)	DOWN (M)	(L/S)	(MIN)	(M)	(MIN)	DOWN (M)	(L/S)	(MIN)	(M)
1 2	4.25		1 2	44.40	1			1 2		1 2			1 2	
3	5.20	3.52	3	35.83	2 3			2 3		2 3			2	
5	9.93		5	19.87	5			5		5			5	
7	13.81	3.51	7	6.23	7			7		7			7	
10	19.89		10	2.78	10			10		10			10	
15	29.05	3.53	15	2.51	15			15		15			15	
20 24	37.67	3 5 2	20 20	2.33	20 30			20 30		20 30			20 30	
26	46.92	2.22	40	1.86	40			40		40			40	
28	46.92	2.16	50	1.68	50			50		50			50	
30	46.92	2.15	60	1.50	60			60		60			60	
			70	1.41	70			70		70			70	
			80 00	1.30	80 00			80 00		80 00			80 00	
			90 100	1.25	90 100			90 100		90 100			90 100	
			110	1.07	110			110		110			110	
			120	0.95	120			120		120			120	
рН			150	0.90	рН			150		рН			150	
ТЕМР		°C	180	0.86	ТЕМР		°C	180		TEMP		°C	180	
EC		µS/cm	210	0.73	EC		µS/cm	210		EC		µS/cm	210	
			240 200					240 200					240	
			360					360					360	
														•
S/W/L:(mbch)	13.95													

BOREI	FORM 5 F CONSTANT DISCHARGE TEST & RECOVERY BOREHOLE TEST RECORD SHEET												
PROJ N BOREH ALT BH ALT BH	NO : IOLE NO: I NO: I NO:	P1582 BRBH6 0 0		MAP REFERI	ENCE:	25.75992 29.9648			PROVINCE: DISTRICT: SITE NAME	:	MPUMA BELFAS BELFAS	MPUMALANGA BELFAST BELFAST	
BOREH WATEF DEPTH	IOLE DEPTH: R LEVEL (mbdl): OF PUMP (m):	79.60 15.70 61.87		DATUM LEVE CASING HEI DIAM PUMP	EL ABOVI GHT: (m INLET(mr	E CASING (n agl): n):	n):	0.27 0.43 165	EXISTING PUMP: 0 CONTRACTOR: AB PUMPS PUMP TYPE: BP10				
CONST	ANT DISCHARG	SE TEST	& RECOVER	Y	ETED	•			1				
IESI S				TEST COMP									
DATE:	09/04/2016	TIME:	07H00		DATE:		TIME: F 1	OBSERV	TYPE OF P	UMP:	OBSER	BP10 VATION HOLE 3	
					NR:		1	NR:		. 2	NR:		
	DISCHARGE B	OREHOL	E		Distance	(m);	5	Distance(m);	5	Distance	e(m);	
TIME (MIN)	DRAW DOWN (M)	YIELD	TIME	RECOVERY	TIME: (min)	Drawdown m	Recovery (m)	TIME: (min)	Drawdown (m)	Recovery	TIME: (min)	Drawdown (m)	
(IVIII 1)	0.99	(1/0)	1	2.32	1		(11)	1	(11)		(^(,,,,))	(111)	
2	1.50		2	2.24	2			2			2		
3	1.91		3	2.10	3			3			3		
5 7	2.42	1.39	5	2.06	5 7			5			5 7		
, 10	2.03	1.30	10	1.98	, 10			10		ļ	, 10		
15	3.01	1.51	15	1.96	15			15			15		
20	3.16		20	1.94	20			20			20		
30 40	3.47	1 5 1	30	1.92	30 40			30			30 40		
40 60	3.97	1.51	60	1.89	40 60			40 60			40 60		
90	4.20	1.51	90	1.89	90			90			90		
120	4.27		120	1.88	120			120			120		
150 180	4.30	1.53	150	1.86	150			150			150		
210	4.30	1.53	210	1.82	210			210			210		
240	4.34		240	1.82	240			240			240		
300	4.36	1.50	300	1.80	300			300			300		
360	4.38	1 5 4	360	1.77	360 420			360			360		
420 480	4.37	1.54	420	1.75	420 480			420			420 480		
540	4.39	1.52	540	1.70	540			540			540		
600	4.39		600	1.68	600			600			600		
720	4.39	1.51	720	1.66	720			720			720		
840 960	4.39	1.53	840 960	1.63	840 960			840 960			840 960		
1080	4.40		1080	1.58	1080			1080			1080		
1200	4.40	1.55	1200	1.56	1200			1200			1200		
1320	4.40	4.55	1320	1.53	1320			1320			1320		
1440 1560	4.40	1.55	1440	1.50	1440 1560			1440			1440 1560		
1680	4.39	1.55	1680	1.44	1680			1680			1680		
1800	4.40		1800	1.39	1800			1800			1800		
1920	4.41	1.56	1920	1.37	1920			1920			1920		
2040 2160	4.42 4.42	1.54	2040	1.34	2040 2160			2040			2040 2160		
2280	4.43		2280	1.29	2280			2280			2280		
2400	4.44	1.54	2400	1.27	2400			2400			2400		
2520	4.44	4 55	2520	1.25	2520			2520			2520		
2640 2760	4.45	1.55	2640	1.23	2640 2760			2640 2760			2640 2760		
2880	4.47	1.55	2880	1.19	2880			2880			2880		
3000			3000		3000			3000			3000		
3120			3120		3120			3120			3120		
3240 3360		+	3240 3360		3∠40 3360			3240 3360		ļ	3∠40 3360		
3480		1	3480		3480			3480			3480		
3600			3600		3600			3600			3600		
3720		<u> </u>	3720		3720			3720			3720		
3840 3960			3840 3960		3840 3960			3840 3960			3840 3960		
4080		1	4080		4080			4080		ļ	4080		
4200			4200		4200			4200			4200		
4320			4320	200 <i>0</i>	4320			4320			4320		
Total time pumped(min):				2880		W/L			W/L			W/L	
Average	e yieia (I/S):			1.50								I	