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BUREAU OF MINERAL RESOURCES
GEOLOGY AND GEOPHYSICS.

RECORDS.

RECORDS 1959/66.

THE EFFECT OF PUMPING FROM A BORE ON THE DRAINAGE PROBLEM AT TORRES STREET, RED HILL

by

E. G. Wilson and L. C. Noakes.

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SUMMARY

"The Drainage Problem at Torres Street, Red Hill" was the subject of a Record by L.C. Noakes in 1958. A recommendation was made that a bore be sunk in the area in order to examine the weathered profile, and to determine whether the problem could be controlled by pumping the bore.

The bore was sunk to 100 feet in December 1958 by a Failing 750 belonging to the Bureau of Mineral Resources and pumping tests were carried out early in 1959 by the Geological Section using both the Aqua-Jet and "Jack" type pumps. Water levels in the affected area were measured from auger-holes while pumping was in progress over a period of three weeks.

Results indicate that pumping from the bore is a practical means of controlling the water table in Block 16 of Section 3, if continuous pumping is done at the right time. The cost of suitable equipment would be about £350 and operating costs would be of the order of £30 per year.

INTRODUCTION

In 1953 water-logging of the area between Torres Street and Wickham Crescent, Red Hill, was investigated by N.H. Fisher and L.C. Noakes at the request of the Department of Works. Following this inquiry a system of deeper drains in Block 16 was completed by the leaseholder in 1954. These measures improved the drainage until the end of 1955. Early in 1956 the ground again became water-logged after heavy rain and these conditions persisted throughout the relatively dry summer of 1956-57.

A second investigation in 1957 was carried out by L.C. Noakes assisted by officers from the Soils and Land Research Divisions, C.S.I.R.O. Canberra. The following recommendation was made:

"A bore should be sunk to fresh rock near auger-hole 7 on the boundary between blocks 15 and 16. This should be cored if possible and cased. The bore is required for:

(a) Exploration of the entire weathered profile and confirmation of a permeable layer near bedrock.

(b) Determination of depth to bedrock to aid interpretation of any geophysical work.

(c) Pumping tests to check the feasibility of control by a bore, and

(d) Possible temporary relief of water logging by pumping, if required before the drainage project is completed."

DRILLING

In 1958 a programme for experimental water bores in the Canberra area was drawn up; a bore near the boundary between Blocks 15 and 16, Section 3, Torres Street, as recommended by Noakes (1958) was included in this programme.

A Failing 750, owned and operated by the Petroleum Technology Section of the Bureau of Mineral Resources, carried out the drilling. Boring commenced on 17th December 1958 and finished at a depth of 100 feet on 21st December 1958. Full details of the drilling operation are included in the Record "Bureau of Mineral Resources Experimental Water Bore Drilling, Canberra 1958." by G.M. Burton and E.G. Wilson. Details of the bore are shown on Plate 2.

The log of the hole is as follows:

City 3

0	- 3 feet	Black soil	
3	- 20½ "	Deeply weathered porphyry	Weathered Red Hill Group may be present as a pendant.
20½	- 22 "	Hard porphyry	
22	- 30 "	Deeply weathered porphyry	
30	- 42 "	Porphyry with hard and soft zones	
42	- 54 "	Slightly weathered porphyry (hard drilling)	
54	- 55½ "	Deeply weathered porphyry	
55½	- 100 "	Slightly weathered porphyry with deeply weathered bands (joints?).	

PUMPING EQUIPMENT

Pumping equipment belonging to the Geological Section, Bureau of Mineral Resources was used in testing this bore. Two types of pumps were used, the Aqua-Jet and the "Jack" type pumps. These pumps are described in the record "Preliminary Pumping Tests of A.C.T. Water Bores" by E.G. Wilson, which is now being prepared.

The Aqua-Jet pump is a Venturi type pump, ideal for raising small quantities of water from a shallow depth. It is mobile, and the use of polythene pipes does away with the necessity of a tripod and lifting gear.

The "Jack" type pump is the standard means of raising water. The equipment is heavy and requires a considerable amount of time for setting up.

PUMPING TESTS

Aqua-Jet Pump Tests

While the drill was on the site pumping tests were attempted on two occasions with the pump suction set at 60 feet. On the first occasion grit became lodged in the footvalve and the pump did not function. The second time, the level of the water was lowered to the footvalve, air entered the system and repriming became necessary.

After the bore was completed at 100 feet, further tests were carried out; since the size of the bit had been reduced to $4\frac{3}{4}$ inches below 60 feet, the Aqua-Jet, because of its size, could not be lowered below that level.

Throughout these tests, the output was calculated from the time taken to fill a 44 gallon drum; in this test 225 galls. per hour was maintained over a number of eight hour tests with the pump suction at 60 feet.

A graph of the water levels during recovery from 50 feet was plotted against time and did not indicate any definite changes in permeability. There are signs of an interface at 32 feet above which the rate of recovery decreases; this may indicate slightly higher permeabilities below 32 feet.

"Jack" Pump Tests

Procedure

The "Jack" type pump was set up on the bore early in February. An extra footvalve was set at 92 feet, 13 feet below the pump, in addition to the footvalve incorporated in the pump. This arrangement was merely used to check its operation in practice. It has been found useful where the pump cannot be lowered past a certain level due to a smaller hole or to a smaller casing. The extra footvalve enables the point of suction to be set up to 20 feet below the pump, thereby increasing the output of the bore and clearance is only required for the lower footvalve (diam. $3\frac{1}{2}$ inches).

The pump was powered by a J.A.P. 6-8 h.p. motor by means of a flat belt. The J.A.P. motor is the motor used for the Aqua-Jet and is mounted on a trailer with an intermediate shaft provided to give the required reduction in revs. per minute.

Over a period of three weeks commencing on the 25th February, the bore was pumped on two occasions for thirty-four hours in addition to eight tests of ten hours each. A total of 90,000 galls. of water was pumped into the stormwater drains. The Jack pump was operated so that all water supplied by the bore was pumped out; i.e., the bore supplied its maximum output at all times. This was obtained by adjusting the pumping rate so that the pump was always delivering a small amount of air as well as water. The air indicates that the level of the water in the bore has been lowered to the footvalve and therefore water from the surrounding rock is entering the bore at the maximum rate possible. The results of the pumping are presented graphically on Plate 3.

The water levels in the surrounding auger-holes were measured morning and night over the whole period, in addition, after the 4th. March measurements were made at regular intervals while pumping was in progress. Water levels in the piezometer were also measured when it was serviceable.

The piezometer consists of a 6 to 7 foot galvanised pipe sunk in the ground with the top above ground level. When sub-surface water is under pressure, the level of water in the pipe is found to be above the water table in the surrounding ground and, at times, above the level of the ground itself; the piezometer thus gives an indication of the extent of the pressure.

Sequence of Events (Plate II)

On 25th February, the total rainfall recorded at the Canberra Climatological Station, Yarralumla, since 1st January was 522 points. The water levels in the auger holes were a few inches below ground level and the surface of the area was dry.

25th February 1959

The output rose from 560 to 570 gallons per hour during the ten hour pumping period. The level of the water in all auger holes had been lowered by ½ inch to 4 inches at the end of the day.

26th February 1959

Overnight the levels in all holes rose by up to 5 inches, in part due to 47 points of rain which fell during the night. Pumping for another ten hours gave a steady output of 570 gallons per hour. All levels in the auger-holes had again fallen by between 1 inch and 3½ inches by the end of the day.

27th February 1959

Overnight the weather was fine and the levels continued to fall in most of the auger-holes; the exceptions were No.8 which was stationary and No.10 which rose by 2 inches. Ten hours of pumping gave a steady output of 590 galls. per hour and at the end of the day the water levels had been lowered by between ½ inch and 2½ inches.

28th February and 1st March 1959

Pumping was discontinued over the weekend when 36 points were recorded on 28th February and 27 points on 1st March. Water levels in the auger holes rose, partly due to surface water entering the holes; No.6, which was protected from surface water continued to fall.

2nd March 1959

On this day very heavy rain fell, 123 points were recorded at Yarralumla for the 24 hours preceeding 9 A.M. on 3rd March. Pumping for ten hours lowered the output of the bore from 610 to 590 galls. per hour; however, water levels in the auger-holes rose with the addition of surface water except No.10 which was unchanged.

3rd March 1959

Overnight most of the levels fell; No.10 was again stationary but No.6 rose by 2½ inches. Pumping for ten hours showed a gradual fall in output from 620 to 600 galls. per hour and the levels in all the auger holes fell by between ½ inch and 2 inches.

4th and 5th March 1959

First 34 hour test

Over these two days pumping was continuous for 34 hours. The output varied from 620 galls. per hour at the beginning of the first day to 610 galls. per hour at mid-night, after which there was a gradual rise to 620 galls. per hour by the end of the test. Heavy rain fell until midnight,

256 points being recorded for the 24 hours ending at 9 A.M. on 5th March. The levels rose with an influx of surface water for the first 14 hours of the test but after the rain ceased, most holes fell except No.9 which was stationary and No.10 which fell for a time, but then rose again.

6th and 7th March 1959

Second 34 hour test

During the night the levels fell in No's 6, 7 and 8, the other holes rose by up to one inch except No.9 which was stationary. Pumping commenced on 6th March with an output of 630 galls. per hour which dropped gradually to 610 galls. per hour by the end of the test. No rain fell during this period and the levels in the auger-holes fell gradually by between two and five inches.

8th March 1959

Thirty one points of rain were recorded at 9 A.M. on 8th March and a rise in the water levels overnight is again partly attributed to surface water and seepage. During the day, pumping for ten hours brought a drop in output from 635 galls. per hour to 620 galls. per hour and a fall of up to 4 inches in the water levels.

9th March 1959

Pumping did not take place on this day and the water levels either fell slightly or remained stationary; the exception was No.10, where a rise of $1\frac{1}{2}$ inches was recorded.

10th March 1959

The output fell from 630 galls. per hour to 620 galls. per hour during ten hours pumping. All the water levels again fell; in addition the piezometer (which had previously been blocked) showed a fall of $3\frac{1}{2}$ inches.

11th and 12th March 1959

The pump did not operate on these two days and the water levels either fell slightly or remained stationary, the exception was the piezometer which rose 2 inches on the 11th and then was stationary.

13th March 1959

During ten hours pumping the output fell from 630 galls. per hour to 620 galls. per hour. All water levels were lowered including the piezometer which fell by 4 inches.

Pumping ceased on the 13th March. On the 14th and 15th the water levels rose but then commenced to fall very slowly over a period of dry weather until 26th March. The falls measured in each observation point between 15th and 26th are as follows:

Piezometer		$4\frac{1}{2}$ inches	
Auger-hole	1	Unchanged	
"	3	$1\frac{1}{2}$ inches	
"	5	1 "	
"	6	$10\frac{1}{2}$ "	
"	7	$2\frac{1}{4}$ "	
"	8	1 "	
"	9	3 "	
"	10	$1\frac{1}{4}$ "	
Borehole		4 "	(despite leakage from around the top of the cement plug)

During pumping, the water level in the bore was kept at the point of suction, 92 feet below the surface. Water levels in the bore between pumping periods have been plotted on Plate III and give a good indication of a build up in pressure; the bore acted as a piezometer despite leakage of water from around the cement plug. From the graph it can be seen that overflowing from the top of the collar took place on the mornings of 6th and 8th of March but as the pressure was reduced by pumping the water level subsided.

The standing water level in this bore between periods of pumping would provide a reliable gauge of underground water pressure from which pumping needs could be assessed.

CONTROL OF THE WATER TABLE

The tests show that pumping at maximum yield begins to lower the water table in Block 16 and at least in portion of Block 15 within a few hours; this effect is obviously consequent on pumping because the water table rises almost to its original position within a day or two after pumping ceases (see Plate 3).

The very low permeability of the surface soil and near-surface weathered rock (Noakes, 1958) indicates that the water table could not be lowered in such a short time by actual movement of water from surface soil towards the borehole; it is the relief of vertical pressure by the removal of water at depth which allows the water table to subside quickly to a lower piezometric level. This process is most clearly shown in the tests by the movement of water level in the piezometer. Auger hole 10, sunk in one of the 'wet spots' where persistent seepage is due to relatively high permeability (Noakes, 1958) responds quickly for that reason also.

Pumping from the bore as a remedial measure, is only supplementary to existing drainage which will still have to handle the main water load. However, in wet spells when the pressure of water at depth causes the water table to rise, the tests indicate that by judicious pumping, the pressure can be relieved sufficiently to keep the water table below the surface.

The amount of pumping required would naturally depend on the rainfall; judging by the last few years, the

pump would probably not be needed for more than a total of three or four months per annum. Pumping should be controlled by meteorological forecasts and by reference to water levels particularly in the bore hole and piezometer. In general practice, two or three weeks continuous pumping might be carried out in January to February and August to September to remove water from storage thereby making room for the falls which commonly eventuate about March and October. At other times, largely dependent on the level of the water table, pumping might start on a forecast of heavy rain or at the onset of a heavy storm and would continue for some days.

It is not claimed that pumping would necessarily prevent water logging under all conditions but should water logging take place there is no doubt that pumping would expedite recovery.

PUMPING EQUIPMENT AND OPERATING COSTS

Pumping equipment for this bore would be required to run for at least a week without attention; a "jack" type pump with a self-oiling, fully enclosed pump-head is recommended, the power to be supplied by a $1\frac{1}{2}$-2H.P. electric motor. The approximate cost of one set of suitable equipment is stated below.

Pump-head, 9" stroke, fully enclosed with V-belts and electric motor	£175
Pump, draw plunger type	£ 29
3" galv. iron delivery pipe (95 feet)	£ 33. 10. 0.
Pump rods (95 feet)	£ 29.
TOTAL:	£266. 10. 0.

In addition there will be the costs of installation of the pump, connection to the electricity supply, and erection of a small hut to protect the equipment from the weather; the total cost would therefore be about £350. The costs quoted above are approximately present day retail prices and are to be used as a guide only.

The equipment quoted above could be driven by a $1\frac{1}{2}$-2 H.P. motor with a speed of 1410 r.p.m.. The Canberra Electricity Supply was consulted for the approximate cost of operating this equipment. At the private consumer's rate of 2.25 pence per unit, the cost of one weeks continuous running would be about £2.

The total period for which pumping would be required each year is uncertain, but is estimated at three to four months. On this basis, pumping costs per annum would be of the order of £30.

CONCLUSIONS

The bore in Section 3 yields over 600 gallons per hour with suction at a depth of 92 feet; tests indicate that this yield is sufficient to pull down the water table over Block 16 and the eastern half of Block 15. The effect of pumping would probably extend to Block 14 (adjoining Block 16 to the south) but pumping at the bore after a considerable wet period would be needed to confirm this.

The pressure exerted by the large amount of water below the black clayey soil is evident in the high water levels in the piezometer and in the bore itself when pumping is not in progress. Removal of water reduces the pressure as evidenced by lower water levels in observation holes and piezometer. Pumping is only supplementary to the existing drainage; however, during wet periods when existing drains are overloaded, pumping should relieve sufficient pressure to prevent the water table from reaching the surface and remaining there.

In dry periods, such as that which ended in 1950, no pumping would be necessary and no costs other than maintenance would be incurred; the installation of relatively cheap pumping equipment seems worth while in contrast to an expensive, deep drainage system which would still require automatic pumping from a sump to the existing drains east of Block 16.

REFERENCES

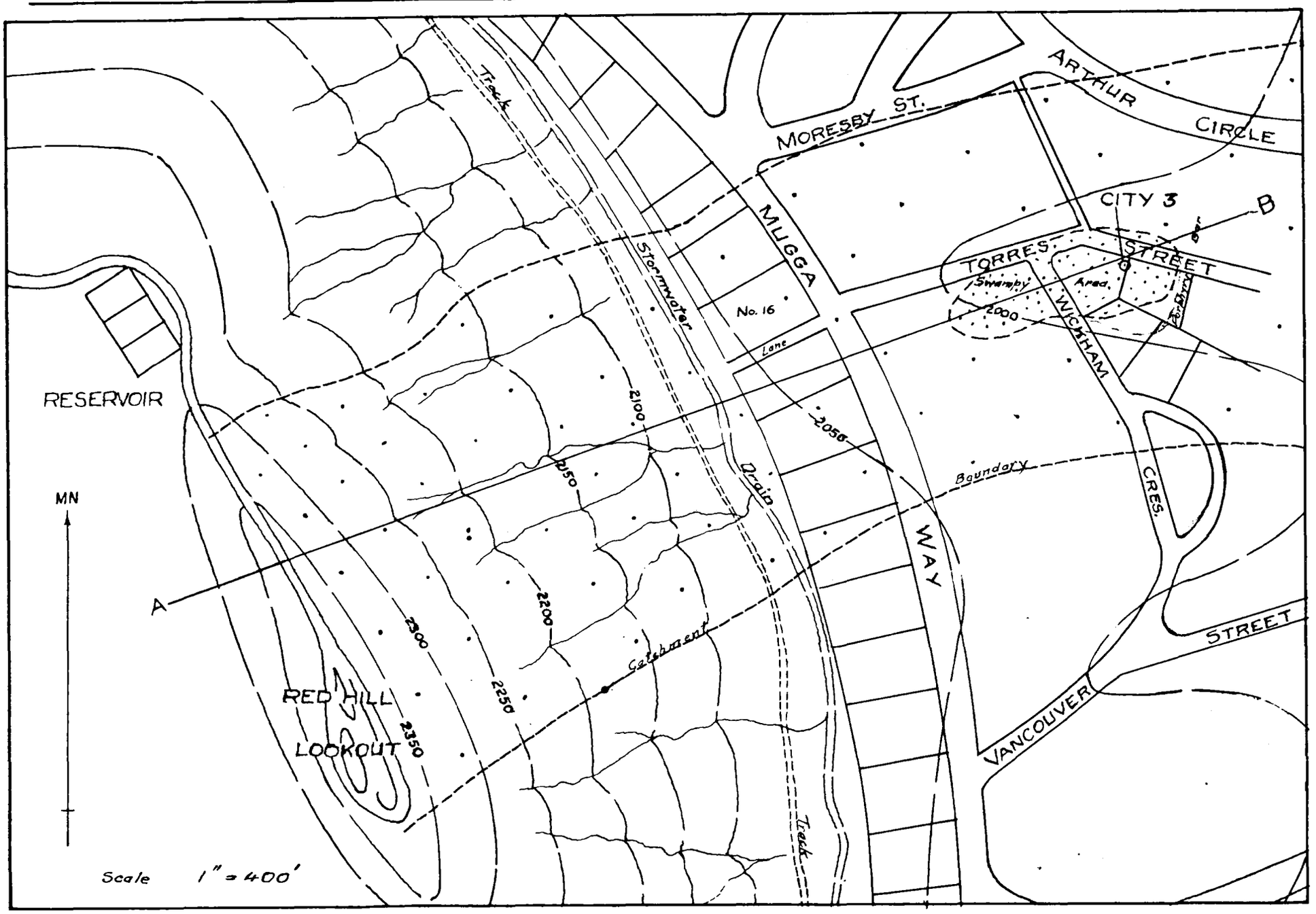
BURTON, G.M. and WILSON, E.G., 1959 - Bureau of Mineral Resources Experimental Water Bore Drilling, Canberra 1958. Bur.Min.Resour.Aust. Rec. 1959/53.

NOAKES, L.C., 1958 - The Drainage Problem at Torres Street, Red Hill. Bur.Min.Resour.Aust. Rec. 1958/11.

WILSON, E.G., 1959 - Preliminary Pumping Tests of A.C.T. Bur.Min.Resour.Aust. Rec., in preparation.

PLAN AND CROSS - SECTION OF THE CATCHMENT CONTRIBUTING TO THE TORRES STREET DRAINAGE PROBLEM

PLATE 1



CROSS - SECTION

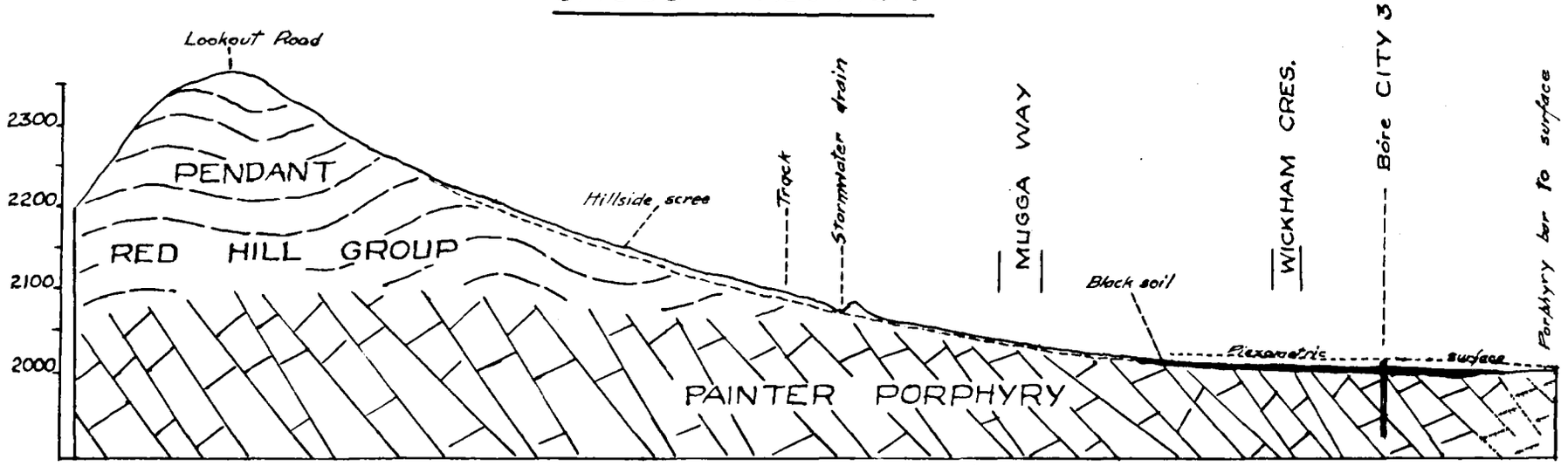
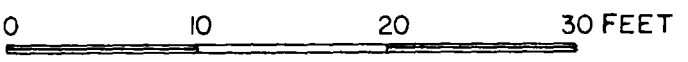
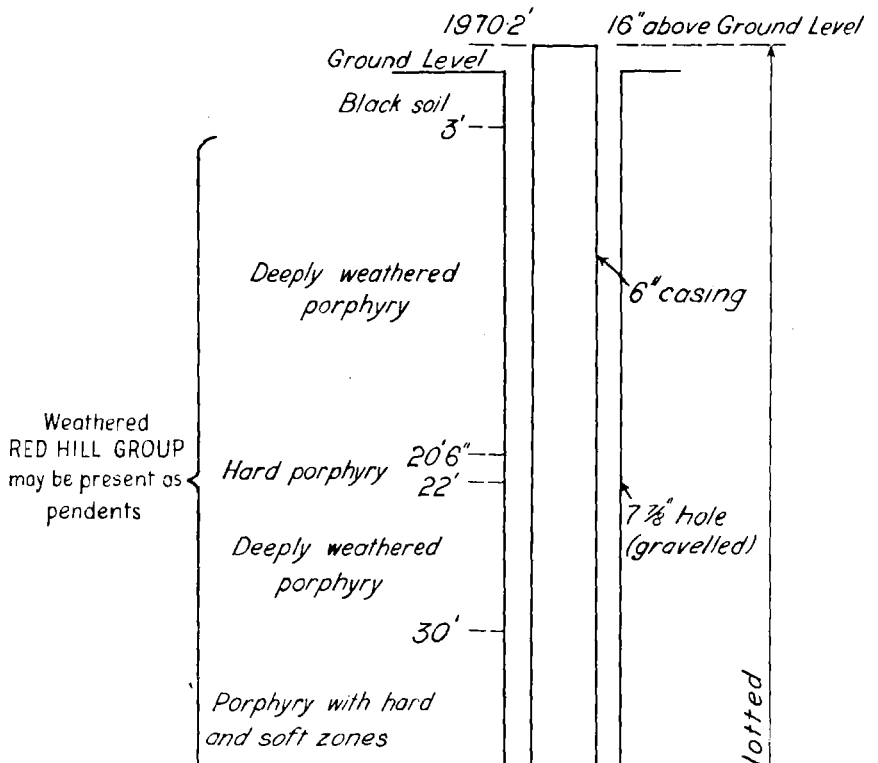
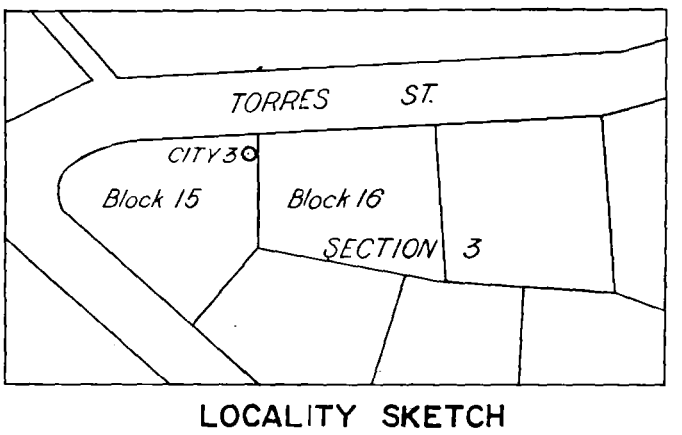


PLATE 2

EXPERIMENTAL WATER BORE CITY 3
RED HILL A. C. T.







LOCALITY SKETCH

ACT. 16-41
RM

Bureau of Mineral Resources, Geology and Geophysics

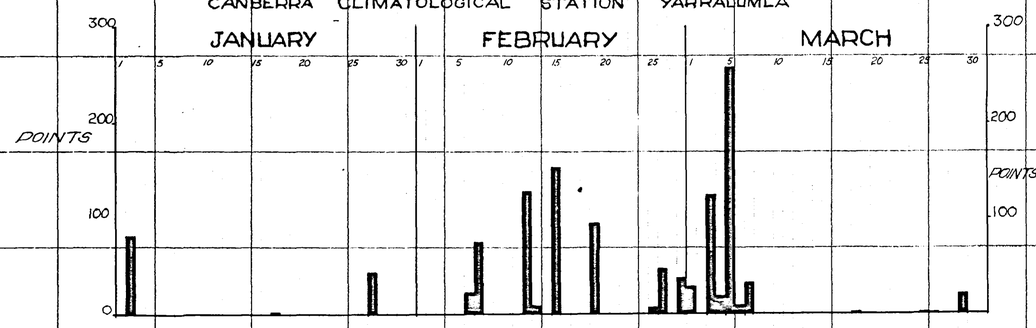
PLATE 3

GRAPHICAL PRESENTATION OF PUMPING RESULTS

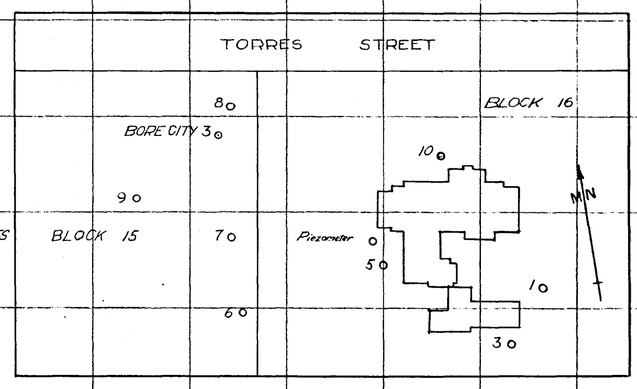
DAILY RAINFALL
OUTPUT OF THE BORE
WATER LEVELS IN
Borehole
Piezometer
Auger-holes
Nos. 1, 3, 5, 6, 7, 8, 9 and 10.

DAILY RAINFALL

RECORDED 9 A.M. AT
CANBERRA CLIMATOLOGICAL STATION YARRALUMLA



LOCALITY SKETCH



FEBRUARY				MARCH															
WED	THU	FRI	SAT	SUN	MON	TUE	WED	THU	FRI	SAT	SUN	MON	TUE	WED	THU	FRI	SAT	SUN	
25	26	27	28	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
6 A.M. 6 P.M.	6 A.M. 6 P.M.	6 A.M. 6 P.M.	6 A.M.	6 P.M.	6 A.M. 6 P.M.	6 A.M. 6 P.M.	6 A.M. 6 P.M.	6 A.M. 6 P.M.	6 A.M. 6 P.M.	6 A.M. 6 P.M.	6 A.M. 6 P.M.	6 A.M. 6 P.M.	6 A.M. 6 P.M.	6 A.M. 6 P.M.		6 A.M. 6 P.M.			

HORIZONTAL SCALE 1 inch = 20 hours

OUTPUT OF THE BORE

GALLS PER HOUR
640
620
600
580
560
540

PUMPING PERIODS

WATER LEVEL IN BORE

Level of Overflow (hole in casing)
TOP OF CASING DATUM 1970·2 FT.
GROUND LEVEL 1968·9 FT.
GROUND LEVEL
0
3"
6"
9"
1'
3"
6"
9"
2'

WATER LEVELS IN PIEZOMETER AND AUGER HOLES

PIEZOMETER BLOCKED
RAIN OVERNIGHT
RAIN OVERNIGHT
SHOWERS
HEAVY RAIN
HEAVY RAIN
SHOWERS
PIEZOMETER
DATUM 1968·7 FT.
TOP OF PIPE
GROUND LEVEL
HOLE 1 DATUM 1967·65 FT.
HOLE 1 DATUM
HOLE 1
HOLE 3 DATUM 1968·9 FT.
HOLE 3 DATUM
Surface 4" below DATUM
HOLE 3
HOLE 5 DATUM 1967·9 FT.
HOLE 5
Surface 1½" above DATUM
HOLE 5 DATUM
HOLE 6 DATUM (1971·8 FT.) LESS ONE FOOT
HOLE 6 DATUM LESS ONE FOOT
HOLE 6
Surface 12½" above DATUM
HOLE 7 DATUM 1961·1 FT.
HOLE 7 DATUM
HOLE 7
Rise due to influx of surface water
Surface 11" above DATUM
HOLE 8
HOLE 8 DATUM 1967·5 FT.
HOLE 8 DATUM
HOLE 9 DATUM 1969·9 FT.
Surface 1¼" above DATUM
HOLE 9
HOLE 9 DATUM
HOLE 10 DATUM 1966·7 FT.
Surface ⅜" above DATUM
HOLE 10
HOLE 10 DATUM
P
1
3
5
6
7
8
9
10

VERTICAL SCALE 1 INCH = 10 INCHES

HORIZONTAL SCALE 1 inch = 20 hours

25	26	27	28	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WED	THU	FRI	SAT	SUN	MON	TUE	WED	THU	FRI	SAT	SUN	MON	TUE	WED	THU	FRI	SAT	SUN
FEBRUARY				MARCH														

BRITISH MADE