DEPARTMENT OF MINES
SOUTH AUSTRALIA

RB 738

CHOWILLA PROJECT

RESERVOIR

GEOLOGICAL INVESTIGATIONS, PROGRESS REPORT NO. 2

PROPOSED STUDY OF EFFECTS ON GROUNDWATER REGIME

Co. Hamley

Client: Engineering and Water Supply Department

by

D.H. STAPLEDON
SUPERVISING GEOLOGIST
ENGINEERING DIVISION

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Rept. Bk. No. 738
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SOUTH AUSTRALIA

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INTRODUCTION

Effects in Vicinity of Dam

It has been appreciated since the first geological report by Johnson, Hiern and Steel (Ref. 1) that the filling of Chowilla Dam would cause some flushing downstream of saline groundwater present in sands beneath the Murray River alluvial flat. This problem has been studied in detail during design of the dam. For the immediate dam area, and for about half a mile downstream, provision is made in the design to collect most saline water displaced during operation.

Possible Effects in Reservoir Rim

Recent field studies in the Tilmy Flat area, and office studies of existing groundwater levels and gradients in the Murray Basin (Refs. 2 and 3, and Fig. 1) suggest that saline groundwater is entering the Murray River in many places both upstream and downstream from the dam. This has also been pointed out by Crawford (Ref. 4) and Helliwell (Ref. 5).

In the first systematic geological examination of the reservoir rim, Boucaut (Ref. 6) drew attention to numerous exposures of Parilla and Loxton Sands bordering the reservoir in the first few miles upstream from the dam. These sands are highly permeable (Ref. 6, p. 4). The main areas of their exposure around the reservoir are shown in black on Fig. 1.

Because of the highly permeable nature of these sands, and the relatively low (R.L.160-R.L.170) water table, it is clear that water flow will occur into them from the reservoir (HWL208). This will form an elevated wedge-shaped layer of fresh water, sloping away from the reservoir rim, the slope angle or angles depending upon the sand permeabilities, and the shape of the present water table. Dr. Emerson, of CSIRO Division of Soils, has stated verbally his belief that this leakage will cause appreciable loss of storage, but observations by Boucaut (Ref. 6, page 6) suggest that the actual leakage is likely to be much less than that calculated theoretically using presently known permeability figures.

Assuming that the loss of storage will not be a serious problem, there is still the probability that over a number of years this water will tend to flow downstream around the margins of the reservoir, and eventually back into the Murray River somewhere downstream from the dam. It is possible that this water could (a) become saline by dissolving salt out of the sands or (b) become mixed with highly saline groundwater, or (c) that it could cause saline groundwater to be flushed downstream. The rate at which this downstream flow could occur, and the quantities of fresh lake water and saline groundwater which could enter the Murray downstream, cannot be predicted at this stage. It is hoped that the adverse effects will be insignificant, but this cannot be

assumed. It is considered that they will depend upon the following main factors:

(a) The geological picture, particularly the vertical and lateral extents of the highly permeable sands.

(b) The amount and effectivness of natural "blanketing" material over the highly permeable sands, and of additional "blanketing" which will occur during operation (Ref, 6, p. 6).

(c) The permeabilities of the sands.

(d) The existing pattern of groundwater flow, and the salinity pattern of the groundwater.

(e) Geometrical considerations, i.e. the slope and lengths of possible leakage paths.

(f) The saline content of the sands.

CURRENT AND PROPOSED WORK

Observation Wells

It is considered that the current programme of deep observation wells on both banks of the river will add greatly to our knowledge of this problem, firstly by giving a more precise picture of the geology, and secondly by giving accurate contours on the present water table, before commencement of filling of the reservoir. From these contours the present directions and approximate velocities of groundwater flow can be calculated. On completion of theprogramme of wells, and of the first few water level observations, it is proposed to present the geological and groundwater data in simplified diagrammatic sections to the E. & W.S. Department, and to suggest that mathematical or model studies, or both, be made of them. It is believed that such

studies, using the range of permeability figures obtained by

Soil Mechanics Limited in the Parilla and Loxton Sands, would give the best possible advance indications of the order of storage water and groundwater migration to be expected. These studies could be made both with and without allowances for blanketing effects around the reservoir rim. It is possible that the need for some artificial blanketing of exposed sand areas may be indicated by these studies.

The Exploration Geophysics Section has recently been developing resistivity techniques for use in hydrological studies, and it is proposed to enlist their aid, at least in the pre-construction stage, and also later if the resistivity method can be shown to be useful.

Water Level Measurements to Date

The Engineering Geology Section has made regular measurements of water levels in completed observation wells on the right bank (Figs.3 and 4, and Table 1), for eleven months. The water levels show minor fluctuations which cannot be satisfactorily explained at this stage. A possible explanation is given in Appendix A.

Suggested Future Arrangement for Water Level Measurements

There are four obvious variables, pool level, regional rainfall, local rainfall, and barometric pressure, which need to be taken into account before we can interpret reliably these water level observations and any future observations. Pool level and regional rainfall figures are readily obtained, but there are no existing facilities for recording the intensity and frequency

of local rainfall and changes in barometric pressure. It is therefore recommended that the Tilmy Flat area be instrumented in the manner suggested in Appendix A, i.e. by one instrument station including pluviograph, water level recorder and barograph, and a number of rain gauges. Another group of rain gauges will probably be required in the area of the proposed observation wells on the left bank.

On the completion of the current programme of about 50 observation bores on both sides of the proposed reservoir (Refs. 7, 8 and 9) it is proposed to transfer the responsibility for maintenance and measurement of these wells to the E. & W.S. Department.

Analyses of Groundwater from Observation Wells

A few analyses have been made of groundwater from the observation wells in the Tilmy Flat area (right bank). Systematic sampling and analysis has not yet been carried out because of contamination of the groundwater by drilling water or drilling mud. Assuming the Parilla Sand permeability as 5×10^{-2} cm/sec. (5.7×10^{4} ft./yr.) and a gradient of 1 in [redacted] the velocity in this area is ofthe order of 11 ft/yr. It has therefore been decided to leave sampling and analysis for contaminated holes until at least a year after completion of drilling.

Hydrogeology Section will continue the programme of sampling and analyses as rapidly as adviseable under these conditions. It is considered desirable to have analyses of samples from 3 known levels in each hole, at 6-monthly intervals. From this data

we will be able to assess whether contamination effects are gone, and changes in salinity with depth below the water surface.

Analyses of Sands to Determine their Salt Content

Arrangements are being made to determine the content of saline materials present within the geological profile. Samples from the current programme of observation wells will be used.

Pre-construction Record of Murray Valley

Hydrogeology Section is making a systematic study of the Murray River and Valley between the dam and Renmark. This study will provide a comprehensive pre-construction record of the following:

(a) The geology.

(b) The salinity of the river.

(c) Location and complete description of any saline water seepages or inflows.

(d) Vegetation.

The record will be in the form of geological plans and sections, photographs in black and white, and in colour, and tables of water flows and analyses. The position of important measurements or observations will be marked on the ground with concrete pegs.

Observations during Operation of Chowilla Project

It is considered that these will need to include the following:

(a) Water levels in observation wells.

(b) Analyses of water in observation wells.

(c) Examination of the Murray Valley downstream from the dam, for new seepages or other changes.

(d) Analyses of River Murray water.

The significance of changes in these, during operation of the reservoir, will have to be assessed by comparison with observed conditions and changes during the period prior to operation.

D.H. STAPLEDON
SUPERVISING GEOLOGIST
ENGINEERING DIVISION

DHS:CAE
5.5.1967

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4. CRAWFORD, G., 1958. Report on Effect of Groundwater on the Salinity of the River Murray. Geol. Surv. S.Aust. Rept. Bk. No. 46/76,

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9. CHOWILLA TECHNICAL COMMITTEE. Minutes of Meeting No. 24.

APPENDIX A

MINUTE ON INSTRUMENTATION, TILMY FLAT

by

C. BLEYS
SENIOR GEOLOGIST
HYDROGEOLOGY SECTION

MINUTES forming ENCLOSURE to ..... *No.* 19

TO THE CHIEF GEOLOGIST:

Re. Water Level and Rain Gauge Equipment

Since the observation boreholes have been completed at Tilmy Flat, rises in water level up to 3 inches have been measured after 1 or 2 inches of rain. These rises could be due to 3 causes.

(1) Downward percolation of rain water along the casing of observation bores.

(2) A rise due to intake in the area where the aquifer crops out.

(3) Barometric.

1. Downward percolation could probably be recorded immediately after the rain but rises in levels would dissipitate in a very short time and not be detectable after 1 week as was the case.

2. If in the intake area a moderate to large quantity of rain finds its way into the aquifer a rise in water level could be recorded well away from such area due to differences in pressure. The movement of groundwater in this case would be vertical instead of horizontal. Such cases have been recorded in other parts of Australia but the rise should then be similar over large areas, or gradually in or decreasing. This again was not the case on Tilmy Flat.

3. The aquifer in Loxton sands at Tilmy Flat is a free water table aquifer. Such aquifer would not reflect any barometric changes. However the Loxton and Parilla sands, are overlain by a probably continuous clay bed which if moist most likely would prevent or retard pressure adjustment in the underlying sands. A fall or rise in barometric level, after rain could therefore result in a rise and fall measured in boreholes. Pressure increases do not have to be the same over the whole of the area and hence differences in levels could occur.

Differences in atmospheric pressures may be the cause of rise and fall in water levels in the observation bores on Tilmy Flat although there is no certainty in this matter. Therefore it is strongly recommended that the following equipment is installed on one of the observation bores drilled in this area.

(1) pluviograph
(2) water level recorder
(3) barograph.

The rain gauge water level recorder designed by the C.S.I.R.O., Multichannel event recorder is probably the best equipment to be used in this case as the pluviograph and water level recorder is combined in one unit. (Ref.)

~~It is~~ He recommended that the multipurpose event recorder described in Technical Memorandum 66/2 of the C.S.I.R.O. together with the transducer described in Technical Memorandum 66/11 (see DM.1470/61) be obtained for the purpose. (Ref.)

A barograph could probably best be obtained through the Commonwealth Bureau of Meteorology as they would be best equipped to advise on the most suitable instrument.

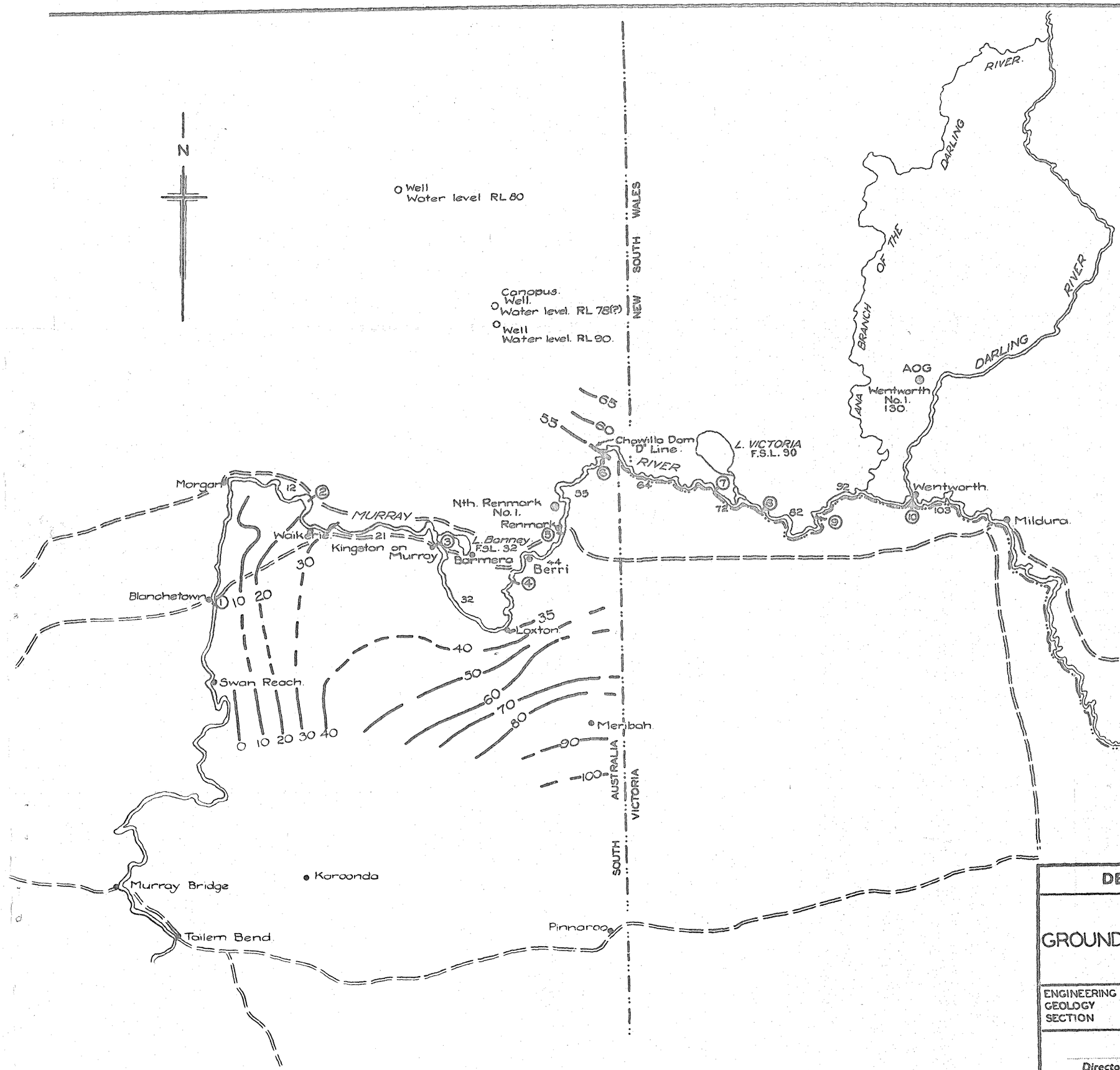
It is suggested that such equipment be used

It is realised that the equipment will have to be installed on boreholes owned by the E. & W. S. Department so that approval to use their bores for the purpose, will have to be obtained.

There is one other factor to be considered. Installation of the equipment on one single borehole would probably not be sufficient. However since the equipment is expensive normal 8 inch rain gauges, suitable for daily reading could be placed in the vicinity of alternate boreholes. They would have to be made available for this work. E. & W.S. Department probably would have sufficient manpower in this district so that they could be the best suited to control and carry out the measurements.

CB:PAL
28/3/67

C. BLEYS
Senior Geologist
Hydrogeology



LEGEND

55 — Pool level feet
③ — ④ Lock No.

Oil well.

30 — Formline - showing approx. level

Inferred Formline.

Note:
Level datum is mean sea level.

Datum for E.& W.S. Dept River Murray Survey is 105 feet below mean sea level.

SCALE
0 20 40 60
MILES

FIG. 1

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CHOWILLA PROJECT

GROUNDWATER INVESTIGATIONS — MURRAY BASIN

WATER TABLE FORM LINES

ENGINEERING GEOLOGY SECTION	W.R.O. Barnicant. GEOLOGIST	Drn. W. B.	SCALE: 1" = 16 miles.
		Tcd. A. McD	66-894 G+J
		Ckd. L.V.W.	
Director of Mines	SENIOR GEOLOGIST	Exd.	DATE: 12-10-66

EQUIPOTENTIAL LINES FROM EXISTING OBSERVATION WELLS. CURRENT PROGRAMME WILL EXTEND THIS COVERAGE UPSTREAM AND DOWNSTREAM. WELLS IN THIS AREA ARE TO BE USED ALSO TO OBSERVE ANY POSSIBLE EFFECTS OF LEAKAGE FROM SALINE WATER DISPOSAL AREAS

N

N.S.W

PROPOSED RESERVOIR H.W.L. R.L. 208

DAM

LOCK 6

WENTWORTH

RENMARK

RENMARK

VIC.

PROPOSED OBSERVATION WELLS (CURRENT PROGRAMME TO DETERMINE EQUIPOTENTIAL AND FLOW LINES UNDER EXISTING "NATURAL" CONDITIONS, AND LATER TO MONITOR EFFECTS OF OPERATION OF STORAGE

● OBSERVATION WELL

○ OBSERVATION WELL, PROPOSED

ALLUVIAL FLOODPLAIN OF RIVER MURRAY

ROAD

TRACK

RESERVOIR RIM SHOWING AREA WITH PANIGA OR LOXTON SAND EXPOSED

0 2 4 6 8

MILES

FIG. 2

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CHOWILLA PROJECT

EFFECTS ON GROUNDWATER REGIME

PROPOSALS FOR OBSERVATION

ENGINEERING GEOLOGY SECTION	GEOLOGIST	Drn. DIK	SCALE: 2miles = 1inch
		Tcd.	67-259 6+5
	DK 20 Apr '67	Ckd.	
Director of Mines	SUP. GEOLOGIST	Exd.	DATE: 28 Apr '67

REDUCED LEVEL – FEET

230
220
210
200
190
180
170
160
150

G95
G94
G93
G97
G91
G92

RAINFALL – POINTS
100
50
0

JUNE JULY AUGUST SEPT. OCT. NOV. DEC. JAN. FEB. MAR. APRIL MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC. JAN. FEB. MAR.

1966 1967 1968

FIG 3

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SALINE WATER DISPOSAL TILMY FLAT
GROUNDWATER MEASUREMENTS IN DRILL HOLES

ENGINEERING GEOLOGY SECTION	GEOLOGIST	DRN. WRB	SCALE AS SHOWN
		TCD. R.A.J.	66-818 G+J
DIRECTOR OF MINES	SUPERVISING GEOLOGIST	CKD. L.V.W.	
		EXD.	DATE 22-9-66

VERTICAL SCALE 1 INCH = 0·1 FEET

G95
GROUNDWATER R.L.
30 AUG.'66 171·79

G94
GROUNDWATER R.L.
30 AUG.'66 168·75

G93
GROUNDWATER R.L.
30 AUG.'66 164·64

G91
GROUNDWATER R.L.
30 AUG.'66 162·31

G92
GROUNDWATER R.L.
30 AUG.'66 160·69

G97
GROUNDWATER R.L.
30 AUG.'66 161·45

G87
GROUNDWATER R.L.
30 AUG.'66 161·59

CHOWILLA CAMP
RAINFALL- POINTS

150
100
50

AUGUST | SEPTEMBER | OCTOBER | NOVEMBER | DECEMBER | JANUARY | FEBRUARY | MARCH | APRIL | MAY | JUNE

1966 1967

FIG 4

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CHOWILLA PROJECT
SALINE WATER DISPOSAL–TILMY FLAT
VARIATIONS IN GROUNDWATER LEVELS
IN DRILL HOLES

ENGINEERING GEOLOGY SECTION	GEOLOGIST	DRN WHITE	SCALE AS SHOWN
		TCD RAJ	67-43 G+J
DIRECTOR OF MINES	SUPERVISING GEOLOGIST	CHD. LVW	DATE 24TH JAN '67
		EXD.	