DEPARTMENT OF MINES
SOUTH AUSTRALIA

PROPOSED LITTLE PARA DAM - EFFECT ON INTAKE TO AQUIFERS OF NORTHERN ADELAIDE PLAINS

by

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Rept.Bk.No. 73/246
G.S. No. 5248
D.M. No. 1221/68
Hyd. No. 2590

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SUMMARY

Hydrographs of bores adjacent to the Little Para River show that it is an important source of recharge to aquifers of the Salisbury area. Recharge takes place via shallow aquifers and then to deeper aquifers through semi-confining beds and possibly through the Para Fault Zone.

On the basis of change in storage of the shallow aquifers average annual recharge is estimated to be 2350 megalitres. It has been estimated, on the basis of stream flow measurements in the Little Para River, that a total annual flow below the dam site of 3318 megalitres is required to maintain the current situation. It is considered that evaporation and transpiration accounts for 968 megalitres of the annual flow.

Urban and rural run-off entering the Little Para River below the proposed dam is estimated to be 1100 megalitres per year of which 600 megalitres may be conserved by appropriate works. If this were done then the quantity which must be released from the dam could be reduced to 2700 megalitres per year.

RECOMMENDATIONS

It is recommended that releases from the proposed dam should be on the following monthly basis:-

MONTH	JAN.	FEB.	MAR.	APRIL	MAY
Quantity (Ml)	99	138	77	78	124
MONTH	JUNE	JULY	AUG.	SEPT.	OCT.
Quantity (Ml)	582	651	524	453	307
MONTH	NOV.	DEC.	TOTAL		
Quantity (Ml)	168	117	3318		

These are the estimated actual flow losses in the Little Para River between the proposed dam and Pt. Wakefield Road, and to maintain the status quo these are the quantities which should be released.

In order to ensure that releases from the proposed storage are not lost to the sea it is recommended that gauging station No.504506 near Pt.Wakefield Road should be upgraded to continuously monitor flows leaving that section of the river.

The possibility of regulating urban and rural run-off and using it for groundwater recharge along the Little Para River should be investigated as this could considerably reduce the quantity required from the proposed dam. However, it is essential that this run-off be investigated to determine whether its quality is suitable for groundwater recharge.

Monitoring of groundwater levels and stream flow should be maintained within the plains area in order to check that the groundwater situation remains unchanged.

INTRODUCTION

A dam is proposed for the lower part of the Little Para River and the effect of impounding water on intake to the groundwater of the Northern Adelaide Plains is required.

East of the Para Fault within the basement rocks there is normally a small flow through the summer. This flow usually disappears before reaching the plains. In dry years during periods of low flow surface water extends for only about 1.5 kilometres west of the Main North Road at Carisbrooke Reserve. In this situation, as it occurred in 1967, all flow either evaporated or penetrated into sand and gravel beds where some of it was transpired and the remainder entered shallow aquifers.

For approximately 5 years flow measurements have been made at several points on the Little Para River and in addition groundwater levels have been taken on a monthly basis from observation bores entering various aquifers at sites extending from Carisbrooke Reserve to Pt. Wakefield Road. With the data now available it is possible to quantify approximately the volume of groundwater intake from river flow.

GENERAL GEOLOGY

The Little Para River in its passage from the site of the proposed dam traverses mainly Precambrian slates with occasional thin quartzites.

The eastern margin of the Northern Adelaide Plains is the Para Fault which in this area has a displacement of about 600 metres. The actual fault zone where the Little Para River emerges from the Para Fault Block is obscured by younger alluvium.

The sedimentary succession in the plains adjacent to the Little Para River consists broadly of two distinctive groups of sediments. The oldest is of Tertiary age and comprises mainly marine sediments - limestone, sands and clay. Included in these sediments are the most important aquifers of the area. The Quaternary sediments forming the younger group of sediments are non-marine apart from a few thin shell beds near the coast. Sediments of the group are predominantly clay, silt or sand with occasional gravel beds near the foothills. Aquifers within this group are sand or gravel beds generally lenticular and thinning and becoming finer grained westward from the Para Fault.

Between the two groups of sediments is a transition bed known as the Carisbrooke Sand, regarded as Pliocene - Pleistocene in age. It has its thickest known development of about 50 metres, in the vicinity of the Little Para River. The Carisbrooke Sand is a fluviatile deposit and in places along the Little Para River has replaced to a large extent, the underlying Pliocene Dry Creek Sands. It appears that the Little Para River has been active since at least the Pliocene when erosion and removal of Dry Creek Sands took place.

HYDROGEOLOGY

Within the Tertiary succession there are three pressure aquifers designated 'A', 'B' and 'C' in order of increasing depth (Table II). Aquifers 'A' and 'B' supply more than 80% of the water used for irrigation in the plains, the remainder being obtained from shallow aquifers within the Quaternary group. Aquifer 'C' is not significant as a source of groundwater; as far as is known it contains only saline water.

The Carisbrooke Sand appears to be generally in hydraulic connection with the underlying Dry Creek Sands and may be regarded as an upper extension of aquifer 'A'.

The shallow aquifers, designated 1, 2, 3, etc. in order of increasing depth are beds of sand or gravel close to the Para Fault and have an average thickness of 8 -10 metres. The top aquifer behaves as an unconfined aquifer but deeper aquifers are semi-confined and behave in a similar way to aquifers 'A' and 'B' (See hydrographs Figs. 2, 3, 4).

It is considered that there are two main methods of intake. The first and most important is from the river bed into shallow aquifers and these in turn leak downward into deeper aquifers. This leakage occurs because of head differences in the various aquifers and although permeability of the intermediate beds is low the area involved is relatively large, hence there is appreciable downward movement of water.

The following table (Table I) presents water level information for the various aquifers obtained from a group of bores in and near Carisbrooke Reserve.

Intake may also occur through the Para Fault zone but its extent is unknown. It is included in the quantity entering shallow aquifers, which occur over the fault zone.

TABLE I Groundwater Level Date - Carisbrooke Reserve

Bore No.	Total Depth (metres)	Casing (metres)	Water Cut (metres)	Water Level (metres) during drilling	Aquifer No.	Reduced Water level at March 1973 DATUM:A.H.D.
P4	183	177	9.1		1	
			32		2	18.4 (Aquifer 'A')
			76		3	
			131		A	
			151		B	
P5	12.4	9.5	8.6	5.5	1	46.96 (Aquifer 1)
P6	26	21	8.6	7.3	1	
			19.8	7.3	2	46.39 (Aquifer 2)
P7	79	72.5	10.1	7.6	1	
			16.5	8.9	2	18.5 (Aquifer 4)
			59	31.5	3	
			72.5	27.4	4	

These figures show that there is a fall in head from Aquifer 1 - 4 and then into Aquifer 'A' - a total of 28.56 metres. Much of the profile in this area is sandy and there is little to separate or distinguish aquifers but it is considered that movement between aquifers can occur quite readily as shown by the hydrographs. When recharge occurs in Aquifer 1, this is reflected in Aquifer 2.

Aquifers 1 and 2 are readily recharged by run-off in the Little Para River as shown by the hydrographs - they are recharged rapidly following the first run-off in each year. On the other hand groundwater levels fall rapidly after flow in the river ceases. There are two main factors involved in this decline - downward leakage through semi-confining beds and a westerly movement through the aquifer. In considering bore hydrographs it should be remembered that pumping for irrigation commences each year in October - November and this accounts for much of the decline, particularly in the western part of the area under consideration.

Average transmissivity of the shallow aquifers, as determined by pumping tests is 200 m^3/day/metre. However, because of variations in sedimentation of the shallow aquifers transmissivity is expected to vary over a wide range, being higher in the coarser sands and gravels near the fault scarp if a constant thickness of aquifer is assumed. Similarly storage coefficient of the aquifers and vertical permeability of the sediments vary considerably.

For purposes of estimating recharge to shallow aquifers it is assumed that the storage co-efficient for these aquifers from the Para Fault to Salisbury is 10^{-1} falling to 10^{-2} west from Salisbury to the Pt. Wakefield Road. Although shallow aquifers are known over most of the Northern Adelaide Plains, low salinity zones occur only adjacent to the Little Para and Gawler Rivers.

For the Little Para River the zone where salinity of Aquifer I is less than 1000 mg/l. has an average width of 1.5 km and extends from the Para Fault to the Pt. Wakefield Road. It is assumed that this is the zone in which shallow aquifers receive recharge from the Little Para River.

Groundwater Recharge

As indicated above two areas are considered for recharge from the Little Para River, and although this is a simplification of the actual situation results obtained should be of the right order, depending on the values of storage co-efficient.

The first zone (Zone I) from Carisbrooke Reserve to Salisbury has an area of 6 square kilometres. If Aquifer I is considered to be uniform and extend throughout this zone then recharge is 1968 amounted to 5.4 metres. On the basis of a storage co-efficient of 10^{-1} the recharge over the zone was:

$6 \times 10^6 \times 5.4 \times 10^{-1}$ cubic metres

$= 3.24 \times 10^6$ cubic metres.

However, 1968 was a year of high rainfall and subsequent run-off, following a year of extremely low rainfall. Shallow aquifers were almost depleted, and there was rapid intake following the first runoff in the river.

Changes in storage (recharge) of Aquifer 1 for 1968 and subsequent years were as follows:

YEAR	RECHARGE
1968	3.24×10^6 cubic metres
1969	9.6×10^5 " "
1970	2.46×10^6 " "
1971	1.08×10^6 " "

An average value for the four year period is 1.94×10^6 cubic metres/year.

For Zone 2 (Salisbury - Pt.Wakefield Road) which is taken to be of the same extent as Zone 1, recharge based on a storage co-efficient of 10^{-2} is as follows:.

YEAR	RECHARGE
1969	3.42×10^5 cubic metres
1970	5.16×10^5 " "
1971	3.78×10^5 " "
Average	4.09×10^5 " "

Average recharge for zones 1 &2 is therefore estimated to be 2.35×10^6 cubic metres (2350 M.l.) per year.

Hydrographs of observation bores in Aquifer 1 show that this aquifer is almost fully recharged 3-4 months after flow commences. Very little of any subsequent flow in the Little Para River enters the aquifers and is lost to the system.

Therefore it is considered that in order to maintain the status quo recharge to the aquifers should average 2350 M.l. per year (515 m. gallons).

SURFACE WATER HYDROLOGY

Losses of river flows have been examined in two reaches

a) Between gauging station 504504 and 504503 known as the 'fault zone'

b) In the reach between gauging station 504504 and the Port Wakefield Road.

a) 64 samples of rates of flow loss between the two gauging stations were analysed and the pattern of loss shown in full line on figure 6 emerged. This is shown in megalitres in Table 3 and amounts to an average loss from streamflow of 1380 M.l. per year. A proportion of this amount is considered to reach the pressure aquifers possibly via the shallow aquifers 1, 2 & 3.

b) Figures 8 & 9 shown flow profiles in the reach below GS.504504 and from these estimates of seasonal potential flow loss rate have been made. These are shown in Table 4. This potential rate is not normally satisfied and figures for 'effective percentage of time' this rate is "normally" satisfied by the river were taken from the river hydrographs for the 5 year period. These range from 4% in January to 100% in June to September. Available flows have also been considered so no estimate of loss rate exceeds the mean available flow rate. The mean flow loss rates for the reach amounting to 1938 M.l./year are derived and shown in Table 5.

Significance of Flow Loss

The total losses for both zones described in a) & b) above is 3318 Megalitres as shown by Table 6. Of this the groundwater system is gaining 2350 M.l. and the use by vegetation and other evaporation must amount to 968 M.l. As long as the river bed is the route for recharge 3318 M.l. will have to be passed into the reach on the pattern of Table 6. After construction of the dam tests could be carried out to determine if recharge could be effected with less evaporation loss by changing the time of release. Until such tests are successfully done, the timing of releases must coincide with the pattern of Table 6 if the groundwater status quo is to be maintained.

Harvesting Urban Runoff

Examination of Figures 8 and 9 reveals the effects of urban drainage in the Salisbury and Elizabeth areas and that there is considerable flow accretion at times. The foregoing work has indicated that something of the order of 2000 M.l. has normally been dissipated between Carisbrooke Park and the Port Wakefield Road. Whatever proportion of this reaches the water table aquifer it is to be expected that a quantity of this order must be passed down to achieve 'normal' recharge under natural conditions.

Urban drainage water, however, has been lost to sea as in such cases as 13.6.73, 15.9.70 and 8.8.72 as seen on the flow rate profiles figures 8 & 9. Bore and river stage hydrographs have been prepared to determine the importance of river stage as opposed to river discharge to groundwater recharge. However, as river stage and discharge are also inter-related a satisfactory conclusion cannot be drawn. Consideration of the 'Drain Equation' for porous media flow leads to the belief that stage is the controlling factor, the boundary condition at the river bank surface remaining on unknown factor. It can be suggested with some certainty that maintaining water stage in the Little Para watercourse in the Salisbury area would benefit the recharge to the water table aquifer and further that a structure designed so to do would retain a proportion of urban drainage water and recharge it to the water table aquifer. The Fabridam type of installation would be ideal for this in a plains type watercourse.

Indirectly the provision of 1000 M.l. of water for this could be valued at over $25,000 per year if originating from the Murray-Millbrook system which is good enough reason to consider harvesting urban runoff here and saving releases from the Little Para Dam.

The urban drainage area draining into the reach is about 6.6 Sq.Km. and the rural portion 31 Sq.Km, the approximate median runoff may be about 1100 M.l. Suppose the holding of the channel to a depth of 4 metres at 4 sites was about 200 M.l. and maintaining this stage was feasible it may be possible to derive 600 M.l. of recharge from urban drainage. The quality aspect of this activity would require scrutiny but use of the Fabridam principle would allow the holding to be selected by quality and simultaneously provide control information back to the Little Para Dam operator when to cut back on releases.

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18th October, 1973

TABLE II

STRATIGRAPHIC SUMMARY OF THE TERTIARY-QUATERNARY SUCCESSION IN THE NORTHERN ADELAIDE PLAINS

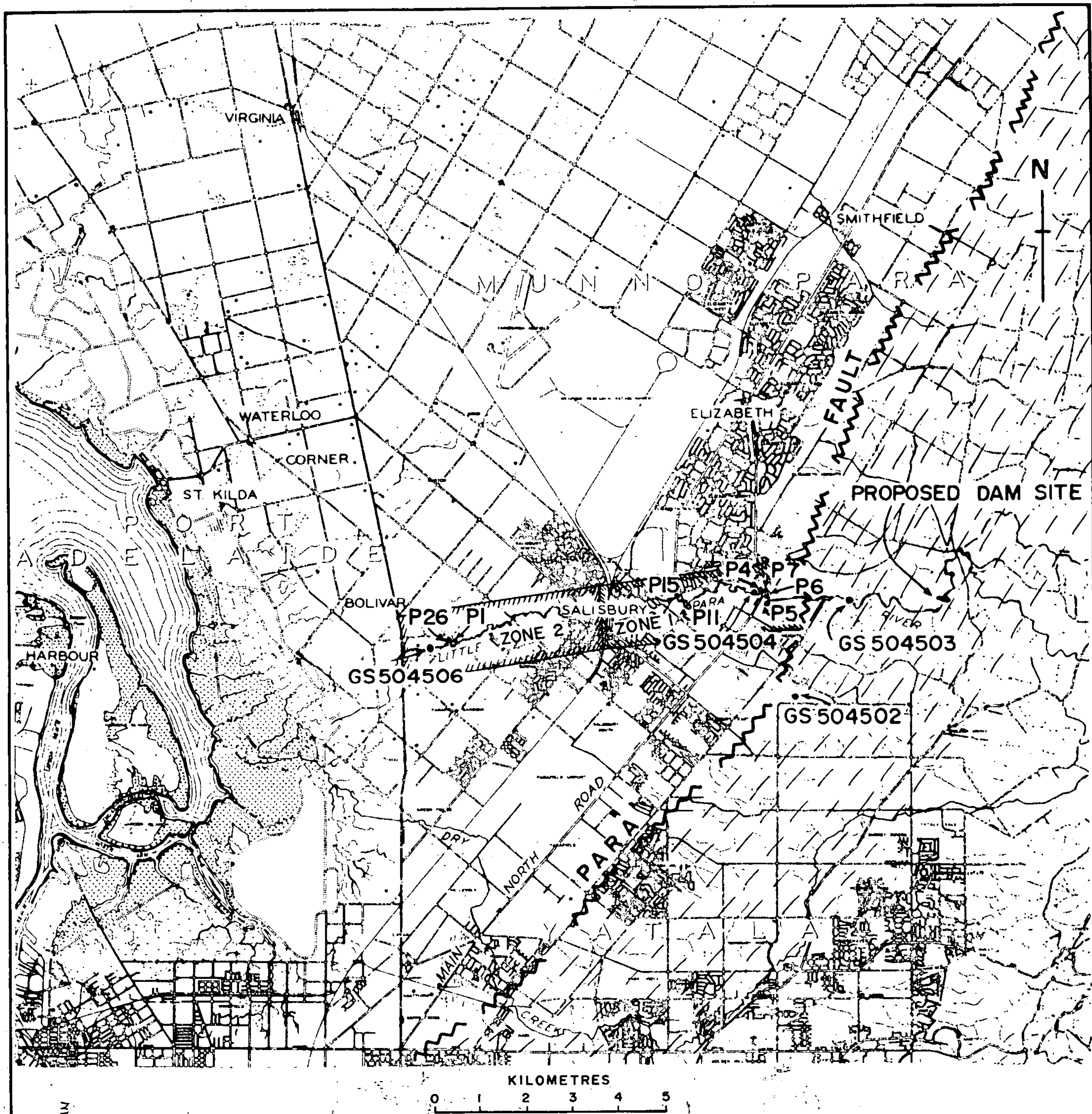
GEOLOGICAL UNIT NAME.	AGE	ENVIRONMENT OF DEPOSITION	OCCURRENCE IN AREA	DESCRIPTION	THICK-NESS (MAX) METRES	REMARKS
ST.KILDA FORMATION	RECENT	MARINE	Adjacent to present coast	Stranded Shell Beds	4.5	
POORAKA CLAY	PLEISTOCENE	ALLUVIAL	Over whole area	Sand, silt and clay	3	
GLANVILLE FORMATION	PLEISTOCENE	MARINE	Adjacent to present coast	Shell Beds	3	
HINDMARSH CLAY	PLEISTOCENE	FLUVIATILE ALLUVIAL	Over whole area	Clay, silt sand and gravel	105	Shallow aquifers consisting of thin sand or gravel beds
CARISBROOKE SAND	PLIOCENE-PLEISTOCENE	FLUVIATILE, ALLUVIAL	Vicinity of Little Para & Gawler Rivers and near Para Fault	Yellow silt and sand	53	Part of Aquifer 'A' in some areas particularly near Little Para River.
HALLET COVE SANDSTONE, DRY CREEK SAND	PLIOCENE	MARINE	Western & Southern part of the area	Calcareous sandstone, limestone and sand	69	Aquifer 'A'

<u>TABLE II</u> (CONTINUED)

PT. WILLUNGA BEDS (UPPER PART)	MIDDLE TO LOWER MIOCENE	MARINE	South of Gawler River	Fossiliferous sandy limestone	37		
MUNNO PARA CLAY	" "	MARINE	" " "	Blue grey clay	12	Confining Bed	
PT. WILLUNGA BEDS (LOWER PART)	LOWER MIOCENE TO OLIGOCENE	MARINE	Over whole area	Fossiliferous sandy limestone	170	Aquifer 'B'	
BLANCHE POINT MARLS	UPPER EOCENE	MARINE	" " "	Marl, siltstone limestone	120	Confining Bed	
SOUTH MASLIN SAND	UPPER EOCENE	RESTRICTED MARINE		Poorly fossiliferous sands	38		
MULOOWURTIE CLAY	UPPER-MIDDLE EOCENE	RESTRICTED MARINE & NON-MARINE	Penetrated in only 3 bores	Silty carbonaceous clay	40	Confining bed where present	Aquifer 'C'
NORTH MASLIN SANDS	MIDDLE EOCENE	FLUVIATILE ESTUARINE		Sand and gravel	31		

ESTIMATED FAULT ZONES LOSS (M.l.)

	JAN	FEB	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
TABLE 3	96	85	74	66	62	51	124	192	243	183	105	99	1380
TABLE 4	POTENTIAL FLOW LOSS RATE GS.504504 TO PORT WAKEFIELD ROAD												
	77	104	164	237	372	531	527	332	210	140	87	65	2846
TABLE 5	ESTIMATED ACTUAL FLOW LOSS RATE GS.504504 TO PORT WAKEFIELD ROAD												
	3	53	3	12	62	531	527	332	210	124	63	18	1938
TABLE 6	TOTAL LOSSES FROM L. PARA DAM TO PORT WAKEFIELD ROAD (M.l.)												
	99	138	77	78	124	582	651	524	453	307	168	117	3318



PRECAMBRIAN — Adelaide System; slates and quartzites.

TERTIARY–QUATERNARY — Marine and non-marine sediments of the St. Vincent Basin

Fault

• P11 Observation bore

• GS 504506 Stream Gauging Station

FIG. 1

HYDROGEOLOGY SECTION	DEPARTMENT OF MINES – SOUTH AUSTRALIA	Scale: 1:125 000
Compiled: R.G. Shepherd	NORTHERN ADELAIDE PLAINS GROUNDWATER STUDY LITTLE PARA RIVER GENERALISED GEOLOGY AND OBSERVATION SITES	Date: 23 Oct. '73
Drn. D.J.M. Ckd.		Drg. No. GH S10551

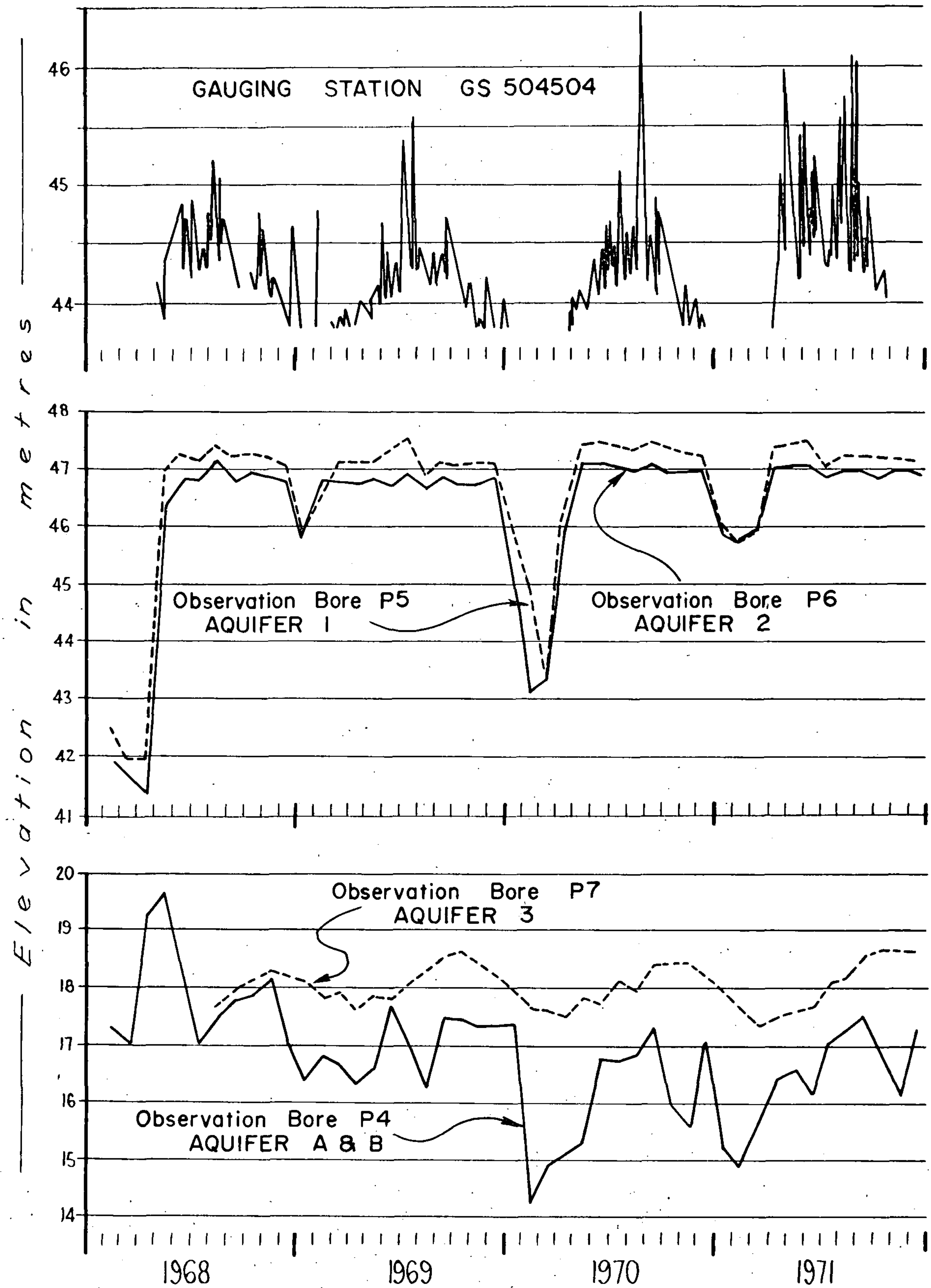


FIG. 2

HYDROGEOLOGY SECTION	DEPARTMENT OF MINES – SOUTH AUSTRALIA	Scale:
Compiled: R.G. Shepherd	NORTHERN ADELAIDE PLAINS GROUNDWATER STUDY CARISBROOKE RESERVE	Date: 23 Oct. '73
Drn. D.J.M. Ckd.	HYDROGRAPHS OF GAUGING STATION GS 505404 AND OBSERVATION BORES P4, P5, P6, P7	Drg. No. GH S10552

300–6.72 C5552

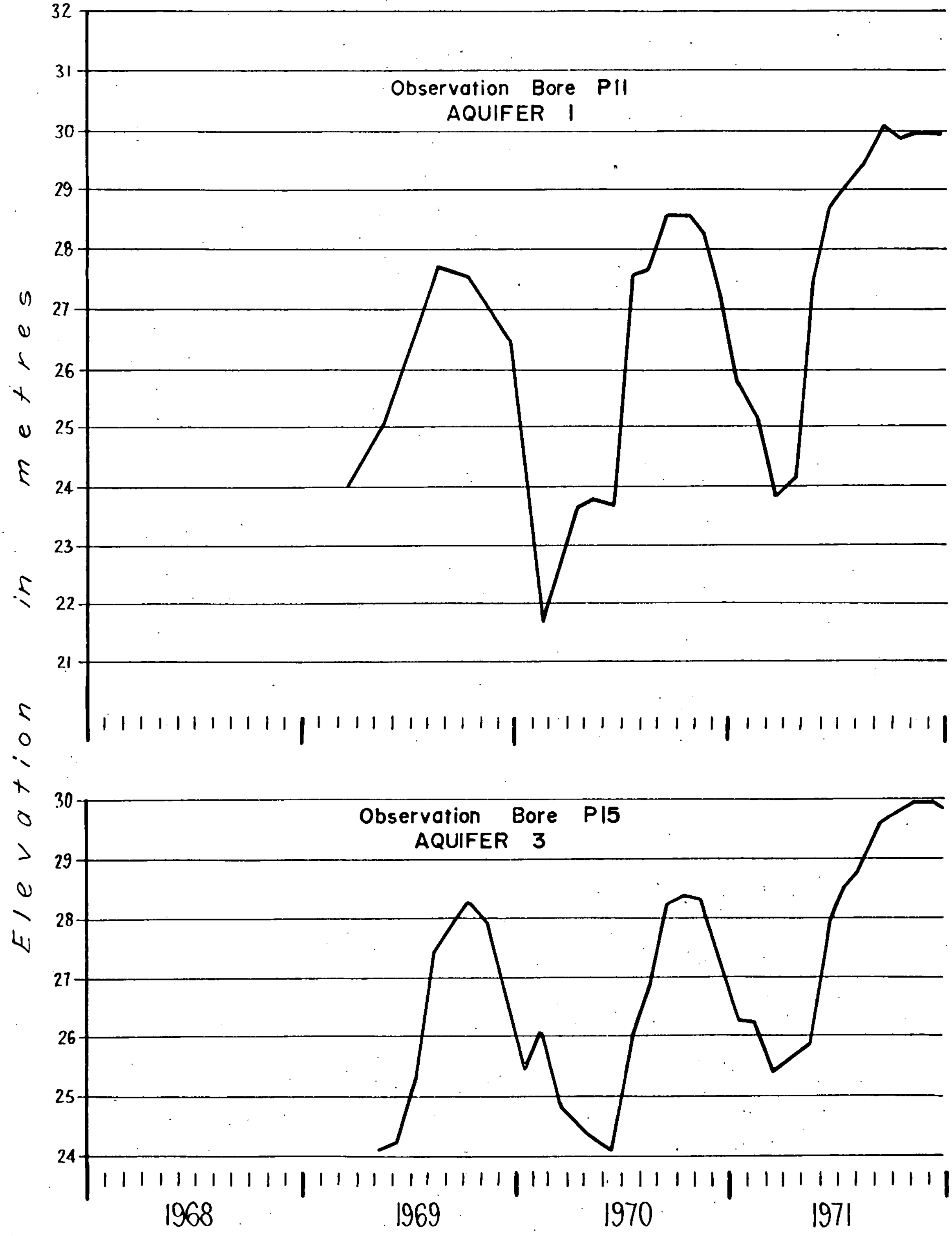


FIG. 3

HYDROGEOLOGY SECTION	DEPARTMENT OF MINES – SOUTH AUSTRALIA	Scale:
Compiled: R.G. Shepherd	NORTHERN ADELAIDE PLAINS GROUNDWATER STUDY SALISBURY AREA HYDROGRAPHS OF OBSERVATION BORES P11, P15	Date: 23 Oct. '73
Drn. D.J.M. | Ckd.		Drg. No. S10553 GH

300–6.72 C5552

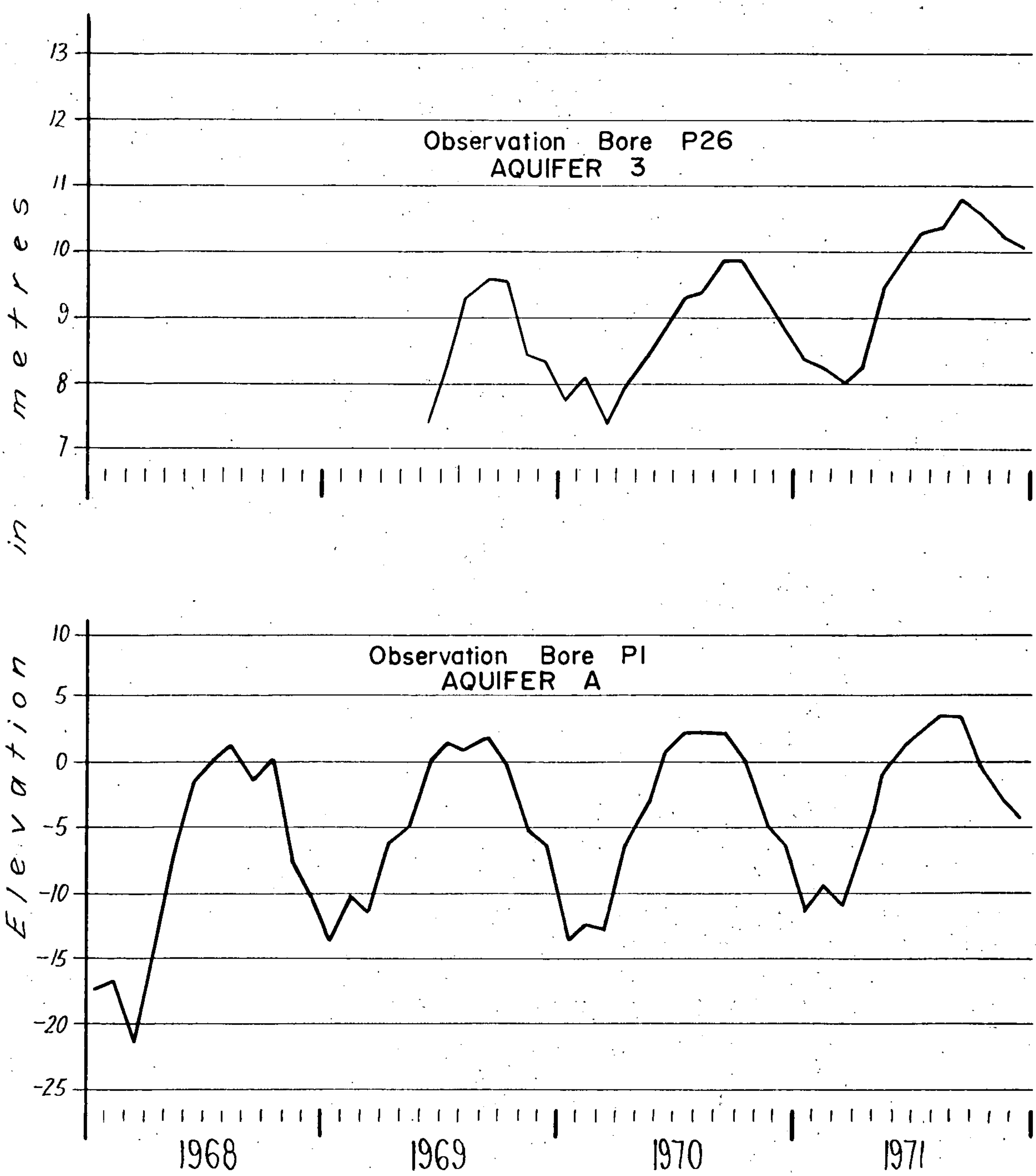
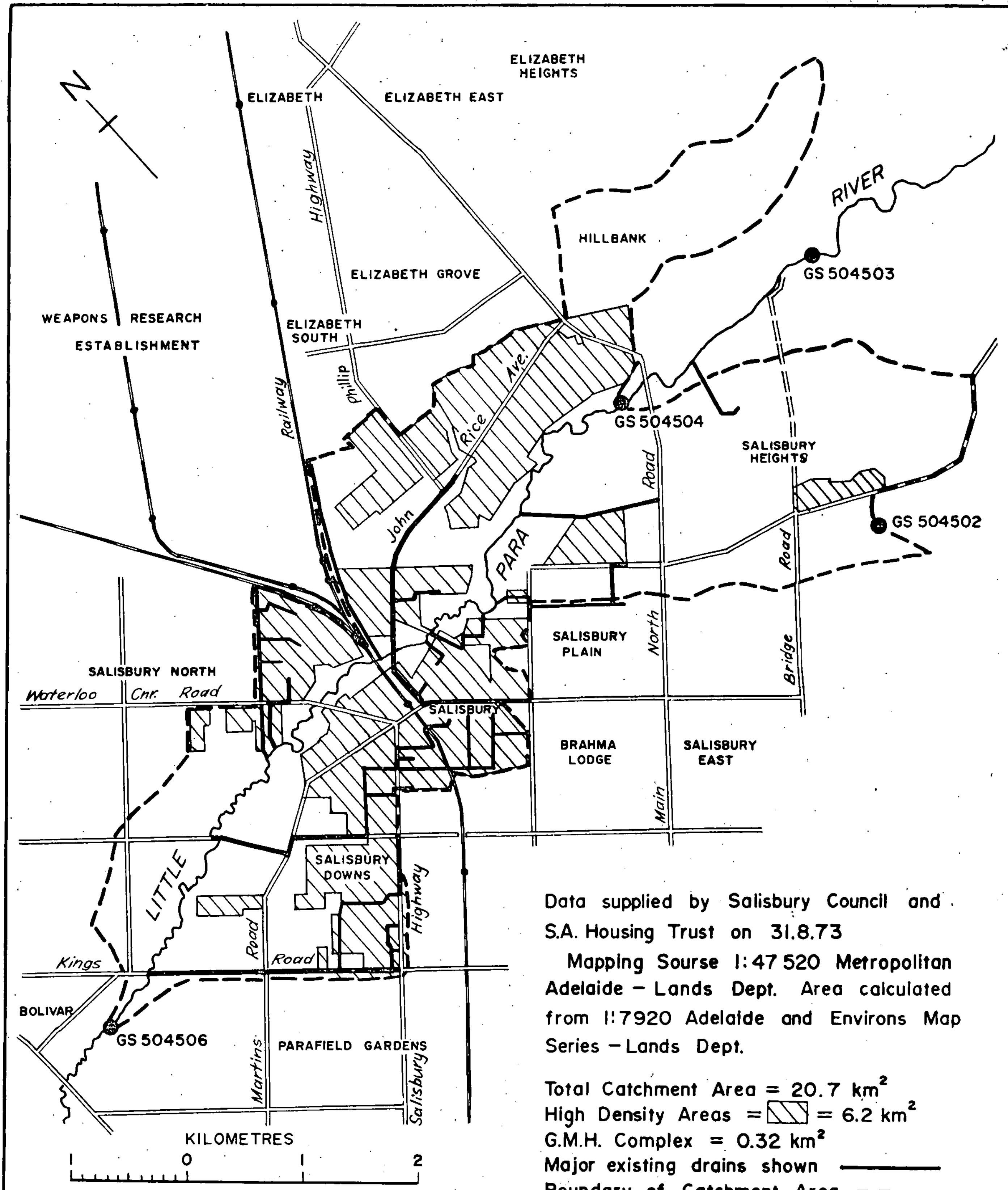


FIG. 4

HYDROGEOLOGY SECTION	DEPARTMENT OF MINES – SOUTH AUSTRALIA	Scale:
Compiled: R.G. Shepherd	NORTHERN ADELAIDE PLAINS GROUNDWATER STUDY BOLIVAR AREA	Date: 23 Oct. '73
Drn. D.J.M. Ckd.	HYDROGRAPHS OF OBSERVATION BORES – P1, P26	Drg. No. S10554 GH

300–6.72 C5552



Data supplied by Salisbury Council and S.A. Housing Trust on 31.8.73

Mapping Sourse 1:47 520 Metropolitan Adelaide – Lands Dept. Area calculated from 1:7920 Adelaide and Environs Map Series – Lands Dept.

Total Catchment Area = 20.7 km^2
High Density Areas = [hatched] = 6.2 km^2
G.M.H. Complex = 0.32 km^2
Major existing drains shown ————
Boundary of Catchment Area – – – –

FIG. 5

ENGINEERING & WATER SUPPLY DEPARTMENT	**DEPARTMENT OF MINES – SOUTH AUSTRALIA**	Scale: 1:47520
Compiled: D.Kingston	NORTHERN ADELAIDE PLAINS GROUNDWATER STUDY	Date: 23 Oct. '73
Drn. D.J.M. Ckd.	LITTLE PARA RIVER	Drg. No.
	CATCHMENT AREA ABOVE GAUGING STATION GS505406	S10555 GH

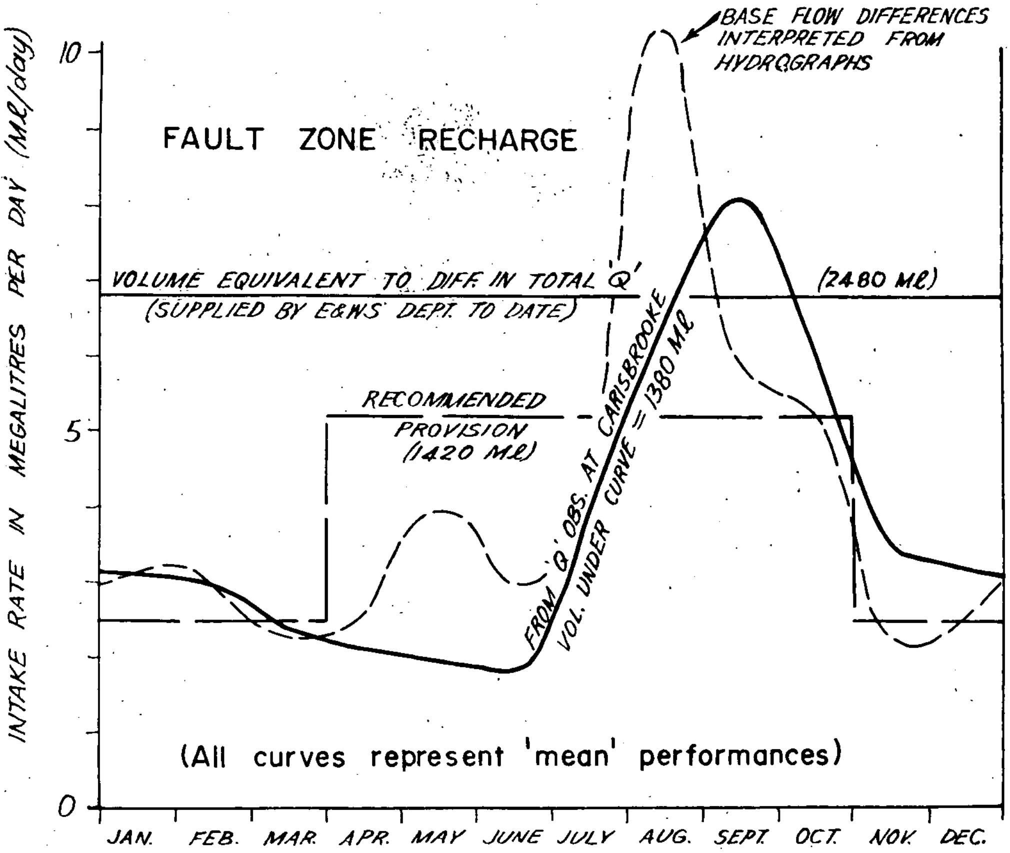


FIG. 6

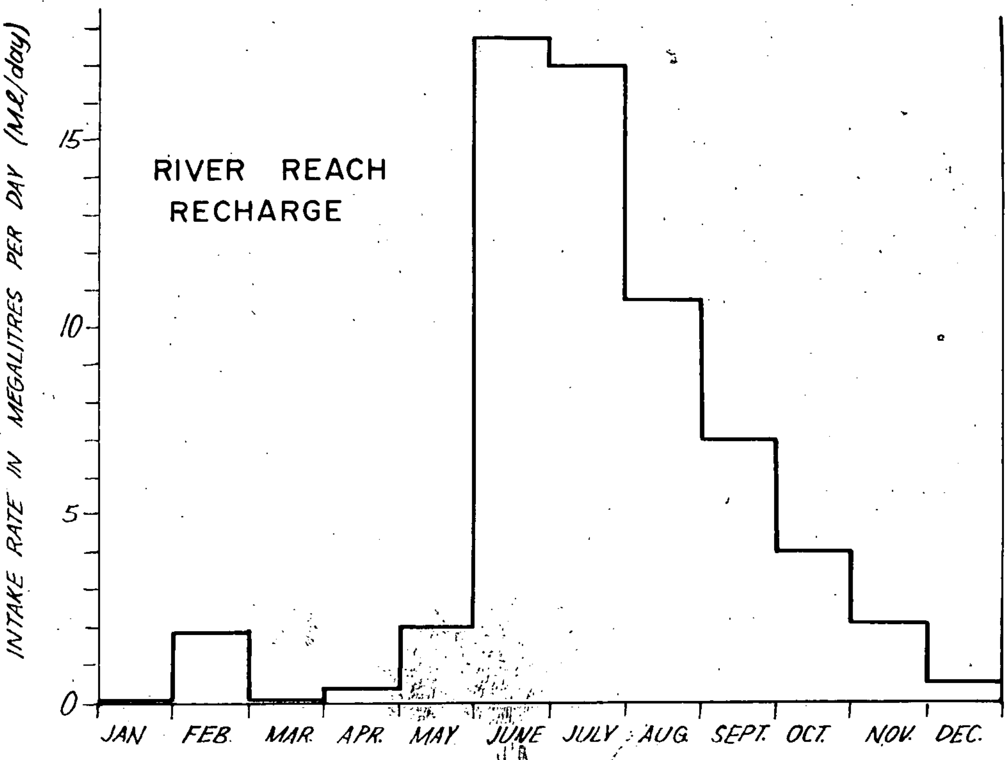


FIG. 7

ENGINEERING & WATER SUPPLY DEPARTMENT	**DEPARTMENT OF MINES – SOUTH AUSTRALIA**	Scale:
Compiled: D.Kingston	NORTHERN ADELAIDE PLAINS GROUNDWATER STUDY LITTLE PARA RIVER FAULT ZONE RECHARGE AND RIVER REACH RECHARGE	Date: 23 Oct. '73
Drn. D.J.M. Ckd.		Drg. No. S10556 GH

300–6,72 C5552

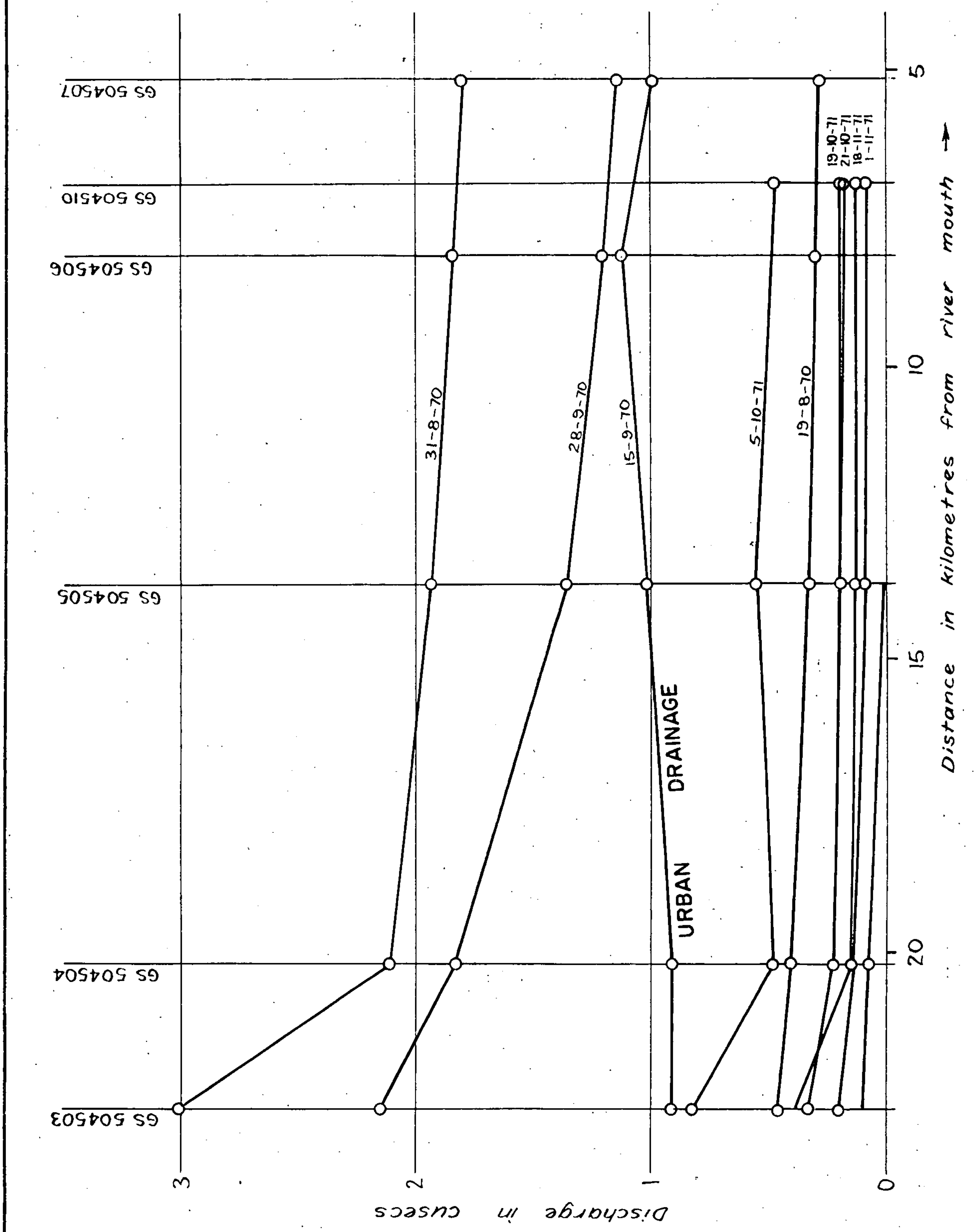


FIG. 8

ENGINEERING & WATER SUPPLY DEPARTMENT	DEPARTMENT OF MINES – SOUTH AUSTRALIA	Scale:
Compiled: D. Kingston	NORTHERN ADELAIDE PLAINS GROUNDWATER STUDY	Date: 23 Oct. '73
Drn. DJM / Ckd.	FLOW LOSS RATES ALONG LITTLE PARA RIVER	Drg. No. S10557
	1970 – 1971	• GH

300–6.72 C5552

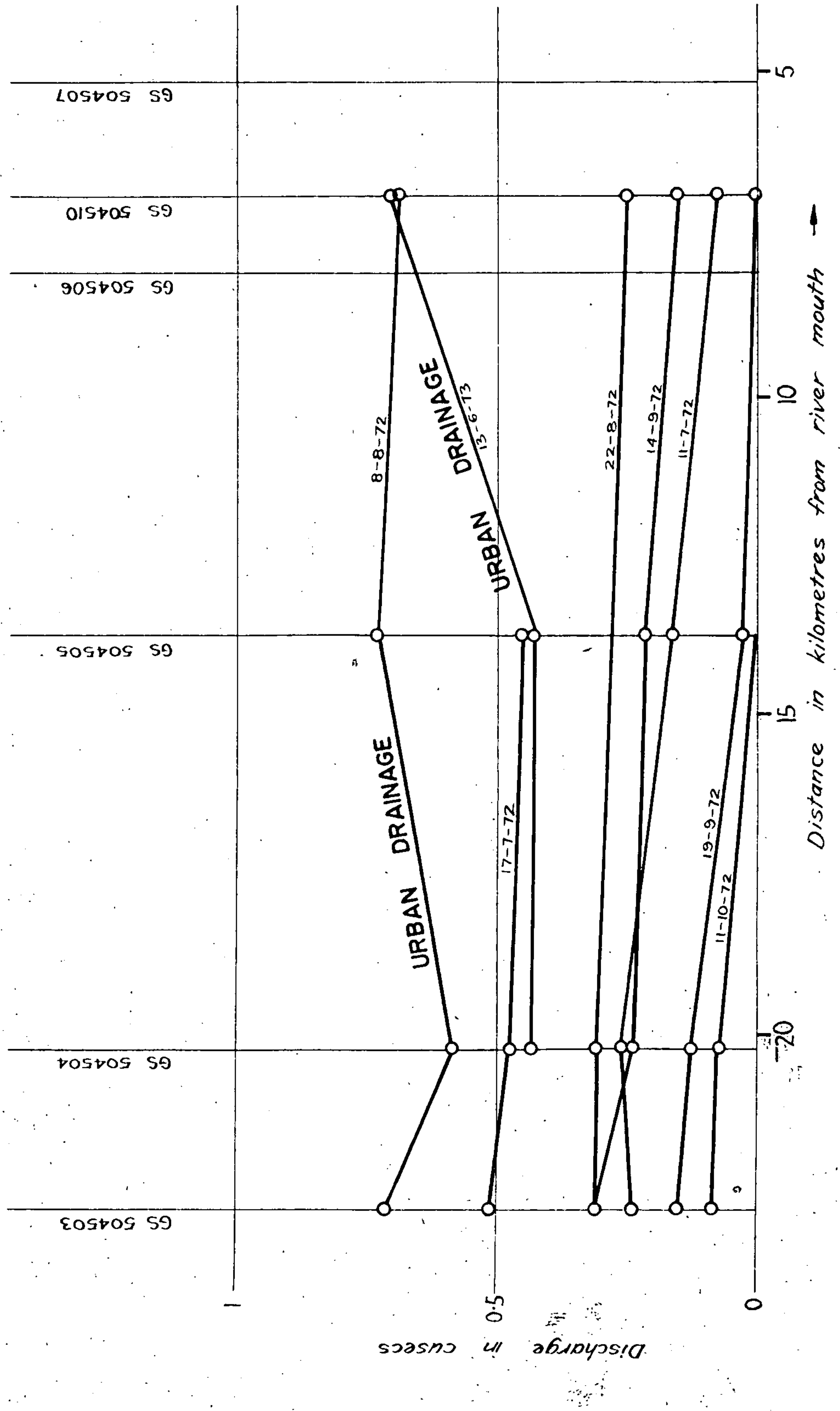


FIG. 9

ENGINEERING & WATER SUPPLY DEPARTMENT	DEPARTMENT OF MINES – SOUTH AUSTRALIA		Scale:
Compiled: D. Kingston		NORTHERN ADELAIDE PLAINS GROUNDWATER STUDY FLOW LOSS RATES ALONG LITTLE PARA RIVER 1972 – 1973	Date: 23 Oct. '73
Drn. D.J.M.	Ckd.		Drg. No. S10558 GH

300–6 72 C5552