PRIMARY INDUSTRIES AND RESOURCES SA

REPORT BOOK 98/1

THE PADDOCKS WETLAND, SALISBURY COUNCIL, AQUIFER STORAGE AND RECOVERY INVESTIGATION

REPORT ON INVESTIGATIONS

by

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DEPARTMENT OF PRIMARY INDUSTRIES
AND RESOURCES SOUTH AUSTRALIA

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THE PADDOCKS WETLAND, SALISBURY COUNCIL, AQUIFER STORAGE AND RECOVERY INVESTIGATION

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Aquifer storage and recovery investigations at this site have been successfully completed. This includes high pressure injection followed by extraction of water with a salinity satisfying that of the intended use. This is the first high pressure injection site which has been implemented in South Australia in a deep confined Tertiary aquifer of low permeability.

Investigation of the upper part of the Tertiary aquifer sequence underlying The Paddocks wetland site in Salisbury Council area (Adelaide, South Australia) indicates that the lower part of the first Tertiary aquifer (aquifer T1B), which has a salinity of 1,860 mg/L at this site, has the potential to store wetland treated storm water for subsequent reuse. Due to the low transmissivity of the aquifer, and high well losses, the experimental injection well was acidised which improved the injection efficiency with mains water by 50%. Even so the injection rate is limited to between 7 and 10 L/s which results in an injection head of ~-70 m during week long injection cycles. This behaviour appears to be repeatable indefinitely with no loss of well efficiency. In 1996 a total of 75 ML was injected followed by a residence period of 97 days. Following this the total injected volume was pumped out at a rate of 15 L/s continuously. The recovery efficiency of this first cycle indicates that 40% was recovered with a salinity similar to that of the injected water, 85% was recovered with a salinity less than 1,000 mg/L (the limit for drinking water), 100% was recovered with a salinity less than 1,300 mg/L (good quality for irrigation). It is estimated that perhaps 120% of the injected volume would have to be pumped to raise the salinity level to that of the original groundwater. This indicates that in this hydrogeological environment the injected water has formed a 'bubble' surrounding the well which has remained relatively stable. Further injection/recovery cycles are expected to result in even better recovery efficiency.

INTRODUCTION

It is estimated that 390,000 ML of storm water/effluent is generated in South Australia annually. Most is discharged, less than 5% being reused. In recent times attitudes have changed and the resource potential of this water is being recognised, particularly in situations where a potable standard is not required.

South Australia currently leads the nation in experimenting and implementing a policy of reuse, particularly for irrigation. This involves aquifer storage and recovery (ASR), a management tool which enables conjunctive surface water and groundwater resource management as an alternative to the traditional management.

ASR has been conducted extensively throughout the world including Australia, where ASR practice is mainly restricted to surface spreading basin recharge to unconfined aquifers. The research and development which has been under way in South Australia over the past few years has been unique in that it has focussed on the injection, storage and recovery of storm water and treated domestic water into shallow unconfined and deep confined aquifer systems. Different aquifer environments have been targeted including fractured rock, Tertiary limestones and Quaternary sands.

1.1 AQUIFER STORAGE AND RECOVERY (ASR) - DEFINITION

Aquifer storage and recovery involves the storage of storm water, treated effluent and potable water by injecting it into aquifers, and its subsequent recovery for beneficial uses such as irrigation, industry or town water supply.

1.2 ASR OBJECTIVES IN SOUTH AUSTRALIA

The major objectives of this technology in South Australia can be summarised as follows:

- Developing ASR technology for use in South Australia and identifying where this technique can be used to enhance the States' water resources by:
  - Establishing the site specific knowledge required to assess the potential for the different types of aquifers to store water for reuse.
  - Examining the potential of using ASR as a management tool to enhance groundwater resources in an area where the resources are under stress.
  - Establishing successful sites in South Australia for the storage and reuse of stormwater and possibly treated wastewater.
- Developing ASR as an integrated surface and groundwater management tool to enhance groundwater resources in an area where resources are under stress using either stormwater or treated waste water.
- Reducing the reliance of urban users on imported (River Murray) water and the associated high infrastructure costs related to storage and distribution. Also reducing the usage of mains water which is treated to drinking water standards for irrigation.
- The restoration of aquifer pressures regionally, the localised reduction in salinity of native groundwater for irrigation and industrial purposes, and creation of low salinity lenses/bubbles within saline aquifers for town water supplies.
- Reducing costs of flood mitigation infrastructure and the outflow of storm waters to the marine environment.
- Reducing the high infrastructure costs associated with mains water supply, especially to country towns, and the development of economically viable alternatives where traditional water supply is impractical or unavailable.
- The reduction in the usage of mains water, treated to drinking water standards, for irrigation.
- Developing strategies for educating state and local government in conjunctive water resource management.

Storm water is the most obvious source of surplus surface water to be stored, but other sources (eg treated effluent) may be considered if they conform to health standards.

1.3 THE PADDOCKS

The Salisbury Council wetland site known as "The Paddocks" (Figure 1) was developed with the long term goal of conjunctive wetland treatment and aquifer storage of storm water. In 1994 Mines and Energy South Australia (MESA) was approached to assist in investigating the potential for ASR at this site. Acknowledgment is given to Mr D Elliot, Mr C Pitman and Mr B Ormsby of Salisbury Council, and to Mr M Brennan of MESA Drilling Services for their support and input into the project.

2. AQUIFER STORAGE AND RECOVERY INVESTIGATION

At The Paddocks site the first Tertiary aquifer (T1B) was selected for investigation for the following reasons:

- An injection well could be completed open hole in aquifer T1B, reducing costs and allowing maximum well efficiency.
- The depth of aquifer T2 would make drilling and well completion costs very much greater than for aquifer T1.

- Shallow sand and gravel aquifers would require screening, adding cost and loss of well efficiency.

2.1 DRILLING

Well 6628-16623 (hereafter referred to as 'this well' or 'the well') was drilled as an exploration/injection/production well and was completed in aquifer T1B in July 1994 (Figure 2). A final standing water level of 9.9 m, a salinity of 1,860 mg/L and an airlift yield of 10 L/s were recorded. Well details are given in Appendix 1, Table 1.

The hydrogeological sequence of interest consists of a Tertiary lime/sandstone occurring between 110 and 169 m. This aquifer is confined by the overlying silty clays.

2.2 PRELIMINARY DISCHARGE TESTING

Step drawdown/injection (well) testing leads to the definition of the well equation (1) for either pumping or injection. This equation allows the calculation of the drawdown/injection head and the associated well loss developed as a result of pumping or injecting into a well at a nominated rate.

$$S = a\,Q + c\,Q^2 + b\,\log_{10}(t)\,Q \qquad (1)$$

where: S = drawdown/injection head (m)
Q = discharge/injection rate (m^3/min)
t = time (minutes)
a,b,c = constants related to head losses (negative for injection)

The well equation may be used to accurately calculate drawdown/injection head for discharge/injection rates less than those of the maximum test rate, and for times less than the test time. The well equation may also be used to predict drawdowns/injection heads for higher rates and longer times.

2.2.1 Step drawdown test 24/7/94

The well was step drawdown tested on 24/7/94, results are plotted in Figure 3. Analysis of the results lead to the well equation.

$$S = 48.81\,Q + 1.22\,Q^2 + 4.76\,\log_{10}(t)\,Q \qquad (2)$$

The well was sampled at this time for a comprehensive set of chemical parameters defined by the Department of Environment and Natural Resources (DENR). The results are given in Appendix 2.

2.3 INJECTION TESTING

2.3.1 Injection test 6/6/95, wetland water

The initial injection trial commenced on 6/6/95 for a period of 1,440 minutes at an injection rate initially starting at 15 L/s using wetland water. Results are plotted in Figure 4.

2.3.2 Injection test 29/9/95, mains water

The well was injection tested on 29/9/95 for a period of 480 minutes at an injection rate of 10.7 L/s using mains water. Results are plotted in Figure 5.

2.3.3 Discussion of pre acidisation injection testing

The injection testing conducted on this well indicated that it was not able to readily accept injection of wetland water, or mains water, developing heads greater than had been expected.

The hydraulic behaviour indicated that:

- Injection with wetland water was 50% as efficient as discharge.
- Injection with mains water was 70% as efficient as discharge.
- Injection with wetland water was 75% as efficient as injection with mains water.

It was apparent that there was a water incompatibility issue. As a result the well was acidised in November 1995 to improve efficiency.

2.4 POST ACIDISATION STEP DRAWDOWN TEST 23/11/95

Following acidisation the well was step drawdown tested on 23/11/95. Results are plotted in Figure 6. Analysis of the results lead to the well equation:

$$S = 35.94\,Q + 1.73\,Q^2 + 4.01\,\log_{10}(t)\,Q \qquad (3)$$

2.4.1 Comparison of pre and post acidisation discharge behaviour

The hydraulic behaviour indicated that the well was 25% more efficient when discharging following acidisation.

2.5 POST ACIDISATION STAGE INJECTION TESTS 28/11/95 - 30/11/95, MAINS WATER

The well was constant injection tested on 28/11/94 and 29/11/94 for periods of 300 minutes at injection rates of 5 and 7.5 L/s respectively. On 30/11/94 the well was constant injection tested for a period of 1,440 minutes at an injection rate of 10 L/s. Results are plotted in Figure 7. Analysis allows the development of well equation for the injecting well as:

$$S = -36.12\,Q - 8.82\,Q^2 - 4.67\,\log_{10}(t)\,Q \qquad (4)$$

2.5.1 Comparison of pre and post acidisation injection behaviour (mains water)

The hydraulic behaviour indicated that:

- The well was ~50% more efficient during injection with mains water following acidisation.
- Injection with mains water was 90% as efficient as discharge following acidisation.

2.6 RECOVERY EFFICIENCY TEST 19/3/96

The total volume of injected water prior to recovery efficiency testing was1.9 ML. The well was recovery efficiency tested on 19/3/96 for a period of 2,880 minutes resulting in the extraction of 2.2 ML. Salinity data is plotted in Figure 8.

- This test followed a residence of 110 days since the mains water injection.
- The initial salinity was 720 mg/L and rose in an almost linear manner to the final value of 1,760 mg/L, still 100 mg/L below the original groundwater salinity.

3. OPERATIONAL INJECTION 1996

Injection headworks were constructed on the site by MESA field staff. During injection the head was continuously monitored by the data logger. Flow rates, salinity of injected water and pressure at surface were manually recorded on a daily basis.

During injection sampling for complex chemistry of the wetland water was undertaken three times to satisfy the monitoring requirement of the Environmental Protection Authority. The results are given in Appendix 3 and indicate that the injection water was of a satisfactory quality.

The well was constant injection tested for 15 cycles between 7/6/96 and 8/10/96. The duration of the cycles varied between 2000 and 17 000 minutes, depending on the availability of water and operational problems. Backflushing was carried out between the cycles at a rate of 15 L/s generally on a weekly basis.

Injection test data is plotted as a continuous series in Figure 9, and in sets of three in Figures 10 to 13. The data logger was damaged some time prior to the commencement of injection cycle 13 commencing on 19/9/96 and as a result the head data has not been included for cycles 13 to 15.

Injection heads increased between the first and fifth cycles up to a level of -73 m. During the following seven cycles injection heads reduced slightly to ~-67 m.

These results may be explained by clogging as a result of precipitation, dissolved gases, temperature and suspended solids and occurred during the first 4 cycles (as indicated in the upward curve at the end of the cycles). Following this the effects of dissolution and backflushing began to increase efficiency. It may be inferred that continued injection cycles may have been sustainable without any further loss of well efficiency. It is possible that if dissolution is occurring that the well efficiency may increase with time

3.1 COMPARISON OF INJECTION BEHAVIOUR (MAINS & WETLAND WATER)

The hydraulic behaviour indicated that injection with wetland water is 60% as efficient as injection with mains water.

4. OPERATIONAL RECOVERY EFFICIENCY JANUARY 1997

This well was recovery tested starting on 14/1/97 for a period of 96,000 minutes resulting in the extraction of 76 ML. Salinity data is plotted in Figure 14.

- This test followed a residence of 97 days since the end of the 1996 injection.
- The recovery efficiency of this first cycle indicated that:
  - 40% was recovered with a salinity similar to that of the injected water (~200 mg/L)
  - 85% was recovered with a salinity less than 1,000 mg/L (the limit for drinking water)
  - 100% was recovered with a salinity less than 1,300 mg/L (good quality for irrigation).
- It is estimated that perhaps 120% of the injected volume would have to be pumped to raise the salinity level to that of the original groundwater.
- Further cycles are expected to result in even greater recovery efficiency.
- A sample analysed for faecal coliforms on 18/2/97 returned a value of 0 faecal coliforms/100 mls. The injection water on 24/7/96 had a value of 38 faecal coliforms/100 mls, although the two following samples on 28/89/96 and 20/9/96 returned a value of 0 faecal coliforms/100 mls.

5. CONCLUSION AND OPERATIONAL RECOMMENDATIONS

Work to date on well 6628-16623 confirms that an irrigation water supply can be injected into aquifer T1B and be stored for subsequent extraction. This is inspite of the high injection heads required for injection at rates between 7 and 10 L/s.

The low transmissivity assists in retarding mixing and movement of water away from the site of the injection well. The recovery efficiency, following the injection of 75 ML and a residence period of 98 days, was excellent resulting in 100% being recovered with a salinity less than 1,300 mg/L (good quality for irrigation).

The following issues are of importance when operating this site.

- Pumping should ideally be restricted so that drawdown does not exceed the top of the aquifer at a depth of 110 m. A maximum long term discharge rate of 15 L/s is recommended.
- The well is sensitive to suspended solids during injection and every effort must be made to ensure that the concentration is kept to a minimum. Due to the efficiency of the wetlands in cleaning the stormwater suspended solids may not be a problem.
- Injection should ideally be restricted so that injection head does not exceed the safe injection head above ground of -110 m, the available injection head is then -120 m (depth to water + safe injection head above ground). A rate of 10 L/s is probably realistic when injecting wetland water, which results in the development of an injection head of ~-70 m.
- The specific capacity value may be used as a measure of when the well should be backflushed. The specific capacity is defined as SC = - [Q/S] (L/s)/m of injection head. From the current data it would be recommended that when the specific capacity value falls below ~0.15 L/s/m of injection head the well should be backflushed.
- Clogging (as a result of precipitation, dissolved gases, temperature and suspended solids) may be dominated by dissolution, which may improve well efficiency with time.

Although limited experience with ASR exists within Australia, South Australia has recently developed the expertise of aquifer injection in various hydrogeological environments. Research and development work undertaken indicates that ASR will be a key conjunctive surface water and groundwater resource management tool in the near future. Well construction is critical to the success of injection, in particular where there are potential water compatibility clogging problems. Wells completed in sedimentary aquifers are more susceptible to clogging than those completed in fractured rock aquifers. Controlled acidisation experiments in carbonate aquifers demonstrate the effectiveness of this method for enhancing well performance.

The results of using ASR in South Australia will be restoration of aquifer pressures, localised reduction in salinity of groundwater where traditionally groundwater was unsuitable for irrigation and the creation of low salinity lenses/bubbles within saline aquifers for town water supply. Consequently infrastructure costs associated with mains water supply will be reduced, and there will be less reliance on imported water.

Fig. 1 *Location of The Paddocks ASR site*

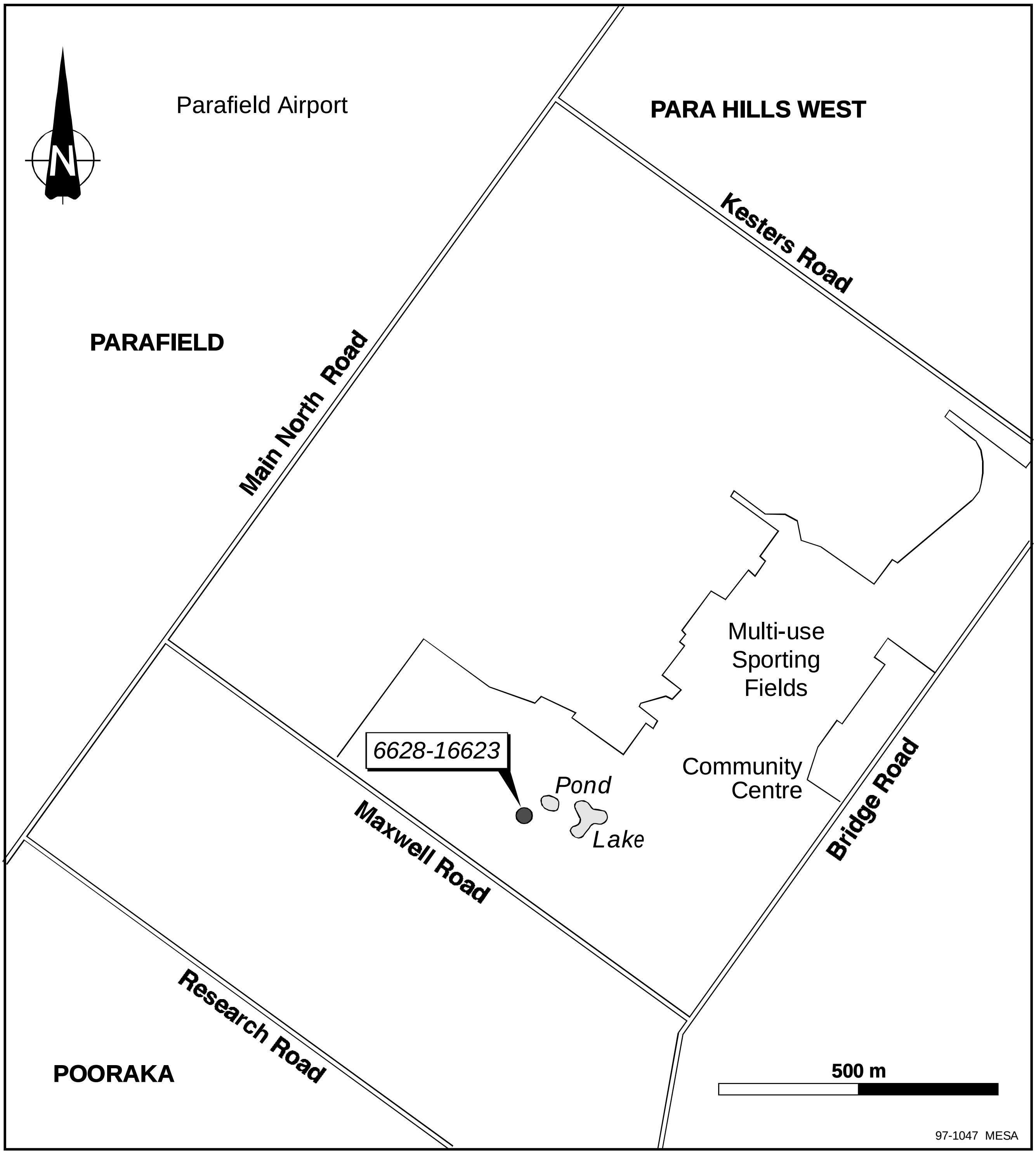


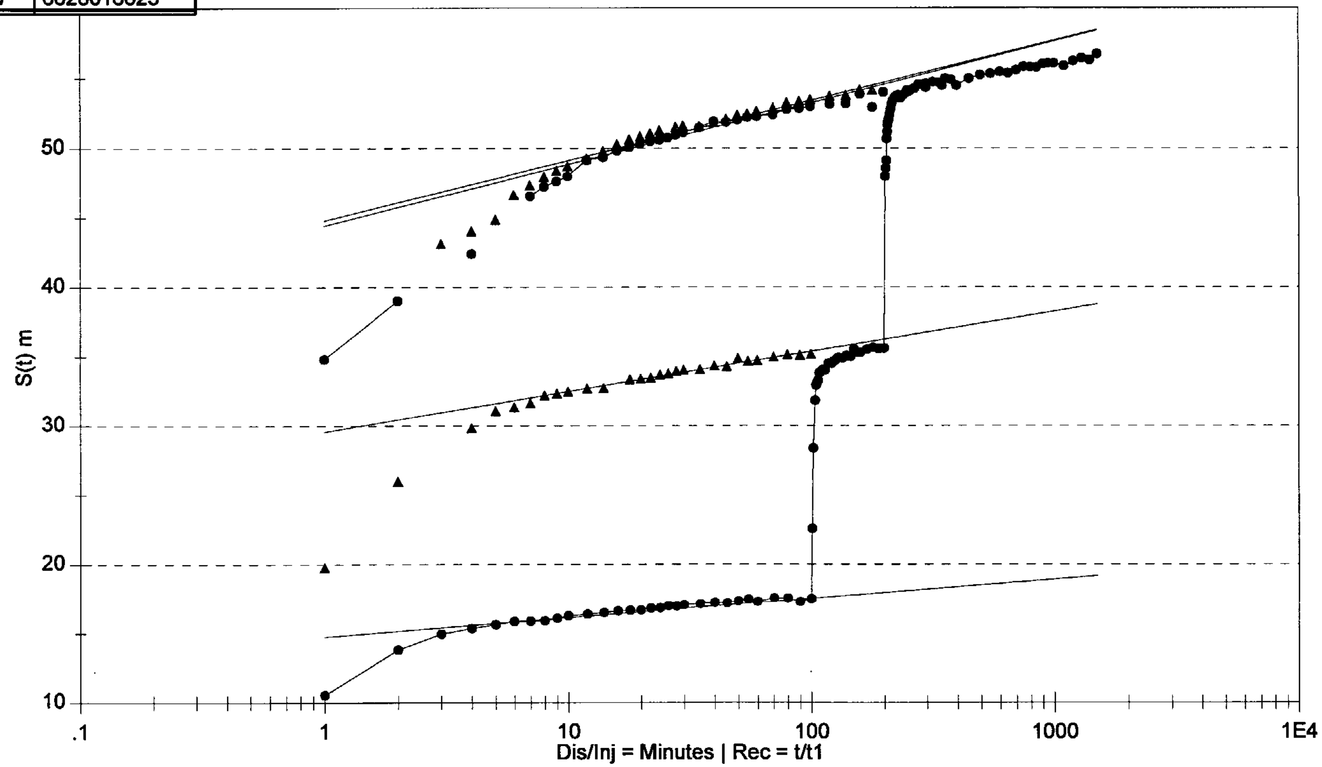
Fig. 2 *Location of The Paddocks ASR well 6628-16623*

INDEXX : 1023 Project : THE PADDOCKS

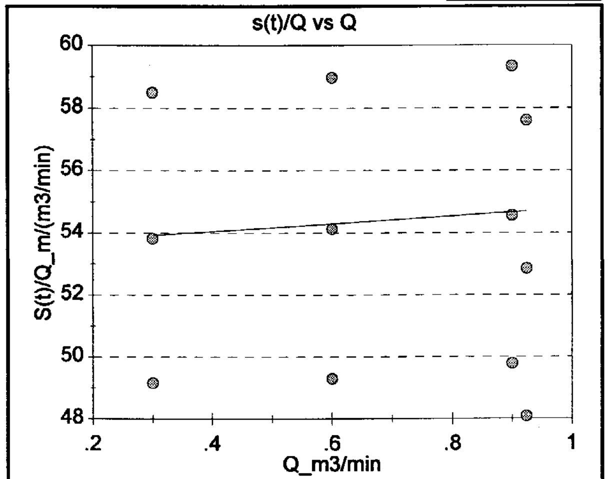
TestType : STEP DRAWDOWN StartDate : 24-07-94 StartTime : 1000

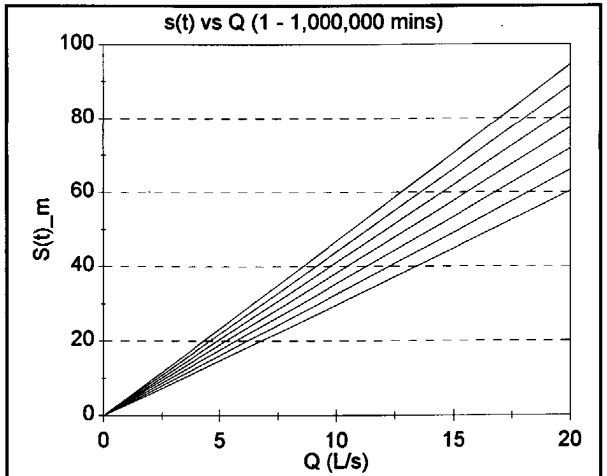
Figure 3

Defn	UnitNo
I/PW	6628016623



S(t) = [a Q + c Q2] + b log(t) Q, where a : 48.81 b : 4.76 c : 1.22





TheStep	Q_L/s	Q_m3/min	Duration_min	St1	St1/Q	St10	St10/Q	St100	St100/Q	dS	dS/Q	T_m2/day
1	5.00	0.30	100	14.75	49.17	16.15	53.83	17.55	58.50	1.40	4.67	56
2	10.00	0.60	100	29.58	49.31	32.48	54.14	35.38	58.97	2.90	4.83	55
3	15.40	0.92	180	44.43	48.09	48.83	52.85	53.23	57.61	4.40	4.76	55
main1	15.00	0.90	1500	44.81	49.79	49.11	54.57	53.41	59.34	4.30	4.78	55

NOTES : Aquifer/well test,Open hole 134 - 164 m,
Pre-acidisation.

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

INDEXX : 1025 Project : THE PADDOCKS

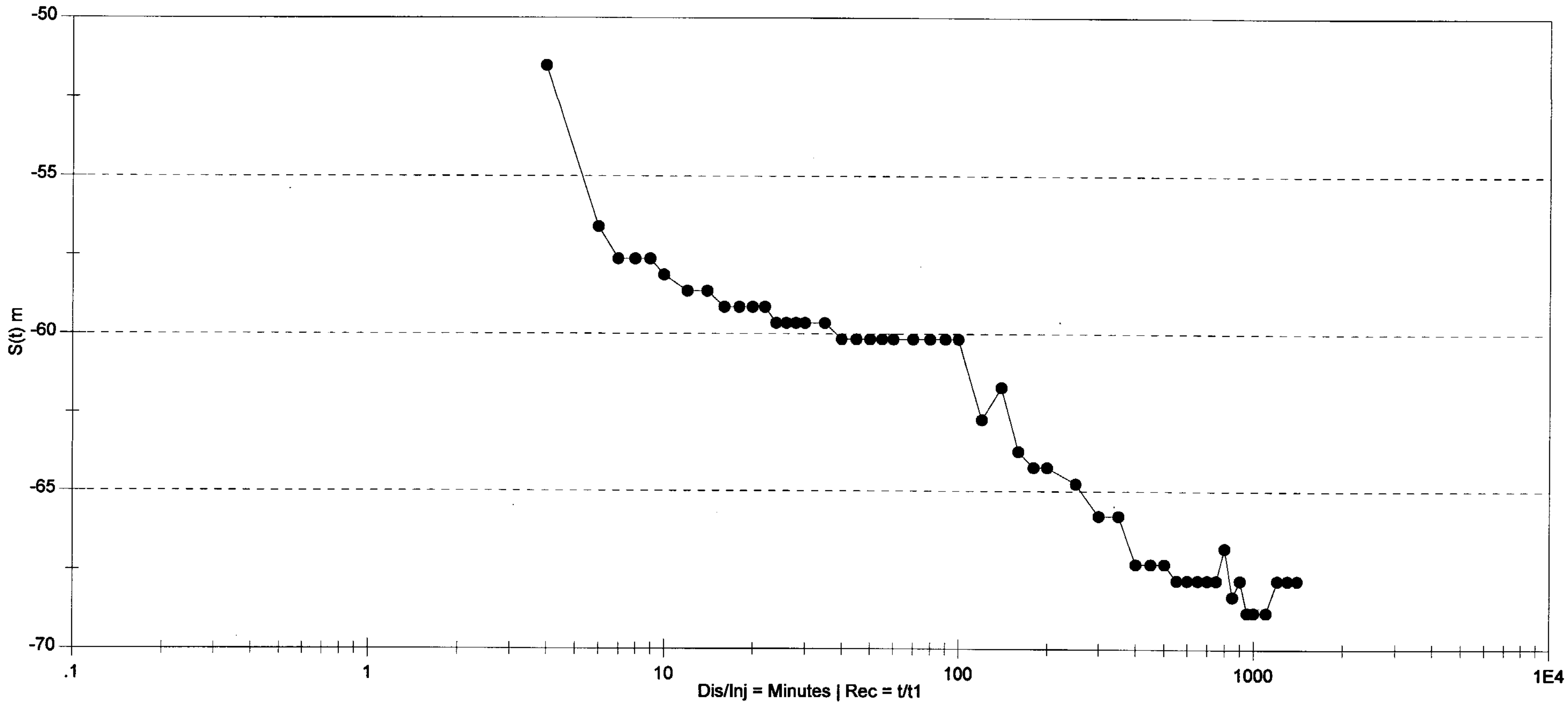
Figure 4

TestType : INJECTION

StartDate : 06-06-95 StartTime : 1040

Defn	UnitNo
I/PW	6628016623

TheStep	Q_L/s	Q_m3/min	RateNote	Duration_min	dS	T_m2/day
1			15 - 4.2	1440	-0.10	



NOTES : Injection from wetland. A constant injection rate was unable to be maintained due to the type of pump used.

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

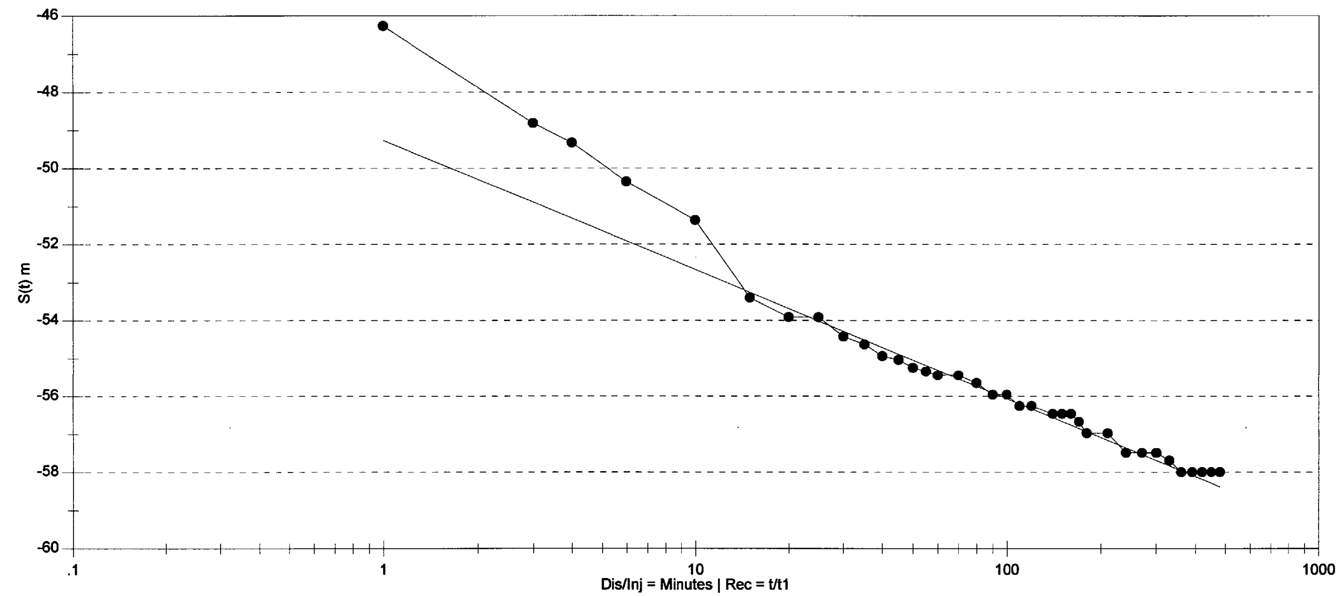
INDEXX : 1043 Project : THE PADDOCKS

Figure 5

TestType : INJECTION StartDate : 29-09-95 StartTime : 0940

Defn	UnitNo
I/PW	6628016623

TheStep	Q_L/s	Q_m3/min	RateNote	Duration_min	dS	T_m2/day
1	10.70	0.64		480	-3.40	50



NOTES : Injection from mains.

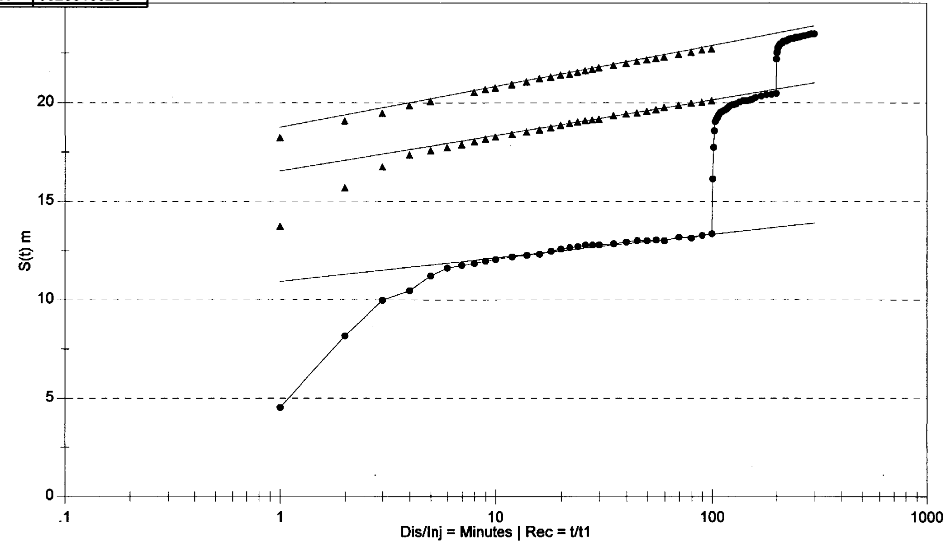
MINES and ENERGY RESOURCES SOUTH AUSTRALIA

INDEXX : 1051 Project : THE PADDOCKS

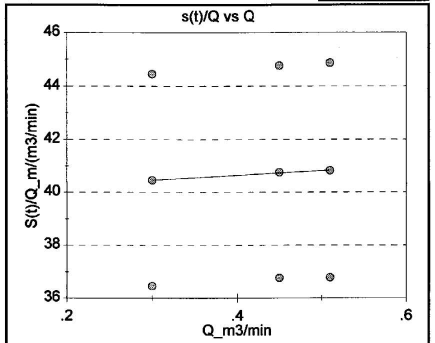
TestType : STEP DRAWDOWN StartDate : 23-11-95 StartTime : 1100

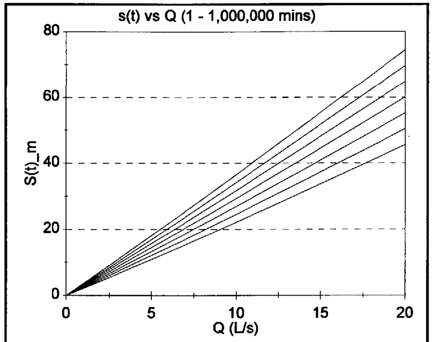
Figure 6

Defn	UnitNo
I/PW	6628016623



S(t) = [a Q + c Q2] + b log(t) Q, where a : 35.94 b : 4.01 c : 1.73





TheStep	Q_L/s	Q_m3/min	Duration_min	St1	St1/Q	St10	St10/Q	St100	St100/Q	dS	dS/Q	T_m2/day
1	5.00	0.30	100	10.94	36.47	12.14	40.47	13.34	44.47	1.20	4.00	66
2	7.50	0.45	100	16.55	36.77	18.35	40.77	20.15	44.77	1.80	4.00	66
3	8.50	0.51	100	18.76	36.79	20.82	40.83	22.88	44.87	2.06	4.04	65

NOTES : Aquifer/well test,Open hole 134 - 164 m,
Post-acidisation.

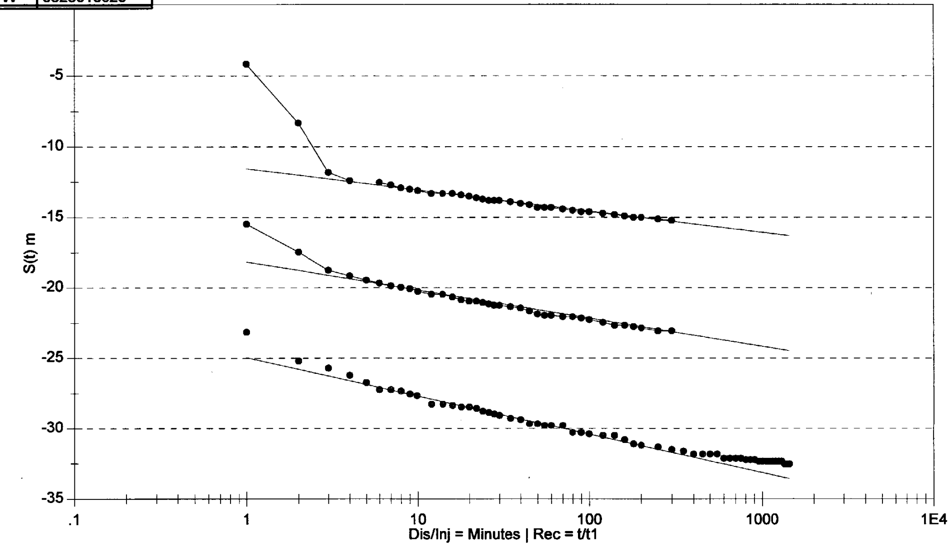
MINES and ENERGY RESOURCES SOUTH AUSTRALIA

INDEXX : 1053 Project : THE PADDOCKS

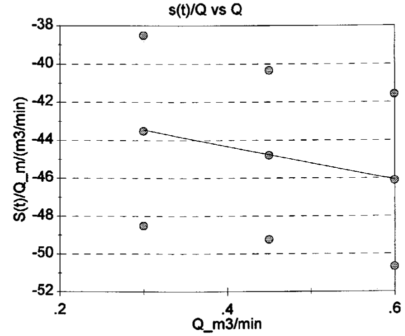
TestType : INJECTION StartDate : 28-11-95 StartTime : 1100

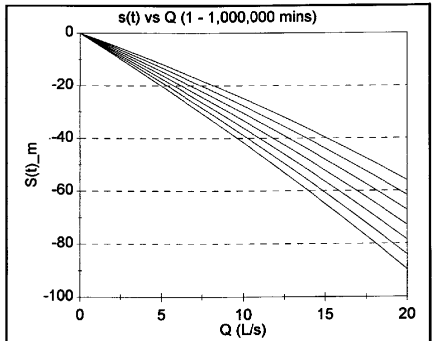
Figure 7

Defn	UnitNo
I/PW	6628016623



$S(t) = [a Q + c Q2] + b \log(t) Q$, where a : -36.12 b : -4.67 c : -8.82





TheStep	Q_L/s	Q_m3/min	Duration_min	St1	St1/Q	St10	St10/Q	St100	St100/Q	dS	dS/Q	T_m2/day
1	5.00	0.30	300	-11.55	-38.50	-13.05	-43.50	-14.55	-48.50	-1.50	-5.00	53
main1	7.50	0.45	300	-18.15	-40.33	-20.15	-44.78	-22.15	-49.22	-2.00	-4.44	59
main2	10.00	0.60	1440	-24.94	-41.57	-27.67	-46.12	-30.40	-50.67	-2.73	-4.55	58

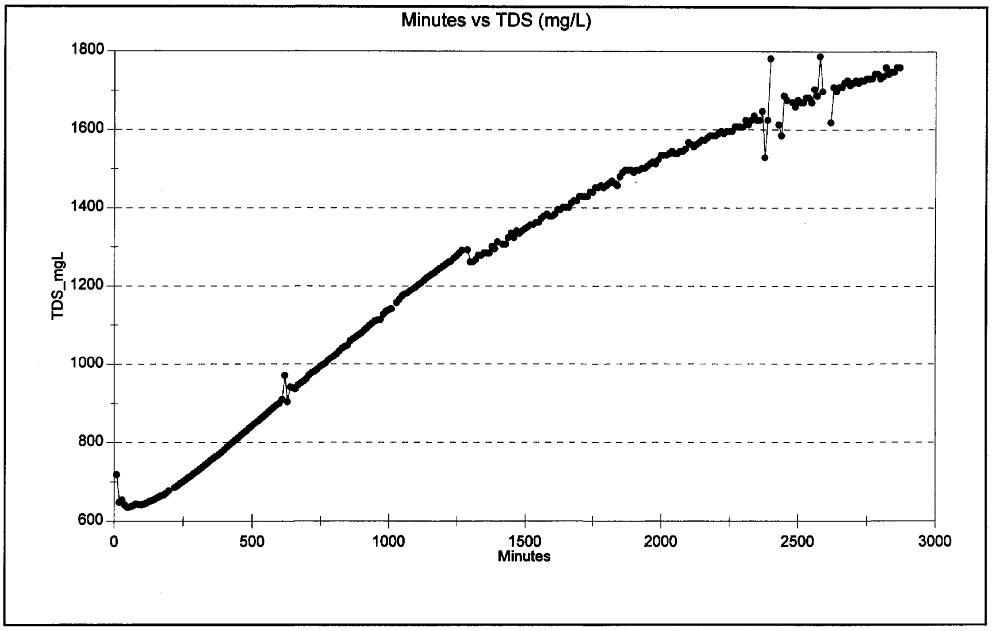
NOTES : Injection from mains.

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

INDEXX : 1065 Project : THE PADDOCKS
StartDate : 19-03-96
StartTime : 1435
TestType : RECOVERY EFFICIENCY
Volume_ML : 2.2

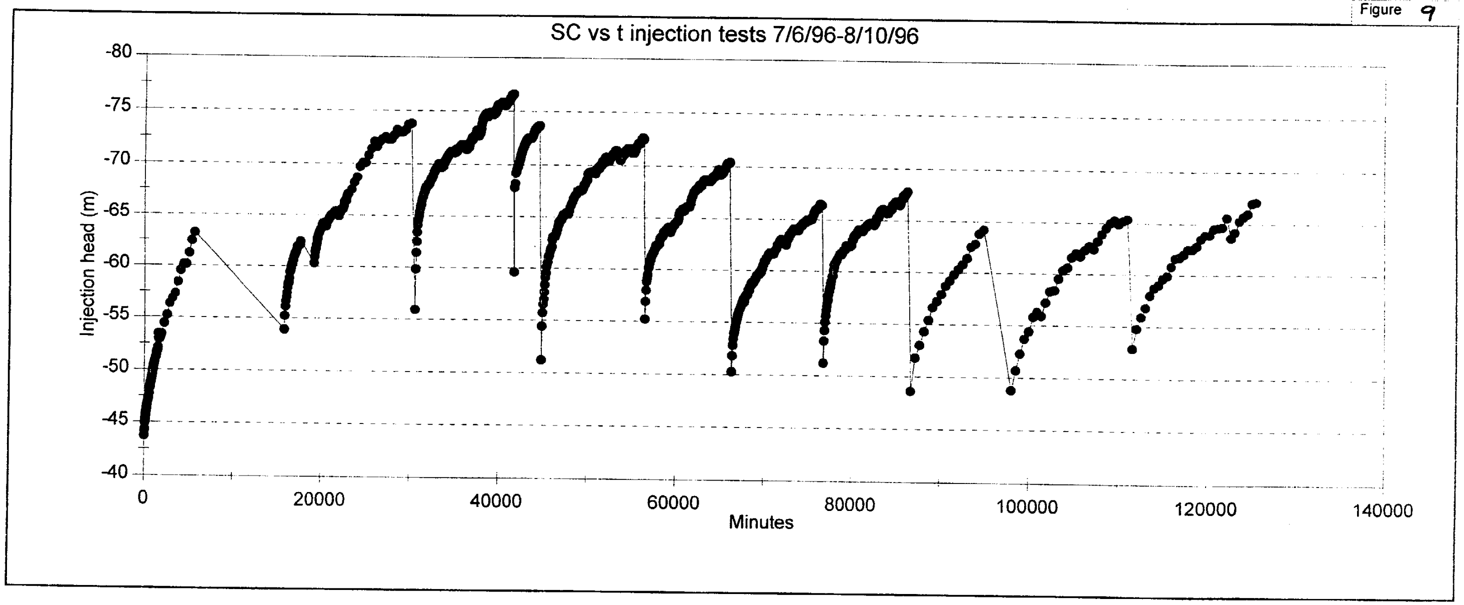
Notes : 24 hour discharge test for salinity monitoring. Residence of 110 days.

Figure 8



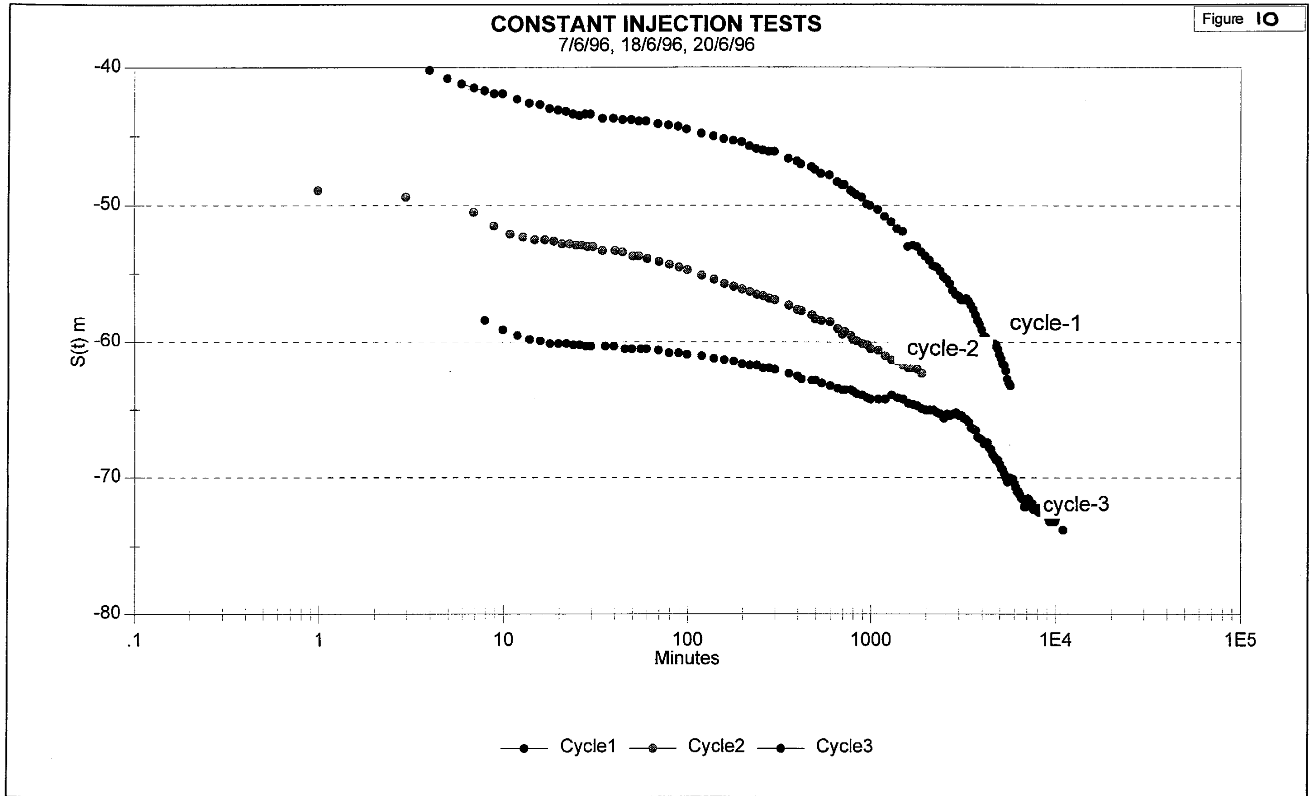
MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Figure 9



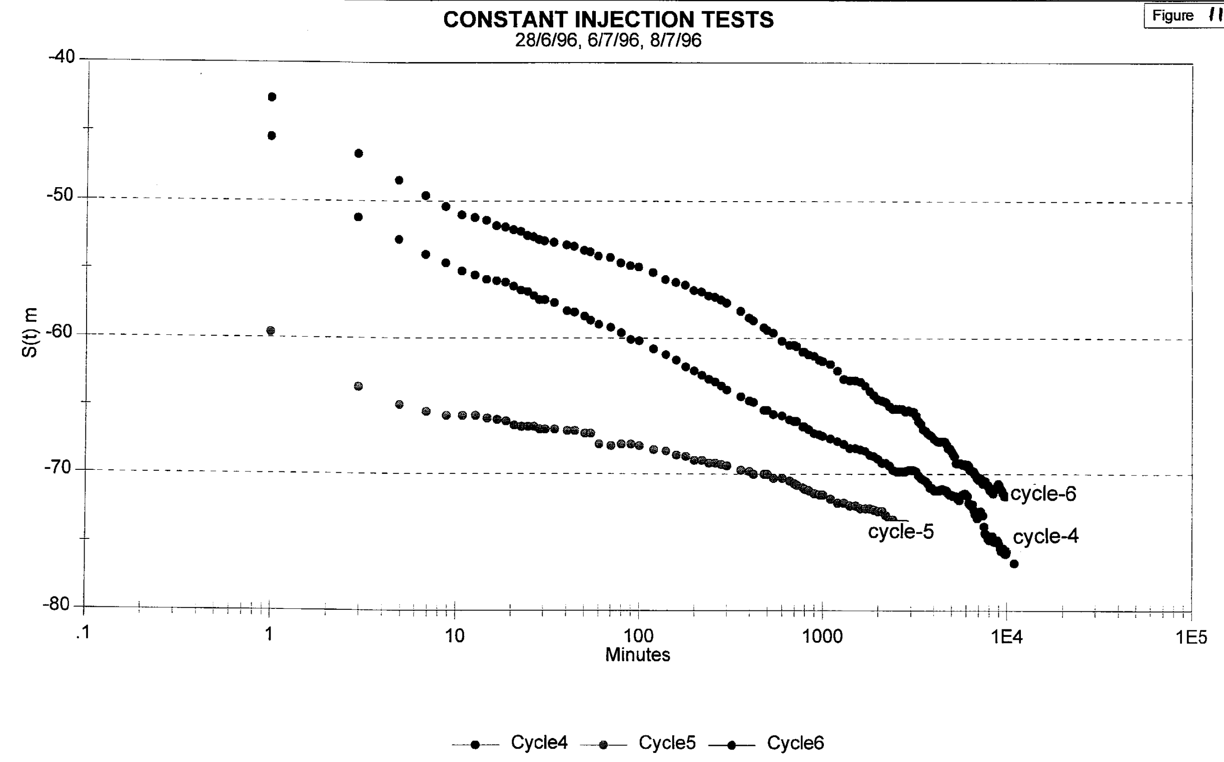
MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Figure 10



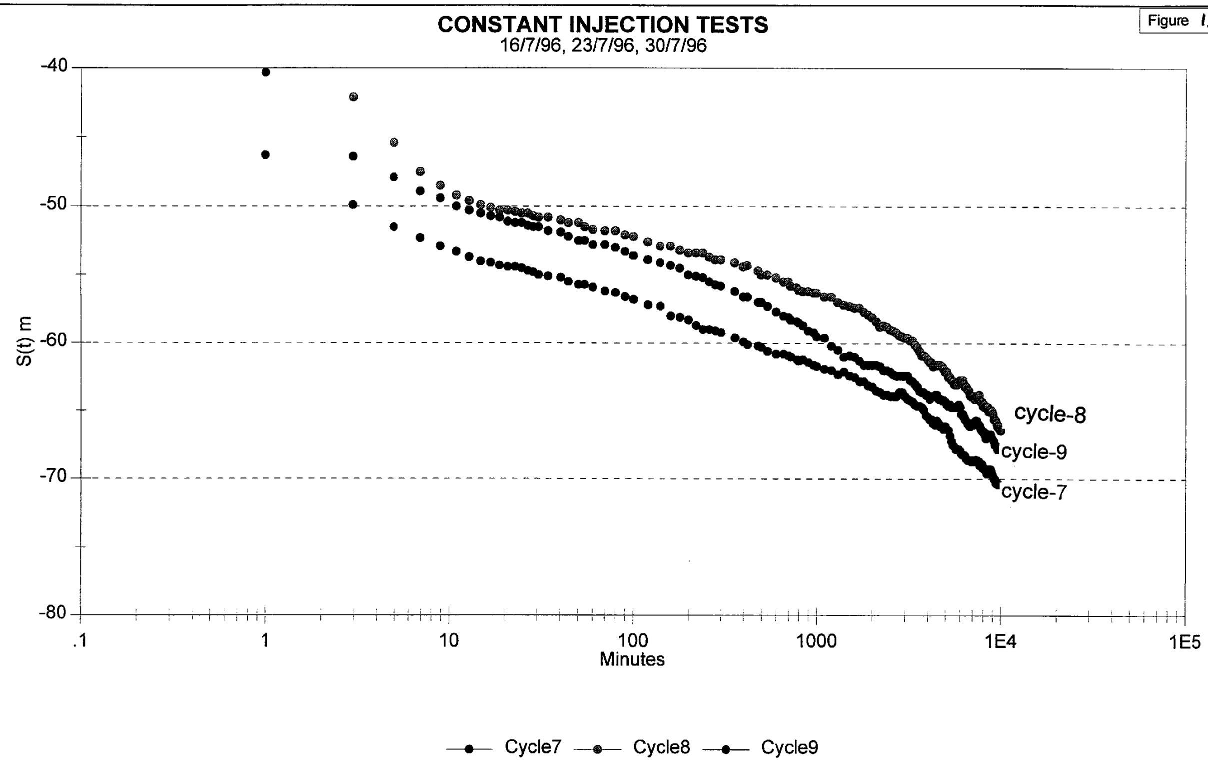
MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Figure 11

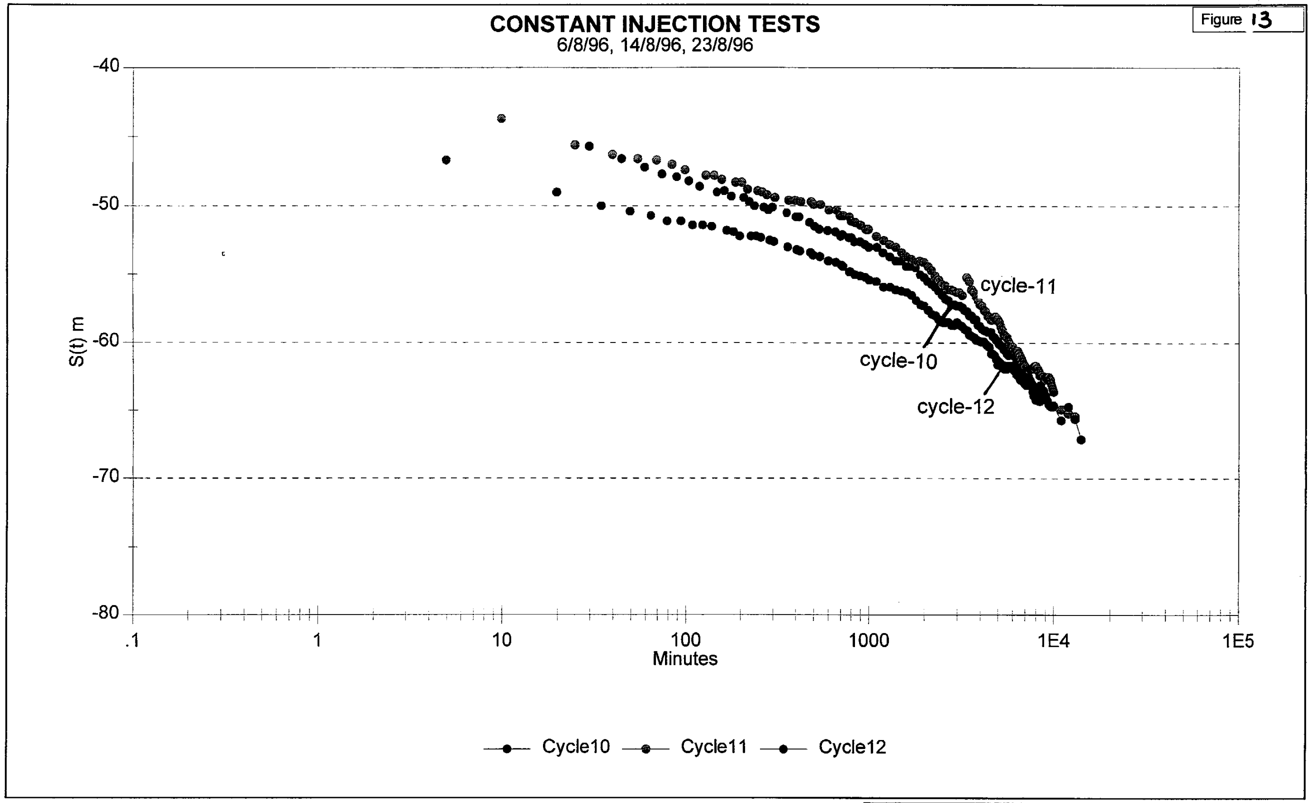


MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Figure 12



MINES and ENERGY RESOURCES SOUTH AUSTRALIA



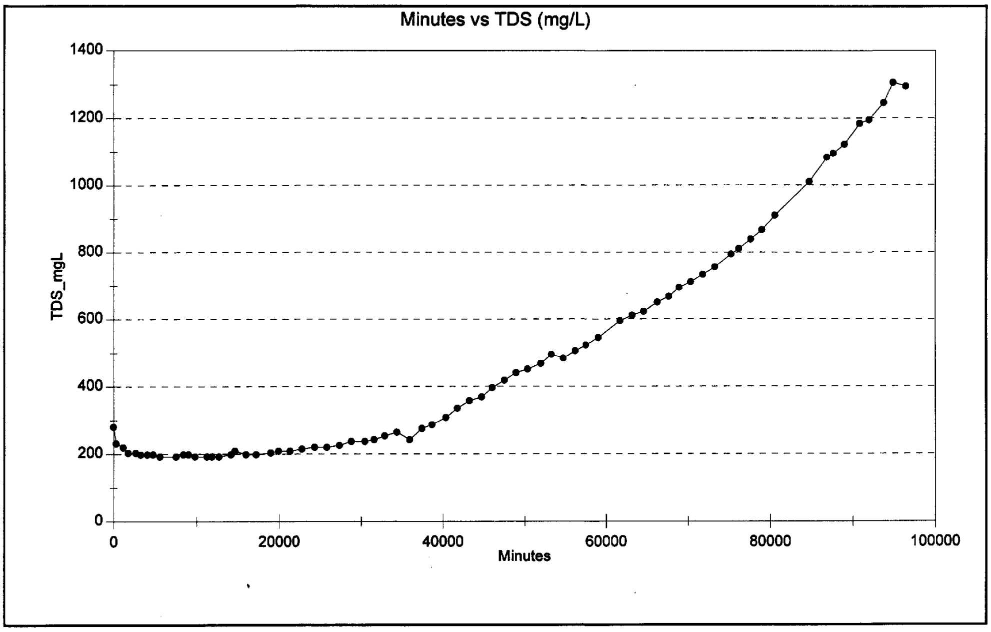
MINES and ENERGY RESOURCES SOUTH AUSTRALIA

INDEXX : 1097 Project : THE PADDOCKS
StartDate : 14-01-97
StartTime : 1045
TestType : RECOVERY EFFICIENCY
Volume_ML : 76.0

Notes : Discharge following injection of 75 ML and residence period of 98 days. NOTE: probe damages and water level data not considered to be accurate.

Recovery efficiency of 76 ML: wrt injected water ~ 40%; wrt drinking water (1,800 EC) ~ 90%; wrt irrigation water (3,000 EC) ~ 100%+.

Figure 14



MINES and ENERGY RESOURCES SOUTH AUSTRALIA

APPENDIX 1 - WELL COMPLETION DETAILS

WELL CONSTRUCTION,HYDROGEOLOGY,LOG DATA

UnitNo : 6628016623	NOTES : Injection well	Completion : 07-07-94	GrndElev_m :
ObsNo :	DrilMeth : Rotary mud	TotalDepth_m : 180.00	AQMon : T1
Permit : 31783		PlugBackDepth_m : 164.00	Well_SWL_m : 9.90
Hundred : YATALA	DevMeth : Airlift from 63 m for 3 hrs until, clean.	Backfilled :	Well_AirliftYield_L/s : 10.0
Section : 3018			Well_EC_uS/cm : 3350
Project : THE PADDOCKS			Well_TDS_mg/L: 1861

Parameter	From_m	To_m	Diameter_mm
FRP CASING	0.00	134.00	201
PRESSURE CEMENT	0.00	134.00	
OPEN HOLE	134.00	164.00	280
CEMENT PLUG	164.00	180.00	

Top_m	Bot_m	Material	Material_Desc	Formation	Age
0.00	6.00	SANDY CLAY	Orange - grey.		
6.00	18.00	SILTY CLAY	Mottled cream - grey,minor pink - orange; minor fine sand component; stiff.		
18.00	21.00	SAND/GRAVEL	Sand and gravel to 2 mm.		
21.00	66.00	SILTY CLAY	Mottled cream - grey,minor pink - orange; minor fine sand component; stiff.		
66.00	78.00	CLAYEY SAND	Cream; fine 0.1 mm,clear Qtz (coarser to 1 mm at base|); sticky.		
78.00	87.00	CLAYEY SAND	Black; to 5 mm at top-grading to coarse (1-2mm), predominantly clear & opaque Qtz,minor black clay.		
87.00	108.00	SAND	Brown; coarse average 1 mm,Qtz,minor clay.		
108.00	110.00	SILTY CLAY	Black		
110.00	114.00	SILTY LIMESTONE	Grey		
114.00	126.00	SHELLS			
126.00	169.00	LIMESTONE	Green - grey; silty - fine sandy limestone interbedded with fine sandy limestone; hard. (+shells).		
169.00	171.00	CLAY	Grey - black.		
171.00	180.00	LIMESTONE	Green grey - yellow; silty fine sandy limestone with interbeds of fine sandy limestone; hard; minor clay interbeds.		

APPENDIX 2 - GROUNDWATER CHEMISTRY

MPL LABORATORIES

A division of Cryston Holdings Pty. Ltd. A.C.N. 009 446 575

CERTIFICATE OF ANALYSIS

CLIENT :Department of Mines & Energy
CONTACT :Kevin Dennis

JOB NO	: SA560
DATE RECEIVED	: 04/08/94
CLIENT ORDER	: n/a

TEST DETAILS: Test details as per relevant Australian Standards (1095.4.1.5 - Total Coliforms and 1095.4.1.6 - Faecal coliforms) and APHA 18th Edition, 1992 (Standard Plate Count).

M NO : M001
SAMPLE ID : W3814/94 Well Permit 31783
03/08/94 0815

ANALYSIS / TEST METHOD	RESULT
Standard Plate Count 35C/48 hours	140 cfu/mL
Standard Plate Count 22C/72 hours	180 cfu/mL
Total coliforms	0 cfu/100mL
Faecal coliforms	0 cfu/100mL

NOTE: Recommended maximums based on NHMRC & AWRC "Guidelines for drinking water quality in Australia (1987)
Standard plate count should not exceed 100 cfu/ml in treated samples.
Total coliforms <10 cfu/100 ml.
95% of scheduled samples should not contain any coliform organisms in 100 ml.

Approved
08/08/94

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P.O.Box 151
Cowandilla
SA 5033

DEPT.MINES&ENER
SA 560
22 August 1994

CERTIFICATE OF ANALYSIS

Sample: 1A

Analyte	Result	Units	Method	Ref: 02352.001
Conductivity	3.4	mS/cm	APHA 2510.B	
pH	7.3		APHA 4500-H.B	
Dissolved_O2	5.6	mg/L	APHA 5210.B	
Ca	86.	mg/L	APHA 3110;3111.A,B,D	
Mg	68.	mg/L	APHA 3110;3111.A,B,D	
Na	610.	mg/L	APHA 3110;3111.A,B,D	
K	19.	mg/L	APHA 3110;3111.A,B,D	
HCO3	525.	mg/L	APHA 2320.B	
SO4	230.	mg/L	SO4_Turbidity	
Cl	700.	mg/L	APHA 4500-Cl.B	
F	0.6	mg/L	4500-F.C	

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22 August 1994

CERTIFICATE OF ANALYSIS

Sample: 2A

Analyte	Result	Units	Method	Ref: 02352.002
Turbidity	13.	NTU	Spectrophotometric	
TSS	5.	mg/L		

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22 August 1994

CERTIFICATE OF ANALYSIS

Sample: 4A

Analyte	Result	Units	Method	Ref: 02352.003
NH3	<0.5	mg/L	SKALAR	
N_TKN	<0.5	mg/L	APHA 4500-N.B; 4500-NH3.B	
NO3	<0.2	mg/L	SKALAR	
P_TOTAL	0.05	mg/L	APHA 18th Ed.,4500-P	
P_PO4	<0.01	mg/L	APHA 4500-P.E	

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CERTIFICATE OF ANALYSIS

Sample: 5A

Analyte	Result	Units	Method	Ref: 02352.004
Fe	0.5	mg/L	APHA 3110;3111.A,B,D	
Pb	<0.05	mg/L	APHA 3110;3111.A,B,D	
Zn	0.01	mg/L	APHA 3110;3111.A,B,D	
Cu	0.03	mg/L	APHA 3110;3111.A,B,D	
Cr	<0.05	mg/L	APHA 3110;3111.A,B,D	
Mn	0.03	mg/L	APHA 3110;3111.A,B,D	
Cd	<0.05	mg/L	APHA 3110;3111.A,B,D	
Ni	<0.05	mg/L	APHA 3110;3111.A,B,D	
As	0.02	mg/L	APHA 3112.B;3114.B	
B	1.1	mg/L	ASTM D4190, APHA 3111B.	

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SA 560
22 August 1994

CERTIFICATE OF ANALYSIS

Sample: 6A

Analyte	Result	Units	Method	Ref: 02352.005
FOC	<0.1	mg/L		
OP_Pesticides *	<0.005	mg/L	GCMS_M1	
OC_Pesticides #	<0.005	mg/L	GCMS_M1	

* OP Pesticides/Triazine were not detected.
OC Pesticides were not detected. #

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DEPT.MINES&ENER
SA 560
22 August 1994

CERTIFICATE OF ANALYSIS

Sample: 7A

Analyte		Result	Units	Method	Ref: 02352.006
TPH	+	<0.1	mg/L	GCMS_M2	

+ Benzene, toluene, ethylbenzene and xylenes were not detected.

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APPENDIX 3 - WETLAND WATER CHEMISTRY

AUSTRALIAN WATER
QUALITY CENTRE

Our Ref	AWQC 187
Enquiries	A Glatz
Telephone	8259 0243

11 November 1996

Mines & Energy SA
Attention : Mr S Howles
PO Box 151
EASTWOOD 5063

Dear Sir

Enclosed are copies of reports forwarded previously by facsimile by Mr T Thompson on 8 November 1996.

Once again, my apologies that results had not been forwarded sooner.

Yours faithfully

A GLATZ
SENIOR CHEMIST INORGANIC CHEMISTRY
AG:GPK

HODGSON ROAD, BOLIVAR, SOUTH AUSTRALIA
POSTAL ADDRESS: PRIVATE MAIL BAG 3, SALISBURY SA 5108
TELEPHONE (08) 259 0211 FACSIMILE (08) 259 0228
E-MAIL: awqc@sawater.sa.gov.au
A BUSINESS UNIT OF THE SOUTH AUSTRALIAN WATER CORPORATION

CHEMICAL ANALYSIS REPORT

REFERENCES :- 06 96 04092 07 96 05858 05 96 04041 04 96 09163

LOCATION 8080 THE PADDOCKS, WELL NO 6628-16623 - MESA — Injection water from Lake
SAMPLE COLLECTED 24/07/96 10:46 RECEIVED 24/07/96

GENERAL DATA		
pH	7.9	pH UNITS
CONDUCTIVITY	214	us/cm
TOTAL DISSOLVED SOLIDS (BY EC)	120	mg/L
TURBIDITY	21	NTU
ANIONS		
FLUORIDE	0.09	mg/L
NUTRIENTS		
AMMONIA AS N	0.027	mg/L
TKN AS NITROGEN	0.31	mg/L
NITRATE + NITRITE AS N	0.080	mg/L
FILT. REACTIVE PHOSPHORUS AS P	0.006	mg/L
PHOSPHORUS - TOTAL AS P	0.032	mg/L
METALS		
ARSENIC - INORGANIC	0.002	mg/L
ARSENIC - SOLUBLE INORGANIC	0.002	mg/L
BORON	0.093	mg/L
CADMIUM - TOTAL	0.0002	mg/L
CADMIUM - SOLUBLE	<0.0002	mg/L
CHROMIUM - TOTAL	0.005	mg/L
CHROMIUM - SOLUBLE	<0.005	mg/L
COPPER - TOTAL	0.011	mg/L
COPPER - SOLUBLE	0.005	mg/L
IRON - TOTAL	0.620	mg/L
IRON - SOLUBLE	0.055	mg/L
LEAD - TOTAL	0.007	mg/L
LEAD - SOLUBLE	0.002	mg/L
MANGANESE - TOTAL	0.010	mg/L
MANGANESE - SOLUBLE	<0.005	mg/L
MERCURY - TOTAL	<0.0001	mg/L
MERCURY - SOLUBLE	<0.0001	mg/L
NICKEL - TOTAL	0.001	mg/L
NICKEL - SOLUBLE	0.001	mg/L
ZINC - TOTAL	0.644	mg/L
ZINC - SOLUBLE	0.467	mg/L
OTHER TESTS		
SUSPENDED SOLIDS	9	mg/L
TOTAL INSECTICIDES	NOT DETEC	ug/L
TOTAL HERBICIDES	NOT DETEC	ug/L

SENIOR CHEMIST

C H E M I C A L A N A L Y S I S R E P O R T

REFERENCES :- 06 96 04827 07 96 06854 05 96 04874 04 96 10880

LOCATION 1191 THE PADDOCKS WELL NO 6628-16623, MESA - Injection water from Lake
SAMPLE COLLECTED 28/08/96 11:45 RECEIVED 28/08/96

GENERAL DATA		
pH	7.4	pH UNITS
CONDUCTIVITY	177	us/cm
TOTAL DISSOLVED SOLIDS (BY EC)	97	mg/L
TURBIDITY	13	NTU
ANIONS		
FLUORIDE	0.06	mg/L
NUTRIENTS		
AMMONIA AS N	0.008	mg/L
TKN AS NITROGEN	0.35	mg/L
NITRATE + NITRITE AS N	0.028	mg/L
FILT. REACTIVE PHOSPHORUS AS P	0.009	mg/L
PHOSPHORUS - TOTAL AS P	0.034	mg/L
METALS		
ARSENIC - INORGANIC	<0.001	mg/L
ARSENIC - SOLUBLE INORGANIC	<0.001	mg/L
BORON	0.117	mg/L
CADMIUM - TOTAL	<0.0002	mg/L
CADMIUM - SOLUBLE	<0.0002	mg/L
CHROMIUM - TOTAL	<0.005	mg/L
CHROMIUM - SOLUBLE	<0.005	mg/L
COPPER - TOTAL	<0.005	mg/L
COPPER - SOLUBLE	<0.005	mg/L
IRON - TOTAL	0.710	mg/L
IRON - SOLUBLE	0.062	mg/L
LEAD - TOTAL	0.010	mg/L
LEAD - SOLUBLE	0.003	mg/L
MANGANESE - TOTAL	0.013	mg/L
MANGANESE - SOLUBLE	0.006	mg/L
MERCURY - TOTAL	<0.0001	mg/L
MERCURY - SOLUBLE	<0.0001	mg/L
NICKEL - TOTAL	0.003	mg/L
NICKEL - SOLUBLE	<0.001	mg/L
ZINC - TOTAL	0.040	mg/L
ZINC - SOLUBLE	0.031	mg/L
OTHER TESTS		
SUSPENDED SOLIDS	4	mg/L
TOTAL INSECTICIDES	NOT DETEC	ug/L
TOTAL HERBICIDES	NOT DETEC	ug/L

. . . .

SENIOR CHEMIST

CHEMICAL ANALYSIS REPORT

REFERENCES :- 06 96 05336 07 96 07589 05 96 05415 04 96 12154

LOCATION 1191 THE PADDOCKS WELL NO 6628-16623, MESA – Injection water from Lake
SAMPLE COLLECTED 20/09/96 9:50 RECEIVED 20/09/96

GENERAL DATA		
pH	7.3	pH UNITS
CONDUCTIVITY	352	us/cm
TOTAL DISSOLVED SOLIDS (BY EC)	190	mg/L
TURBIDITY	2.6	NTU
ANIONS		
FLUORIDE	0.10	mg/L
NUTRIENTS		
AMMONIA AS N	0.023	mg/L
TKN AS NITROGEN	0.67	mg/L
NITRATE + NITRITE AS N	0.024	mg/L
FILT. REACTIVE PHOSPHORUS AS P	0.012	mg/L
PHOSPHORUS - TOTAL AS P	0.076	mg/L
METALS		
ARSENIC - INORGANIC	0.003	mg/L
ARSENIC - SOLUBLE INORGANIC	<0.001	mg/L
BORON	0.205	mg/L
CADMIUM - TOTAL	<0.0002	mg/L
CADMIUM - SOLUBLE	<0.0002	mg/L
CHROMIUM - TOTAL	<0.005	mg/L
CHROMIUM - SOLUBLE	<0.005	mg/L
COPPER - TOTAL	<0.005	mg/L
COPPER - SOLUBLE	<0.005	mg/L
IRON - TOTAL	0.214	mg/L
IRON - SOLUBLE	0.072	mg/L
LEAD - TOTAL	0.008	mg/L
LEAD - SOLUBLE	0.002	mg/L
MANGANESE - TOTAL	0.021	mg/L
MANGANESE - SOLUBLE	<0.005	mg/L
MERCURY - TOTAL	<0.0001	mg/L
MERCURY - SOLUBLE	<0.0001	mg/L
NICKEL - TOTAL	0.001	mg/L
NICKEL - SOLUBLE	<0.001	mg/L
ZINC - TOTAL	0.039	mg/L
ZINC - SOLUBLE	0.034	mg/L
OTHER TESTS		
SUSPENDED SOLIDS	7	mg/L
TOTAL INSECTICIDES	NOT DETEC	ug/L
TOTAL HERBICIDES	0.61	ug/L
SIMAZINE	0.61	ug/L

SENIOR CHEMIST

DEPT OF MINES AND ENERGY - MICROBIOLOGY REPORT (AWQC 187)

LAB REF	SAMPLING DATE	FAECAL COLIFORMS /100mL	HET. IRON PPTG.BACT 30C/7DAYS /mL	IRON PPTG.BACT MI'SCOPIC EXAM
THE PADDOCKS - WELL NO. 6628-16623				
08 96 13667	24/07/96	38	350	DETECTED a

a - MICROSCOPICAL EXAMINATION OF THE SAMPLE SHOWED LOW NUMBERS OF NON-FILAMENTOUS IRON ASSOCIATED MICRO-ORGANISMS

SENIOR MICROBIOLOGIST

SOUTH AUSTRALIAN WATER CORPORATION AUSTRALIAN WATER QUALITY CENTRE 04/09/96 14:27:10 PAGE 1

GENERAL REQUESTS FOR ANALYSIS - MICROBIOLOGY REPORT

LAB REF	SAMPLING DATE	FAECAL COLIFORMS /100mL	HET. IRON PPTG.BACT 30C/7DAYS /mL	IRON PPTG.BACT MI'SCOPIC EXAM
THE PADDOCKS WELL NO 6628-16623, MESA				
08 96 16262	28/08/96	9	160	NOT DETEC a

a - MICROSCOPICAL EXAMINATION OF THE SAMPLE DID NOT DETECT FILAMENTOUS OR NON-FILAMENTOUS IRON ASSOCIATED MICRO-ORGANISMS.

SENIOR MICROBIOLOGIST

BORE WATER REQUESTS FOR ANALYSIS - MICROBIOLOGY REPORT

LAB REF	SAMPLING DATE	FAECAL COLIFORMS /100mL	HET. IRON PPTG.BACT 30C/7DAYS /mL	IRON PPTG.BACT MI'SCOPIC EXAM
THE PADDOCKS WELL NO 6628-16623, MESA				
08 96 18039	20/09/96	0	11000	NOT DETEC a

a - MICROSCOPICAL EXAMINATION OF THE SAMPLE DID NOT DETECT FILAMENTOUS OR NON-FILAMENTOUS IRON ASSOCIATED MICRO-ORGANISMS.

[signature]
SENIOR MICROBIOLOGIST