REF. NO.: 2001/148

DATE: 18 OCTOBER 2002

NCWADI WATER SUPPLY PROJECT

GEOHYDROLOGICAL REPORT ON THE DEVELOPMENT OF PORDUCTION BOREHOLES FOR BULK WATER SUPPLY

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Our Ref No: 2001/148

Partners in Development
36 Cowens Crescent
BLACKRIDGE
3201

18th October 2002

Att: Mr Dave Still

GEOHYDROLOGICAL REPORT ON THE DEVELOPMENT OF PRODUCTION BOREHOLES FOR THE NCWADI WATER SUPPLY PROJECT

As per your instruction, we carried out a geohydrological investigation and groundwater development program in the Ncwadi area. The details of this investigation are outlined in this report.

1. SCOPE OF WORK

The projected bulk water demand of this community is estimated at about 300 kl/day and this programme was implemented to secure this bulk water demand through development of a single production borehole with a standby borehole as backup.

Our Scope of Work during this investigation included the following:

- Pump testing of existing exploration borehole
- Geophysical survey
- Drilling & pumptesting of 1 new exploration borehole
- Upgrading of existing and exploration boreholes to production boreholes

2. GENERAL INFORMATION

2.1 Project Area

The Ncwadi project area is situated in southern KwaZulu-Natal, 32km west by road of the town of Richmond. The community straddles the district road, which links the town of Richmond with the Bulwer / Boston road (See Locality Plan Dwg No. 2001/148 Figure 1).

The community comprises a significant number of low-density homesteads, which are distributed on the flanks of the Nhlambane Stream. This stream flows in an easterly direction through the project area before joining the Elands River, which forms the eastern boundary of the community and is a tributary of the Mkomazi River.

The project area consists of rugged terrain with elevations rising from 980m at the Ncwadi Station to over 1 400m on the surrounding hilltops.

2.2 Geology

The lower lying areas of the project area along the Nhlambane Stream are underlain by shale and subordinate sandstone of the Volksrust Formation of the Ecca Group in the Karoo Sequence, whilst siltstone and fine-grained sandstone of the Adelaide formation of the Beaufort Group underlie the higher lying areas. Younger Jurassic aged dolerite dykes and sills have extensively intruded into these sediments (see Dwg No. 2001/148 Figure 2).

The dolerite sills cap the tops of the higher lying hills surrounding the project area due to their resistance to erosion. The underlying sediments and the younger intruded dolerite on the valley flanks have been extensively eroded and re-deposited as talus, colluvium and alluvium on the lower slopes and valley axis area and the soils contain abundant tightly packed hard dolerite boulders.

2.3 Geohydrology & Groundwater Development Potential

The sediments of the Karoo Sequence and the intruded dolerite represent secondary or fractured rock aquifers, with negligible primary storage or permeability. Groundwater storage and movement is generally confined to fractures, joints and bedding planes within the rockmass. In this kind of aquifer, the indurated contact zones associated with the dolerite intrusions are often highly fractured and these zones may enhance groundwater storage and transmissivity in these discrete preferential groundwater flow paths.

The overlying re-deposited river alluvium found in the valley lines and the underlying highly weathered Karoo rocks may, in some instances act, as quasi-primary aquifers with some primary storage and permeability that developed during the re-deposition and weathering of the near surface Karoo rocks to regolith.

Median borehole yields in the sediments and intruded dolerite formations usually range between 0.1 and 3 l/s. Boreholes that intersect the indurated contact zones of dolerite intrusions or highly weathered zones below the regional water table often produce yields ranging from 1 – 20 l/s.

Groundwater recharge is highly dependent on rainfall recharge and it is estimated that rainfall recharge is of the order of 3 – 5% of MAP.

Groundwater quality in this region is generally good and borehole water in this region usually meets the SABS 241:1999 Standards for Drinking Water. The presence of Iron and Manganese is quite common in the groundwater in this region but these constituents do not usually present a significant health hazard. Infants and breast-fed babies are however at risk when concentrations exceed 2 mg/l.

The presence of Iron does however impart a metallic taste and the water may stain laundry and wetted surfaces. This environment also offers ideal conditions for the development of Iron reducing Bacteria, which manifests as orange slime and fine sediment, which may impair the performance of poorly constructed and overused production boreholes.

3. DESK STUDY

3.1 Existing Exploration Borehole

Partners in Development (PID) supplied information on the existing exploration borehole, which was drilled and pump tested in June 1996 by Messers Sampi Ungerer Drilling under the supervision of Steffen, Robertson & Kirsten for Umgeni Water. A copy of the borehole log and pump test data is contained in Appendix I.

During an initial site visit with PID, this borehole was shown to our Project Hydrogeologist and its location is show on Dwg No. 2001/148 Figure 3 (BH B).

4. FIELD INVESTIGATION

4.1 Geophysical Survey

Although the existing borehole produced sufficient water to meet the bulk water demand of this community, this borehole had to be up-graded to production borehole status and a "standby" borehole had to be developed.

A geophysical survey was carried out to identify a target for drilling of the new exploration borehole and the position and orientation of the geophysical traverses are shown on Dwg No. 2001/148 Figure 3.

A WADI - VLF conductivity meter and Proton magnetometer was used in this survey and the graphically plotted geophysical survey data is shown in Appendix II, whilst a brief description of each traverse is given below.

Traverse 1

Traverse 1 was carried out in a west to east direction past the existing borehole. The traverse was "noisy" but a well-defined anomaly occurred between 30 and 60m in the vicinity of the existing borehole at 45m.

Traverse 2

Traverse 2 was carried out parallel to Traverse 1 approximately 30m upslope and an anomaly was detected between 20 and 60m and a drilling target was pegged at station 45m.

4.2 Pump Testing of Existing Borehole

Messers SA Drilling established on site on the 22nd February 2002 to pump test the existing borehole at Ncwadi. It was found that the borehole collapsed from its original recorded depth of 106m to a depth of 24.54m and the test pump was therefore only installed to a depth of 21.75m. The static water level (SWL) in this borehole was measured as 3.60m bgl (below ground level), which resulted in an available drawdown (ADD) of 18.15m.

A series of 4 Stepped Drawdown Tests were conducted at rates ranging from 11 - 60 kl/hr. During the fourth step (60 kl/hr), the borehole collapsed further and the test had to be abandoned.

4.3 Drilling of New Exploration Borehole (Exploration BH D)

Due to the collapse of the existing borehole it was decided to proceed with the drilling of a new exploration borehole at the target pegged on geophysical Traverse 2. If this borehole proved successful it would serve as a standby borehole. A new production borehole would then be drilled and constructed next to the existing collapsed borehole.

Messers SA Drilling established on site on the 24th March 2002 and drilled, with considerable difficulty, an exploration borehole approximately 30m from the existing borehole. The borehole was completed to a depth of 90m with 30m of mild steel casing installed through the overburden, which consisted of clay, dolerite boulders and highly weathered dolerite and shale. Water was struck between 24 and 26m in the weathered dolerite and perforated casing was installed from 24 to 30m through the water-bearing horizon. A final blow yield of 16 kl/hr was recorded.

The location of the borehole is shown on Dwg No. 2001/148 Figure 3 and the geological and construction log for the completed borehole is contained in Appendix III.

4.4 Pump Testing of New Exploration Borehole

SA Drilling's test rig re-established on the 3rd May to test the exploration borehole. The SWL in this borehole was measured as 6.50m bgl and the test pump was installed at 60m to provide an ADD of 53.5m.

A series of 4 Stepped Drawdown Tests were conducted at rates from 6 to 24 kl/hr, which resulted in a final drawdown of 53.03m. The water level recovered to 97% of the pre-test level 6 hours after the pump was switched off at the end of the last step. The pumptest data show a slight improvement of borehole efficiency during the 2nd step, which was run a 12 kl/hr but efficiencies declined rapidly at pump rates of 18 and 24 kl/hr.

Based on the results of the Stepped Drawdown Tests, a discharge rate of 16 kl/hr was selected for the 24hr Constant Discharge (CD) Test. At the end of the 24hr pump cycle, a final drawdown of 25.32m was recorded and the drawdown curve clearly shows that near steady-state conditions never developed during this test. The water level recovered to 95% of the pre-test level 24 hours after the pump was switched off at the end of the CD test.

The pump test data was analysed using the FC Method, which is a dedicated pumptest software package. The analyses returned a safe sustainable yield of 12 kl/hr on a 10hr cycle (120kl/day). This is however less than the required yield of 300kl/day for the standby borehole and it was decided not to develop this borehole as a standby production borehole.

The graphically plotted results for the pump test as well as the management recommendation sheet are contained in Appendix IVa.

4.5 Drilling of New Production Boreholes

4.5.1 SA Drilling

Messers SA Drilling re-established on the 3rd May 2002 to drill a new production borehole next to the existing production borehole. Despite using specialised drilling techniques they were unable to drill through the overburden, which consisted of clay and large dolerite boulders <1m in diameter and had to abandon drilling at a depth of 8m.

It was then decided that only Odex drilling would ensure that a borehole could be successfully drilled through this difficult formation and Messrs. J & M Drilling were asked to provide costs for the drilling of an 8" Odex borehole. They submitted a quotation, which was accepted and they subsequently established on site on 22nd June 2002.

4.5.2 J&M Drilling (Production BH C)

Although drilling initially proceeded well, the Odex shoe, which allows the steel borehole casing to be driven as the borehole is drilled, broke off at a depth of 15m and drilling had to be abandoned.

The casing was pulled out of the hole and a second attempt was made but the Odex shoe again broke off at a depth of 17m. The contractor then decided to attempt to complete the borehole by using the "drill and drive" technique but the drilling operations had to be halted at a depth of 25m when the Odex casing string parted.

A meeting and discussions was held on site between J & M drilling, our Project Hydrogeologist and a representative of PID. It was agreed that an attempt would be made to complete the borehole to its required depth of at least 36m by using standard rotary percussion drilling techniques before installing a uPVC inner casing with a diameter of 160mm. The limited diameter of the 160mm uPVC casing to be installed in the newly drilled production borehole would preclude installation of both the pump and associated monitoring probes and the existing collapsed exploration borehole will therefore be cleaned out and used for the installation of monitoring equipment.

The contractor managed to drill to a depth of 37.5m and successfully installed 26.1m of 160mm diameter factory slotted uPVC casing and 11.6m of plain 160mm diameter uPVC casing. The annulus was gravel packed before developing the borehole. A final blow yield of ±50 kl/hr was recorded on completion of borehole development.

Although it had originally been anticipated that J & M drilling would also drill the standby borehole, the fact that the ODEX system was irreparably damaged resulted in termination of their appointment and the appointment of a 3rd drilling contractor with ODEX drilling capability.

4.5.3 KwaNatal Drilling (Production BH A & Monitoring BH B)

Messrs KwaNatal Drilling were asked to provide costs for the drilling of an additional 7" Odex borehole to serve as the standby borehole and cleaning out of the original collapsed exploration borehole to serve as a monitoring borehole. Their quotation was accepted and they established on site on the 26th July 2002.

A new generation Symetrix Odex system was used to drill the standby borehole. Drilling proceeded well and the standby borehole was completed to a depth of 36m within a day. The ODEX casing string comprised a blank section from 0 – 18m with perforated sections from 18 – 36m. A final blow yield of ±50 kl/hr was recorded on completion of the borehole development.

The rig was then setup on the original exploration borehole and this hole was cleaned out to a depth of 36m before installing 140mm diameter uPVC casing. This casing string included a factory-perforated section between 18 and 36m and the annulus of the well was gravel packed using 2 – 4mm quartz-silica gravel.

The location of the four boreholes is shown on Dwg No. 2001/148 Figure 3 and the geological and construction logs for the completed boreholes can be seen in Appendix III.

4.6 Pump Testing & Monitoring of Completed Wellfield

4.6.1 Production Borehole A & Monitoring BH B

Messers SA Drilling re-established on site on the 22nd August 2002 to pumptest the boreholes. The pumptest rig was installed at Production BH A drilled by Messers Kwa-Natal Drilling. The SWL level in this well was measured at 4.85m bgl and the test pump element was installed to a depth of 25m to provide an ADD of 20.15m.

4.6.1a Step Test – BH A

A series of 4 Stepped Drawdown Tests of 60-minute duration was conducted at rates ranging from 21 – 66 kl/hr, which resulted in a total drawdown of 18.87m. The water level recovered to 88% of its pre-test level 4.5 hours after ending the 1 hr pump cycles.

Although well efficiencies fluctuated they remained high throughout the test.

4.6.1b Step Test – BH B Monitoring

The water level of borehole B was monitored during the pumping and recovery cycles and the results are summarised in Table 1 below.

Table 1 – BH A Step Test Monitoring

Monitoring BH No	Distance from BH A	Drawdown At End of Steps	Recovery At 240minutes	% Recovery At 240minutes
B	7.5m	11.06m	2.13	81%

4.6.1c 24 hour CD Test – BH A

Based on the Stepped Drawdown Test results, an abstraction rate of 40kl/hr was selected for the CD Test. At the end of the 24hr pump cycle, a total drawdown of 15.18m bSWL was achieved. The water level recovered to only 83% of its pre-test level 24 hours after the end of the pump cycle.

4.6.1d 24hr CD Test – Monitoring Boreholes

The water level of the other boreholes in the "wellfield" was monitored during the CD Test and recovery cycles and the results are summarised in Table 2 below.

Table 2- BH A CD Test Monitoring

Monitoring BH No	Distance From BH A	Drawdown At End of 24hr CD	Recovery After 24 hours	% Recovery After 24 hours
B	7.5m	11.39m	2.58m	77%
C	13.4m	11.26m	2.47	78%
D	32.0m	7.80m	2.46	68%

4.6.2 Production Borehole C

On completion of pumptesting production BH A, the pumptest rig was installed at Production BH C drilled by Messrs. J&M Drilling. Due to the small diameter of this borehole it was not possible to install both the pump and conduit for water level recording and water level readings for the duration of the test were taken from the newly reconstructed monitoring BH B. The SWL in this well was measured at 4.93m bgl and the test pump element was installed to a depth of 25m in BH C to provide an ADD of 20.07m.

4.6.2a Step Test – BH C

A series of 3 Stepped Drawdown tests of 60-minute duration were conducted at rates ranging from 20 – 60 kl/hr, which resulted in a total drawdown of 10.20m in BH B. The water level recovered to 71% of its pre-test level 4.5 hours after ending the 1 hr pump cycles.

The high well efficiencies increased throughout the test.

4.6.2b Step Test Monitoring – BH's A & D

The water level of boreholes A & D was monitored during the pumping and recovery cycles and the results are summarised in Table 3 below.

Table 3 - BH C Step Test Monitoring

Monitoring BH No	Distance from BH C	Drawdown At End of Steps	Recovery At 240minutes	% Recovery At 240minutes
A	13.4m	9.03	2.08	77%
D	29.9m	6.34m	4.46	30%

4.6.2c 24 hour CD Test – BH C

Based on the stepped drawdown test results, an abstraction rate of 40kl/hr was again selected for the CD Test. At the end of the 24hr pump cycle, a total draw down of 11.26 b SWL was achieved. The water level only recovered to 73% of its pre-test level 24 hours after ending the pump cycle. The drawdown curve shows a continuous declining trend throughout the test.

4.6.2d CD Test Monitoring BH's A & D

The water level of the other boreholes in the "wellfield" was again monitored during the CD Test and recovery cycles and the results are summarised in Table 4 below.

Table 4 - BH C CD Test Monitoring

Monitoring BH No	Distance From BH C	Drawdown At End of 24hr CD	Recovery After 24 hours	% Recovery After 24 hours
A	13.4m	11.26m	2.16	81%
D	29.9m	9.70m	4.37	55%

The graphically plotted results for the pump tests of boreholes A and C are contained in Appendix IVb.

5. SUSTAINABLE YIELD

The theoretical sustainable yield of the wellfield was derived using the FC Method; a dedicated fractured rock aquifer pumptest analyses programme, which uses a combination of conventional analyses methods.

For this analyses the following conditions were applied in the conceptual aquifer model:

- A sustained pumping period of 365 days without rainfall recharge was assumed.
- The analyses was based on both production boreholes A & C being equipped but only one being utilised at a time.
- BH's B & D would not be equipped and used for monitoring only.

The pumptest analyses clearly shows that all four boreholes share a common aquifer and are hydraulically linked.

None of the available pumptest analyses methods take cognisance of poor recovery. It is clearly evident from the pump test results shown in Tables 2 & 4 above and the plotted monitoring data for BH B for the testing of production boreholes A & C, which is contained in Appendix IVc, that the aquifer was partially de-watered during the pumptest programme.

It is however important to consider that rainfall recharge has not been considered in the sustainable yield calculation and it is reasonable to assume that the aquifer will respond quite rapidly to recharge from significant rainfall events in the effective groundwater catchment area and flow in the Nhlambane Stream.

The above was considered and factored into the final sustainable yield analyses, which returned safe sustainable daily yield of **300kl/day** or 30kl/hr on a 10 hour cycle.

6. WATER QUALITY

A water sample was collected during the CD test on the production BH's A & C and submitted to Umgeni Water for Abr. SABS 241 (1999) analyses to determine if the borehole water complies with the Kempster Guidelines for Potable Water Supplies (1996).

The analysis returned a classification of Class 0 and is suitable for long-term domestic use.

The detailed water quality results can be seen in Appendix V.

7. CONCLUSIONS

- The available water quality analyses data and field water quality measurement show that the groundwater quality within the project area is excellent, with low levels of Dissolved Solids (EC's <30 mS/m) and pH close to 7.

- This aquifer exhibits very high transmissivity characteristics and pumptest data returned values of the order >35 m^2/day. However, the poor recovery data strongly suggest that storativity is limited and that abstraction during the pumptest programme "mined" the stored water and exceeded the rate of recharge derived from throughflow.

- Well efficiencies are high and laminar flow conditions will be maintained at abstraction rates of up to 60 m^3/hr.

- It is quite obvious that without regular rainfall recharge, continued abstraction at 300 kl/day, will impact negatively on the sustainability of the aquifer due to the limited storage.

- It is therefore necessary to consider augmentation or risk reduction management practices to ensure that the daily bulk water demand of this water project can be met in the long-term.

8. RECOMMENDATIONS

Implementation of the water supply system is already quite advanced and it is imperative that the available options for ensuring a sustainable bulk water supply to this system are defined and implemented.

8.1 Production BH's A & C

- Appropriate pump systems capable of delivering the required flow at the total working head must be selected for both the above systems.

- The pump control and borehole monitoring systems must include fully automated control systems such as timer switches, dry-run protection, auto-restart systems, running hour meters and extensive lightning / electrical surge protection.

- Consideration should also be given when designing the abstraction systems to make it impossible for more than one pump to be run at a time to prevent de-watering and possible damage to the aquifer and pump systems.

- The pump installations must be installed in lockable, vandal proof, vented concrete manholes. The control panels must be situated close by (but clear of flood lines) in lockable fibre-cement kiosks.

- Water samples must be taken on a quarterly basis and submitted to a registered laboratory for analyses according to the latest SABS guidelines for drinking water to check whether the water remains suitable for domestic consumption.

- In view of the limited storage and poor recharge characteristics of this aquifer, failure to implement a reliable and sustained borehole-monitoring programme will undoubtedly result in production borehole or pump failure and possibly lead to irreparable damage to the aquifer. It is thus vital to implement a regular borehole monitoring programme to ensure proper management and fine-tuning of abstraction rates and daily pump cycles.

- In order to achieve this, static and dynamic water levels, flow rates and daily abstraction volumes must be recorded before during and after daily pump cycles. This data must be forwarded to the Hydrogeologist at regular intervals (initially once a week), for evaluation and review of the management recommendations.

- Due to the remote location of this project and practical difficulties associated with manual monitoring, we strongly recommend that electronic pressure sensors and flowmeters linked to a Remote Information Forwarding System (RIFS) are installed in monitoring borehole B. This system will ensure that the data, which is recorded at pre-set intervals, is forwarded via the GSM network to a server from where it can be down-loaded daily by the Hydrogeologist. Information and costs on RIFS are attached in Appendix VI of this report.

- Evaluation of this data will reveal the effect and influence of rainfall recharge on the hydraulic characteristics of the boreholes and aquifer, which is vital to avoid "mining" of the aquifer.

8.2 Augmentation

Consideration should be given to development of additional production borehole "outside" the groundwater catchment area of the existing wellfield or capturing the spring flow, which feeds the Nhlambane River, to augment the supply from the wellfield.

We trust that the above meets with your approval and will be pleased to answer any queries you may have in this regard.

We trust that meets with your requirements and we await your further instructions on this matter.

Yours faithfully,

Rupert Sebire
GEOMEASURE GROUP (PTY) LTD

FIGURES

GEOMEASURE GROUP
Groundwater & Environmental Consultants

LEGEND

N

Study Area

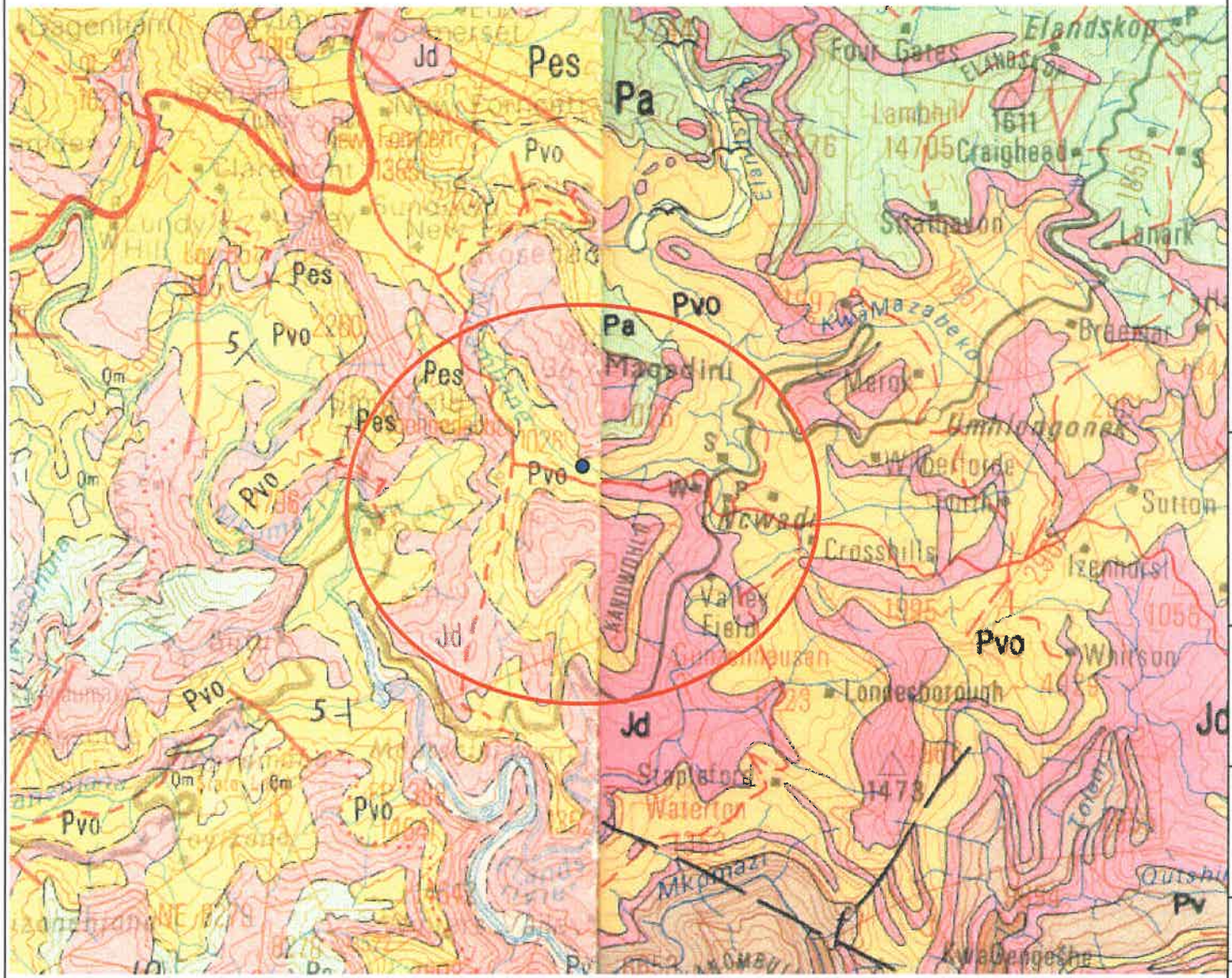
GEOMEASURE GROUP

NCWADI PRODUCTION BOREHOLES

LOCALITY PLAN

10 0 10 20 30 40 Kilometers

DWG NO 2001/148
FIGURE 1



LEGEND :

- Ncwadi Project Area
- Boreholes
- Jd — Dolerite
- Pa — Fine grained sandstone
- Pvo — Shale
- Pv — Inter bedded sandstone and shale
- Pp — Dark grey shale

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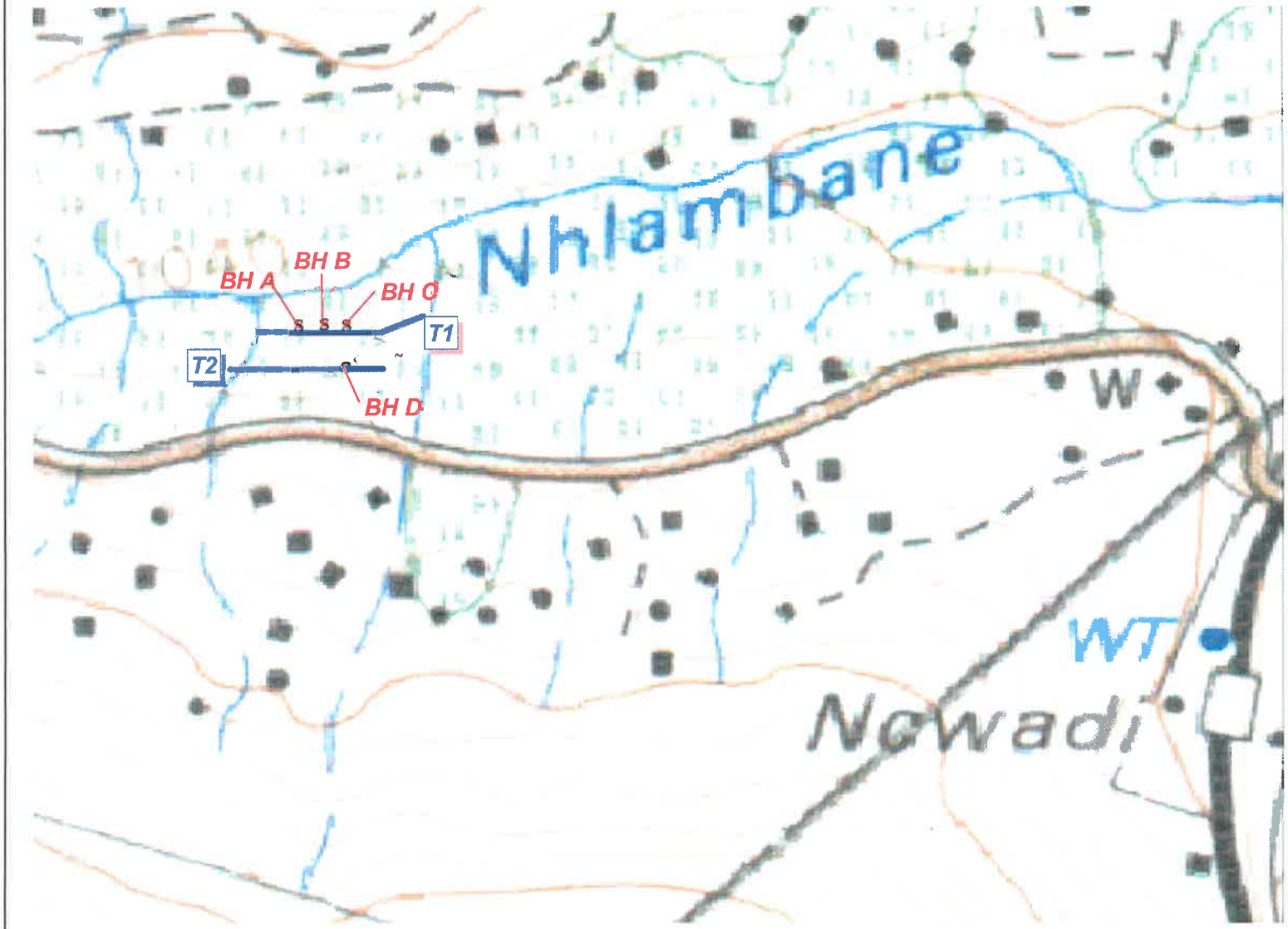
PROJECT:
NCWADI PRODUCTION BOREHOLES

TITLE:
GEOLOGICAL MAP

SCALE: 1:100 000

DWG No: 2001/148 FIG 2



LEGEND

N

S Borehole Positions

Geophysical Traverses

GEOMEASURE GROUP

NCWADI PRODUCTION BOREHOLES

SITE PLAN SHOWING GEOPHYSICS AND BOREHOLE POSITIONS

0 0.5 1 1.5 Kilometers

DWG NO 2001/148
FIGURE 3

APPENDIX I

EXISTING EXPLORATION BOREHOLE – BOREHOLE LOG AND PUMPTEST DATA

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Groundwater & Environmental Consultants

BOREHOLE FIELD RECORD

RECORDED BY : A Mavurayi DATE: 24.06.96

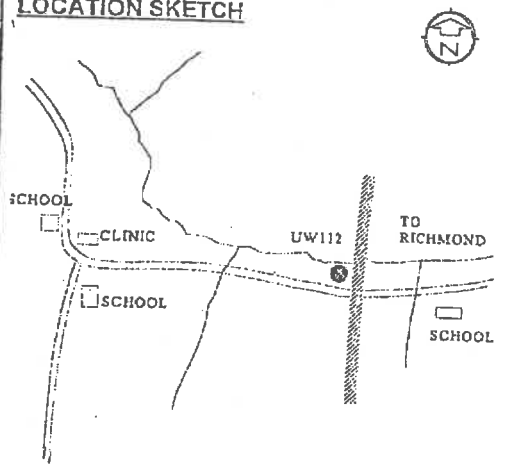
A. BOREHOLE LOCATION

1. "BH" NUMBER : UW112
2. POSITION : 29°46' 780'S, 30°00' 323"E
3. 1:50 000 MAP SHEET NO : 2930 CC
4. AIRPHOTO REF : 9433 STRIP 3
5. DISTRICT : Thembeni (Hlanganani)
6. VILLAGE : Mcwadi

B. SITING DETAILS

1. SITED BY : A Mavurayi
2. DATE: 17.05.96
3. TARGET: Dyke Contact

LOCATION SKETCH



C. DRILLING AND CONSTRUCTION DETAILS

1. BOREHOLE LOGGED BY : A Mavurayi
2. DRILLER : Ungerer - Roelf
3. DRILLING METHOD : Rotary Percussion
4. DATE DRILLED: 17.06.96 to 21.06.96
5. FINAL DEPTH : 106m
6. BLOW YIELD : 40.0m³/hr
7. DRILLING SIZES & DEPTHS : 7.5" From 0 - 24m
   6.5" From 24 - 106m
8. CASING, SIZES & POSITION : 7.5" From 0 - 24m
9. CASING TYPE : Opex
10. SCREEN OR SLOT SIZES & POSITION: NIL
11. DEVELOPMENT METHOD : Blowing
12. DEVELOPMENT DURATION : 4 Hours
13. CASING RETRIEVED : Nil
14. STEEL CAP INSTALLED: Yes
15. BLOCK CAST: Yes
16. DATE OF ASSESSMENT: 24.06.96

D. WATER:

1. MAIN STRIKES AT (m): 24m 90 m
2. STATIC WATER LEVEL: 4.4m
3. PH : -
4. CONDUCTIVITY: -
5. TEMPERATURE: -

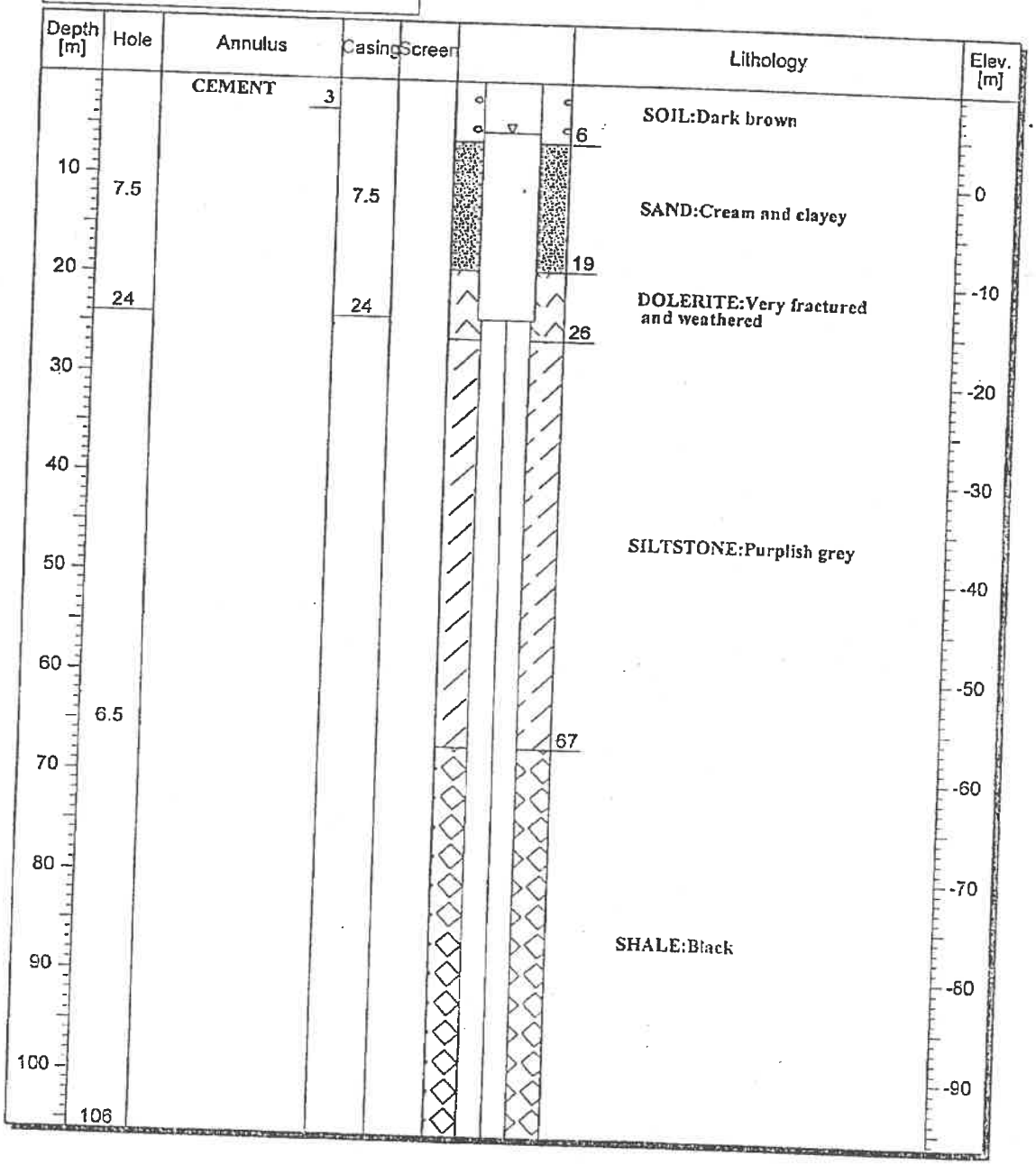
REMARKS

Well Log: Lithology & Construction

Well Ident	Name
UW112	THEMBENI GROUNDWATER INVESTIGATION

Drill. Method		Dates completed	
ROTARY PERCUSSION		21/06/96	
W/strike	Yield	Meas. Pt. Elev.	
24	106		

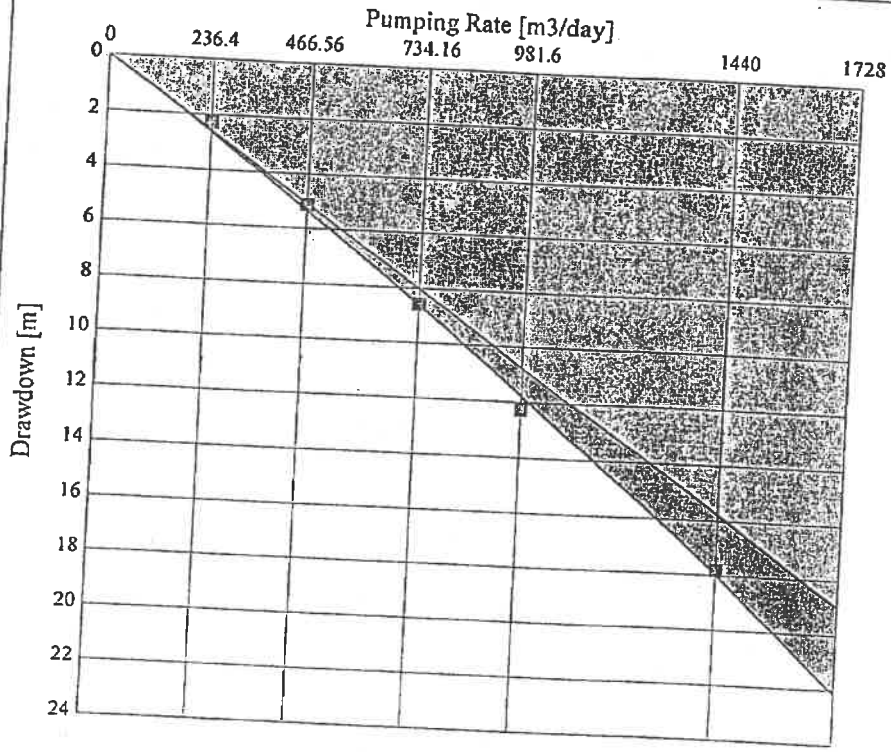
Water Level (m AMSL)
4.58



THEMBENI GROUNDWATER INVESTIGATION

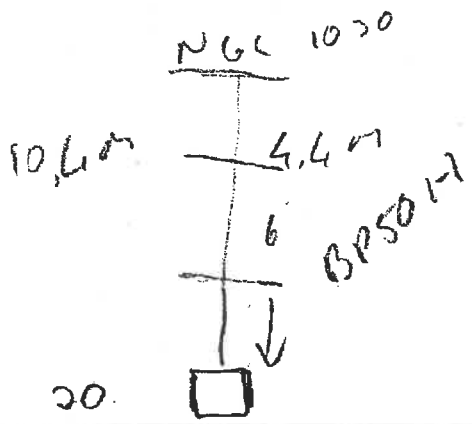
Well Ident
UW112

B	C	p	Efficiency (%)
0.01097	1.054E-06	2.00	91.56



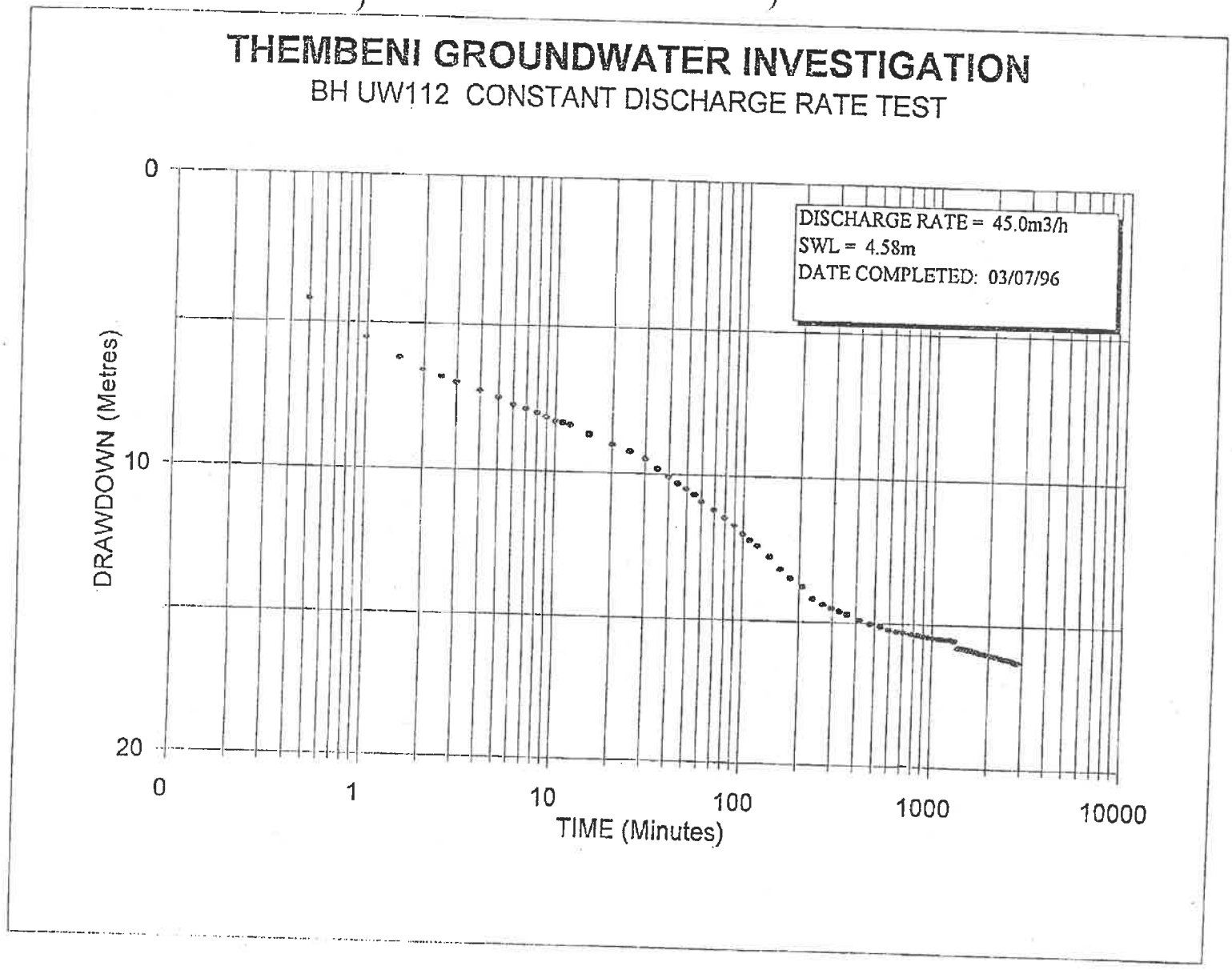
Drawdown	2.29	5.12	8.59	12.27	17.79	22.1
Pumping Rate	236.4	466.56	734.16	981.6	1440	1728 *
Aquifer Loss	2.59	5.12	8.05	10.76	15.79	18.95
Well Loss	0.06	0.23	0.57	1.02	2.18	3.15
Efficiency [%]	100	99.9	93.7	87.7	88.8	85.8

The last step is extrapolated for 20% higher last Q.



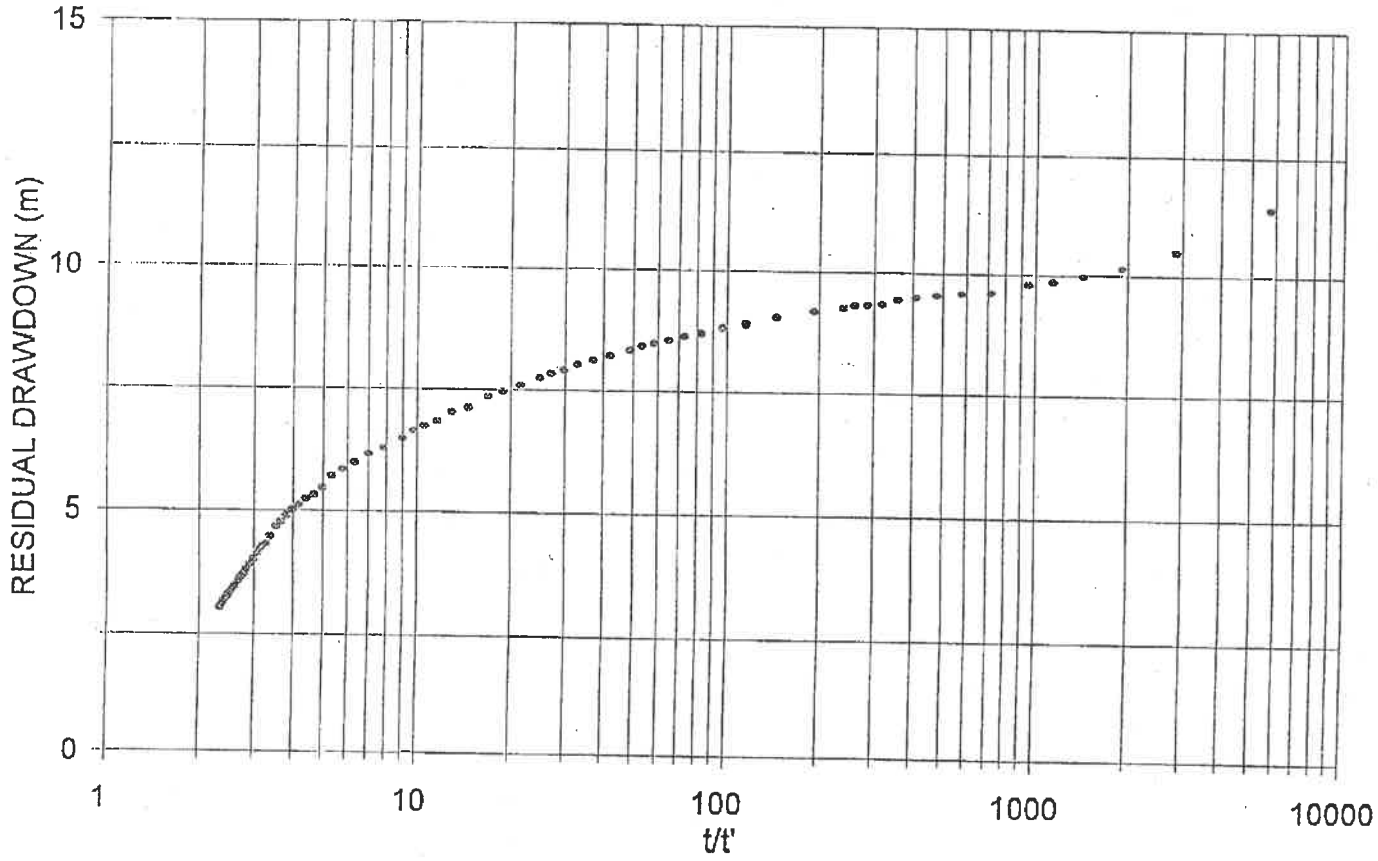
THEMBENI GROUNDWATER INVESTIGATION

BH UW112 CONSTANT DISCHARGE RATE TEST



THEMBENI GROUNDWATER INVESTIGATION

BH UW112 RECOVERY TEST

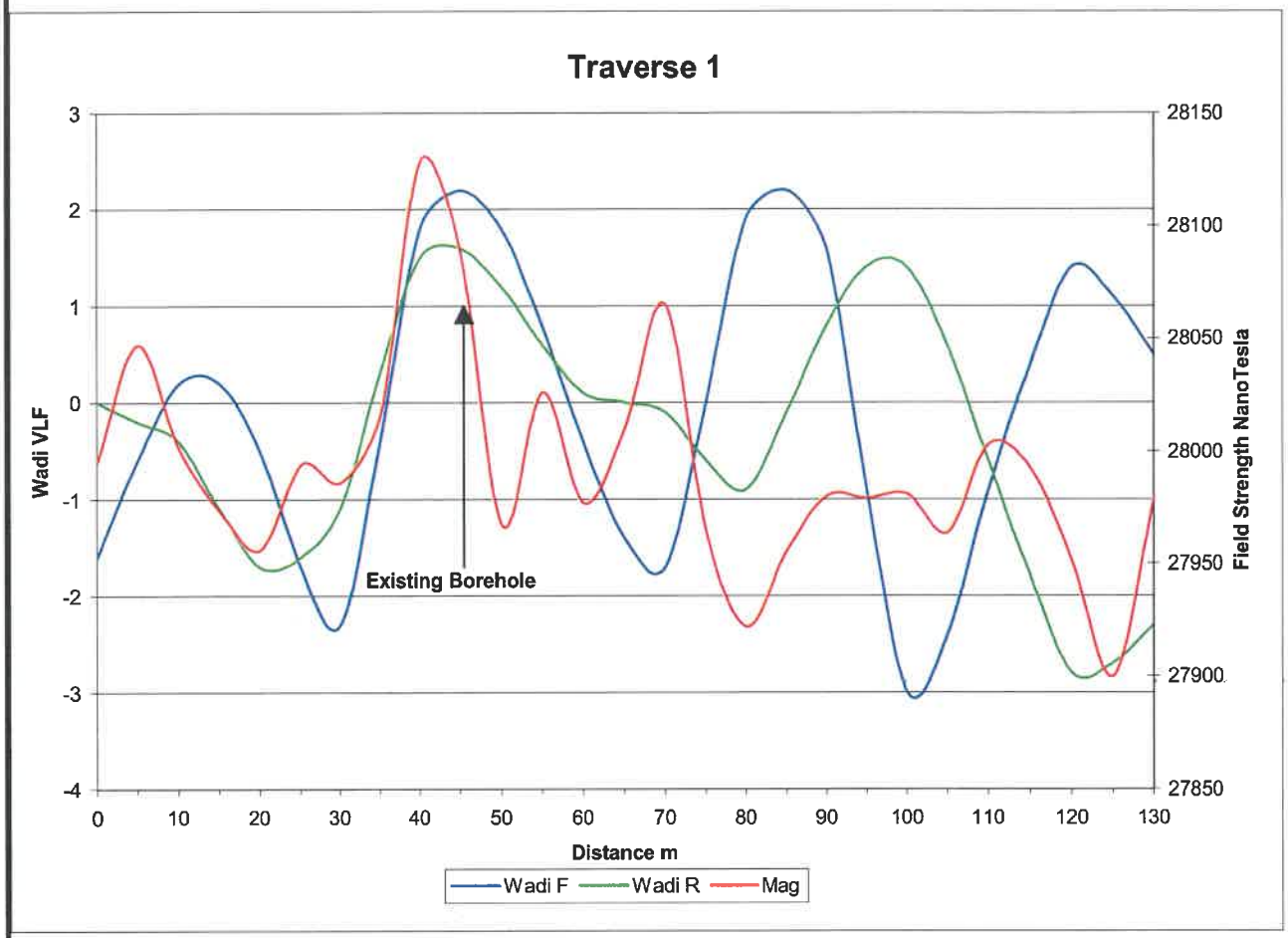


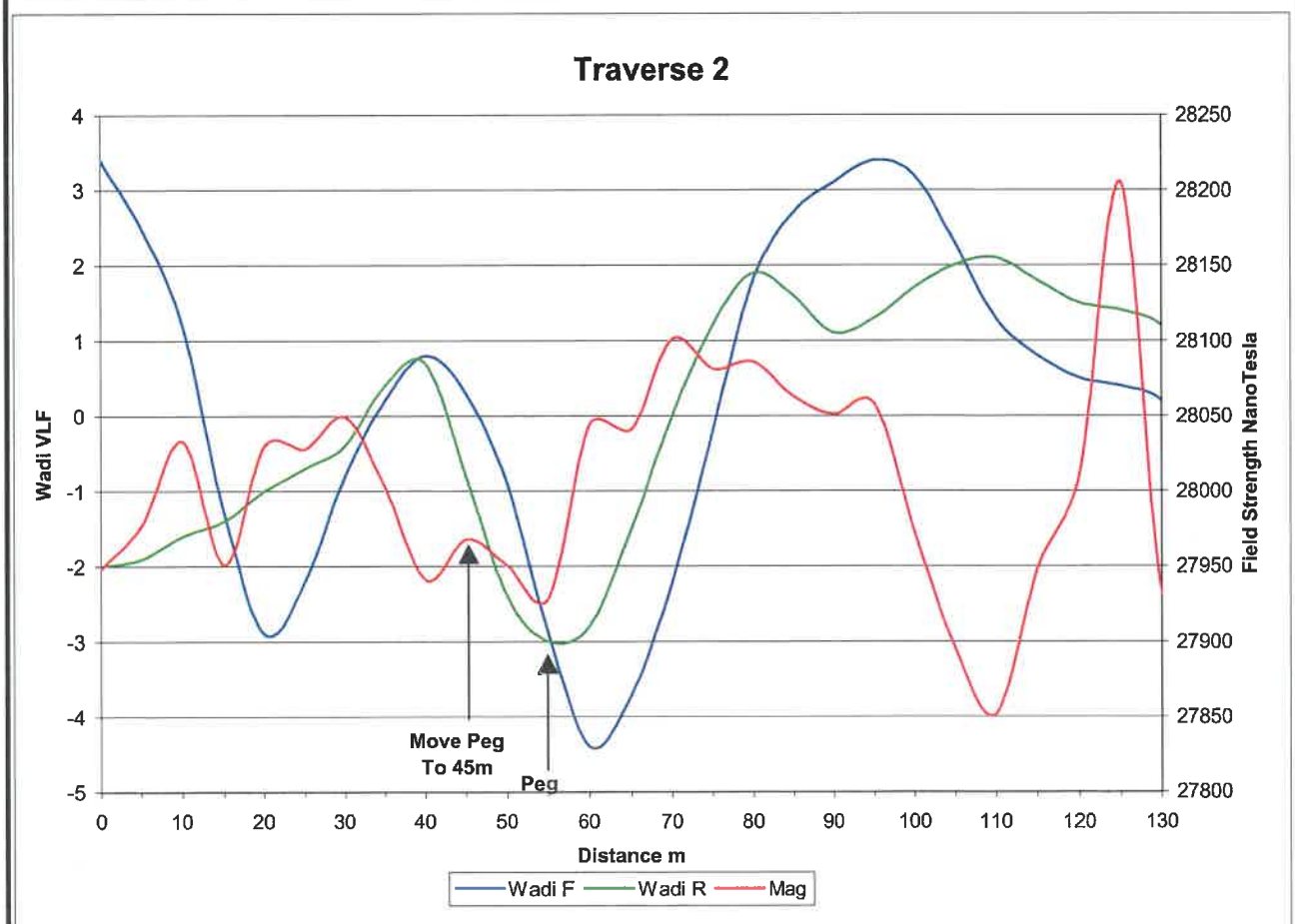
APPENDIX II

GEOPHYSICAL DATA PLOTS

GEOMEASURE GROUP
Groundwater & Environmental Consultants

NCWADI PRODUCTION BH DEVELOPMENT



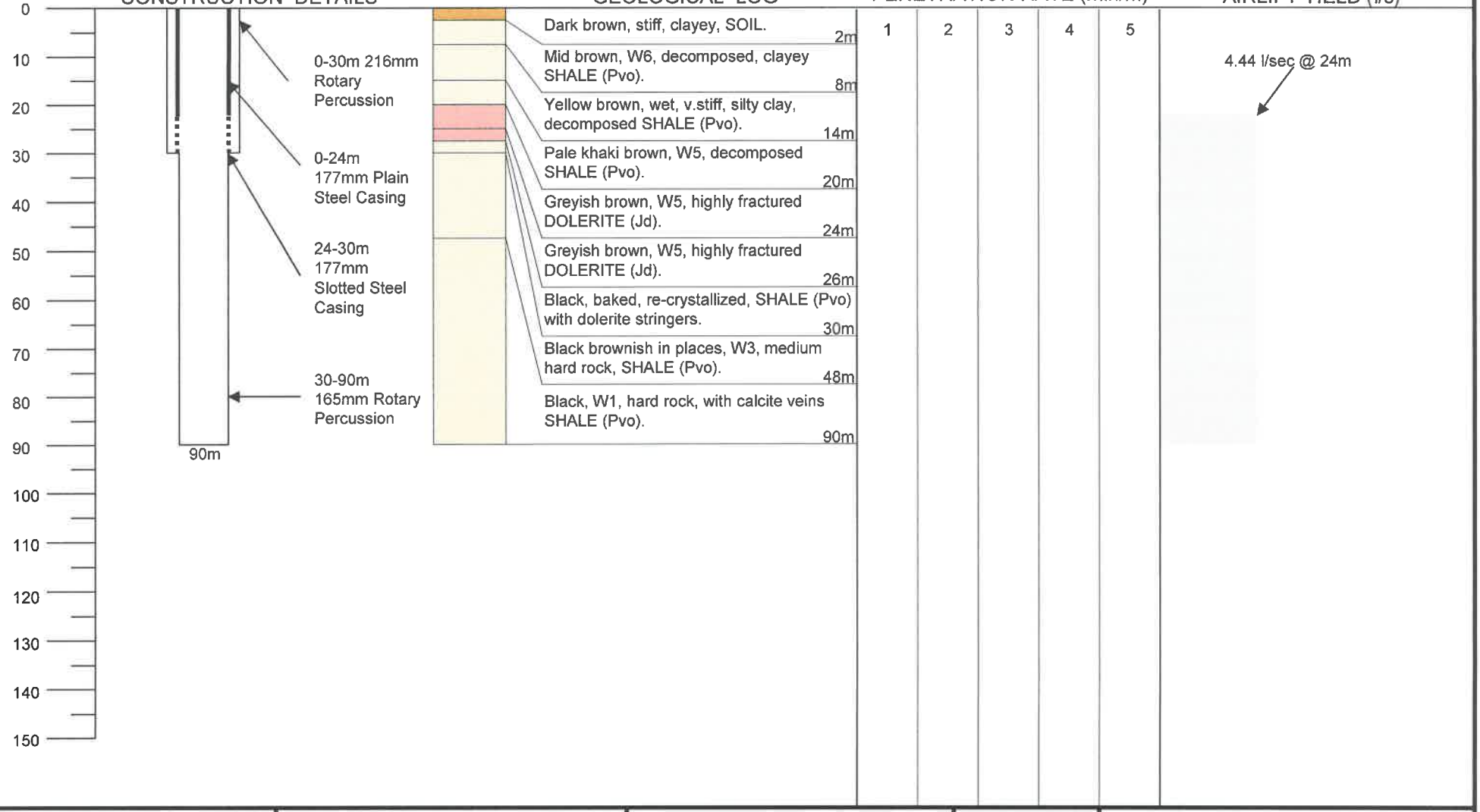


APPENDIX III

BOREHOLE LOGS

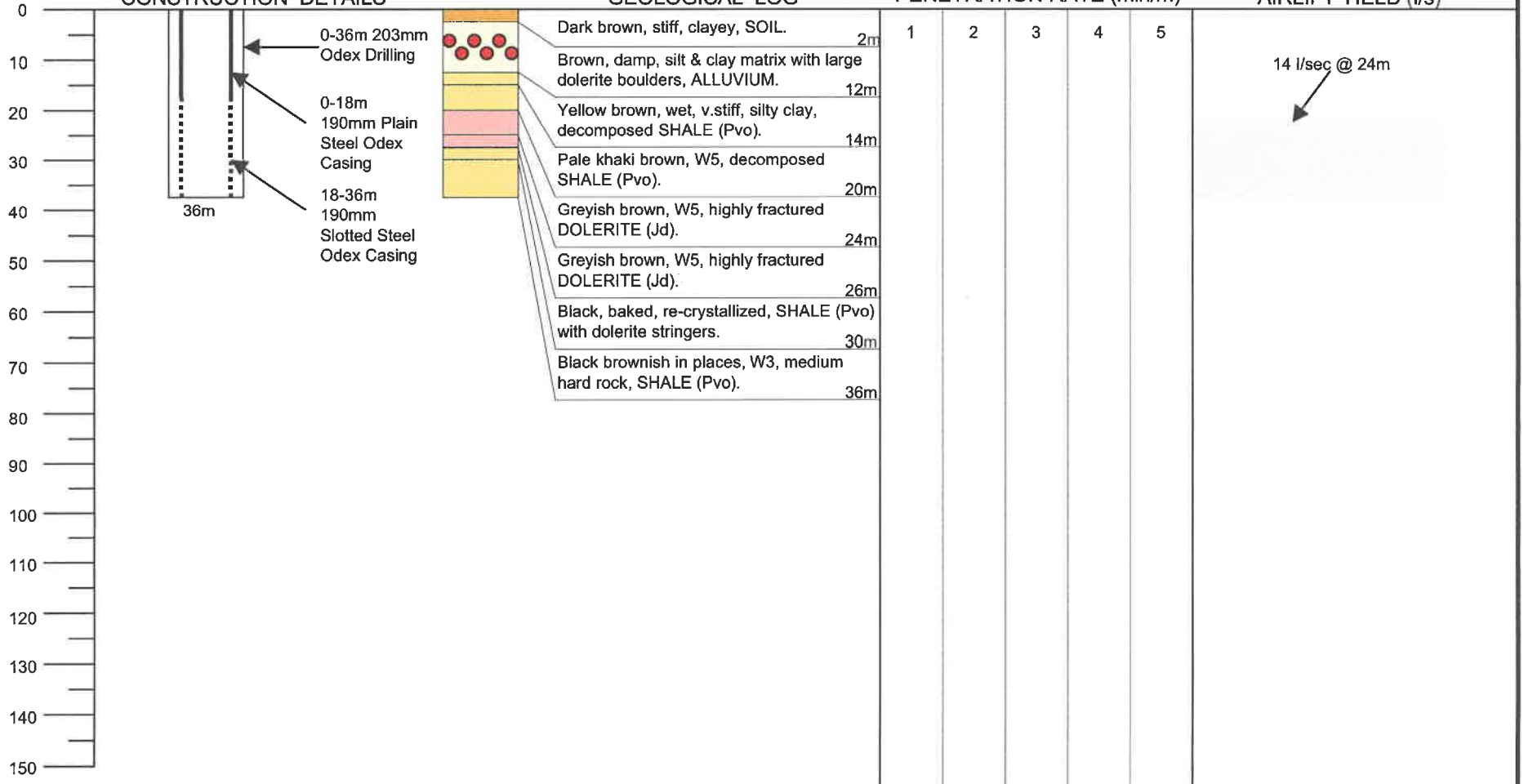
GEOMEASURE GROUP
Groundwater & Environmental Consultants

BOREHOLE GEOLOGICAL AND CONSTRUCTION LOG



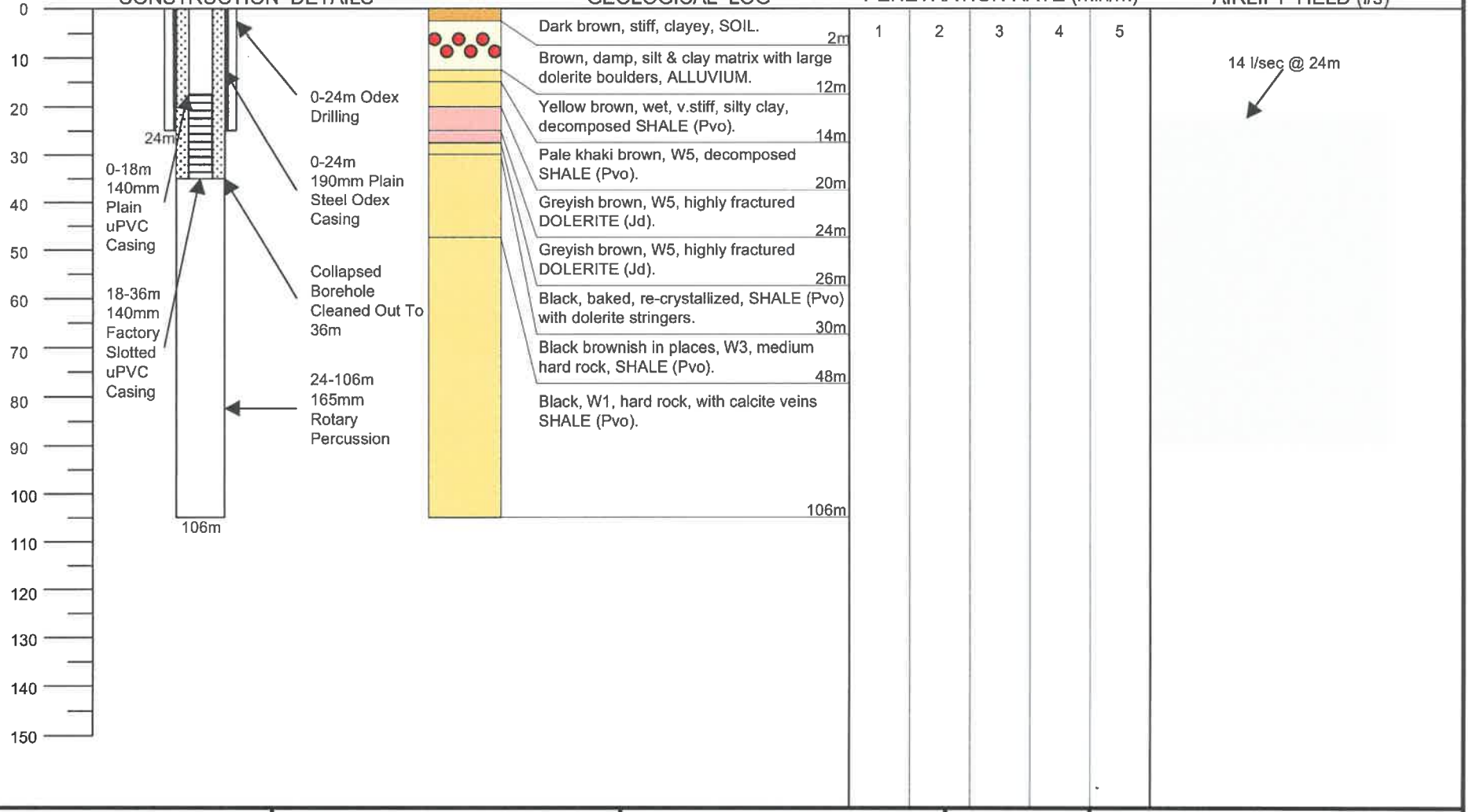
PROJECT: NCWADI WATER PROJECT **DATE DRILLED: 26/03/2002** **BH NO: BH D**	**LOGGED BY: R. SEBIRE** **CONTRACTOR: S.A. DRILLING** **MACHINE: SCHRAMM T450** **DRILLER: MYELLA**	**BOREHOLE COORDINATES** **29° 46' 45.5" S** **30° 00' 21.1" E**	**JOB NO.** **2001/148**	GEOMEASURE GROUP *Groundwater Exploration & Development Consultants*

BOREHOLE GEOLOGICAL AND CONSTRUCTION LOG



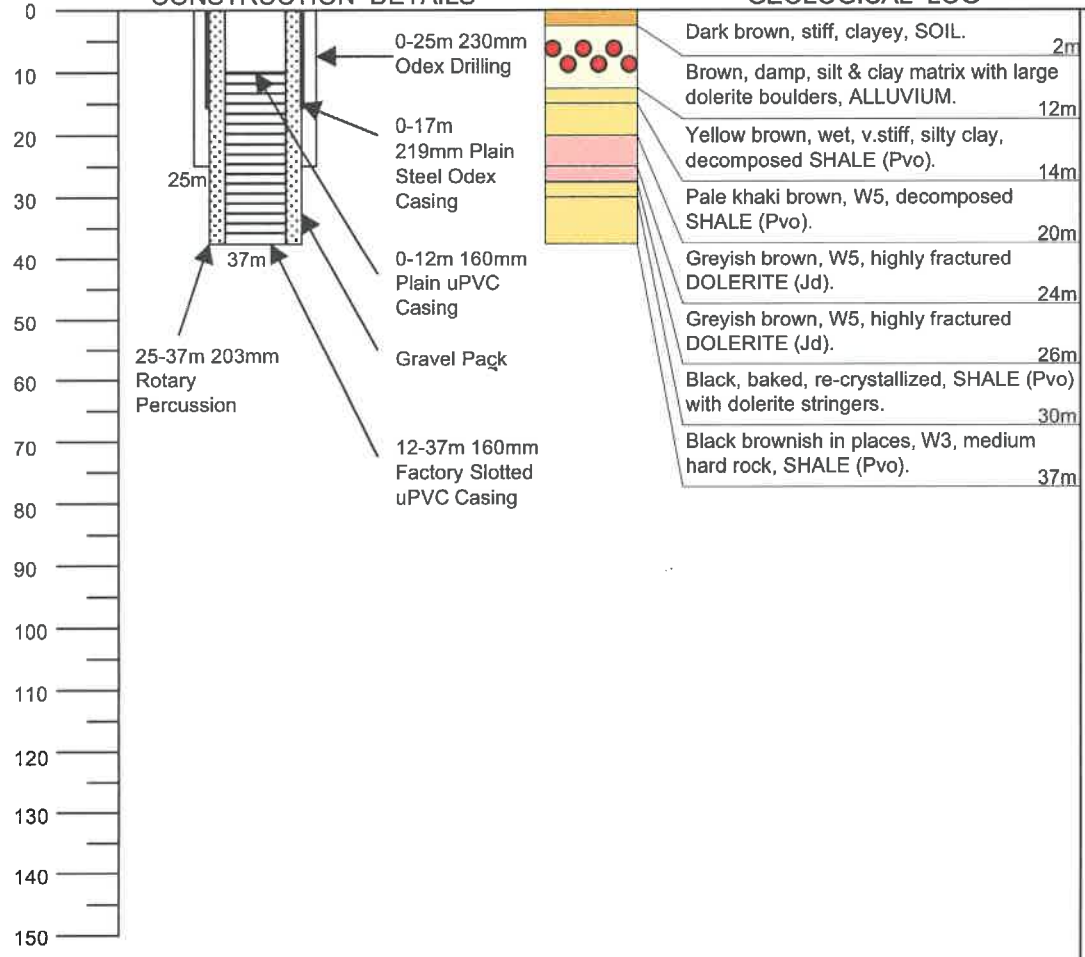
PROJECT: NCWADI WATER PROJECT **DATE DRILLED: 26/07/2002** **BH NO: PRODUCTION BH BH A**	**LOGGED BY: R. SEBIRE** **CONTRACTOR: KAW NATAL** **MACHINE: SUPER ROCK** **DRILLER: HENDRICK**	**BOREHOLE COORDINATES** **29° 46' 44.6" S** **30° 00' 19.1" E**	**JOB NO.** **2001/148**	GEOMEASURE GROUP Groundwater Exploration & Development Consultants

BOREHOLE GEOLOGICAL AND CONSTRUCTION LOG



PROJECT: NCWADI WATER PROJECT	LOGGED BY: A. MAVURAYI / R. SEBIRE	BOREHOLE COORDINATES	JOB NO.	GEOMEASURE GROUP
DATE RE- DRILLED: 27/07/2002	CONTRACTOR: KWA NATAL	29° 46' 78.0" S		
BH NO: MONITORING BH BH B	MACHINE: SUPER ROCK	30° 00' 32.3" E	2001/148	
	DRILLER: HENDRICK			

BOREHOLE GEOLOGICAL AND CONSTRUCTION LOG



PENETRATION RATE (min/m)

1	2	3	4	5

AIRLIFT YIELD (l/s)

14 l/sec @ 24m

PROJECT: NCWADI WATER PROJECT DATE DRILLED: 22/06/2002 BH NO: PRODUCTION BH BH C	LOGGED BY: R. SEBIRE CONTRACTOR: J & M DRILLING MACHINE: THOR DRILLER: VERNON	BOREHOLE COORDINATES 29° 46' 44.6" S 30° 00' 21.0" E	JOB NO. 2001/148	GEOMEASURE GROUP Groundwater Exploration & Development Consultants

APPENDIX IV

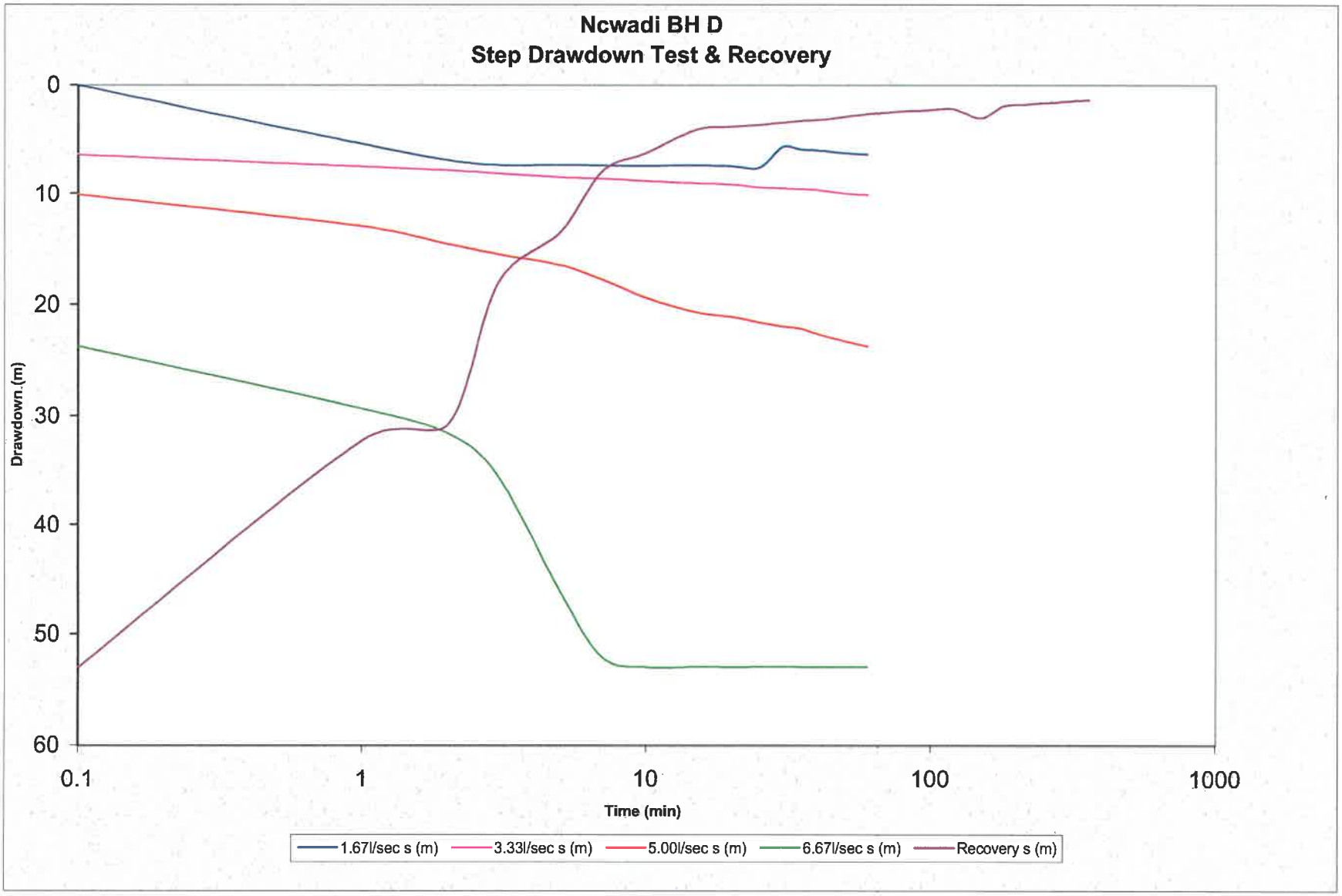
PUMPTEST DATA AND ANALYSES

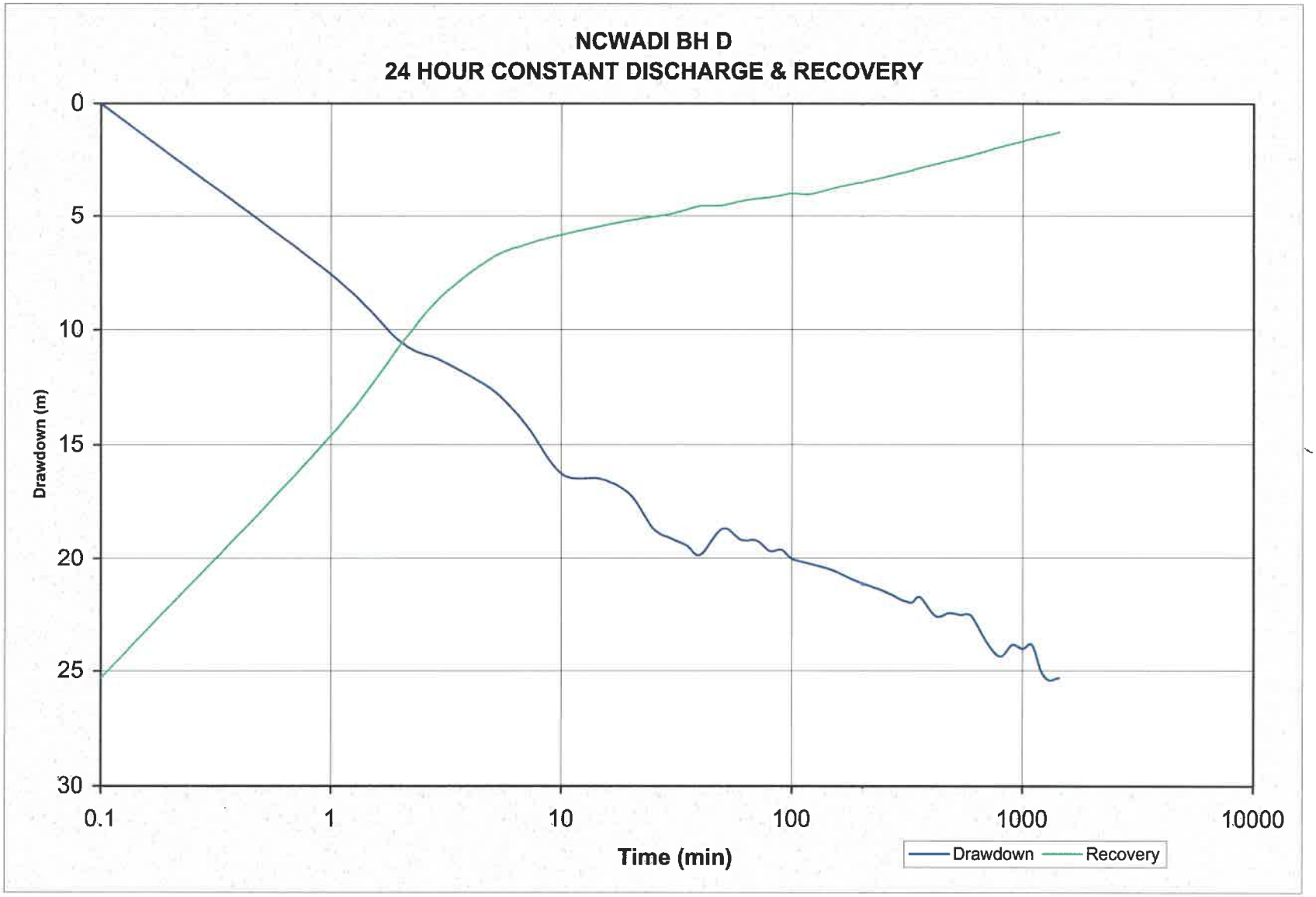
GEOMEASURE GROUP
Groundwater & Environmental Consultants

APPENDIX IVa

NEW EXPLORATION BOREHOLES (BH D)

GEOMEASURE GROUP
Groundwater & Environmental Consultants


Ncwadi BH D
Step Drawdown Test & Recovery
Drawdown (m)
0
10
20
30
40
50
60
0.1
1
10
100
1000
Time (min)
1.67l/sec s (m)
3.33l/sec s (m)
5.00l/sec s (m)
6.67l/sec s (m)
Recovery s (m)


NCWADI BH D
24 HOUR CONSTANT DISCHARGE & RECOVERY
Drawdown (m)
0
5
10
15
20
25
30
0.1
1
10
100
1000
10000
Time (min)
Drawdown
Recovery

MANAGEMENT RECOMMENDATION SHEET

BOREHOLE No :	BH D NCWADI	**LOCATION :**	NCWADI		
DATE :	3-05-2002	**COORDINATES :**	29° 46' 45.5" **S**	30° 00' 21.1"	**E**

BOREHOLE INFORMATION

Completed Depth (mbgl)	90.00
Diameter (mm)	165
Casing (m)	30.00
Water Strikes (mbgl)	24.00
Static Water Level (mbgl)	6.50
Test Pump Intake (mbgl)	60.00
Available Drawdown (m)	53.50
Airlift Yield (l/hr)	24000
Airlift Yield (l/s)	6.67

STEP TESTS

	Pump Rates l/s	m^3/hr	Drawdown (m)	Specific Capacity l/s/m	m^3/hr/m	Length of step (min)
Step No 1	1.67	6.00	6.38	0.261	0.941	60
Step No 2	3.33	12.00	9.06	0.368	1.324	60
Step No 3	5.00	18.00	23.78	0.210	0.757	60
Step No 4	6.67	24.00	53.03	0.126	0.453	60
Step No 5						
Step No 6						

Recovery Test	Total DD (mbswl)	Recovery (mbswl)	Recovery Time (min)	Recovery %
	53.03	1.34	360	97

CONSTANT DRAWDOWN TEST

Final Drawdown (mbswl)	Pump Rates l/s	m^3/hr	Duration of DD Test (min)	Specific Capacity l/s/m	m^3/hr/m	Duration of Recovery (min)	Recovery (mbswl)	Recovery %
25.32	4.44	16.00	1440	0.176	0.632	1440	1.25	95

	Calculation of Transmissivity Values			
Volume Extracted (kl)	DDΔs	RECΔs	DD m^2/day	REC m^2/day
383.96	2.46	3.93	28.58	17.86

MANAGEMENT RECOMMENDATIONS

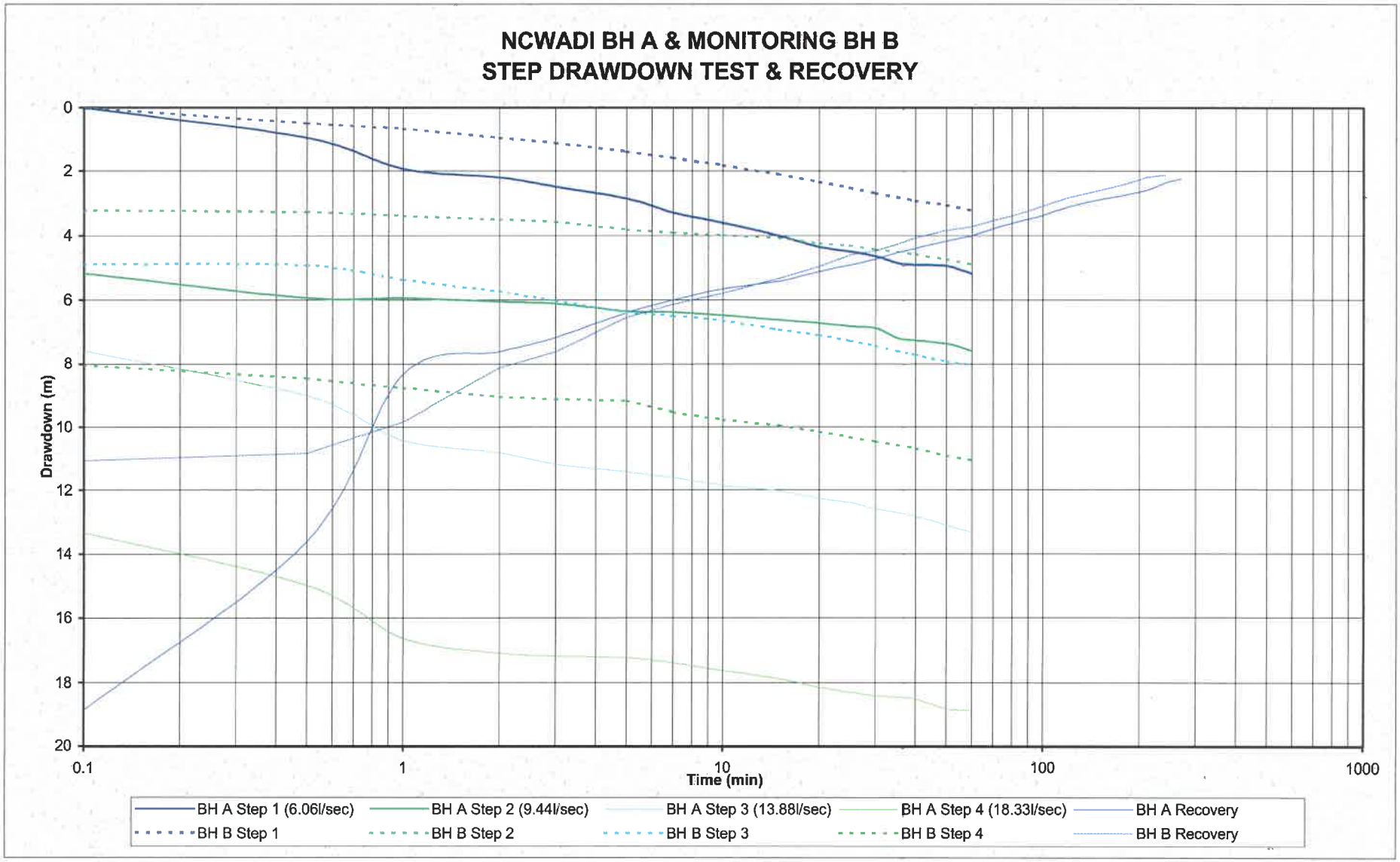
Pump Installation (mbgl)	Dynamic Water Level (m)	Rec. Pumping Cycle (hrs/day)	Rec. Pumping Rate on Pump Cycle m^3/hr	l/s	m^3/day
40	20	10	12	3.33	120.00

GEOMEASURE GROUP
Groundwater & Environmental Consultants

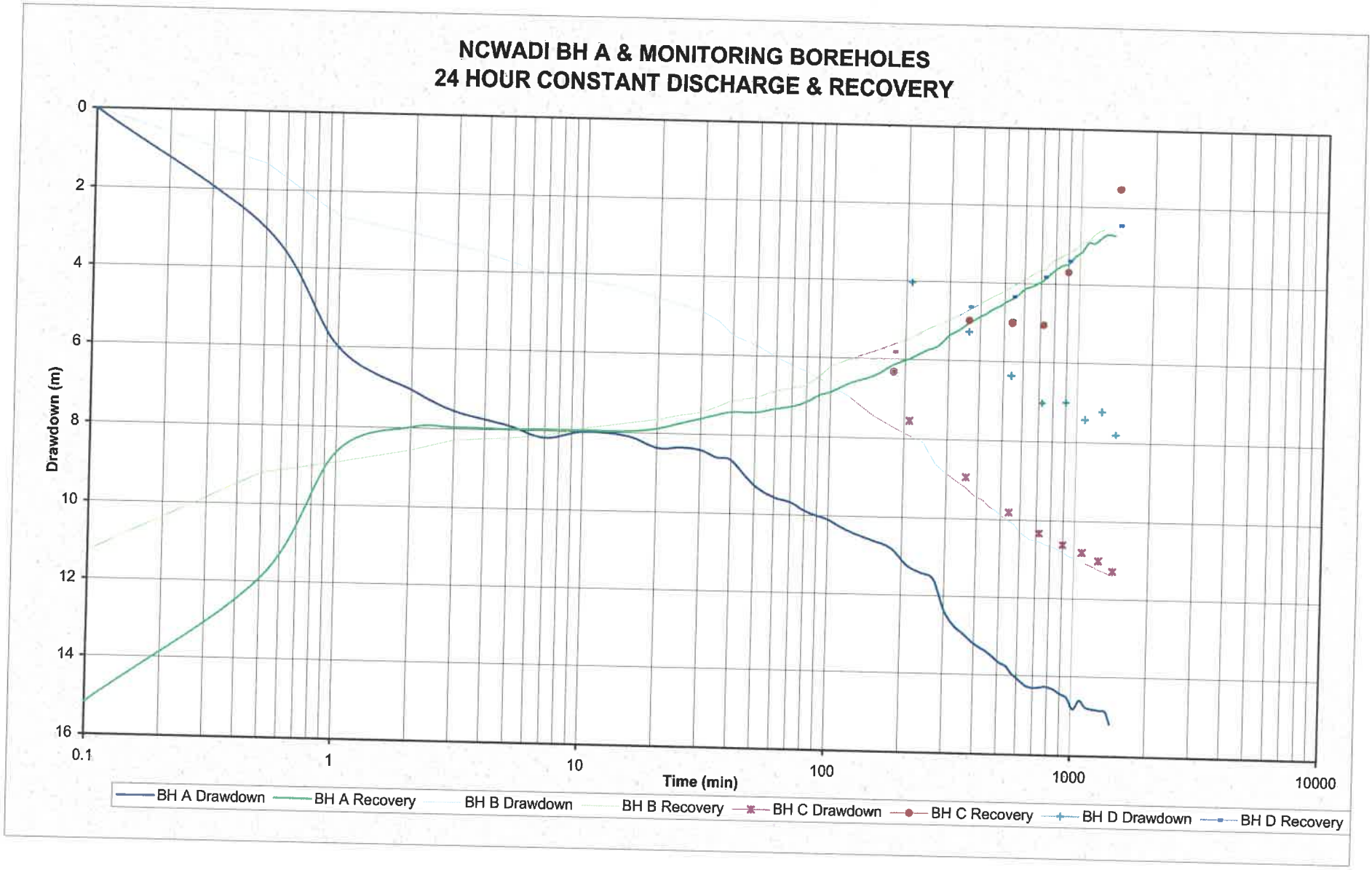
APPENDIX IVb

PRODUCTION BOREHOLES A & C

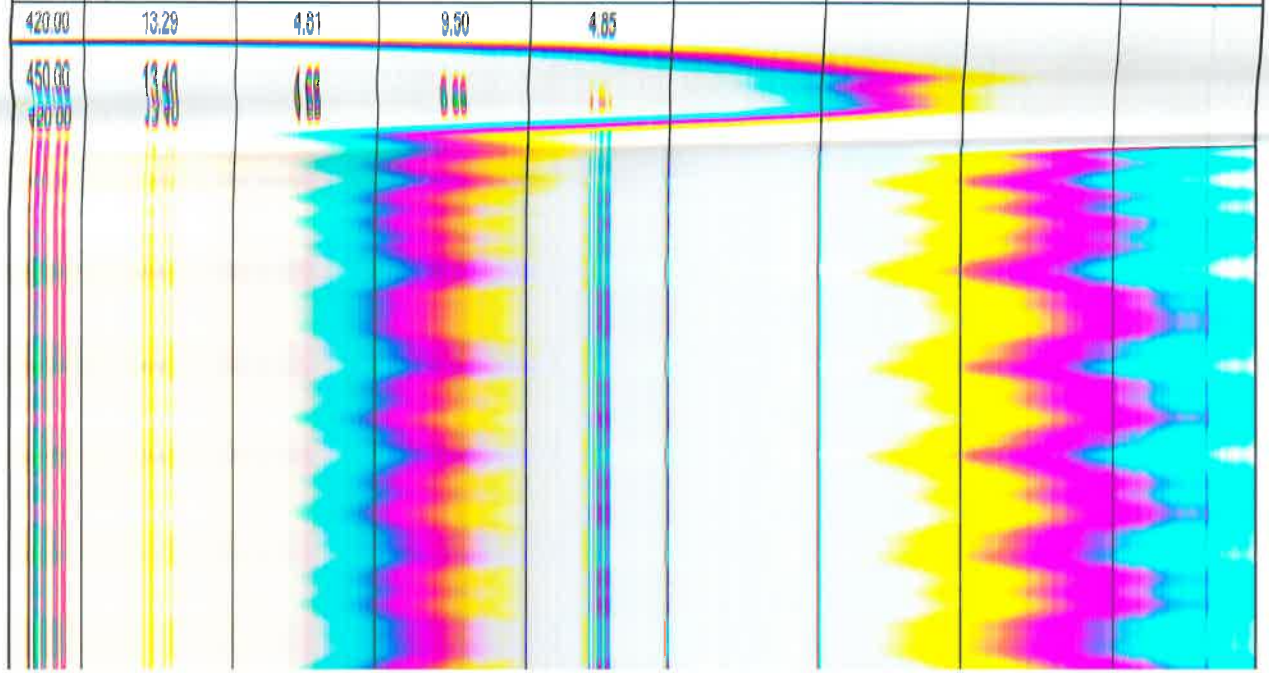
GEOMEASURE GROUP
Groundwater & Environmental Consultants


NCWADI BH A & MONITORING BH B
STEP DRAWDOWN TEST & RECOVERY
Drawdown (m)
0
2
4
6
8
10
12
14
16
18
20
0.1
1
10
100
1000
Time (min)
BH A Step 1 (6.06l/sec)
BH A Step 2 (9.44l/sec)
BH A Step 3 (13.88l/sec)
BH A Step 4 (18.33l/sec)
BH A Recovery
BH B Step 1
BH B Step 2
BH B Step 3
BH B Step 4
BH B Recovery

	BH A					BH B				
Time	BH A Step 1 (6.06l/sec)	BH A Step 2 (9.44l/sec)	BH A Step 3 (13.88l/sec)	BH A Step 4 (18.33l/sec)	BH A Recovery	BH B Step 1	BH B Step 2	BH B Step 3	BH B Step 4	BH B Recovery
0.10	0.00	5.18	7.60	13.33	18.87	0.00	3.23	4.90	8.05	11.06
0.50	0.96	5.94	9.02	14.98	13.60	0.50	3.27	4.94	8.45	10.83
1.00	1.92	5.94	10.43	16.63	8.32	0.67	3.40	5.38	8.77	9.84
2.00	2.20	6.05	10.83	17.09	7.62	0.96	3.51	5.74	9.06	8.12
3.00	2.49	6.12	11.20	17.18	7.16	1.12	3.58	6.03	9.12	7.61
5.00	2.86	6.35	11.44	17.24	6.39	1.39	3.81	6.38	9.17	6.54
7.00	3.29	6.38	11.62	17.40	5.99	1.57	3.91	6.51	9.53	6.13
10.00	3.61	6.48	11.85	17.63	5.65	1.81	3.99	6.65	9.78	5.78
15.00	4.00	6.62	12.02	17.88	5.41	2.10	4.07	6.94	9.95	5.33
20.00	4.35	6.73	12.27	18.13	5.11	2.34	4.25	7.10	10.16	4.95
25.00	4.50	6.82	12.40	18.30	4.90	2.52	4.31	7.28	10.33	4.60
30.00	4.64	6.89	12.60	18.40	4.73	2.69	4.44	7.44	10.46	4.47
35.00	4.85	7.19	12.72	18.45	4.54	2.81	4.51	7.60	10.58	4.26
40.00	4.91	7.27	12.84	18.50	4.40	2.92	4.58	7.72	10.68	4.06
50.00	4.93	7.37	13.11	18.82	4.17	3.06	4.74	7.94	10.91	3.84
60.00	5.18	7.60	13.33	18.87	4.00	3.23	4.90	8.05	11.06	3.73
70.00					3.79					3.54
80.00					3.62					3.39
90.00					3.49					3.24
100.00					3.37					3.08
120.00					3.11					2.83
150.00					2.90					2.60
180.00					2.75					2.42
210.00					2.60					2.20
240.00					2.37					2.13
270.00					2.24					


NCWADI BH A & MONITORING BOREHOLES
24 HOUR CONSTANT DISCHARGE & RECOVERY
Drawdown (m)
0
2
4
6
8
10
12
14
16
0.1
1
10
100
1000
10000
Time (min)
BH A Drawdown
BH A Recovery
BH B Drawdown
BH B Recovery
BH C Drawdown
BH C Recovery
BH D Drawdown
BH D Recovery

	BH A		BH B		BH C		BH D	
Time	BH A Drawdown	BH A Recovery	BH B Drawdown	BH B Recovery	BH C Drawdown	BH C Recovery	BH D Drawdown	BH D Recovery
0.10	0.00	15.18	0.00	11.39				
0.50	3.00	11.92	1.34	11.35				
1.00	6.00	8.66	2.67	11.30				
2.00	7.05	7.98	3.05	11.27				
3.00	7.56	7.96	3.33	9.20				
5.00	7.89	7.97	3.74	8.91				
7.00	8.18	7.96	4.02	8.57				
10.00	8.00	7.96	4.18	8.30				
15.00	8.08	7.96	4.34	8.21				
20.00	8.37	7.88	4.60	8.12				
25.00	8.35	7.73	4.75	7.92				
30.00	8.40	7.61	4.92	7.77				
35.00	8.58	7.50	5.15	7.66				
40.00	8.64	7.43	5.50	7.54				
50.00	9.27	7.42	5.74	7.47				
60.00	9.55	7.32	6.02	7.31				
70.00	9.67	7.25	6.22	7.15				
80.00	9.88	7.13	6.37	7.07				
90.00	10.00	6.96	6.53	6.88				
100.00	10.10	6.86	6.71	6.79				
120.00	10.36	6.63	6.98	6.71				
150.00	10.59	6.43	7.44	6.48				
180.00	10.78	6.14	7.70	6.23		6.32		5.82
210.00	11.22	5.97	7.92	6.02	7.53		4.04	
240.00	11.41	5.78	8.09	5.82				
270.00	11.57	5.65	8.63	5.63				
300.00	12.36	5.37	8.87	5.46				
330.00	12.75	5.22	9.06	5.25				
360.00	12.95	5.05	9.22	5.12	8.94	4.97	5.26	4.63
390.00	13.15	4.92	9.41	4.98				
420.00	13.29	4.81	9.50	4.85				
450.00	13.40	4.68	9.68	4.74				



	BH A		BH B		BH C		BH D	
Time	BH A Drawdown	BH A Recovery	BH B Drawdown	BH B Recovery	BH C Drawdown	BH C Recovery	BH D Drawdown	BH D Recovery
0.10	0.00	15.18	0.00	11.39				
0.50	3.00	11.92	1.34	11.35				
1.00	6.00	8.66	2.67	11.30				
2.00	7.05	7.98	3.05	11.27				
3.00	7.56	7.96	3.33	9.20				
5.00	7.89	7.97	3.74	8.91				
7.00	8.18	7.96	4.02	8.57				
10.00	8.00	7.96	4.18	8.30				
15.00	8.08	7.96	4.34	8.21				
20.00	8.37	7.88	4.60	8.12				
25.00	8.35	7.73	4.75	7.92				
30.00	8.40	7.61	4.92	7.77				
35.00	8.58	7.50	5.15	7.66				
40.00	8.64	7.43	5.50	7.54				
50.00	9.27	7.42	5.74	7.47				
60.00	9.55	7.32	6.02	7.31				
70.00	9.67	7.25	6.22	7.15				
80.00	9.88	7.13	6.37	7.07				
90.00	10.00	6.96	6.53	6.88				
100.00	10.10	6.86	6.71	6.79				
120.00	10.36	6.63	6.98	6.71				
150.00	10.59	6.43	7.44	6.48				
180.00	10.78	6.14	7.70	6.23		6.32		5.82
210.00	11.22	5.97	7.92	6.02	7.53		4.04	
240.00	11.41	5.78	8.09	5.82				
270.00	11.57	5.65	8.63	5.63				
300.00	12.36	5.37	8.87	5.46				
330.00	12.75	5.22	9.06	5.25				
360.00	12.95	5.05	9.22	5.12	8.94	4.97	5.26	4.63
390.00	13.15	4.92	9.41	4.98				
420.00	13.29	4.81	9.50	4.85				
450.00	13.40	4.68	9.68	4.71				
480.00	13.54	4.59	9.80	4.58				
510.00	13.68	4.48	9.93	4.47				
540.00	13.75	4.40	10.03	4.36	9.80	5.01	6.36	4.34
570.00	13.94	4.29	10.12	4.27				
600.00	14.06	4.15	10.31	4.17				
660.00	14.27	4.05	10.50	4.07				
720.00	14.30	3.90	10.55	3.97	10.32	5.05	7.02	3.82
780.00	14.27	3.70	10.64	3.92				
840.00	14.32	3.54	10.71	3.73				
900.00	14.44	3.48	10.82	3.64	10.61	3.68	7.00	3.39
960.00	14.53	3.28	10.92	3.41				
1020.00	14.82	3.16	10.97	3.30				
1080.00	14.60	2.92	11.04	3.19	10.80		7.42	
1140.00	14.76	2.94	11.11	3.09				
1200.00	14.81	2.83	11.17	2.90				
1260.00	14.83	2.73	11.24	2.89	11.00		7.22	
1320.00	14.85	2.70	11.29	2.72				
1380.00	14.87	2.73	11.34	2.62				
1440.00	15.18	2.54	11.39	2.58	11.26	1.51	7.80	2.46

MANAGEMENT RECOMMENDATION SHEET

BOREHOLE No : BH A NCWADI
DATE : 22/08/2002
LOCATION : NCWADI
COORDINATES : 29° 46' 44,6" S 30° 00' 19.1" E

BOREHOLE INFORMATION

Completed Depth (mbgl)	36.00
Diameter (mm)	160
Casing (m)	36.00
Water Strikes (mbgl)	21-24
Static Water Level (mbgl)	4.85
Test Pump Intake (mbgl)	25.00
Available Drawdown (m)	20.15
Airlift Yield (l/hr)	50000
Airlift Yield (l/s)	13.89

STEP TESTS

STEP TESTS	Pump Rates l/s	Pump Rates m^3/hr	Drawdown (m)	Specific Capacity l/s/m	Specific Capacity $m^3/hr/m$	Length of step (min)
Step No 1	6.06	21.82	5.18	1.170	4.212	60
Step No 2	8.34	30.02	2.42	3.446	12.407	60
Step No 3	13.89	50.00	5.73	2.424	8.727	60
Step No 4	18.34	66.02	5.54	3.310	11.918	60
Step No 5						
Step No 6						

Recovery Test	Total DD (mbswl)	Recovery (mbswl)	Recovery Time (min)	Recovery %
	18.87	2.24	270	88

CONSTANT DRAWDOWN TEST

Final Drawdown (mbswl)	Pump Rates l/s	Pump Rates m^3/hr	Duration of DD Test (min)	Specific Capacity l/s/m	Specific Capacity $m^3/hr/m$	Duration of Recovery (min)	Recovery (mbgl)	Recovery %
15.18	11.11	40.00	1440	0.732	2.635	1440	2.54	83

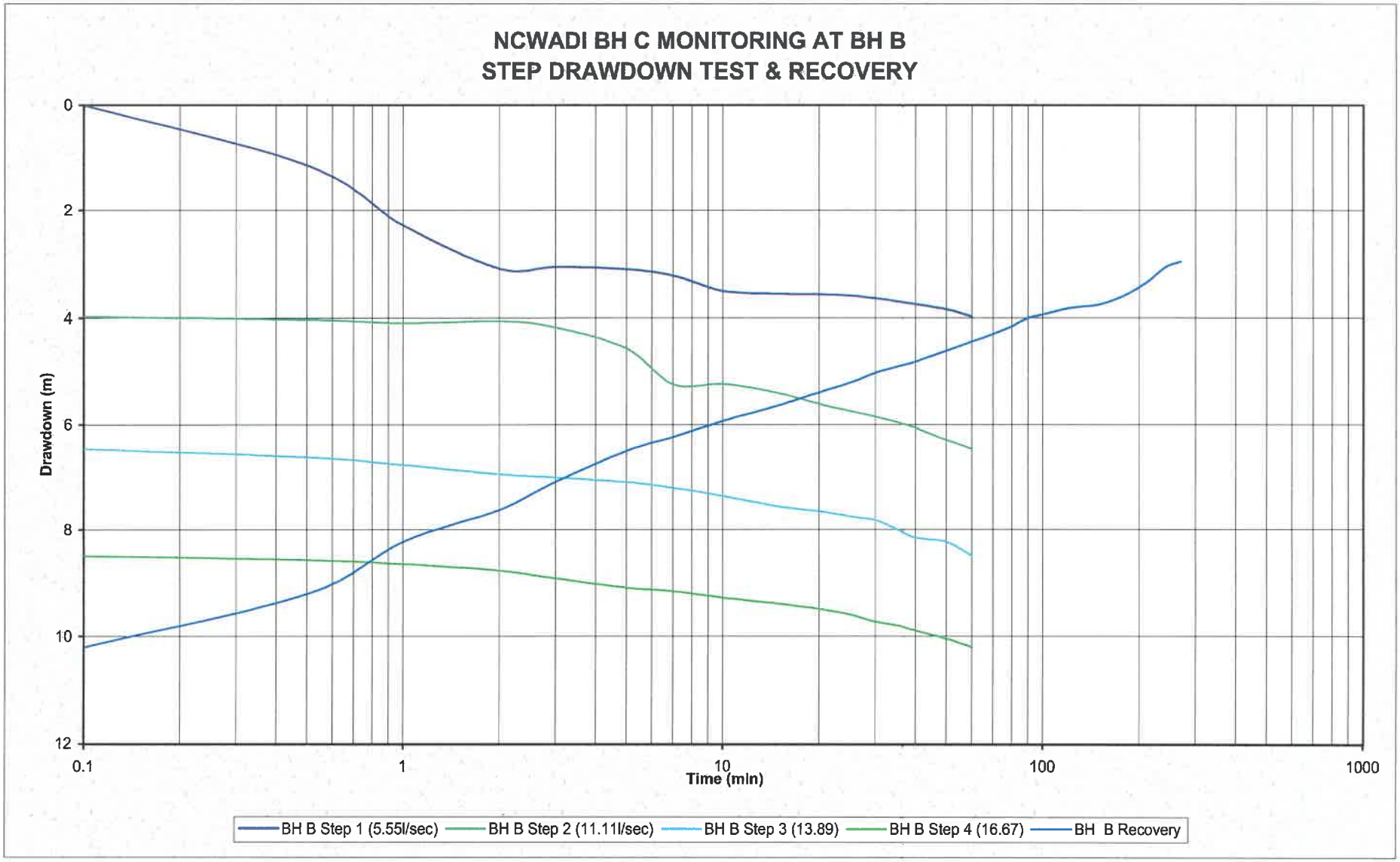
Calculation of Transmissivity Values

Volume Extracted (kl)	$DD\Delta s$	$REC\Delta s$	DD m^2/day	REC m^2/day
959.90	4.94	4.16	35.56	42.23

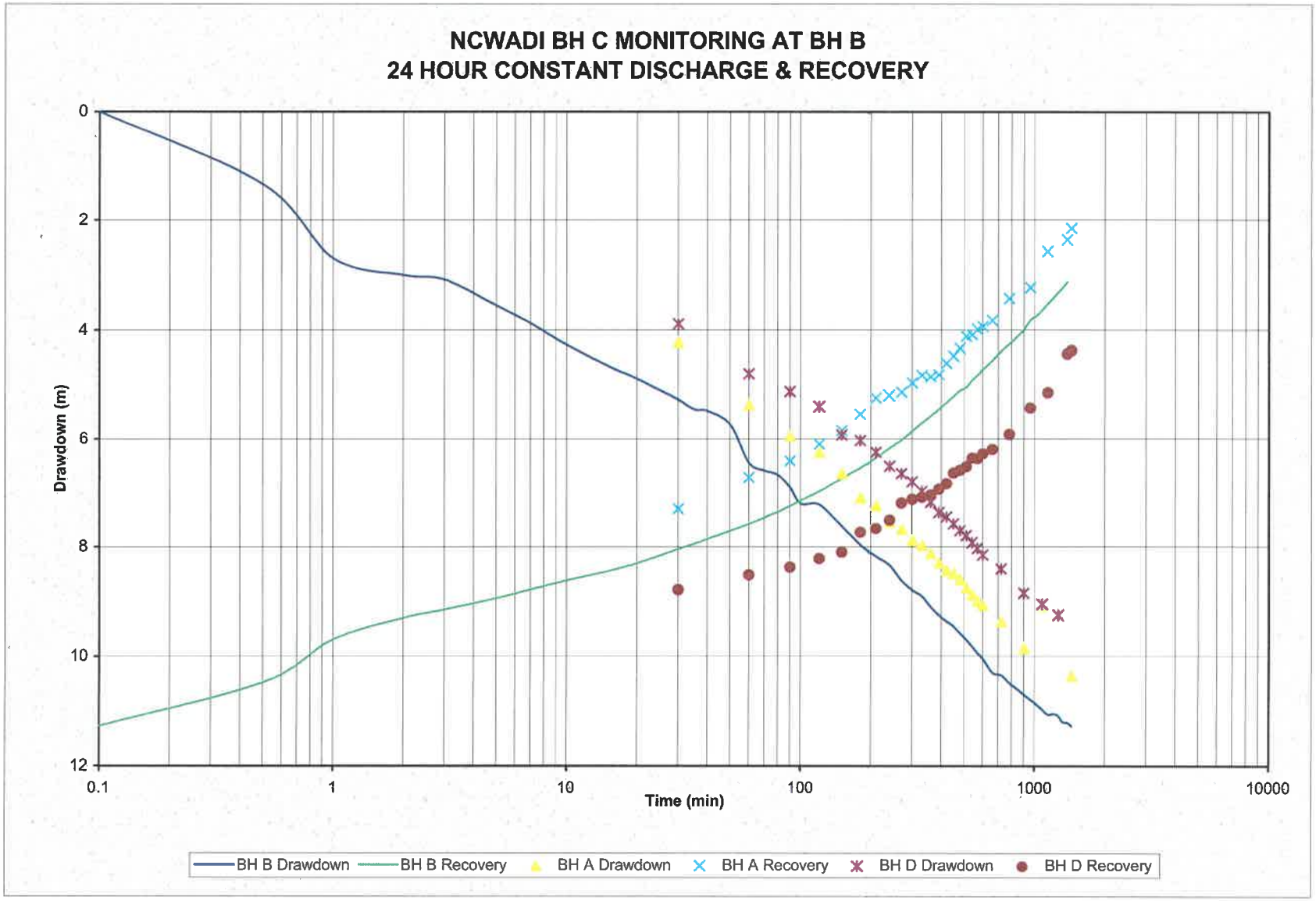
MANAGEMENT RECOMMENDATIONS

Pump Installation (mbgl)	Dynamic Water Level (m)	Rec. Pumping Cycle (hrs/day)	Rec. Pumping Rate on Pump Cycle m^3/hr	l/s	m^3/day
25	18	10	30	8.33	300.00

GEOMEASURE GROUP
Groundwater & Environmental Consultants


NCWADI BH C MONITORING AT BH B
STEP DRAWDOWN TEST & RECOVERY
Drawdown (m)
0
2
4
6
8
10
12
0.1
1
10
100
1000
Time (min)
BH B Step 1 (5.55l/sec)
BH B Step 2 (11.11l/sec)
BH B Step 3 (13.89)
BH B Step 4 (16.67)
BH B Recovery

	BH B				
Time	BH B Step 1 (5.55l/sec)	BH B Step 2 (11.11l/sec)	BH B Step 3 (13.89)	BH B Step 4 (16.67)	BH B Recovery
0.10	0.00	3.98	6.46	8.49	10.20
0.50	1.14	4.04	6.62	8.57	9.21
1.00	2.28	4.10	6.77	8.65	8.22
2.00	3.09	4.06	6.94	8.77	7.62
3.00	3.05	4.18	7.00	8.91	7.08
5.00	3.10	4.57	7.09	9.09	6.50
7.00	3.22	5.24	7.20	9.16	6.23
10.00	3.50	5.23	7.36	9.28	5.93
15.00	3.55	5.41	7.56	9.39	5.63
20.00	3.56	5.61	7.65	9.49	5.39
25.00	3.58	5.75	7.75	9.59	5.21
30.00	3.64	5.85	7.82	9.72	5.02
35.00	3.70	5.96	8.00	9.79	4.91
40.00	3.75	6.06	8.15	9.89	4.81
50.00	3.85	6.29	8.23	10.05	4.61
60.00	3.98	6.46	8.49	10.20	4.44
70.00					4.30
80.00					4.16
90.00					4.00
100.00					3.94
120.00					3.83
150.00					3.76
180.00					3.58
210.00					3.35
240.00					3.07
270.00					2.96


NCWADI BH C MONITORING AT BH B
24 HOUR CONSTANT DISCHARGE & RECOVERY
Drawdown (m)
0
2
4
6
8
10
12
0.1
1
10
100
1000
10000
Time (min)
BH B Drawdown
BH B Recovery
BH A Drawdown
BH A Recovery
BH D Drawdown
BH D Recovery

	BH B		BH A		BH D	
Time	BH B Drawdown	BH B Recovery	BH A Drawdown	BH A Recovery	BH D Drawdown	BH D Recovery
0.10	0.00	11.26				
0.50	1.35	10.48				
1.00	2.69	9.69				
2.00	3.00	9.30				
3.00	3.08	9.15				
5.00	3.55	8.94				
7.00	3.87	8.78				
10.00	4.27	8.62				
15.00	4.65	8.45				
20.00	4.89	8.30				
25.00	5.10	8.16				
30.00	5.27	8.04	4.23	7.30	3.88	8.78
35.00	5.45	7.95				
40.00	5.48	7.86				
50.00	5.74	7.71				
60.00	6.44	7.58	5.37	6.72	4.79	8.51
70.00	6.59	7.46				
80.00	6.67	7.35				
90.00	6.90	7.25	5.95	6.41	5.12	8.37
100.00	7.20	7.15				
120.00	7.22	6.98	6.25	6.10	5.40	8.21
150.00	7.62	6.74	6.64	5.85	5.92	8.09
180.00	7.96	6.54	7.10	5.55	6.02	7.73
210.00	8.17	6.35	7.24	5.25	6.24	7.66
240.00	8.34	6.17	7.55	5.20	6.50	7.50
270.00	8.62	6.02	7.68	5.14	6.64	7.19
300.00	8.79	5.86	7.88	4.97	6.79	7.12
330.00	8.90	5.71	7.97	4.83	6.97	7.08
360.00	9.10	5.58	8.12	4.86	7.17	7.04
390.00	9.25	5.45	8.29	4.82	7.36	6.93
420.00	9.36	5.33	8.43	4.61	7.44	6.83
450.00	9.45	5.22	8.49	4.48	7.57	6.63
480.00	9.58	5.11	8.60	4.34	7.70	6.58
510.00	9.70	5.05	8.75	4.12	7.79	6.51
540.00	9.82	4.92	8.87	4.09	7.92	6.35
570.00	9.94	4.83	8.99	3.99	8.02	6.36
600.00	10.04	4.72	9.07	3.94	8.14	6.27
660.00	10.29	4.56		3.83		6.19
720.00	10.34	4.39	9.36		8.40	
780.00	10.48	4.26		3.43		5.91
840.00	10.59	4.13				
900.00	10.69	3.99	9.85		8.84	
960.00	10.78	3.82		3.23		5.42
1020.00	10.87	3.74				
1080.00	10.96	3.63	9.08		9.05	
1140.00	11.05	3.52		2.57		5.14
1200.00	11.04	3.42				
1260.00	11.07	3.32			9.25	
1320.00	11.19	3.23				
1380.00	11.20	3.13		2.37		4.43
1440.00	11.26	3.07	10.35	2.16		4.37

MANAGEMENT RECOMMENDATION SHEET

BOREHOLE No : BH C NCWADI
LOCATION : NCWADI
DATE : 27/08/2002
COORDINATES : 29° 46' 44.6" S 30° 00' 21.0" E

BOREHOLE INFORMATION

Completed Depth (mbgl)	37.00
Diameter (mm)	160
Casing (m)	36.00
Water Strikes (mbgl)	21-24
Static Water Level (mbgl)	4.93
Test Pump Intake (mbgl)	25.00
Available Drawdown (m)	20.07
Airlift Yield (l/hr)	50000
Airlift Yield (l/s)	13.89

STEP TESTS

	Pump Rates l/s	m^3/hr	Drawdown (m)	Specific Capacity l/s/m	$m^3/hr/m$	Length of step (min)
Step No 1	5.56	20.02	3.98	1.397	5.029	60
Step No 2	11.11	40.00	2.48	4.480	16.127	60
Step No 3	13.89	50.00	2.03	6.842	24.633	60
Step No 4	16.67	60.01	1.71	9.749	35.095	60
Step No 5						
Step No 6						

Recovery Test	Total DD (mbswl)	Recovery (mbswl)	Recovery Time (min)	Recovery %
	10.20	2.28	60	78

CONSTANT DRAWDOWN TEST

Final Drawdown (mbswl)	Pump Rates l/s	m^3/hr	Duration of DD Test (min)	Specific Capacity l/s/m	$m^3/hr/m$	Duration of Recovery (min)	Recovery (mbgl)	Recovery %
11.26	11.11	40.00	1440	0.987	3.552	1440	3.07	73

Calculation of Transmissivity Values

Volume Extracted (kl)	DDΔs	RECΔs	DD m^2/day	REC m^2/day
959.90	3.4576	4.37288	50.81	40.18

MANAGEMENT RECOMMENDATIONS

Pump Installation (mbgl)	Dynamic Water Level (m)	Rec. Pumping Cycle (hrs/day)	Rec. Pumping Rate on Pump Cycle m^3/hr	l/s	m^3/day
25	18	10	30	8.33	300.00

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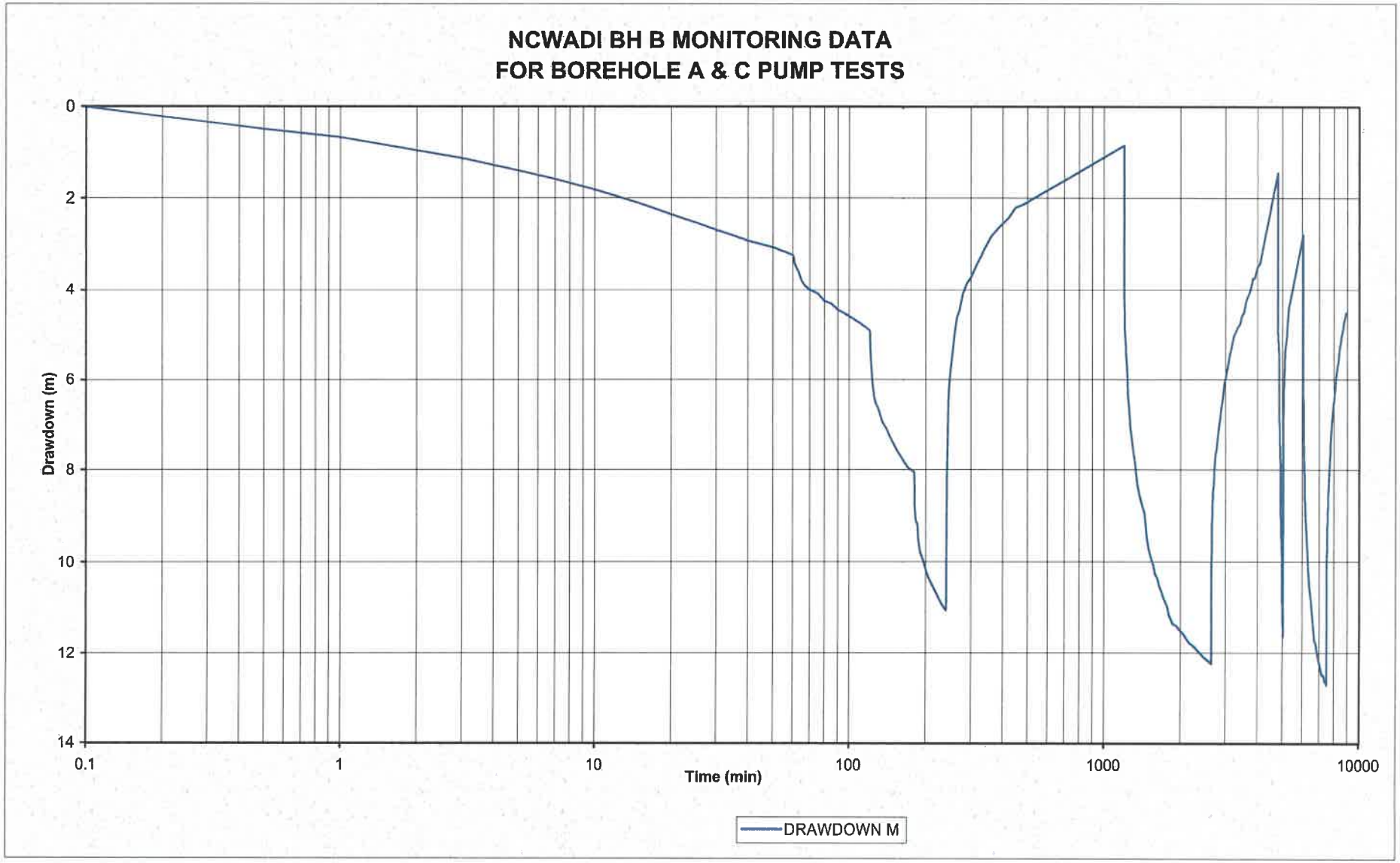
Groundwater & Environmental Consultants

APPENDIX IVc

MONITORING BOREHOLE (BH B)

GEOMEASURE GROUP


NCWADI BH B MONITORING DATA
FOR BOREHOLE A & C PUMP TESTS
Drawdown (m)
0
2
4
6
8
10
12
14
0.1
1
10
100
1000
10000
Time (min)
DRAWDOWN M

APPENDIX V

WATER QUALITY

GEOMEASURE GROUP
Groundwater & Environmental Consultants

CLASSIFICATION SYSTEM FOR ASSESSMENT OF SUITABILITY OF BOREHOLE WATER FOR POTABLE USE (INSTITUTE FOR WATER QUALITY STUDIES, KEMPSTER 1996)

SAMPLE NAME : NCWADI PRODUCTION BOREHOLES

DETERMINANT	CLASS 0	CLASS 1	CLASS 2	CLASS 3	Sample No 2002-1205
pH					7.2
EC mS/m	0 - 70	70 - 150	150 - 370	> 370	29.1
Total Dissolved Solids	0 - 450	450 - 1000	1000 - 2450	> 2450	203.7
Units (mg/l)					
Calcium as Ca	ns	ns	ns	ns	20.9
Magnesium as Mg	0 - 30	30 - 70	70 - 100	> 100	12.1
Chlorides as Cl	0 - 100	100 - 200	200 - 600	> 600	2.93
Sulphates as SO4	0 - 200	200 - 400	400 - 600	> 600	<0.16
Iron as Fe	0 - 0.1	0.1 - 0.2	0.2 - 2.0	> 2.0	0.02
Manganese as Mn	0 - 0.05	0.05 - 0.1	0.1 - 1.0	> 1.0	<0.01
Nitrates as N	0 - 6	6.0 - 10	10 - 20.0	> 20	2.07
Sodium as Na	0 - 100	100 - 200	200 - 400	> 400	10.4
Fluoride as F	0 - 1.0	1.0 - 1.5	1.5 - 3.5	> 3.5	<0
Zinc as Zn	0 - 3.0	3.0 - 5.0	5.0 - 10.0	> 10	
Bacteriological					
Faecal Coliforms /100 ml	0	0 - 1	1.0 - 10	> 10	0

Class 0 & 1 - Suitable for long term domestic use
Class 2 - Suitable for short term domestic use.
Class 3 - Not suitable for domestic use.

ANALYTICAL ANALYSIS IN ACCORDANCE WITH SABS 241 (1999)

REF No: 2001/148

SITE NAME: NCWADI

DETERMINANT	Units	Ideal Limit	Acceptable Limit	Max Allowable Limit	Sample 2002-1205
Appearance		ns	**ns**	ns	Slightly Turbid Colourless
Odour & Taste		ns	**ns**	ns	Very Slightly Solvent
pH		6.0-9.0	**5.0-9.5**	4.0-10	7.2
Colour mg/lPt	°H	15	**20**	50	2
Turbidity	NTU	0.1	**1**	10	**0.72**
Conductivity	mS/m	70	**150**	370	29.1
Total Dissolved Solids	TDS/l	450	**1000**	2400	203.7
MACRO - DETERMINANDS mg/l					
Alkalinity	$CaCo_3$/l	ns	**ns**	ns	107
Total Hardness	$CaCo_3$/l	ns	**ns**	ns	102
Calcium	Ca/l	80	**150**	300	20.9
Magnesium	Mg/l	30	**70**	100	12.1
Sodium	Na/l	100	**200**	400	10.4
Potassium	K/l	25	**50**	100	<1.00
Iron	Fe/l	0.01	**0.2**	2	**0.02**
Manganese	Mn/l	0.05	**0.1**	1	<0.01
Nitrate	N/l	6	**10**	20	2.07
Chloride	Cl/l	100	**200**	600	2.93
Ammonia	N/l	0.2	**1**	2	
Arsenic	As/l	0.01	**0.05**	0.2	
Cadmium	Cd/l	0.003	**0.005**	0.02	
Sulphate	SO4/l	200	**400**	600	<0.16
Zinc	Zn/l	3	**5**	10	
MICRO - DETERMINANDS ug/l					
Fluoride	F/l	700	**1000**	1500	<100
BACTERIOLOGICAL REQUIREMENTS					
Total plate count	per/1ml	100	1000	10000	
Total coliforms	per/100ml	0	10	100	0
Faecal E. Coli	per/100ml	0	1	10	0

Black - Values Within Ideal Limits

Blue - Values Within Acceptable Limits

Orange - Values Within Max Allowable Limits

Red - Values Exceed the Maximum Allowable Limits

APPENDIX VI

RIFU INFORMATION AND COSTS

GEOMEASURE GROUP
Groundwater & Environmental Consultants

UTILITY REMOTE MONITORING

WE CUSTOMISE UTILITY NETWORK SOLUTIONS

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Johannesburg
South Africa

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2030
South Africa

Tel: +27 (11) 476-9339
Fax: +27 (11) 476-2041
e-mail: info@leocell.com

GEOMEASURE GROUP
36 Haraldene Road
Glenwood
4001
South Africa

EP021004
Ref: QU00111
Date: October 18, 2002

For Attention: Rupert Sebire

Dear Rupert

Herewith please find prices for the Remote Intelligent Field Unit utilizing GSM/SMS Communication and Satellite Communication including instrumentation for water level and flow rate measurement.

1) Remote Intelligent Field Unit (RIFU)

Generic RIFU	R 20'088-00 per unit (Satellite Communication)
Generic RIFU	R 9'486-00 per unit (GSM/SMS Communication)

The price given for the RIFU only allows for the unit as manufactured by LEOCell and do not allow for any additional material and equipment.

2) Monthly communication cost per RIFU utilizing Satellite Communication

Data frequency	15 min	30min	1 hour	2 hour	3 hour	6hour	12 hour	24 hour
No of daily messages	96	48	24	12	8	4	2	1
Vistar	R335	R335	R335	R335	R335	R335	R335	R335
GSM (MTN)	R732	R415	R257	R177	R151	R125	R111	R105

A once off connection fee of R105.00 is applicable per GSM/SMS terminal. The connection fee for the Vistar terminal is included in the price.

The monthly communication cost is dependant on the cost structure of the Communication Network Service Provider and at least the following:

- Rate of data reporting
- Number of channels transmitted

3) Instrumentation

STS pressure sensor without build-in lightning protection (Range: Up to 250m Accuracy: 0.5% Output: 1-5V or 4-20mA)	R 5'892-00 per sensor
STS sensor cable	R 56-00 per meter
STS filter	R 68-00 per filter
Gems level sensor (Range: Any range Accuracy: 0.25% F.S. Output: 4-20mA)	R 2'820-00 per sensor
Cable / meter	R 12-00 per meter
Stainless steel strain wire (Recommended for cable lengths longer than 200m)	R 30-00 per meter

Two types of sensors are offered mainly in consideration of costs. There is no comparable data on these sensors regarding their performance. The Department of Water Affairs currently uses the STS level sensor for borehole water level measurement.

LEOCell purchase these sensors from an instrumentation manufacturer and supply it together with the remote monitoring equipment. There is no recommendation from us with regard to which sensor to use.

Since the RIFU interfaces directly with any standard 4-20mA, 0-10V, 0-5V, 1-5V, etc analogue instruments or pulse output instrument, the sensors can be supplied by Geomeasure Services or the end-user should it be preferred.

4) Installation costs and travelling expenses

Installation costs:	R 250 / hour
Travelling time:	R 150 / hour
Travelling:	R 2-80 / km
Accommodation	Where applicable

Note: The contents of this document may be changed by LEOCell on a periodic basis to ensure that the system continuously complies to the highest technical standards and requirements.

Details of the installation and travelling expenses will accompany the invoice at invoice stage.

5) General terms and conditions

- If, for any reason, the rate of SMS transmissions increases to more than what is quoted for, then the costs will be for the clients account.
- Prices and costs given are valid for 30 days from the date of this quote.
- Payment strictly 30 days upon submission of an invoice.
- The sale of any of the LEOCell products is subject to acceptance of the LEOCell Conditions of Sale, which is available on request.
- All prices quoted exclude VAT.

Regards

Etienne Maritz for
LEOCell

Tel: +27 (11) 476 9339
Cell: +27 (82) 783 0530

Note: The contents of this document may be changed by LEOCell on a periodic basis to ensure that the system continuously complies to the highest technical standards and requirements.