6823
REPT.BK. NO.74/184
6923
GW

SECTION

/184

SOUTH-EAST WATER RESOURCES

TEST AREA 1

RESULTS OF PUMP TESTS CONDUCTED IN THE PERIOD APRIL 1969 TO JANUARY 1970

B.M. HARRIS

Department of Mines
South Australia —

74/184

DEPARTMENT OF MINES

SOUTH AUSTRALIA

GEOLOGICAL SURVEY

ENGINEERING DIVISION

SOUTH-EAST WATER RESOURCES

TEST AREA 1

RESULTS OF PUMP TESTS CONDUCTED IN THE PERIOD APRIL 1969 TO JANUARY 1970

BY

B.M. HARRIS

GEOLOGIST

HYDROGEOLOGY SECTION

Rept.Bk. No. 74/184
G.S. No. 5500
Hyd. No. 2666
D.M. No. 1060/69

12th September 1974

CONTENTS

TABLES

FIGURES

All remaining plans lost

DEPARTMENT OF MINES
SOUTH AUSTRALIA

Rept.Bk.No.74/184
G.S. No.5500
Hyd. No.2666
D.M. No.1060/69

SOUTH-EAST WATER RESOURCES TEST AREA 1 RESULTS OF PUMP TESTS CONDUCTED IN THE PERIOD APRIL 1969 TO JANUARY 1970

INTRODUCTION

In April 1969 and January 1970, four pumping tests were conducted in Test Area No.1. This area is located between Robe and Beachport (Figs. 1 and 2). In this report the results of pumping tests are presented and other methods of examining the groundwater hydrology are discussed. The drilling and geological investigations are described in Progress Report No. 4.

BOREHOLE CONSTRUCTION

Table 1 below gives details of the pumping and observation holes.

TABLE 1

Details of Boreholes

Pump Hole No.	Observation Hole No.	How Drilled	Distance to pump hole (feet)	Diameter (inches)	Depth (ft)	Casing
P1		Cable tool	0	8	555	169ft. of 8" dia.
	R1	Rotary	20	4¾	318	60ft.of 3" dia.PVC.
P2		Cable tool	0	8	300	118ft. of 8" dia.
	R6	Rotary	20	4¾	300	70ft.of 3" dia. PVC.
P3		Cable tool	0	8	490	60ft. of 8" dia.
	R10	Rotary	20	4¾	300	60ft. of 3" dia.PVC
262008402 (Private bore) at Ackson Park		Rotary	0	12	30	8ft. of 12" dia.
	262008403	Rotary	11	6	30	8ft. of 6in. dia.

In the cable tool holes P1, P2, P3, the steel casing fits tightly against the sides. However, casing in the rotary holes (R1,R6, R10) is smaller in diameter than the hole and so two rubber flanges were fitted around the lower end of the casing to form a seal against the sides of the hole (Fig.13).

A summary of the pumping details is given in Table 2.

TABLE 2

Pumping Details

PUMP HOLE NO.	LENGTH OF TEST (HRS)	PUMP TYPE	PUMP INTAKE SETTING	PUMPING RATE (CU.SECS)	(L/SEC)
P1	24	8" 5 stage turbine	150	1.07	30.3
P2	24	" " "	110	1.225	34.7
P3	24	" " "	50	1.22	34.5
262008402 (Ackson Park)	12	Centrifugal	-	4.40	124.5

HYDROGEOLOGY

As Progress Report No. 4 describes the hydrogeology in detail, the following discussion concerns only those aspects of the geology relevant to the pumping tests.

The rocks are calcarenites (permeable limestones) and calcisiltites and calcilutites (partly impermeable marls) (Harris 1969). Bedding is essentially horizontal and there is a definite sequence which is recognizable over the Test Area. However, there are local minor variations. The sequence is considered to be rigid and to be hydraulically continuous. An exception occurs in the locality of Bores P3 and R10 where deeper sections of the

Gambier Limestone are under pressure. The water level in P3 (490 ft. deep) is about 3ft. higher than R10 (300ft. deep.)

PUMPING TEST ANALYSIS

General

The time-drawdown values from the tests were plotted on both semilogarithmic and logarithmic paper. The semi-log plots are curve-like indicating unsteady flow due to gravity drainage under water-table conditions. Steady conditions were not attained in the tests on bores P1, P2, P3 and therefore, they are not suitable for straight line analysis. A straight line solution for the transmissivity (T) was obtained from the test at Ackson Park as the effects of gravity drainage became negligible after 360 minutes.

The logarithmic plots were analysed by matching on the Unconfined Aquifer Type Curves (Boulton 1963). In the tests on bores P1 and P3, useful values of T were calculated but because the tests did not continue long enough, the estimates of Specific Yield (Sy) are uncertain, although their values are of the right order of magnitude.

Pumping Test at Hole P1

In the pumping hole P1 there were fluctuations in drawdown and most of these do not appear to be connected with pumping rate variations (Fig.3). In the observation hole R1, the semi-log plot describes a smooth curve (Fig.4). At 1000 minutes a sharp increase in pumping rate has carried a marked increase in drawdown.

The logarithmic plot from R1 has yielded the following estimates of aquifer properties.

Transmissivity (T) = 1.46×10^{-2} cusecs/ft

= 118 m^3/day/m

Specific Yield (Sy) = 0.25

Pumping Test at Hole P2

The semi-log plots (Figs. 6 & 7) have a step-like nature which is possible due to cavity drainage. The fluctuations do not appear to be connected with pumping variations which were small throughout the test (Fig.6). In the observation hole R6 (Fig.7) the drawdown curve rises sharply after 200 minutes and when pumping ceases it is about 0.4ft., above the original static level. This was probably caused by pumped waters re-entering the aquifer in the vicinity of R6.

It is not possible to calculate aquifer properties from these results.

Pumping Test at Hole P3

The semi-log plots (Figs. 8 and 9) show a fluctuation in drawdown after 550 minutes which appears to have been caused by variations in the pumping rate.

Type curve analysis gives the following estimates of aquifer properties:-

T = 2.48×10^{-1} cusecs/ft (average)

= 1990 m^3/day/m

Sy = 0.37

The hydraulic conditions at the site as discussed throw some doubt on the validity of these results. The value of Sy however appears to be of the right order of magnitude.

Pump Test at Hole 262008402
Ackson Park, Hundred of Bray

This private bore only penetrates the near surface aeolianite material (Bridgewater Formation) and is very high yielding. There are several other high yielding bores in the locality indicating that the area is relatively homogeneous.

The semi-log plot of time-drawdown values from the observation hole shows almost a continuous S-shaped curve (Fig.11). The bi-logarithmic plot (Fig.12) was matched on unconfined aquifer type curves and the following aquifer characteristics calculated:-

$T = 2.74 \times 10^{-1}$ Cusecs/ft.

$= 2201\ m^3/day/m$

$Sy = 0.62$

The value of Sy is very large and should be used with caution. Shallow bores in this area yield large quantities of water with very small drawdowns and test drilling showed the formation to be cavernous. Therefore, the aquifer appears to be homogeneous in the sense that the cavities are evenly distributed throughout the formation.

DISCUSSION

General

Of the four pumping tests only three gave useful results. In two of these three (P1 and P3) analysis would have been more

certain had the tests continued for longer periods. The results from the P3 test in particular should be used with care.

The values for Sy are high, but samples from drill holes and porosity determinations from resistivity logging in the Gambier Limestone indicate that they are of the right order of magnitude.

A value of $T = 10^{-2}$ Cusecs/ft. (80 m^3/day/m) can be taken as a conservative figure for the Gambier Limestone aquifer at this stage.

The value of $T = 2.78 \times 10^{-1}$ cusecs/ft. (2,233 m^3/day/m) for the shallow aquifer appears to be reasonable for that locality.

It was originally thought that all the Gambier Limestone aquifer was confined because some fine-grained beds were thought to be confining. These tests have shown the aquifer to be unconfined.

To obtain satisfactory results, pumping tests in unconfined aquifers must continue for long periods until the effects of delayed yield from gravity drainage are negligible. It is also necessary to have several observation holes to:-

(a) give additional estimates of aquifer characteristics by unconfined aquifer type curve analysis.

(b) to independently check the results from (a) by the distance/drawdown method.

(c) to check that the aquifer is homogeneous in the area influenced by the test.

Calculation of Underflow

In the following calculation, the underflow is estimated by Darcy's Law.

Darcy's Law	Q	=	$\frac{TLdL}{de}$
where	Q	=	Underflow
	T	=	Transmissivity
	$\frac{dL}{de}$	=	Hydraulic gradient
	L	=	Width of flow
Assume	T	=	10^{-2} cfs/ft.
	$\frac{clh}{dl}$	=	3ft. per mile
The underflow per mile of coastline:	Q	=	3×10^{-2} cfs.

Therefore, the underflow for 90 miles of coastline (area A of Morton 1969) is:

$Q = 3 \times 10^{-2} \times 90$ cfs.

$= 2.7$ cfs. or 1950 acre ft/annum

$= 6{,}600\ m^3$/day

Morton (1969) calculated outflow for Area A for the Bridgewater Formation and the Gambier Limestone grouped together and used a value of transmissivity equal to 43,200 ft^3/ft/day. From these pump tests in this report a value of T for the Bridgewater Formation and Gambier Limestone combined is 24,000 ft^3/ft/day. However, the Bridgewater Formation is discontinuous in areal extent and does not participate in the regional underflow.

Validity of Pumping Test Method

The recent tests indicate that the method is probably suitable in Test Area 1 at least. However, other approaches should be tried to ensure that the pumping test method can be

used with confidence.

There are three possible approaches:-

(a) Observation of water levels near bores being pumped for very long periods, e.g., town water supply bores. During dry periods water is pumped for long periods and completely removed from the locality of the bore. This allows near equilibrium conditions to be attained. Several towns draw their water supplies from the Gambier Limestone and their bores would be suitable for long term pump tests providing observation holes were available.

(b) Flow Net Analysis

A flow net can be constructed around a relatively small area where large amounts of groundwater are being extracted.

The industrial area just southeast of Millicent may be suitable for this type of analysis.

CONCLUSIONS AND RECOMMENDATIONS

Pumping tests in the Gambier Limestone under water-table conditions must continue for relatively long periods to obtain useful results. More than one observation hole is preferable.

For the main aquifer (Gambier Limestone) T is conservatively estimated to be 10^{-2} cfs./ft. (80 m^3/day/m).

The two values of Sy obtained are 0.25 and 0.37.

However, the values of Sy from these tests is uncertain because the tests were too short and there was only one observation bore at each test.

For the shallow aquifer (Bridgewater Formation) one test showed:

$T = 2.74 \times 10^{-1}$ Cusecs/ft.

Sy = 0.68

This latter result is only considered to be representative of that locality and should be used with caution. Results from other areas may be considerably different.

It is important that other methods be tried to ensure that the pumping test method can be used with confidence. Therefore it is recommended that:-

(a) The possibility of using town water supply bores as long term pumping tests be investigated.

(b) The possibility of using flow net analysis in an area near Millicent be examined.

B.M.H. per JDW

BMH:SG.
12.9.74

B.M. HARRIS
GEOLOGIST
HYDROGEOLOGY SECTION

REFERENCES

BOULTON, N.S., 1963. ....

HARRIS, B.M., 1969. ....

MORTON, 1969. ....

PRICKETT, T.A., 1965. "Type Curve Solution to Aquifer Tests under Water Table Conditions" Groundwater Vol.3, No.3 1965

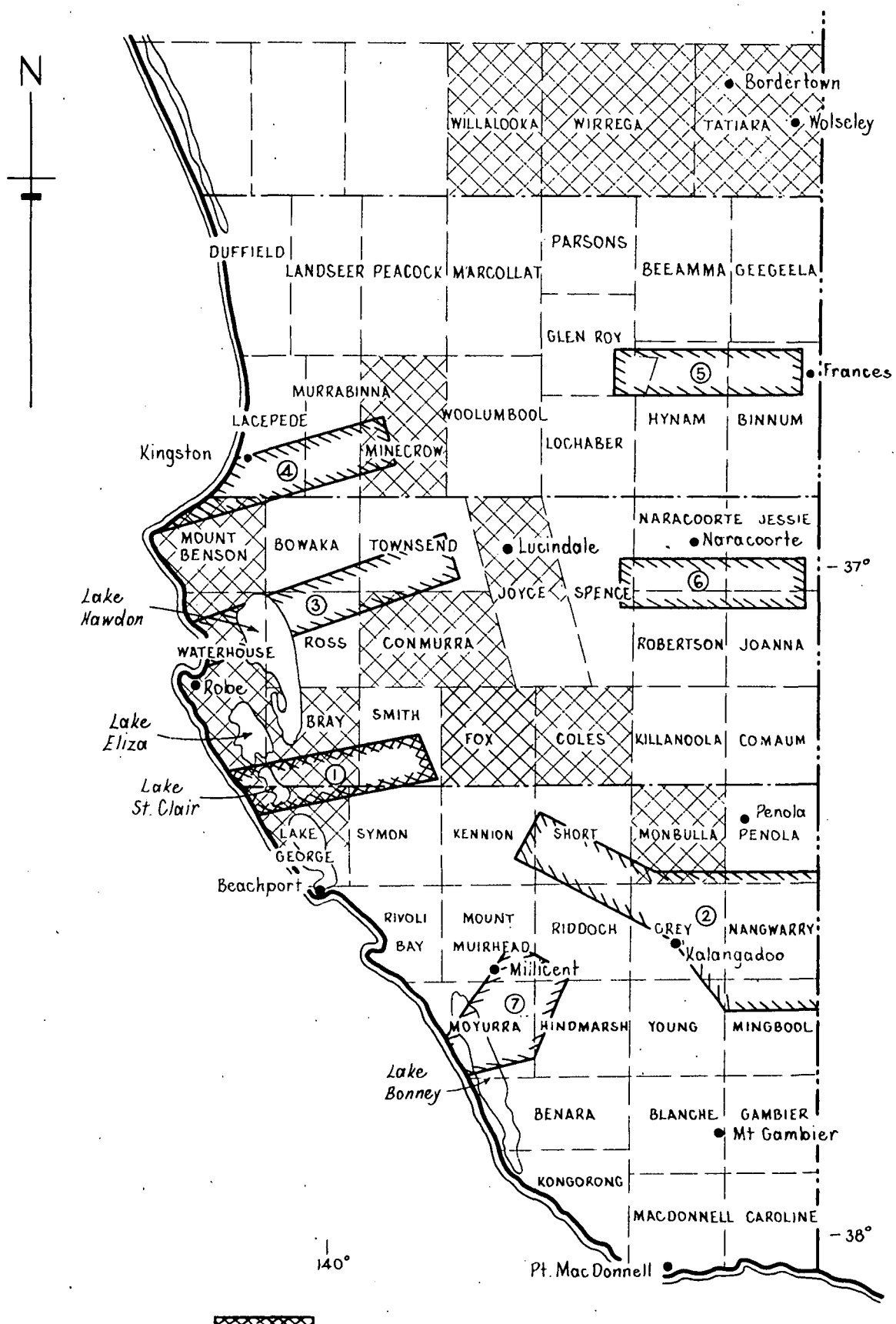


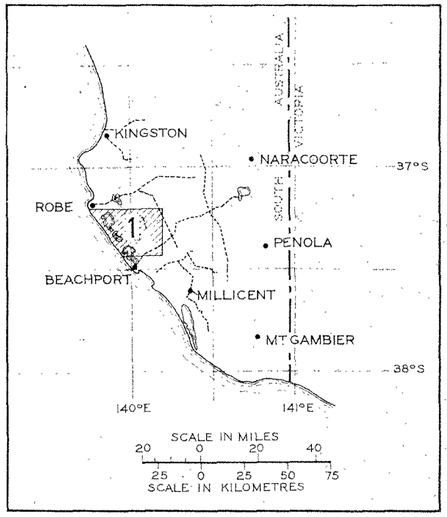
FIG. 1

DEPARTMENT OF MINES — SOUTH AUSTRALIA

HYDROGEOLOGY SECTION	Drn. B.H.	SOUTH-EAST WATER RESOURCES	SCALE. 1inch = 16miles
	Tcd. R.H.	COMPLETED & PROPOSED INVESTIGATIONS	S7383
	Ckd. L.V.W.	**JULY 1969**	Kae
GEOLOGIST	Exd.	LOCALITY PLAN	DATE: 23 July 1969

F. No. S7383 M.L.

LOCALITY MAP



LEGEND

- Road
- Drain
- Hundred Boundary
- SMITH 631 Hundred Name
- A26 Borehole into UNIT A AQUIFER with programme number.
- R3 Borehole into UNIT B AQUIFER with programme number.

QUATERNARY

- DUNE RANGE — Bridgewater Formation either exposed or covered by shallow soils.
- INTERDUNE AREA — Mainly covered by clay soils and swamps as shown.

FIG: 2

BASE PLAN COMPILED FROM DEPARTMENT OF LANDS 80 CHAIN SCALE HUNDRED PLANS

DEPARTMENT OF MINES — SOUTH AUSTRALIA

SOUTH-EAST WATER RESOURCES TEST AREA 1

GEOLOGY AND PHYSIOGRAPHY

HYDROGEOLOGY SECTION	GEOLOGIST	Drn. I.F.	SCALE: AS SHOWN
		Trd. AMD	69-406 Kde
Director of Mines	ASS'T. GEOLOGIST	Ckd. L.V.W.	
		Exd.	DATE: 27 Oct '69