REPT.BK.NO. 74/69

GEOLOGICAL SURVEY

COMPLETION AND AQUIFER TEST REPORT AT BORE PAR 37 - NARACOORTE RANGE PADTHWAY

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South Australia —

DEPARTMENT OF MINES

SOUTH AUSTRALIA

GEOLOGICAL SURVEY

ENGINEERING DIVISION

COMPLETION AND AQUIFER TEST REPORT AT BORE PAR37 - NARACOORTE RANGE PADTHAWAY

by

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HYDROGEOLOGY SECTION

NARACOORTE REGIONAL OFFICE

4th March, 1974

Rept.Bk.No. 74/69
G.S. No. 5388
Hyd. No. 2639
D.M. No. 226/69
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DEPARTMENT OF MINES
SOUTH AUSTRALIA

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COMPLETION AND AQUIFER TEST REPORT AT BORE PAR 37 - NARACOORTE RANGE PADTHAWAY

Adj. Section 73, Hundred of Parsons

Location: General: Naracoorte Range, northern part of Padthaway irrigation basin.

Region: 1

County: MacDonnell

Hundred: Parsons

Section: adj. 73

Permit No:A 113

INTRODUCTION

Recent investigations into the hydrogeology and water balance of the Padthaway irrigation basin have suggested that the current level of consumption of groundwater for irrigation purposes is very close to the safe yield and that any appreciable increase in groundwater consumption would lead to an increase in salinity throughout the basin.

With the extension of the Underground Waters Preservation Act over the Southeast, including Padthaway, it has become necessary to critically examine applications for permits to drill additional bores. Because of this, it is desirable to have additional and more reliable data from which a more accurate and refined assessment of safe yield can be determined.

It has been estimated by Harris (1971) that more than 80% of the recharge to the Padthaway basin occurs by the flow of groundwater from the Naracoorte Range into the irrigation area. It was therefore decided

to carry out an aquifer test further back into the range than previous tests to gain a better idea of the hydrogeology of the range and to refine the recharge estimate.

PAR 37, the bore at which the aquifer test was conducted, is one of a line of observation bores across the range, designed to examine the water table in cross-section. Its locality is shown in Fig. 1.

CONSTRUCTION DETAILS

Drilling of PAR 37 commenced on July 9, 1973 and was carried out with a cable tool rig. Drilling was completed on August 28, 1973. A 203 mm hole was drilled to a depth of 88 metres, 203 mm casing being driven to a depth of 77 metres. The formation was considered sufficiently competent to leave 11 m of open hole throughout the test.

The bore was developed simply by pumping until the water was clear of sand. At the completion of the test, the bore was lined with 76 mm P.V.C. from surface to 85 m with perforated section from 79 m to 85 m. A Linatex seal was attached to the P.V.C. at 79 m. All 203 mm casing was withdrawn. A covered standpipe was cemented in place and a marker peg erected. A sketch of the bore is shown in Fig. 2.

The observation bore PAR 41 was located 20 m from PAR 37. Drilling commenced on August 24, 1973 and was completed on September, 27, 1973. A 152 mm hole was drilled to a depth of 84 m, 152 mm casing being driven to a depth of 74 m. At the completion of the aquifer test, the casing was withdrawn and the borehole backfilled and abandoned.

BOREHOLE GEOLOGY AND HYDROGEOLOGY

Sludge samples were collected at 2 metre intervals during drilling, and where lithology changes were noted by the driller. The bore log is shown in Appendix A.

The sedimentary section penetrated by PAR 37 consists of:

Gambier Limestone: 76 - 88 m. This unit consists of cream to yellow calcarenite and calcisiltite. The section is dominantly sandy with minor bryozoal content and occasional shell fragments.

Bridgewater Formation: surface - 76 m. This formation of Pleistocene age, constitutes the dune range system of the Southeast aligned sub parallel to the coastline and consists of calcareous aeolianite. In the Naracoorte Range at PAR 37, the Bridgewater Formation consists of cream to deep yellow, medium to coarse grained, loosely consolidated calcareous sand with much fine silty and clayey material. Some clayey horizons occur in the upper part of the section and it is considered that these would impede direct downward infiltration of rainwater to the water table. A perched water table may occur over limited areas.

The static water levels at PAR 37 and PAR 41 were 64.70 m and 64.64 m respectively at the time of the aquifer test.

A recently completed line of observation bores across the Naracoorte Range at Padthaway, which incorporates PAR 37 and PAR 41, shows that the water table slopes gently to the west across the range and that groundwater moving through the range forms part of the regional underflow.

WATER SAMPLING

During drilling, water samples were taken where cut and analysed for approximate total dissolved salts. A sample was also collected at the conclusion of the aquifer test and subsequently analysed. The final analysis is shown in Appendix B.

AQUIFER TEST

Upon completion of the observation bore, PAR 37 was pumped for a period of 2,900 minutes. (48 hours 10 minutes). The average pumping rate was 3.8 litres per second and some deviation from this figure was recorded during the test. The pumping rate graph is shown with the drawdown plot on Fig. 3. Water level readings were taken with an electric probe at the following time intervals:

start	to	10 minutes:	1 minute intervals
10	to	30 minutes:	2 minute intervals
30	to	50 minutes:	5 minute intervals
50	to	100 minutes:	10 minute intervals
100	to	200 minutes:	20 minute intervals
200	to	1 000 minutes:	50 minute intervals
1 000	to	end:	100 minute intervals

Measurements were made with a metric tape. A graph showing the variation in drawdown plotted against the base 10 logarithm of time is shown in figure 3.

The pumping rate throughout the test was restricted by the available drawdown in the pumped bore. The top of the pump was set at 79 metres. This allowed a maximum drawdown of 13 metres from 65 to 78 metres, leaving 1 metre of water over the pump to prevent the intake of air. The pump was therefore restricted to 2,500 r.p.m., at which speed the average discharge was 3.8 litres per second.

At such a slow speed, it was difficult to maintain a constant discharge and the effect of fluctuations in the discharge can be seen on the drawdown curve. The effect of such fluctuations have been compensated for in the determination of Δs over one log cycle.

Drawdown in the observation bore was extremely slow, being only 5 centimetres in the first 50 minutes. After approximately 50 minutes, both drawdown and recovery curves adopt a steeper slope and it is on this part of the drawdown curve that the transmissivity has been calculated. The slope of this line is 0.155 m per log cycle (Δs). A good approximation of the value of transmissivity (T) of the aquifer can be determined from the graph by the Jacob method, using the formula:

$$T = \frac{0.183 \times Q}{\Delta s}$$

where T = transmissivity (litres/sec/metre)

Q = pumping rate (litres/second)

Δs = drawdown per log cycle of time (metres)

Substituting the measured values into the above equation gives:

$$T = \frac{0.183 \times 3.8}{0.155}$$

$$= 4.49 \text{ litres/second/metre} = 388 \text{ m}^3\text{/day/m}$$

One of the main sources of error in this calculation lies in the fact that full penetration of the aquifer was not achieved. As the full thickness of the aquifer is not known at this locality, the correction to be applied cannot be determined. However, the above value gives a good approximation of the combined transmissivity of the Bridgewater Formation and Gambier Limestone in this part of the Naracoorte Range.

Because of the shape of the graph, a satisfactory value of t_o is difficult to obtain. It is therefore necessary to use a formula independent of t_o to obtain a value of storage coefficient (S).

The equation:

$$S = \frac{2.25\, T t/r^2}{\log^{-1}_{10} (4 \times Ts/2.30Q)}$$ is used

At a time t = 400 minutes. s = 0.18 metre.

On substitution this becomes:

$$S = 2.25 \times 4.49 \times 10^{-3} \times \frac{400}{400} \times 60$$

$$\text{Log} \frac{-1}{10} \frac{4 \times 4.49 \times 10^{-3}}{2.30 \times 3.8 \times 10^{-3}} \times 0.18$$

$$= 4.12 \times 10^{-3}$$

This value accords well with the observed steep cone of drawdown and the fine grained silty and clayey matrix (?) material of Bridgewater sand.

The change in slope of the drawdown and recovery curve at approximately 50 minutes is due to an impermeable boundary condition. There are no bores in the vicinity of PAR 37 that could have commenced a significant discharge during the test so this factor can be discounted. The change in slope is most probably due to a change in transmissivity of the aquifer a short distance from the pumping bore. Such a change would not be incompatible geologically within such an aquifer as the calcareous aeolianite of the Bridgewater Formation.

A plot of the logarithm of drawdown against the logarithm of time was drawn to see whether or not the aquifer exhibited any of the characteristics of a semi-confined aquifer because of the clay layers encountered during drilling. The log - log plot does not exhibit such features but its shape does suggest some delayed yield from storage during the latter stages of the test. This plot is shown on Figure 4.

DISCUSSION

1. The combined transmissivity of the Bridgewater Formation and Gambier Limestone at PAR 37 is 388 cubic metres per day per metre approximately. For comparison, values of transmissivity obtained from previous aquifer tests in the Naracoorte Range are tabulated overleaf:

Hundred	Bore No.	Transmissivity (m^3/day/m)	
Glenroy	PA 20	1 555	*
Glenroy	PA 43	363	*
Parsons	PA 38	1 123	*
Parsons	PAR 37	388	

* From Harris, B.M., 1973.

It can be seen that there is some considerable variation in values of transmissivity throughout the range. Such variations must make estimates of recharge to the basin somewhat difficult. It is possible that "zones" of transmissivity higher than that at PAR 37 exist through which most of the water that recharges the basin must flow.

The hydraulic gradient at PAR 37 is approximately 3 metre/kilometre. From Darcy's law:

$$Q = K A \frac{dh}{dL}$$

$$= T \frac{dh}{dL}$$

through a vertical strip of aquifer 1 metre wide.

Where Q = quantity of flow through a segment of aquifer and

$\frac{dh}{dL}$ = hydraulic gradient

$$Q = \frac{4.49 \times 3.0}{1000}$$

$$= 1.35 \times 10^{-2} \text{ litre/second}$$

$$= 425 \text{ m}^3\text{/annum}$$

CONCLUSIONS

1. The transmissivity of the combined Gambier Limestone and Bridgewater Formation aquifers at bore PAR 37 in the Naracoorte Range is 388 cubic metres per day per metre approximately.

2. The drawdown and recovery curves suggest the presence of a nearby hydrogeological boundary condition related to a reduction in transmissivity.

3. The transmissivity at PAR 37 varies somewhat from other values obtained within the Naracoorte Range at Padthaway. It is considered that the value obtained in this test is an abnormally low value although it does compare well with the value obtained at PA 43.

4. If this value of transmissivity were applied over the whole length of the range recharging the Padthaway basin, (approximately 32 km) the recharge would be only 1.36×10^7 m^3 whereas the recharge from the range has been estimated by Harris to be approximately 2.46×10^7 m^3/annum.

OJW Bowering per JDW

4th March, 1974
OJWB:IA

O.J.W. BOWERING
ASSISTANT SENIOR GEOLOGIST

A P P E N D I X A

BORELOG

DEPARTMENT OF MINES SOUTH AUSTRALIA

HYDROGEOLOGY SECTION

BORE LOG

HIRER *DEPARTMENT OF MINES*

Drill type *Percussion*
Circulation –
Driller *N. McMinn*
Start *9-7-73*
Finish *23-9-73*

Logged by *A Fennell*
Date logged *2-8-73*
Bore Diameter *6"*
DEPTH *88'*

A.M.G. Zone
Coords: E
" N
Datum Elev.
(rel Ref. Pt. Elev.
Surface Elev.

HUNDRED *PARSONS*
SECTION *Adj 73*
STATE No. *568007303*
Project No. *PAR 37*
Docket No. *231/2A/69*
Bore Serial No. *103/74*

Depth of Water cut (m)	Depth to standing water (m)	SUPPLY litres/sec	SUPPLY Method of test	TOTAL DISSOLVED SOLIDS Milligrammes/litre	TOTAL DISSOLVED SOLIDS Analysis W. No.
67	*64.7*	—	—	*1538 (full analysis)*	*4369/73*
67	—	—	—	*1200*	*3509/73*
67	*64.7*	—	—	*1455*	*3610/73*

REMARKS *"Permit no. A113. Production bore for aquifer test to determine transmissivity value for the Bridgewater formation in the Naracoorte Range*

CASING | WATERS CUT | WATER LEVEL | DEPTH (m) | CORE | GRAPHIC LOG | AGE | UNIT

84m of 3" PVC.

DEPTH (m) from	to	DESCRIPTION
0.0	*2.0*	*SOIL ZONE: ARENITE; quartz particles, up to 0.25mm well graded, pale grey. Abundant organic matter*
2.0	*36.0*	*ARENITE; (quartz) 0.10 to 0.50mm. Clayey in parts, red-brown → pale yellow-brown → yellow-brown from 6 metres 10–30% calcarenite (0.2 mm average size), bryozoa sticks and foraminifera are discernable. Larger quartz grains are clear, and sub-angular.*

Drn: *G.J.T.* | Sheet *1* of *4*
Date: *25.2.74* | Bore Folder No.

PF Nº S10537 MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING | WATERS CUT | WATER LEVEL | DEPTH (m) | CORE | GRAPHIC LOG | AGE | UNIT

DEPTH (m) from to | DESCRIPTION

84m of 3" P.V.C.

20
25
30
35
40

36·0 68·0 QUARTZ ARENITE; - CALCARENITE ; majority of samples are (0·25 to 0·50mm) quartz particles. Some particles up to 1·00mm. diameter. 20 to 30% of samples composed of yellow and white calcareous fragments. Abundant shell fragments. brown to light brown. Larger quartz grains are sub-rounded to rounded

Borehole State No. 568007303

Drn: G.J.T. | Sheet 2 of 4

Date: 25·2·74 | Bore Folder No.

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING	WATERS CUT	WATER LEVEL	DEPTH (m)	CORE	GRAPHIC LOG	AGE	UNIT	DEPTH (m) from	to	DESCRIPTION
84m of 3" P.V.C.			45 50 55 60 65							

Borehole State No. 5680073O3

Drn: G.J.T.

Date: 25.2.74

Sheet 3 of 4

Bore Folder No.

PF Nº S10537a MH

DEPARTMENT OF MINES — SOUTH AUSTRALIA

CASING | WATER CUT | WATER LEVEL | DEPTH (m) | CORE | GRAPHIC LOG | AGE | UNIT

84m of 3" PVC.

70 75 80 85 90

DEPTH (m) from	to	DESCRIPTION
68·0	88·0	CALCARENITE - 80 to 90% calcareous particles 0·25 to 1·00mm, bryozoa sticks are in abundance and shell fragments (particles are yellow and white). Some strongly cemented together. 10 to 20% arenite (quartz groins up to 1·00mm in diameter. Brown → yellow brown → off white. Coral chips present throughout entire 20metres.
		END OF HOLE 88metres.

Borehole State No. 568007303

Drn: G.J.T. | Sheet 4 of 4

Date: 25·2·74 | Bore Folder No.

PF Nº S10537a MH

A P P E N D I X B

SALINITY DATA

WATER ANALYSIS REPORT — AMDEL COMPUTER SERVICES

SAMPLE NO. W4389-73 — JOB NO. 1605-74

CHEMICAL COMPOSITION

		MILLIGRAMS PER LITRE MG/L	MILLIEQUIVS. PER LITRE ME/L
CATIONS			
CALCIUM	(CA)	136.	6.8
MAGNESIUM	(MG)	53.	4.4
SODIUM	(NA)	310.	13.5
POTASSIUM	(K)	7.	.2
ANIONS			
BICARBONATE	(HCO3)	456.	7.5
SULPHATE	(SO4)	73.	1.5
CHLORIDE	(CL)	556.	15.7
NITRATE	(NO3)	<1	.0

TOTALS AND BALANCE

CATIONS (ME/L) 24.8 — DIFF = .1
ANIONS (ME/L) 24.7 — SUM = 49.5

DIFF*100. / SUM = .3 %

DERIVED AND OTHER DATA

CONDUCTIVITY (E.C.)
MICRO-S/CM AT 25 DEG. C 2328.

	MILLIGRAMS PER LITRE MG/L
TOTAL DISSOLVED SOLIDS	
A. BASED ON E.C.	
B. CALCULATED (HCO3=CO3)	1359.
C. RESIDUE ON EVAP. AT 180 DEG. C	
TOTAL HARDNESS AS CACO3	558.
CARBONATE HARDNESS AS CACO3	374.
NON-CARBONATE HARDNESS AS CACO3	184.
TOTAL ALKALINITY AS CACO3	374.
FREE CARBON DIOXIDE (CO2)	
SUSPENDED SOLIDS	
SILICA (SIO2)	
BORON (B)	

	UNITS
REACTION - PH	7.4
TURBIDITY (JACKSON)	
COLOUR (HAZEN)	
SODIUM TO TOTAL CATION RATIO (ME/L)	54.4 %

REMARKS

NAME- DEPT OF MINES
ADDRESS-PADTHAWAY AREA

DATE COLLECTED-20-9-73
DATE RECEIVED-

HUNDRED- PARSONS
SECTION- ADJ 73
HOLE NO-PAP 30
SUPPLY- 3300
SAMPLE COLLECTED BY-N MCMINN

WATER CUT- 67.00 M
WATER LEVEL-64.70 M
DEPTH HOLE- 88.00 M

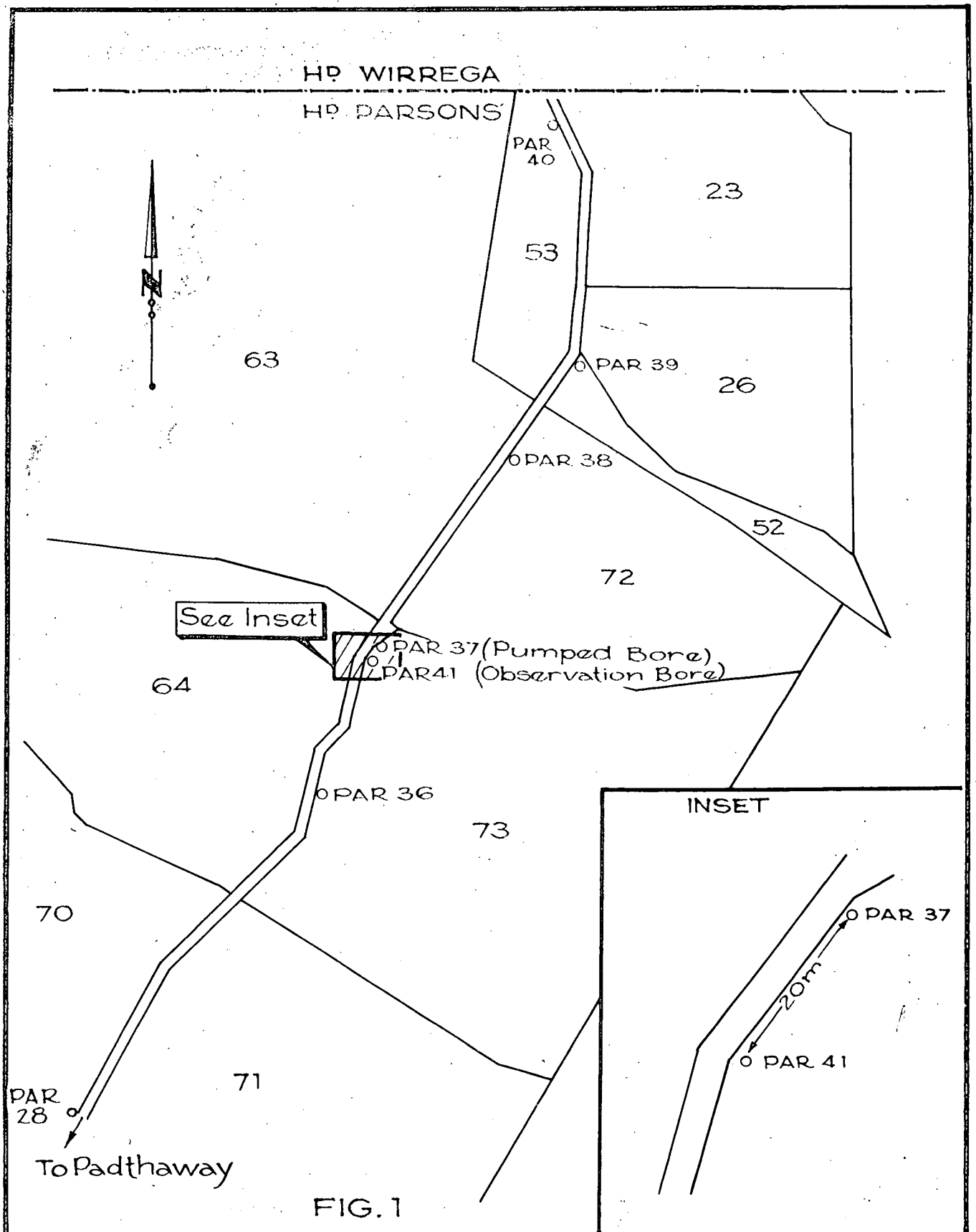


FIG. 1

DEPARTMENT OF MINES — SOUTH AUSTRALIA

HYDROGEOLOGY SECTION	Drn. O.B Tcd. G.M. Ckd. A.E. Exd.	S.E. WATER RESOURCES - PADTHAWAY INVESTIGATION ADJ. SEC. 73 HP PARSONS BORE LOCATION PLAN	SCALE: 1" = 40 chns S 10584 Kc 5 DATE: 22·10·73

500—2,69 665

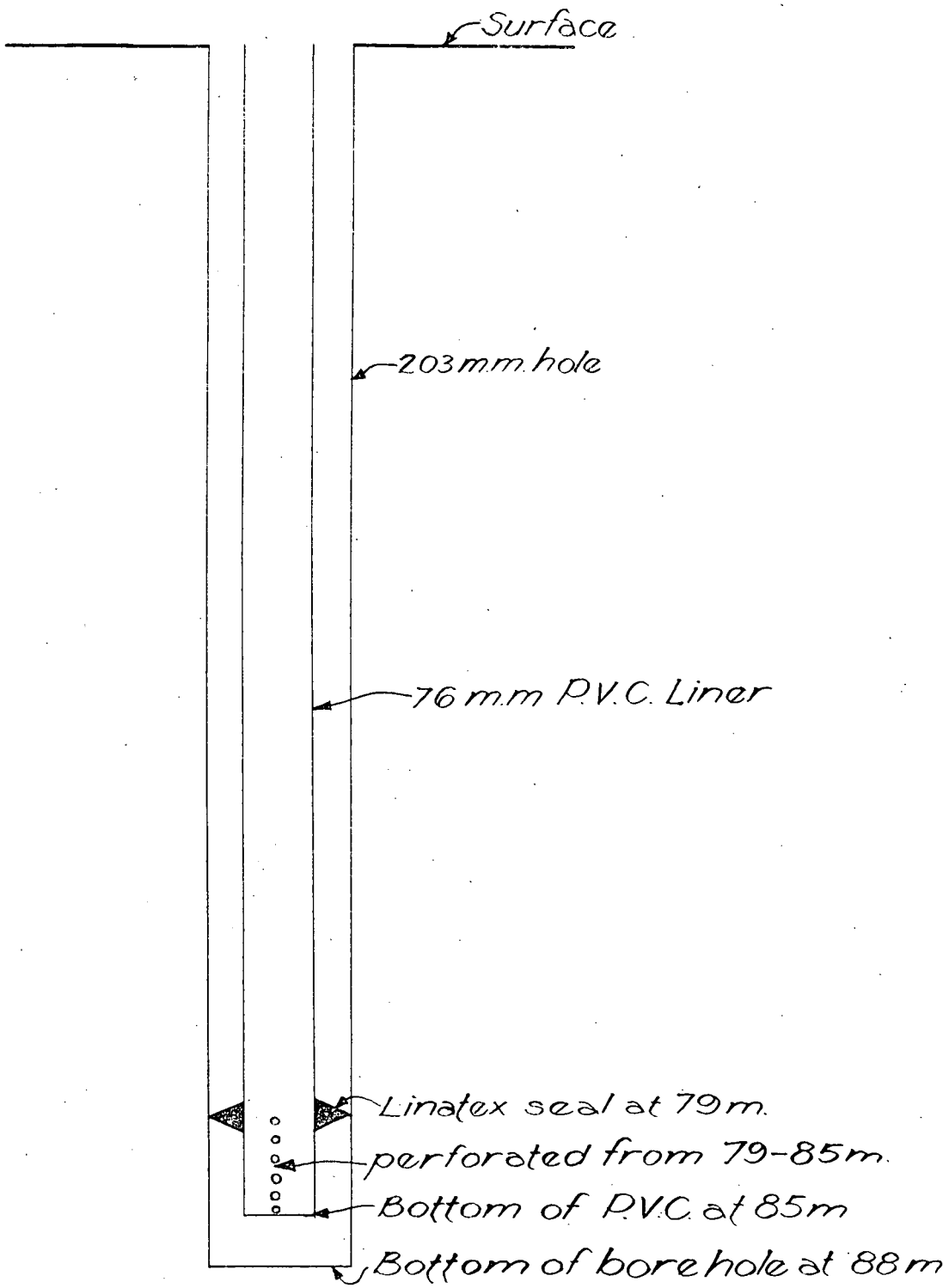
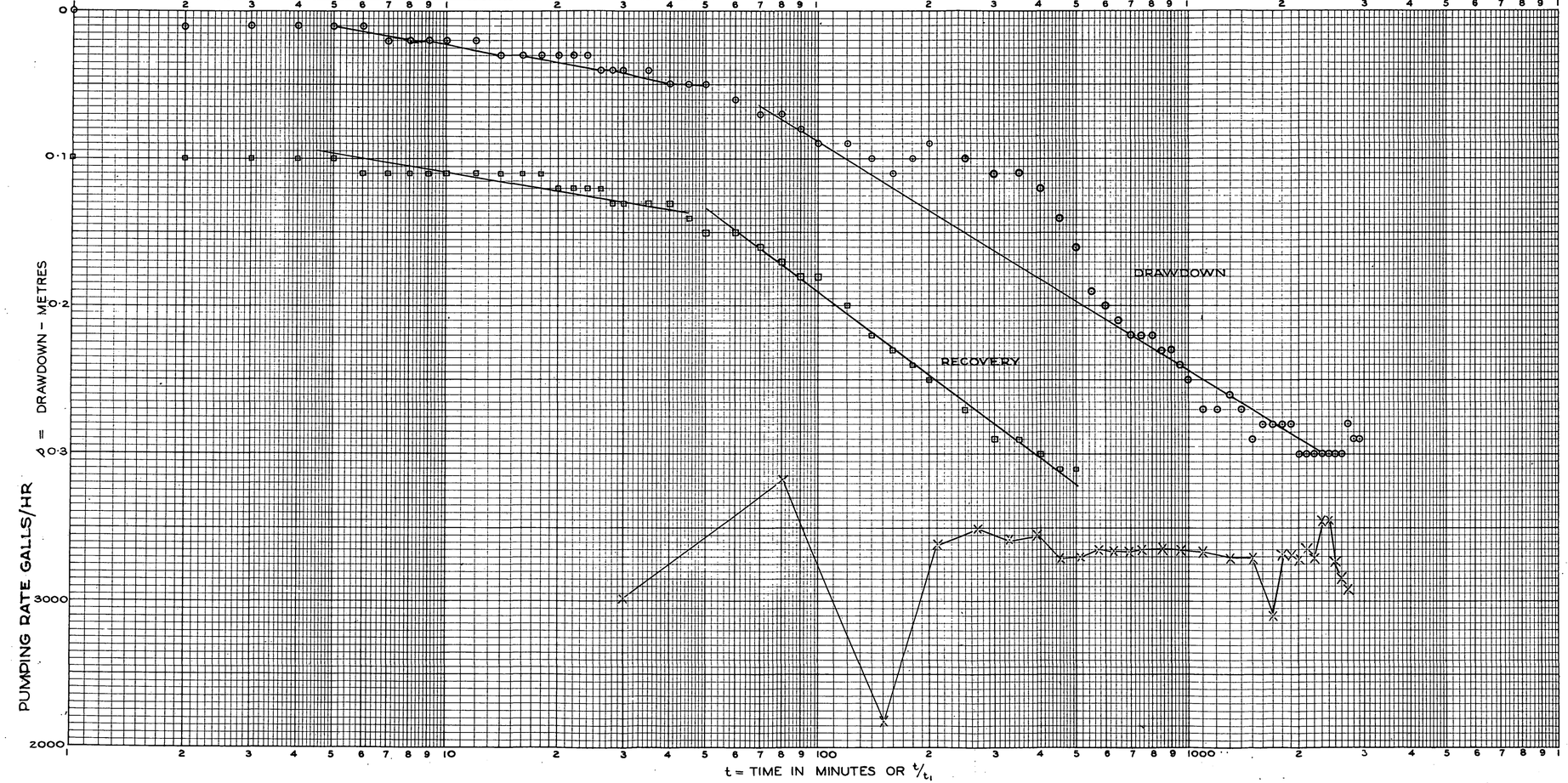


FIG. 2

DEPARTMENT OF MINES — SOUTH AUSTRALIA

HYDROGEOLOGY SECTION	Drn. OWJB	S.E. WATER RESOURCES-PADTHAWAY INVESTIGATION	SCALE: DIAGRAMMATIC
	Tcd. G.M		S 10585
	Ckd. A.F	CASING DETAILS OF BORE PAR 37	Kc5
	Exd.		DATE: 5 NOV. 1973

500—2.69 665



s' = RECOVERY (RESIDUAL) - METRES

BOREHOLE STATE Nº_____ TYPE OF PUMP_____

DEPTH TO WATER LEVEL DISCHARGE STARTED AT____ON_____

AT TEST START (l_2)_____(L) ** " STOPPED AT____ON_____

PUMP INTAKE DEPTH (l_1)_____(L) AQUIFER FROM_____TO_____(L)

*AVAILABLE DRAWDOWN_____(L) HOLE DEPTH_____(L)

EQUATIONS

$$T = \frac{0.183 \times Q}{\Delta s} \qquad S = \frac{2.25 \times T t_o}{r^2}$$

In which

T= Transmissivity ($L^3/t/L$)

Q= Pumping Rate . (L^3/t)

Δs= Drawdown per log cycle. (L)

S= Storage Coefficient

t_o= Zero drawdown time- (t)

r = Distance to Observation Bore- (L)

1 day = 8.64×10^4 secs.

DATA

Q	Δs	t_o
3·8 litres	0·155m	—

CALCULATIONS

$$T = \frac{0.183 \times 3.8}{0.155} = 4.49 \text{ litres/sec/metre}$$

" $S = \frac{2.25 \times \quad}{\quad} =$

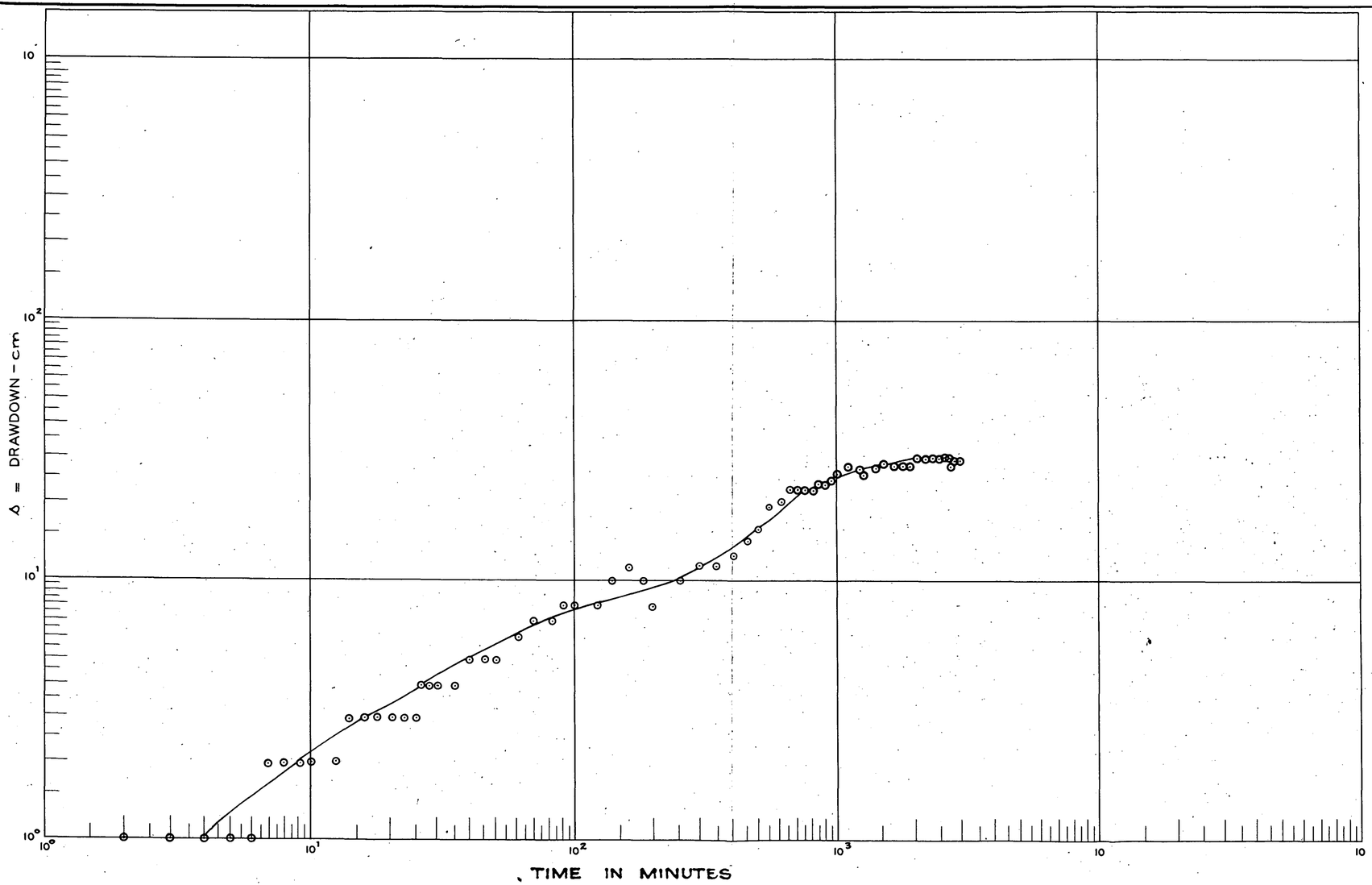
FIG. 3

** L = unit of length.
t = time unit.

*Available drawdown = $l_1 - (l_2 + \text{-----})$

HYDROGEOLOGY SECTION	DEPARTMENT OF MINES—SOUTH AUSTRALIA	DM. /
COMPILED: O.J.W.B.	SE. WATER RESOURCES-PADTHAWAY. INVESTIGATION	DATE: 5 Oct 1973
DRN. G.M. CHD. A.F.	AQUIFER TEST — NARACOORTE RANGE	DRG. No. 73-743 Kc5
	18-20 SEPT 1973	

P.F. No. 69—953 MH



Δ = RECOVERY (RESIDUAL) - FEET

BOREHOLE STATE N°_____
DEPTH TO WATER LEVEL_____
AT TEST START_____(L) *
PUMP INTAKE DEPTH_____(L) "
AVAILABLE DRAWDOWN_____(L)

TYPE OF PUMP_____
DISCHARGE STARTED AT_____ ON____
" STOPPED AT_____ ON____
AQUIFER FROM_____TO_____(L)
HOLE DEPTH_____(L)

BASIC EQUATIONS

$$T = \frac{Q}{4\pi\Delta} Wu \qquad S = \frac{4Tut}{r^2}$$

In which
T = Transmissivity $(L^3/t/L)$
Q = Pumping Rate (L^3/t)
Δ = Drawdown (L)
Wu = function of u
S = Storage Coefficient (dimensionless)
t = time (t)
r = Distance to observation hole (L)

DATA

Q	Δ	t	Wu	u	1 day = 8.64×10^4 sec.

CALCULATIONS

* L = unit of Length
t = time unit

FIG.4

HYDROGEOLOGY SECTION	DEPARTMENT OF MINES - SOUTH AUSTRALIA	D.M. /
COMPILED: O.J.W.B	S.E. WATER RESOURCES - PADTHAWAY INVESTIGATION	DATE: 5 OCT. 1973
DRN: G.M. CHD: A.F.	AQUIFER TEST - NARACOORTE RANGE 18-20 SEPT. 1973	DRG. NO. 73-742 Kc5