ADELAIDE RIVER WATER SUPPLY
INVESTIGATION OF GROUNDWATER RESOURCES
1982/83

Prepared by
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SYNOPSIS

A groundwater resource investigation has been undertaken for the Adelaide River Township between November 1982 and March 1983. Two new bores were constructed specifically to meet the Adelaide River town water supply requirements. An additional bore was constructed as part of the investigation that is suitable for connection into the town water supply. The total peak pumping capacity of all production bores, allowing for adequate standby capacity, is now 7.7 litres per second.

The annual safe yield of the borefield was estimated to be in the order of $4 \times 10^3$ cubic metres.

This supply will meet the town requirements including the new sporting oval demands, based on the available water demand data until 1991.
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<table>
<thead>
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<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>m</td>
<td>Metre</td>
</tr>
<tr>
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<td>Kilometre</td>
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<tr>
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<td>km²</td>
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<td>Litre</td>
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<td>Megalitre</td>
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<td>ML/day</td>
<td>Megalitre per day</td>
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<td>Kilopascals</td>
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<td>SWL</td>
<td>Standing Water Level</td>
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<td>NHMRC</td>
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1. INTRODUCTION

1.1 Aims

The aim of this project was twofold.

1. To construct two replacement production bores capable of pumping acceptable quality water for the immediate benefit of the town. Bore RN 7600 would be replaced by one with a capability of pumping 3 L/s. A suggestion had been made to replace bore RN 5185, with a bore capable of producing close to 2 L/s. However, it was believed that a better bore supply was possible, and that the optimum location would be dependent on the groundwater resources investigation.

Water quality, in particular the manganese concentration, was of critical importance as this factor had caused expensive reticulation problems which was traced to the water quality of bore RN 8302. This necessitated the production bore to be deleted as a primary source.

2. To quantify the groundwater resources in order to meet the town's needs predicted up to the year 2000. An investigation would be conducted within two kilometres of the township, defining the aquifer type and its physical and chemical quality parameters.

1.2 History

The township 110 kilometres south of Darwin developed around the crossing of the Stuart Highway over the Adelaide River and the adjacent North Australian Railway Station and its support facilities, which were built in 1888. (Refer to Figure 1.2(a)). It is probable that the early water supply was extracted from the river. Storage was facilitated by an earth banked reservoir behind the station.

In the early 1940's the area became the centre of a major army encampment and hospital zone, and many water bores were drilled encountering small supplies. At least two are reported to have existed in the town area. One behind the present hotel, and another south of the river.

In 1965 the Water Resources Branch of the Northern Territory Administration Department of the Interior, drilled four boreholes, in and around the depot compound administered by the Commonwealth Department of Works. Of these, two bores RN5146 and RN5185 were constructed for town use. (Refer to Figure 1.2(b)). This program occurred when the town was relocated from south of the river to its existing location on the northern side.
LOCATION MAP

Fig 1.2(a)
Fig 1.2(b)

LEGEND

- BORE-UNCASED
- BORE-CASED
- BORE-EQUIPPED

"A-B-C" LOCATION OF VERTICAL CROSS SECTION

ADELAIDE RIVER AREA
BORE LOCATIONS
A further eight bores have been drilled since 1965 resulting in the Construction of four town production bores - RN's 5185, 7600, 8302 and 8838. This was to meet the increase in population to the present 383 persons and to also meet the water demands for the following developments - the war graves gardens reticulation, the town sewerage system and the street landscape beautification scheme. The water demand for the most recent development, the sporting oval complex developed in 1982, could not have been met by the existing bores. In addition the planned Australian National Railway construction programme would increase demand.

A situation of water shortages was approaching due to a number of bores becoming unusable. There are a number of reasons for this.

Strata collapse, a result of poor construction techniques, has occurred in two bores RN 5146 and RN 5185 - and is suspected of being the cause of failure in bore RN 5331. These bores are now abandoned. Pump replacement difficulties in bore RN 7600 has occurred, diminishing the available yield significantly. The concentration of manganese in the water from bore RN 8302, which was continuously operated is sufficient to have resulted in blockage of the reticulation pipework. Expensive replacement was then required.

A geophysical resistivity programme of three traverses, preceded drilling. An unusually delayed wet season permitted the drilling rig to gain access to all sites required.
2. HYDROGEOLOGY

General

This section is a summary of the interpretation of results obtained from drilling, surface field mapping, strata logging and test pumping. Bores with registered numbers below 21,000 were drilled prior to this investigation.

A discussion under the following topics is included in this section - geology, aquifer parameters, groundwater movement and recharge, and water quality.

2.1 Geology

a) Background

A study of the results from previous drilling, suggested that two types of aquifers existed in the town borefield. (1) A river alluvial sand aquifer; and (2) a fractured rock type. It is now known that only the second occurs.

b) Geomorphology

The town area is composed of a mature land surface, of a flat arable landscape, with a few strike hills of basement shales. Across this, the river has incised into the bedrock, and has deposited some levee and floodout alluvium. Small patches of swampy ground occur. One kilometre to the west the uplands are bounded by the prominent fault scarp of the Adelaide River fault. It strikes north-south, and is extensive for many kilometres. Refer to Figure 2.1(a) for the geology and Figure 2.1(b) for the geological cross section and representative aquifer yields.

c) Bedrock Strata

The Burrell Creek formation of Proterozoic age, is the most widespread unit of the Pine Creek Geosyncline and forms the bedrock. In this area it consists predominantly of siltstones and interbedded graywackes, grading to carbonaceous siltstone units. Massive and coarse to pebbly graywacke beds occur in the scarp and uplands area. Some vein quartz and minor pyrite mineralisation also occurs in fracture zones. This strata was intersected by investigation bores.

d) Bedrock Structure

From previous drilling data, the structural fractures appeared to control the aquifer yield, in comparison to lithology grain size.
LEGEND

BURRELL CREEK FORMATION

- Coarse Felspathic Graywacke
- Siltstone, interbedded Graywacke
- Fault
- Inferred Fault
- Dip
- Inferred Strike of Resistant Shales
- Plunging Anticline

ADELAIDE RIVER
GEOLOGY

Fig 2.1(a)
WEATHERED ZONE

CARBONACEOUS SILTSTONE

RESISTANT BEDS OF SHALE

MUDFLAT DEPOSITS

IMPERMEABLE BURRELL CREEK FORMATION - INTERBEDDED AND SILTSTONE AND GRAYWACKE

GEOLOGICAL CROSS-SECTION A-B-C THROUGH BOREFIELD
SEE Figure 1.2(b) FOR LOCATION

Fig 2.1(b)
Three investigation boreholes were drilled to intersect the major fault eg. bores RN 21910, RN 21911, RN 21917. An appraisal of the drilling and geophysical results have demonstrated this to be a poor zone of aquifer development. The existence of a second fault 1 km west of the racetrack was indicated by B.M.R. mapping and its location appeared to be clearly supported by the resistivity results. Subsequent drilling gave unexpectedly poor results, (e.g., Bores RN 21914, RN 21915). Carbonaceous siltstones were intersected.

These carbonaceous and pyritic siltstone beds were placed stratigraphically above the resistant shales and have been identified as the cause of the very significant, geophysical low anomalies. The strike of this strata occurs elsewhere at bore sites RN 21911 and RN 21912.

The coincidence of mapped faults and photo lineations comprising discontinuous shallow lagoons, (eg. adjacent to the old highway north of the old Snake Creek bridge) reflect the erosive nature of this lithology type. An appraisal of the structural pattern of faulting and simple folding in the study area was undertaken, with the aid of air photo interpretation, and the initial drilling results. This further defined the lithology boundaries.

Within 1.5 km of the township, the topography is dominated by a ridge of resistant shale beds outcropping as sharp hills. The extended limbs of this vee shaped ridge, outcrops north and north east of the town. An anticline structure, plunges steeply to the south with an axis direction north-south and centered through the town. Within this anticlinal structure, fracture development has taken place with subsequent aquifer development (eg. bores RN 7600, RN 8838 and RN 21942). Limited aquifers occur on the outside of this anticlinal ridge.

The weathered profile extends from the surface to a range of 20 to 35 metres below the ground surface in the borefield area. Within this profile optimum aquifer development is in the slightly weathered to the adjacent fresh rock zones. In the very, to well weathered depth zones, the siltstones and the graywacke matrix have reverted to a clayey state and form the aquitard above the aquifer. However, connection for leakage to the semiconfined fractured rock aquifer do occur, and are identified in Section 2.3.
e) Surface Fluvial Deposits

These extend through the area from the river to the hills and to the north of the Snake Creek area. Levee bank and slip off slope deposits on the inside of river bends are common close to town.

Drilling has identified the earlier erosional valley of the river further to the north than the present channel eg. bores RN 21916, RN 21940 and RN 21944. Fluvial deposits of silt, sand and basal silty-gravels at ten to twelve metres below the ground surface have been intersected. Below those sediments the weathered zones of the Burrell Creek formation exist. It is considered likely that the river cut and fill deposits extend north to the Snake Creek area. This view is supported by results of drilling eg. bore RN 21943, and the absence of bedrock and the pattern of meanders of this creek. These sediments provide storage for the aquifer system, and the borefield water levels are found to be within this zone.

Drilling to date has not identified aquifers as existing within this surface unit. Dampness to minor seepage only was recorded in the basal silty gravels eg. bores RN 21943, RN 21944.

2.2 Aquifer Parameters

A total of nine boreholes have been test pumped prior to this investigation. Three new bores have been tested in the present investigation. Details of the types of tests conducted on the new bores and the plotted results, including the observation plots are presented in Appendix A. A summary of the results are given in Table 2.2.

The aquifer system can be viewed as been hydraulically bounded where a lithological strata change occurs outside the perimeter of the anticline structure. The semiconfined aquifer in the fractured bedrock occurs at two levels. Refer to the hydraulic model - Figure 2.2 constructed from drilling and pumping test results. From the results obtained from the pumped and observation bores, the hydraulic parameters are similar for the central borefield. They differ in the area where the bores intersect only the top or higher level fractured aquifer eg. bores RN 21942 and RN 21944. The borefield model can be divided into two blocks as indicated on Figure 4(a) in order to reflect these results as shown in Table 2.2. The two designated blocks adjoin across the borefield area between bore RN 8838 and bores RN 21942 and RN 21944.
### Table 2.2

**AQUIFER PARAMETERS (EXISTING PROD AND NEW)**

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<th>Bore RN</th>
<th>Discharge L/s</th>
<th>Test Type</th>
<th>Observation Bore</th>
<th>Distance 'r' metres</th>
<th>Transmissivity 'T' m²/day</th>
<th>Storage coeff. 's'</th>
<th>Leakage 'L'</th>
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<td>5331 215m 56 1x10⁻³</td>
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**5:HYDRO1**
SCHEMATIC CROSS-SECTION OF AQUIFER PARAMETERS, GROUNDWATER MOVEMENT
"DRY" SEASON, NON-PUMPING

Fig 2.2
A uniform transmissivity of 34 m$^3$/m/day and a uniform leakage coefficient of $2 \times 10^{-4}$ has been adopted for both blocks of the computer modelled borefield. The storage coefficient as derived from the test results has been calculated to be $8 \times 10^{-5}$ for the northern block in the area where only the upper fractured aquifer occurs. A storage coefficient of $1 \times 10^{-5}$ has been calculated for the southern block across the area where two fractured rock aquifers occur.

It was noted that for the southern block the test results from bore RN 21918 exhibited an accelerated drawdown at higher rates. This was due to the bores proximity to the aquifer boundary. The delayed response due to pumping in the observation bores is due to the two level-aquifer system in this area. The pumping bore cuts the bottom aquifer and the observation bores the top aquifer.

In the northern block the test results for bore RN 21942 gave a rapid time response in the observation bores RN 21940 and RN 21943 due to interconnection in the same top fractured aquifer. An absence of discharge boundaries during the test confirmed this area to be towards the centre of the borefield.
2.3 Groundwater movement and recharge

Prior to this investigation, water levels from bores were not monitored on any regular basis. Any existing water level data is that which was recorded at the time of its test pumping and for some, levels were recorded immediately following its drilling. During this investigation water levels were monitored and the data presented in Table 2.3. This has provided the basis for the potentiometric contours of the town bore field area. Figure 2.3, represents the contours, which are derived from data collected on 20 April 1983, following wet season rainfall recharge. Available data also indicates that the aquifer recharge began after mid February following infrequent storms. High continuous rainfall fell in March to April and this is reflected in the recharge period to 20 April 1983.

As shown on Figure 2.3 groundwater flows towards the river from both the northern southern side. Recharge occurs over both the area adjacent and over the steeply dipping shales of the outcropping hills. It is also directly recharged from the surface fluvial deposits which extensively cover the borefield from the river to the Snake Creek area to the north. This provides a large area of recharge. The saturated and coarse basal section of the sediments provide storage.

Leakage is believed to be via both shear fractures and steeply dipping bedding joints and via the tabular interbeds of coarse graywacke which have in the weathered zone, broken down to predominantly 'in-situ sand'. The frequency and persistence of quartz veined fractures below the bedrock interface is also indicative of leakage pathways, due to the induration of the strata adjacent to the quartz mineralisation.

It is also likely that the location of the town sewerage evaporation ponds is within the recharge area.

However, it is considered that due to a number of factors any possible contamination is unlikely.

(1) a small volume of sewerage is produced at present, and is not expected increase rapidly if account is taken of the projected growth rate as discussed in section 3 - Water Demand.

(2) the area is underlain by approximately nine metres of silt and sandy silt material.

(3) the water table after recharge was at a depth of 4.5 m below ground level. This data is extrapolated from bore RN 21943 placed to monitor this situation.
LEGEND

- BORE-UNCASED
- BORE-CASED
- BORE-EQUIPPED
-

POTENTIOMETRIC
CONTOURS (metres)

NB- BORE RN 8838 PUMPING

ADELAIDE RIVER TOWN BOREFIELD POTENTIOMETRIC LEVEL CONTOURS

Fig 2.3
Table 2.3 SURVEY AND POTENTIOMETRIC LEVEL DATA

<table>
<thead>
<tr>
<th>BORE RN</th>
<th>GND. LEVEL AT BORE (m AHD)</th>
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5: HYDRO1
2.4 Water Quality

All existing water quality data on bores in the study area is given on Table 2.4. Generally the quality is typical of aquifers in fractures of the Burrell Creek formation.

The total dissolved solids ranges from 200 in production bore RN 8838 to 82 in test production bore RN 21942, and is 130 in production bore RN 21918. The pH of the bores varies from 6.7 to 6.2. Refer to Table 2.4 for the water quality data, of all bores. All discharge flows were very clear and acceptable to taste. Bore RN 21942 was analysed for heavy metals, as the strata contained frequent but minor sulphide mineralisation. The results were of acceptable levels.

Manganese Problem

An exception to the general satisfactory water quality is the manganese concentration. The significance of this aspect is that water with an analysis high in iron and manganese from Production bore RN 8302, of 0.21 mg/L and 1.32 mg/L respectively, has caused the town reticulation pipework to become severely blocked by encrustation. This internal coating deposit has been analysed, and consists of hydrated oxides of iron and manganese. This problem has necessitated expensive replacement of town pipework and domestic meters and has caused the effective disuse of this town production bore.

The W.H.O. 'International Standards' for drinking water give 0.05 mg/L as the highest desirable level for manganese, and 0.5 mg/L as the maximum permissible. For iron the concentration is 0.1 mg/L as the highest desirable level and 1.0 mg/L as the maximum permissible.

As a consequence of the severity of the manganese problems, during this present investigation, sample analysis for manganese has been important in the final selection of production bore sites. This sampling was done by pumping with an electrical submersible pump. The following bores were sampled in this manner - bore RN 21912, RN 21914, RN 21918, RN 21940. Bore RN 21942 was demonstrated to be in the same aquifer as RN 21940, and favourable analysis results from the latter was sufficient prerequisite to construct bore RN 21942 to production standards. Following construction and testing the final manganese concentration was 0.1 mg/L.

Likewise, acceptable water analysis of bore RN 5185 was required before the construction of production bore RN 21944 adjacent to it. The final concentration following construction and testing was 0.1 mg/L.
### WATER QUALITY DATA TABLE 2.4

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- 9628 - Field Measurement
- 9638 - Results 2/7/83  22/2/82 close to results pumping RN 21918 (5 placement bore 10 m distant)
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Investigation hole RN 21918 was pumped at 1.5 L/s for a few hours and the manganese content was analysed at 0.05 mg/L. However, following construction, and test pumping at 6.5 L/s the manganese concentration increased to 0.9 mg/L. This concentration compares similarly to an analysis result as derived from the adjacent bore RN 7600 and which was 0.5 mg/L. The sample was taken in February 1982, whilst production pumping was in progress. At this location, these manganese concentration changes could be related to the changes noted in the aquifer hydraulic parameters. The t.d.s. of bore RN 21918 is 120 mg/L and 130 mg/L at the lower and higher pumping rates respectively. This suggests that a deeper zone of the aquifer exists and is only reflected by pumping at high rates. Therefore, this bore will need to be monitored for manganese. It is possible that it may have to be pumped at a lower rate to be within acceptable limits.

The cause of the high manganese content cannot be defined. A relationship with water of low total dissolved solids was once suspected as bore RN 8302 has a t.d.s. of 36 to 68 mg/L and a manganese concentration of 1.32 mg/L. However in this investigation, bore RN 21942 with a t.d.s. of 82 has a low manganese content, and contrasts with bore RN 21918 where the opposite occurs.

Aquifer strata was also considered. Bore RN 8302 is located adjacent to the carbonaceous siltstone strata. But aquifers cut in this material gave an intermediate manganese concentration. e.g. bore RN 21912 and RN 21914.

Aquifer pH may have some control over the total manganese concentration and the pH results were considered. Unfortunately only a few field pH results are available. Bores high in manganese have a field pH of 6.0 and 6.2. This compares to bores with a low manganese and a field pH of 6.6 e.g. bore RN 8838.

Overall the results at hand are inconclusive to identify the cause of the manganese concentration. The manganese oxide mineral pyrolusite was noted in the fractures of the weathered zone profile, in its normal dendritic form. This is usual in this formation. It is probable that very low pH water has dissolved the mineral and taken it into the aquifer via direct infiltration. This cannot be proven.

The use of groundwater high in manganese for irrigation purposes has been considered. It had been suggested that a supply taken from bore RN 8302 could be utilised for watering the sporting ovals. As direct recharge is believed to occur, then the possibility was considered of connection with and 'contamination of' aquifers at the discharge location.
Manganese will precipitate into the subsoil as MnO$_2$ when the pH is neutral to alkaline. On a sporting oval with little vegetation litter, it can be assumed that with aeration any groundwater irrigated would tend to become neutral. The addition of some agricultural lime would ensure alkaline conditions and ensure that the manganese was not transmitted as recharge.
3. WATER DEMAND

The data for the present and expected future demand of the water supply for the Adelaide river township has been compiled by G. Clark, Planning Section Water Division.

The population of this community is 383 (1981 census) persons. This is comprised of a mixed community of suburban type dwellings, commercial services and an aboriginal community living in a developing area, south of the river.

In the 1982 dry season the town borefield produced 300 kL per day. Bore RN 8302 has been put on standby only status. Bores RN 7600 and RN 8838 are the main production bores. Following are the metered discharges of these bores:

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<td>RN 7600</td>
<td>4 L/s for five hours pumping per day</td>
</tr>
<tr>
<td>RN 8838</td>
<td>2.5 L/s continuous pumping</td>
</tr>
</tbody>
</table>

It is calculated that the "Mean Day Man Month demand in 20 hours" is 4.2 L/s. It is assumed that the demand will grow directly in proportion to the population. Of the 380 persons in the present community the numbers actually served by town reticulation is not known. The Department of Lands has suggested that 4% would be the growth rate for the population based on regional growth predictions. The expected demand is given in Figure 3 showing predicted peak water demand requirements.

The above figures have not taken into account the accelerated demand due to the completion of the new sporting ground oval complex. This is expected to use around 2 L/s. The combined total demand would be around 6 L/s. This can be met by the use of the new bore RN 21942 in conjunction with bores RN 8838 and RN 21918. Bore RN 21944 can be brought into the system in the long term, or brought in as a second standby into the system.
Fig 3
4. MODELLING OF BOREFIELD PERFORMANCE

To assess drawdown performance of the town borefield, the aquifer system was simulated by the use of a finite difference computer model developed by Prickett and Lonquist. This model has been modified to compensate for a leaky aquifer system.

In order to run the model a number of assumptions for the aquifer system were made:

(a) The areal extent in the study area as shown on Figure 4(a) which outlines an area 2.4 km by 2.4 km. The boundaries were defined by a combination of the factors of geology along the southern and western margins. For the northern and eastern margins similar strata overlain by flat topography was expected to give a minimal drawdown for a year of pumping simulation.

(b) Nodes represent an area 100 m by 100 m.

(c) The groundwater through flow is neglected.

(d) Leakage head as provided by the fluvial sediments and weathered graywacke beds above the aquifer is assumed to be constant. The leakage co-efficient from the test results for the model was \(2 \times 10^{-7}\). During stages of the model development the storage contained in the fluvial sediments was calculated and checked against the amount of leakage into the system.

(e) Semi-confined conditions exist for the fractured rock aquifer with a uniform Transmissivity of 34 m\(^2\) per day. The storage co-efficient has been found to have a value of \(8 \times 10^{-5}\) for the northern sector of the model and \(1 \times 10^{-5}\) for the southern sector which includes the production bores RN 21918 and RN 8838.

(f) It is fully recharged each wet season.

The assumptions were based on drilling and test pumping within the interpreted geological structure. Through flow is neglected due to a lack of data including the effects of the superimposition of the river draining through the borefield.

This model was calibrated from the test pumping data obtained from the observation bores monitored during the tests on bores RN 21918, RN 21942 and RN 21944. Data plotted on Figures 4(b) and 4(c) show that the match of field drawdown and model predictions are close.
LEGEND

SUGGESTED GAUGING SITES

COMPUTER MODEL BOUNDARY

COMPUTER MODEL AREA
AND
SUGGESTED RIVER GAUGING SITES

Fig 4(a)
Fig. 4(b) 

Comparison of Field and Model Drawdowns

PUMPED BORE RN 21942

OBSERVATION BORE RN 21943
COMPARISON OF FIELD AND MODEL DRAWDOWNS

PUMPED BORE RN 21944

OBSERVATION BORE RN 9688

TIME (min)

DRAWDOWN (m)

Fig 4(c)
The model was used to predict the drawdown over the borefield by the pumping of all recommended production bores. An example of the drawdown contours produced is given in Figure 4(d) which shows the contours produced by pumping production bore RN 8838 at 2.3 L/s. Simulation of pumping was also done for bore RN 8302 at 3.5 L/s, bore RN 21918 at 4.4 L/s, bore RN 21942 at 3.7 L/s and bore RN 21944 at 1.7 L/s. In this way, drawdown interference due to the action of pumping other bores could be estimated. Recommended pumping rates based on the results of this are given in Table 4.

Finally the model was run to predict the drawdown due to simultaneously pumping bores RN 21918 at 4.25 L/s and bore RN 21942 at 3.7 L/s for one year. Refer to Figure 4(e) for the simulated drawdown of the two bores pumping together.
LEGEND

- BORE-UNCASED
○ BORE-CASED
□ BORE-EQUIPPED

-1.0- DRAWDOWN CONTOURS

SIMULATED DRAWDOWN
CONTOURS FOR BORE
RN 8838 PUMPING FOR
1 YEAR AT 2.3 L/s

Fig 4(d)
LEGEND

- BORE-UNCASED
- BORE-CASED
- BORE-EQUIPPED

SIMULATED DRAWDOWN CONTOURS FOR PUMPING
BORES RN 21918 AT 4.25 L/s AND RN 21942 AT 3.7 L/s
FOR 1 YEAR

Fig 4(e)
### TABLE 4 - RECOMMENDED PUMPING RATES FOR PRODUCTION BORES

<table>
<thead>
<tr>
<th>Production Bore RN</th>
<th>Recommended Pumping Rates L/s for Regime</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>7600</td>
<td>3.8</td>
</tr>
<tr>
<td>8302</td>
<td>3.3</td>
</tr>
<tr>
<td>8838</td>
<td>2.9</td>
</tr>
<tr>
<td>21918</td>
<td>4.3</td>
</tr>
<tr>
<td>21942</td>
<td>3.9</td>
</tr>
<tr>
<td>21944</td>
<td>2.1</td>
</tr>
</tbody>
</table>

Where:
- A - Production bores pumped by themselves
- B - RN 8838, RN 21918, RN 21942
- C - RN 21918, RN 21942
- D - RN 21918, RN 21942, RN 21944
- E - RN 8838, RN 21918, RN 21942, RN 21944
- F - RN 8302, RN 21918, RN 21942, RN 21944
- G - Maximum exploitation. All pumping.

**Note:** Bore RN 7600 and bore RN 21918 cannot be pumped together.
5. CONCLUSIONS

The 1982/83 groundwater investigation was successful in obtaining sufficient groundwater to meet the town domestic requirements until the year 1991. If the sporting oval requirements are not included then the present resource is adequate until the year 2000.

The project has resulted in the construction of one replacement production bore, RN 21918 in addition to the construction of a second production bore RN 21942. A third bore RN 21944 was also constructed.

Of the total 15 bores which were drilled, 12 were set up for piezometric monitoring points, of which 7 are located to monitor drawdowns due to pumping.

The main borefield aquifer has been identified as the fractured rock type at two levels below the surface, in the siltstone and graywacke bedrock formation. Shallow fluvial sediments are widespread and provide storage for recharge of the system.

The characteristics of the main aquifer system have been identified and are described as follows:

(a) Bores RN 21942 and RN 21944 have located the shallower fractured aquifer immediately below the weathered zone of the bedrock. This aquifer is recharged by leakage from the overlying sedimentary strata of the Burrell Creek Formation, through vertical type joint fractures and via the weathered graywacke beds.

(b) Bore RN 21918 (as was bore RN 8838) has identified the above aquifer at a similar depth to that just described and a second and larger yielding aquifer within the fresh rock zone. In these bores negligible fluvial sediments were cut, as the bores have been located on the shoulders of the former river valley system. (Refer to geological cross section Figure 2.1(b)).

As other aquifer fractures transect both siltstone and graywacke beds, the strata grain size is insignificant regarding aquifer yield.

The areal extent of the aquifer system is bounded along the south and west by the dominant anticlinal ridge. It appears to extend to the north, where it is overlain by the surficial fluvial sediments, deposited from the Snake Creek and Adelaide River systems. Further drilling in this area is needed to define this.
The fractured rock aquifer is best developed in the axial zone of the anticline.

In general the water quality is good, except for manganese at some locations. The source of manganese could not be positively identified, from the available data.

The peak water demand has been calculated to be 360 m³/day for the 1982 year. Due to the completion of the town sporting oval, the demand for irrigation water of this facility would be around 170 m³/day, for the months April to November. This would peak at 4 L/s for part of the any day in order to operate travelling irrigator type equipment. This could be met by the town storage facility. Pre wet rainstorms would be expected to lower demand, during the two months of lowest standing water levels.

Thus the total average maximum demand for 1983 is expected to be 6.4 L/s or 550 m³/day. At an expected growth rate of 4% future demands should be met until year 1991 by the pumping of bores RN 8638 and RN 21942 with bore RN 21918 as the standby bore. However, as the yield of the standby bore is only around 70% of the yield of either of the two main pumping bores the standby capacity could be increased to 100% standby from either of three sources.

1. Bore RN 21944, the third bore constructed to production standards and which will be required after the year 1991 due to expected growth demand.

2. Ex production bore RN 8302 which is presently on standby, due to the manganese concentration, however this is not recommended.

3. The river as a source for irrigating the sporting oval.

After 1991, in order to cater for the standby capacity, with the sporting oval requirements being met by the town supply, future groundwater supplies will have to be met by additional investigation drilling. However, if the water for the sporting oval is taken from another source, then the present resource is sufficient including standby capacity to last until the year 2000. The Adelaide River could be utilised as an alternative source, as records show that the river on average stops flowing in 1 out of three years. When this occurs sufficient and deep water holes within the main channel exist, to continue exploitation of this source.

Information at hand shows that the present extraction rate, is well within the safe yield of the system. Any ancillary projects should utilise the river as an extraction source, until such times as the performance of the aquifer system has been more accurately assessed.
6. RECOMMENDATIONS

It is recommended that:

1. Each production and standby bore in the town borefield be sampled for the manganese concentration every month until the levels are shown to have stabilised. This must be commenced as soon as practicable, with feedback to the investigations branch of Water Division.

2. Monitoring of water levels be undertaken in bores RN 5331, RN 5185, RN 8303, RN 9628, RN 9688, RN 21912, RN 21916, RN 21919, RN 21940, RN 21943. A continuous recorder should be placed on bore RN 5331.

3. Production bore RN 21942 be the main continuously pumping bore with RN 8838 taking up the shortfall.

4. Production bore RN 21918 be the main standby bore, as its standby capacity is equal to the extraction rate of RN 21942.

5. Bore RN 8302 be abandoned due to excessive manganese concentration.

6. Further field investigations are required to:
   (i) Determine the amount, and the effects of leakage from the fluvial sediments to the aquifer system via the weathered zone and the extent of the aquifer to the north and east.
   (ii) Due to the variations in the manganese concentration in the bores, the water should be pumped directly to the storage tanks where blending will occur. Domestic supply lines should not be taken directly from the rising main.

7. Some surface water field work be carried out to gauge the flow of the Adelaide River through the town borefield. Three places should be gauged as shown on Figure 4.

8. The performance of the aquifer system should be reviewed in 1988, to allow for a lead up period to the time when bore RN 21944 is expected to be brought into the system. Then additional standby capacity will be required.
7. REFERENCES

BUREAU MINERAL RESOURCES, Geological map of Batchelor-Hayes Creek Area. 1:100 000 scale 1981 edition.


HAZEL, C.P., Groundwater Hydraulics.


APPENDIX A

The following is a summary of fieldwork carried out.

1. Geophysics

Reference is made to the details of the survey as given in the report compiled by P Furness - HYDROGEOPHYSICAL REPORT 82/13 - ADELAIDE RIVER RESISTIVITY SURVEY.

The aim of the survey was to locate fracture zones within the Burrell Creek Formation, and to define the lithological units which were generally unexposed and covered by fluvial sediments.

To do this 4.8 line kilometers of pole-dipole resistivity profile traversing were carried out. Schlumberger depth soundings on each of the three traverses were made. This covered areas north, north-east and south-west of the town. Refer to Figure A.1.

A number of anomalies were outlined and appeared to strongly reflect the geological structural features, and in particular the major faults.

Subsequent drilling of the anomalies did not intersect significant fractures. However, it identified the lithology of the folded strata in the area. By a reinterpretation of the geophysical results the geological structure of the area was defined. Airphoto interpretation and published geological maps were thus combined to develop a model of fracture development. This led to the location and construction of a production bore in a new area.

2. Drilling

A total of 15 boreholes were drilled in this 1982/83 investigation, with an average depth of 53 metres. Three bores were constructed to testing/production standard. Boreholes suitably located have been constructed as permanent water level monitoring points for the borefield.

The drilling rig utilised was an Ingersol Rand TH60 model, top head drive rotary rig. The drilling proceeded with only minor delays.

Bore construction details are given in Table A2. A brief comment on each bore follows:

Bore RN 21910 was drilled on a difficult sloping site, which has been built up, but never drilled in the 1974 investigation. The purpose was to intersect the faulted contact zone of the lithological coarser graywacke unit. The steep sided valley of Snake Creek, through which pass the road and rail-line to Batchelor, had every indication of
TRAVERSE LOCATION MAP

TRAVERSE 1

TRAVERSE 2

TRAVERSE 3

ADELAIDE RIVER GEOPHYSICAL RESISTIVITY PROFILES

Fig A.1
been a significant offshoot fault, to the dominant Adelaide River fault scarp. However, the hole was drilled to 67 m for an airlift yield of 0.5 L/s at 22.5 m depth.

Bore RN 21911 was drilled on the geophysical anomaly site 130 m W Traverse 3 north of the town. This site coincided with the distinct surface feature - adjacent and immediately east of the main fault scarp. Carbonaceous and pyritic siltstone strata was drilled to 73.4 m, and no supply was intersected. The lithology type explained the magnitude of the geophysical anomaly. This location indicates that proximity to the fault, does very little towards fracturing in this fine grained siltstone strata.

Bore RN 21912 was drilled on geophysical traverse 2, site 430 m W to test the potential east of the town. It was thought that fracturing across the strike would exist and that due to the proximity to the river, some recharge potential did exist. The hole was drilled to 67 metres for an airlift yield of 1 L/s from fractures at 19 m increasing to 1.5 L/s at 30 m. The final yield of 2.0 L/s is probably due to development whilst drilling. Carbonaceous siltstones, with minor pyrite and chlorite mineralisation was intersected and jointing was in evidence to depth.

Bore RN 21913 was drilled on geophysical Traverse 1 site 1625 m E. This site had geographical and geophysical similarities to bore RN 7600 which had intersected a significant aquifer. Shale siltstone and interbedded graywacke was drilled to 43 m depth. No water was encountered.

Bore RN 21914 was drilled on geophysical Traverse 1, site 1400 m E. At this site, the resistivity traverse exhibited the lowest value in the broader low feature. It was believed that, due to the proximity to a geologically mapped fault zone, this site was favourable for fractured strata. The yield was 1 L/s at 42 m and the total depth was 55.0 m. The strata intersected was again black carbonaceous siltstone to depth, with no mineralisation.

Bore RN 21915 was drilled at the western edge of the major resistivity low feature on Traverse 1 at site 1325 m E, as per suggestions from the geophysical group, with the reasons outlined above. Although this site was on the eastern shoulder of the small linear creek which coincided with the mapped fault, the airlift yield was 0.2 L/s from 30 m. Total depth was 49 m, in shales to carbonaceous siltstone with minor quartz and pyritic mineralisation. It is obvious that the large resistivity low was caused by this conductive lithology, and not any fractured strata.
Bore RN 21916  While access permitted, before the rain set in, the western limit of the resistivity anomaly on Traverse 2 at site 600 m W was drilled to 43 m depth for 0.7 L/s yield at 27 m. The strata of alluvium, siltstone to fine graywacke was intersected. The water occurred in a narrow brown stained fractured level. In addition proximity to town services and the recharge potential from the river, had a bearing on the site selection.

Bore RN 21917 was drilled to check out the remaining resistivity feature on traverse 3, at site 245 m W. Additional features leading to site selection was proximity to the main fault scarp of the coarse graywacke units and the location within a small valley formed across strike of this unit. Adjacent outcrop indicated a lack of deep weathering enhancing infiltration. A supply of 0.001 L/s was rapidly exhausted and the total depth was 43 m, of interbedded graywacke and siltstone.

Bore RN 21918 was drilled to achieve one aim of this project, which was to construct a replacement production bore for bore RN 7600. This site was adjacent to established facilities of reticulation and power, and in the area south of the river at the southern edge of the borefield.

The strata was siltstone and interbedded graywacke from the surface. In-situ weathering of the strata to clay returns was noted from 6 to 17 m. A small aquifer of 0.3 L/s was cut near 30 m, and the main aquifer was cut immediately below 40 m, within the unweathered strata. Casing 206 mm (ID) was set to 40 m and 9 L/s of very clear water was airlifted (See Appendix B for further details).

Bore RN 21919 was drilled on a site where a study of air photographs had indicated a lineation running from an erosional nick in the anticlinal ridge to a tangential line to the southern bend in the river. This area would further define the extent of the aquifer to the south west margin of the borefield. An airlift yield of 1 L/s was cut at 35 m. Alluvium overlaid siltstone and interbeds of fine graywacke with massive to fine quartz veining and minor pyrite. Total depth was 67 m.

Bore RN 21940 was drilled following a study of data collected from the investigation drilling, to that date. An aquifer model emerged which required further testing. Consequently a site was chosen on crown land directly north of the built up area and at the centre of the emerging area of interest. A supply of 2 L/s at 39 m depth was obtained from an investigation hole. A study of the results from follow up sample pumping suggests that a higher airlift would be obtained from a larger diameter investigation hole. Total depth was 43 m in alluvium overlying graywacke interbeds. This bore was later constructed as a monitoring bore for the production bore RN 21942.
Bore RN 21941 was drilled following the success of the previous bore and was located on the edge of the sporting oval reserve which was then under construction on cleared ground. Sand alluvium overlying weathered to fresh graywacke and siltstone with quartz and sulphide mineralisation was drilled to 52 m. A supply of 1 L/s increased to 2 L/s while drilling from 39 to 49 m. The hole was reamed and 206 mm casing placed to 19.90 m and an airlift yield of 7 L/s was then obtained from the 19 m to 25 m interval. The hole was back filled to 25 m and a cement plug placed and subsequently airlifted 6 L/s proving the existence of the aquifer above 25 m. Due to hole disturbance caused by the displacement of a large volume of alluvial-sand during the investigation hole drilling, it was decided to construct it as a monitoring hole and drill a production bore adjacent to this site. A close study of the drilled strata cuttings indicated that the aquifer started at 20 m.

Bore RN 21942 was drilled 7 metres from the previous pilot hole, with mud and 206 mm steel casing was pressure cement grouted to 20.0 m. A clean supply of 10 L/s was obtained over the interval 24.1 m to 33 m. Total depth was 36 m. See Appendix B for further details.

Bore RN 21943 was drilled on an air photo lineation feature in an area midway between the production bore RN 21942 and the town sewerage ponds situated 0.45 k to the north. The purpose was to test the aquifer potential to the north, and also to be as a monitoring hole for subsequent aquifer testing. It was drilled to a depth of 55 m, and no water supply was airlifted to the surface. The strata was alluvials overlying very weathered to fresh siltstone.

Bore RN 21944 was the third production bore drilled. It was sited in the Works Depot Yard adjacent to bore RN 5185, which was no longer in use, due to water quality deterioration problems. In recent years iron hydroxide has formed a yellow-brown flocculation problem shortly after pumping into the storage tank. It is thought that seepage contamination has occurred, from the top strata aquifer via slumping down the annular space outside the casing. Fluvial sediments to 12 m overlay weathered siltstone and graywacke bedrock. The supply was cut at 29 m, and the hole finished at 43 m. The supply was measured at 2 L/s. The bore was constructed as a production bore to tap the supply in the fractured rock aquifer. For further details see Appendix B. This bore can serve as a second standby bore for the town system.
### APPENDIX A

Table A.1 Lithology of boreholes drilled

<table>
<thead>
<tr>
<th>FN</th>
<th>DEPTH TO/FRESH STRATA</th>
<th>LITHOLOGY</th>
<th>AQUIFER</th>
</tr>
</thead>
<tbody>
<tr>
<td>21910</td>
<td>0-6</td>
<td>Fill, clay Interbedded med. graywacke, siltstone. Slightly metamorphosed.</td>
<td>0.5 L/s</td>
</tr>
<tr>
<td></td>
<td>-12</td>
<td>12 m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-39</td>
<td>Interbedded coarse, graywacke, siltstone. Slightly metamorphosed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-67.2</td>
<td>Interbedded coarse, graywacke, siltstone. Slightly chloritised.</td>
<td></td>
</tr>
<tr>
<td>21911</td>
<td>0-6</td>
<td>Claystone, alluvials Silicate, mottled</td>
<td>dry</td>
</tr>
<tr>
<td></td>
<td>-15</td>
<td>Silicate, mauve, gray very weathered soft</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-24</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-73.4</td>
<td>Siltstone, carbonaceous (graphite), pyrite, chloritised jointing, quartz veins.</td>
<td></td>
</tr>
<tr>
<td>21912</td>
<td>0-9</td>
<td>Silt, sand basal gravel</td>
<td>1 L/s at 20 m</td>
</tr>
<tr>
<td></td>
<td>-15</td>
<td>Siltstone, mottled mauve colour, weathered, fissile</td>
<td>2 L/s at 50 m</td>
</tr>
<tr>
<td></td>
<td>-24</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-66</td>
<td>Siltstone, gray brown, quartz, Mnstain &amp; vuggy</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Siltstone carbonaceous (graphitic), fissile, chloritised siltstone and joints, occasional calcite, pyrite.</td>
<td></td>
</tr>
<tr>
<td>21913</td>
<td>0-3</td>
<td>Colluvium, shale rubble, red brown</td>
<td>deud</td>
</tr>
<tr>
<td></td>
<td>-18</td>
<td>Siltstone gray, micaceous, graphitic brown joints, especially at 20 m minute seepage.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>18/24</td>
<td>18/24</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-43</td>
<td>Graywacke, siltstone interbedded gray colour.</td>
<td></td>
</tr>
</tbody>
</table>

5:HYDRO1
<table>
<thead>
<tr>
<th>Location</th>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>21914</td>
<td>0-2</td>
<td>Ferricrete, mottled</td>
</tr>
<tr>
<td></td>
<td>-21</td>
<td>Siltstone, mauve, brown to gray, silty, weathered soft, but indurated near surface.</td>
</tr>
<tr>
<td></td>
<td>-55</td>
<td>Siltstone gray, richly carbonaceous (graphite as floating greasy scum)</td>
</tr>
<tr>
<td>21915</td>
<td>0-2</td>
<td>Shale red brown (as colluvium)</td>
</tr>
<tr>
<td></td>
<td>-24</td>
<td>Siltstone, mottled, olive brown to dark gray, extremely weathered</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>Siltstone, gray to blackish carbonaceous, shearing frequent at mineralisation, quartz, pyrite.</td>
</tr>
<tr>
<td></td>
<td>-48.9</td>
<td>Siltstone, graybrown, fractures brown.</td>
</tr>
<tr>
<td></td>
<td>-42.8</td>
<td>Graywacke gray, fine, soft possibly very slightly weathered</td>
</tr>
<tr>
<td>21916</td>
<td>0-9</td>
<td>Alluvials, clay, silt consolidated, sand, gravels, magnesite</td>
</tr>
<tr>
<td></td>
<td>-18</td>
<td>Graywacke, siltstone interbedded, quartz frequent</td>
</tr>
<tr>
<td></td>
<td>-31</td>
<td>Siltstone, grey brown, fractures brown.</td>
</tr>
<tr>
<td></td>
<td>31</td>
<td>Graywacke, med grain, gray duid interbedded with siltstone gray to blackish. Minor quartz, pyrite.</td>
</tr>
<tr>
<td></td>
<td>-42.8</td>
<td>Graywacke gray, minor quartz</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Siltstone, graywacke interbedded only slightly weathered</td>
</tr>
<tr>
<td></td>
<td>9-42.8</td>
<td>Graywacke, med grain, gray duid interbedded with siltstone gray to blackish. Minor quartz, pyrite.</td>
</tr>
<tr>
<td>21917</td>
<td>0-6</td>
<td>Siltstone as brown shale. surface indurated.</td>
</tr>
<tr>
<td></td>
<td>-15</td>
<td>Siltstone very weathered to soft, buff colour powder.</td>
</tr>
<tr>
<td></td>
<td>-30</td>
<td>Siltstone gray interbedded to fine quartz, massive veining.</td>
</tr>
<tr>
<td></td>
<td>-42</td>
<td>Siltstone gray, minor quartz</td>
</tr>
<tr>
<td></td>
<td>33</td>
<td>Graywacke fine gray and siltstone</td>
</tr>
<tr>
<td>21918</td>
<td>0-12</td>
<td>Alluvials, clay silt consolidated, mottled, sand, quartz base.</td>
</tr>
<tr>
<td></td>
<td>-15</td>
<td>Graywacke coarse, weathered as sand</td>
</tr>
<tr>
<td></td>
<td>-21</td>
<td>Quartz massive veining, siltstone</td>
</tr>
<tr>
<td></td>
<td>33</td>
<td>Fractures brown, minor hard ferruginous siltstone</td>
</tr>
</tbody>
</table>

5: HYDRO
Interbedded siltstone and
graywacke, frequent quartz
veins, and mineralization
calcite, pyrite vuggy.

Alluvials-silt, consolidated
alluvium, mottled, porous,
nodular.
Claystone gray, waxy and
weak sandstone and consol-
dated silty sand
Graywacke as very weathered
coarse sand, to fresh, fine
gray at 33
with interbedded siltstone
gray to black. Some
chloritisation on jointing
and intergranular.

Silt, clays sands, gravels
at base.
Siltstone pink and as above
chart.
Siltstone, gray brown
fractures.
Production bore mud drilled.
Silt, sandy clays consolidated
alluvium nodular, mottled,
iron cemented sandstone,
manganese stains
Gravels, sand well sorted
medium, and silt, clays
Siltstone, very weathered
pink, as clay, joints puff
colour
Siltstone brown gray, bleached
evidence of shearing fractures
manganese stained, gray colour
at 19.8 m
Siltstone gray, interbed
graywacke, fractures brown
and vuggy. No quartz.
Siltstone, interbedded carb-
onaceous siltstone. Well
fractured, mineralised
quartz, sulphides, vuggy
chloritised as in shear zone.
<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>21943 0-16</td>
<td>Silt, sandy consolidated alluvium mottled quartz gravel and clays. 12 m Manganese stains on joints etc. seepage</td>
</tr>
<tr>
<td></td>
<td>Siltstone, brown weathered, quartz, some fractures.</td>
</tr>
<tr>
<td>-19</td>
<td>Siltstone grey soft (as clay) minor .... graywacke</td>
</tr>
<tr>
<td>-28 30</td>
<td>Siltstone minor graywacke and carbonaceous siltstone.</td>
</tr>
<tr>
<td>-55</td>
<td></td>
</tr>
<tr>
<td>21944 0-5</td>
<td>Sandy clay, brown, semi consolidated</td>
</tr>
<tr>
<td>-6</td>
<td>Sand, medium poorly sorted, red clay 10 m damp</td>
</tr>
<tr>
<td>-12</td>
<td>sandy clays, nodular, pebble bed, gravels, coarse sand to clay</td>
</tr>
<tr>
<td>-21</td>
<td>Siltstone, weathered cream jointed brown colour</td>
</tr>
<tr>
<td>-36 27</td>
<td>Graywacke grey brown to gray at 2 L/s at 29 m</td>
</tr>
<tr>
<td></td>
<td>27 m.</td>
</tr>
</tbody>
</table>

S:HYDRO1
## APPENDIX A

### BORE CONSTRUCTION

<table>
<thead>
<tr>
<th>BORE RN</th>
<th>DRILLING &amp; CONSTRUCTION DATES</th>
<th>DEPTH DRILLED (m)</th>
<th>CASING DETAILS</th>
<th>FINAL STATUS AND AIRLIFT YIELD</th>
</tr>
</thead>
<tbody>
<tr>
<td>21910</td>
<td>13/12/82 to 14/12/82</td>
<td>67.2</td>
<td>0-6.3 m of 150 mm open hole</td>
<td>obs 0.45 L/s</td>
</tr>
<tr>
<td>21911</td>
<td>15/2/82</td>
<td>73.4</td>
<td>0-12.1 m 150 mm open to</td>
<td>obs nil</td>
</tr>
<tr>
<td>21912</td>
<td>15/2/82 to 16/12/82</td>
<td>67.2</td>
<td>0-8.6 m 150 mm Open to 19 m only</td>
<td>obs 2 L/s</td>
</tr>
<tr>
<td>21913</td>
<td>17/12/83</td>
<td>42.8</td>
<td>0-2.2 m 150 mm</td>
<td>obs nil</td>
</tr>
<tr>
<td>21914</td>
<td>18/12/83</td>
<td>55.0</td>
<td>0-6.2 m 150 mm 0-41.7 m 50 mm PVC</td>
<td>obs 1 L/s</td>
</tr>
<tr>
<td>21915</td>
<td>20/12/83</td>
<td>48.9</td>
<td>0-6.1 m 150 mm</td>
<td>obs 0.2 L/s</td>
</tr>
<tr>
<td>21916</td>
<td>21/12/83</td>
<td>42.8</td>
<td>0-12.5 m 150 mm 0-42.8 m 50 mm PVC</td>
<td>obs 0.7 L/s</td>
</tr>
<tr>
<td>21917</td>
<td>21/12/83</td>
<td>42.8</td>
<td>0-6.1 m 150 mm</td>
<td>obs 0.001 L/s</td>
</tr>
<tr>
<td>21918</td>
<td>(Inv) 10/1/83 to 12/1/83</td>
<td>61 m</td>
<td>0-6.1 (temporarily)</td>
<td>2 L/s</td>
</tr>
<tr>
<td>Prod.</td>
<td>7/2/83 to 10/2/83</td>
<td></td>
<td>0-42.9 m steel 206 mm Prod 42.9-50 open</td>
<td>9 L/s</td>
</tr>
<tr>
<td>21919</td>
<td>12/1/83 to 13/1/83</td>
<td>67.2</td>
<td>0-6.2 m 150 mm</td>
<td>obs 1 L/s</td>
</tr>
<tr>
<td>21940</td>
<td>14/1/83 to 15/1/83</td>
<td>59.8</td>
<td>0-18.2 m 150 mm</td>
<td>obs 2 L/s</td>
</tr>
<tr>
<td>21941</td>
<td>17/1/83 to 19/1/83</td>
<td>52.5</td>
<td>0-18.9 m steel 206 mm obs 6 L/s 0-20 m PVC 50 mm</td>
<td></td>
</tr>
<tr>
<td>21942</td>
<td>20/1/83 to 22/1/83</td>
<td>37 m</td>
<td>0-20 m steel 206 mm Prod 10 L/s</td>
<td></td>
</tr>
<tr>
<td>21943</td>
<td>24/1/83</td>
<td>55 m</td>
<td>0-20.3 m steel 150 mm obs nil</td>
<td></td>
</tr>
<tr>
<td>21944</td>
<td>27/1/83 to 3/2/83</td>
<td>42.9</td>
<td>0-28.2 m steel 150 mm Prod 2 L/s</td>
<td></td>
</tr>
</tbody>
</table>

**HYDRO1**
3. Test Pumping

A. Pumping of unconstructed boreholes

Prior to the construction planning of production bores these investigation bore holes were tested for:

1. water quality, and

2. to gauge performance by pumping with an electrical submersible pump, for short durations.

<table>
<thead>
<tr>
<th>BORE RN</th>
<th>RATE</th>
<th>DURATION (MINS)</th>
<th>DRAWDOWN AT END OF TEST</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>21912</td>
<td>1.7</td>
<td>180</td>
<td>3.9 m</td>
<td>Clear discharge after 30 mins</td>
</tr>
<tr>
<td>21918</td>
<td>1.7</td>
<td>200</td>
<td>1.9 m</td>
<td>Clear discharge from 1 min</td>
</tr>
<tr>
<td>21940</td>
<td>1.7</td>
<td>60</td>
<td>2.5 m</td>
<td>Clear discharge from 12 min</td>
</tr>
<tr>
<td>7600</td>
<td>1.7</td>
<td>200</td>
<td>2.6 m</td>
<td>Following removal of lines</td>
</tr>
</tbody>
</table>

B. Testing of production boreholes

1. Development

Airlifting at the end of the construction phase delivered clear and clean water. The discharge during preliminary pumping was also completely clear. Subsequent performance demonstrated complete development.

2. Step Tests

A multi step drawdown test involving four step rates, each interval of 100 minutes, was conducted on the new bores RN 21918, RN 21942 and RN 21944. In addition the ex production bore RN 7600 was also step tested following a construction, modification.

3. Constant rate test

Each new test bore was pumped at a constant rate, during which time all available observation boreholes were monitored for drawdown response.

<table>
<thead>
<tr>
<th>BORE RN</th>
<th>RATE</th>
<th>DURATION</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>21918</td>
<td>6.5</td>
<td>1000 mins</td>
<td>Bore forked. 24 hr was planned.</td>
</tr>
<tr>
<td>21942</td>
<td>5.5</td>
<td>24 hrs</td>
<td>Leakage effect.</td>
</tr>
<tr>
<td>21944</td>
<td>2.0</td>
<td>24 hrs</td>
<td>Leakage effect.</td>
</tr>
</tbody>
</table>

5:HYDRO1
4. Recovery

On completion of the 1 day constant rate tests the residual recovery of the water levels in each pumped and monitoring bore was recorded.

The results of the tests are presented as plots as follows. The drawdown vs log time for the pumped bores are shown in Figures A 3(a) to A 3(h). The plot of logarithm of drawdown versus the logarithm of time for the observation bores monitored are shown in Figures A 3(i) to a 3(r).
Fig A.3(a)

Pumped Bore RN 7600

Discharge

Step Drawdown Test

Date 24-8-72
Fig A.3(b)

PUMPED BORE RN 7600

STEP DRAWDOWN TEST

DATE 21-2-83
PUMPED BORE RN 21918

DISCHARGE

DATE 17-2-83

STEP DRAWDOWN TEST
Fig. A.3(d)

PUMPEO BORE RN 21942

STEP DRAWDOWN TEST

DATE 11-2-83

DRAWDOWN (m)

Q = 3.0 L/s
Q = 4.8 L/s
Q = 5.5 L/s
Q = 6.4 L/s

TIME (min)

0 2 4 6 8 10 20 40 60 80 100 200 400 600 1000 2000
STEP DRAWDOWN TEST

PUMPED BORE RN 21944

DISCHARGE

DATE 23-2-83

Fig A.3(e)
FIG. A.3(i)

DATE: 18-2-83

CONSTANT DISCHARGE TEST

PUMPED BORE RN 21918

DISCHARGE: 6.5 L/s

Q = 6.5 L/s

DRAWDOWN (m)

TIME (min)

TIME (min)
Fig A.3(g)

PUMPED BORE RN 21942

DISCHARGE 5.5 L/s

CONSTANT DISCHARGE TEST

DATE 14-2-83

TIME (min)

DRAWDOWN (m)

Q=5.5 L/s
Fig A.3(h)

PUMPED BORE RN 21944

DISCHARGE 2.0 L/s

DATE 24-2-83

CONSTANT DISCHARGE TEST
Fig A.3(i)

PUMPED BORE RN 21918

OBSERVATION BORE RN 5331

DATE 18-2-83

CONSTANT DISCHARGE TEST

THEIS TYPE CURVE
Fig. A.3(1)

PUMPED BORE RN 21918

OBSERVATION BORE RN 7600

CONSTANT DISCHARGE TEST

DATE 18-2-83
PUMPED BORE RN 21918

OBSERVATION BORE RN 8303

CONSTANT DISCHARGE TEST

DATE 18-2-83

THEIS TYPE CURVE
Theis Type Curve

Drawdown (m)

Pumped Bore RN 21918

Observation Bore RN 21919

Constant Discharge Test

Date 18-2-83
PUMPED BORE RN 21942

OBSERVATION BORE RN 21912

DATE 14-2-83

CONSTANT DISCHARGE TEST
Fig A.3(n)

PUMPED BORE RN 21942

OBSERVATION BORE RN 21916

CONSTANT DISCHARGE TEST

DATE 14-2-83
Fig A.3(o)

DRAWDOWN (m)

PUMPED BORE RN 21942

TIME (min)

OBSERVATION BORE RN 21940

CONSTANT DISCHARGE TEST

DATE 14-2-83
PUMPED BORE RN 21942

OBSERVATION BORE RN 21941

CONSTANT DISCHARGE TEST

DATE 14-2-83
Fig A.3(q)

PUMPED BORE RN 21942

OBSERVATION BORE RN 21943

CONSTANT DISCHARGE TEST

DATE 14-2-83
Fig A.3(r)
APPENDIX B

BORE DEVELOPMENT/CONSTRUCTION

The investigation drilling in this area highlighted two problems to be overcome in the construction of the test holes.

Firstly the lack of borehole annular space whilst drilling with a small bit significantly reduced the airlift yield.

Secondly where fluvial sands were intersected, some difficulty arose when aquifers were intersected at depth and the airlift flow washed out the sand strata, if sufficient casing had previously not been set.

A description of the problems were encountered in the construction of bores RN 21918, RN 21942 and RN 21943, and recommendations to overcome them, follows.

1. Production bore RN 21918

This bore was constructed to replace the unsatisfactory behaviour of production bore RN 7600, which had been constructed in 1971 with the aquifer recorded at 49 m and a maximum pumping rate of 5 L/s was recommended, at that time. Refer to Figure B for construction diagram.

Bore RN 21918 was drilled firstly as a pilot hole, then tested by pumping and finally constructed. The sequence was as follows:

(1) Commence drilling with a 203 mm button bit and hammer drill to 5.7 m and run 160 mm of surface casing.

(2) Drill a 140 mm hole with a button bit and hammer drill to 61 m depth. The drill pipe is 114 mm diameter, leaving an annular space 13 mm wide. The airlift yield fluctuated up to 2 L/s at 47 m depth, but dropped back to 1.5 L/s. Seepage had increased from 0.01 L/s to 0.3 L/s over the interval 28.5 to 39 m.

(3) At this stage as a check that the aquifer (of bore RN 7600) had been fully penetrated, an electrical submersible pumping test was carried out for 200 mins at discharge rate of 1.5 L/s for a final drawdown of 1.8 m. Water samples for analysis were taken. It was decided, that in fact the aquifer was fully penetrated and that the reduced airlift could be attributed to the annular space restriction from drilling the hole with a small bit.
CONSTRUCTION LOG OF BORE RN 21918

Fig B(1)
(4) The surface casing was removed and the hole enlarged to 250 mm with a button bit and hammer drilling continued to a depth of 40 m, and 210 mm slimline type steel casing run to that depth.

(5) The casing was pressure cement grouted.

(6) The cement (1 m inside the casing) was drilled out to 210 m diameter with a button bit and hammer drilled to 50 m. The airlift supply increased from 3 L/s at 40.5 m to 9 L/s at 44 m. The flow was very clean and clear, and it was considered unnecessary to place screens in the bore. Subsequent testing verified this decision.

It is possible that the very weathered siltstone encountered had formed a wall cake of mud further restricting the annular space, prior to reaming out. It is recommended that in this area investigation holes with a diameter greater than 140 mm be drilled to more correctly determine the airlift yield.

In steep dipping strata, a drill collar should be used to ensure that the casing will run freely.

2. Production bore RN 21942

At this locality within the sport recreation ground an investigation bore RN 21941 was drilled and the supply encountered greatly disturbed the top sand strata, to the extent that any plans to finalise construction were abandoned. As this bore airlifted approximately two cubic metres of medium coarse sand with the yield flow, it was apparent that the top strata consisted of fluvial sediments including silt, sands and basal gravels, deposited from previous channels of the Adelaide River, and that the contact with the weathered 'bedrock' lay between 12 to 15 m below ground. The fractured aquifer was ascertained to be at a depth of around 20 m. Refer to Appendix A DRILLING BORE RN 21941. Refer to figure B(2) for construction diagram.

The drilling and construction of bore RN 21942 follows:

(1) Drilling commenced with 270 mm rock roller bit and biogel drilling mud and drilled to 20.0 m. The base of the alluvials was at 12 m depth.

(2) Casing 210 mm was run to 20.0 m and pressure cement grouted to seal off the alluvials from the aquifer.

(3) The cement was drilled out with a 203 mm button bit and hammer drilled to 37 m. The airlifted yield started with 3 L/s at 24.1 m to 9 L/s at 31 m with a final airlift supply of 10 L/s.
CONSTRUCTION LOG OF BORE RN 21942

Fig B (2)
This bore was subsequently airlifted for 3 hours to test the aquifer response from observation bore RN 21940. The airlift flow was clean throughout.

From the drilling of the two bores at this locality it is apparent that initial airlift yields from bedrock aquifers will be 'lost' into recharging the porous alluvial strata if not cased, and will continue to do so until saturation point is reached. The water supply will reach the surface at a delayed time, from the time of aquifer penetration. The depth to the aquifer will be incorrectly deduced. The airlifted supply will lead to the problem of sand wash and formation collapse with the eventual abandonment of the hole.

It is recommended for future drilling in this area underlaid by river channel deposits, that the fluvial strata be cased off fully, which will require particular attention be directed towards logging of the drilling returns. Casing of 210 mm diameter should be used for two reasons:

1. The time of drilling and running surface casing to around 20 m depth is not great.
2. A larger diameter bit is then catered for when drilling on, and the annular space restriction problem is avoided. The 210 mm diameter casing can be retrieved, if only a small supply is cut.

3. Production bore RN 21944

This bore was completed to production standard in the defunct 'Works' Department depot yard, adjacent to the ex-production bore RN 5185 and its ancillary equipment. The investigation bore was drilled to identify the aquifer in this area. Four bores had previously been drilled in the yard, but the information available failed to pinpoint the supply source, either from the alluvial sands or in the fractured bedrock aquifer.

More information was also required on the extent of the aquifer to the west from the new production bore RN 21942. In particular information on the depth and extent of the fluvial deposits; as intersected in bores RN 21940, RN 21942, RN 21943 was required, as this strata is believed to contribute the majority of the storage capacity of the town bore field.

The bore was constructed to production standards as this had previously been recommended by J Milne, Principal Engineer Groundwater Section, as a standby bore adjacent to the reticulation system, and as a source of water for temporary projects, (e.g., Railway, road construction) which would cause minimum interference with the town water supply.
A description of the drilling and construction of this bore follows. Refer to Figure B(3) for details of construction.

(1) Commence drilling with a 140 mm button bit and air hammer drill to 36.7 m. Weathered bedrock was cut at 12 m and seepage noted at 29 m.

(2) Ream out with a 203 mm button bit and hammer to 23.8 m, and run casing 170 mm diameter to that depth, in order to case off the alluvial strata.

(3) Clean out the hole with the 140 mm button bit to 36.7 m and a supply of 2 L/s was airlifted.

(4) It was thought that a greater pumping supply was possible, similar to that obtained in RN 21942, and plans were made to place 210 mm casing.

(5) The hole was reamed out again to 250 mm diameter and casing 210 mm was run to 17.5 m and cemented in. However, later on, cleaning out drilling revealed that the cement was unsuccessfully displaced into the annular space. It was decided that the smaller supply of 2 L/s could be pumped adequately through 170 mm casing.

(6) Casing 170 mm diameter was run to 28.2 and cement grouted in.

(7) The 210 mm casing was then removed.

(8) The hole was then drilled out with a 150 mm button bit and hammer drilled to 42.9 m. A supply of 1 L/s at 32.2 m increased to 2 L/s kg 38.7 m.

The strata intersected was fluvial silt, sands and basal gravels to 12 m. Dampness was noted at 10 m, and seepage recorded by 13.7 m. This came from the base of the fluvial strata in assorted gravels, sand and silt. Weathered siltstone and interbedded graywacke extended from 12 to 27 m depth. Fractured and stained graywacke was noted at 29 m, and coincides with the beginning of the main aquifer. Fine graywacke persisted to final depth.

In conclusion the alluvial strata cut and depth of it is identical to the area around bore RN 21942.

The main aquifer is in the fractured graywacke of the basement Burrell Creek Formation, with a seepage supply in the top fluvial gravels. The mixture with silty sands probably diminishes this strata as a medium yielding aquifer. Nevertheless the response of a screened bore constructed to tap the strata from 10 to 12 metres depth would be of interest. This was not done in this investigation.
CONCRETE SURROUND

CASING 0.25 m ABOVE GROUND

BACKFILLED

254 mm HOLE

200 mm HOLE

152 mm ID STEEL CASING

150 mm OPEN HOLE

CONSTRUCTION LOG OF BORE RN 21944

Fig B(3)
The question raised by the conflict of data from bores drilled prior to this investigation in the year area was answered, by the drilling of this hole. The basement siltstones are very weathered to a few metres above the aquifer, and could have been interpreted as alluvium.

When the supply was cut the flow of water wasted in the top unconsolidated sands etc to the extent that over 50% of the returns consist of sand and pebbles. Thus the aquifer would have been thought to be in a sand strata at depth.

Recommendations for future drilling would be the same as given for bore RN 21942. In addition it is suggested that some attention be given to construct a screened bore to test the seepage aquifer in the top fluvial sediments, to assess the parameters of the aquifer for the total system. Cement grouting would be required to seal off the alluvial aquifer from the fractured rock aquifer.
APPENDIX C
ESTIMATION OF SAFE YIELD

An estimate of the safe yield has been made as follows:

1. Calculated from through flow discharging into the river.

The calculation of throughflow has been done before wet season recharge which did not occur until late February 1983 and also at the end of recharge in late April 1983. Gradients of the water table were taken from a number of bores and river base levels were taken from the height of the flow over the gauging weir. This is approximate as the discharge height is no doubt higher than the river flow level, but no field observations were taken of spring discharge higher in the banks of the river.

(a) Throughflow on 20 April 1983

Throughflow \(= T \times i \times W\)

where

\(T\) = Transmissivity
\(i\) = Potentiometric level gradient
\(W\) = Aquifer thickness

assumptions \(T = 34 \text{ m}^3/\text{m/day}\) uniform for the field from the test pumping results
\(W\) = The length of the river parallel to the centre of the bore field and is approx 1.5 km.

Calculated throughflow of the individual contributions from the northern and southern areas of the river should be similar and the total throughflow therefore would be 1550 cubic metres per day or 18 L/s.

This would be conservative as potentiometric gradients would be greater with higher recharge levels. The period of recharge was short in 1983, and from the rainfall pattern the water levels were probably still rising.

In this period the production bore RN 8838 pumped 2.5 L/s to supply the town. However, it is located adjacent to the discharge zone and thus cannot be added to the 18 L/s calculated.

This extraction rate, equates to 14% of the calculated throughflow.
(b) Throughflow in mid February 1983 (pre recharge)

Again throughflow - T x i x W

Calculated throughflow was calculated again from both areas of the borefield. The total, throughflow calculated separately for the southern and northern sides of the river is 820 cubic metres of water per day or 9.5 L/s.

(c) Annual Throughflow

The total annual throughflow can be assumed to vary from 1550 cubic metres/day down to 820 cubic metres/day. This calculates to a total throughflow volume of 4 x 10^7 cubic metres per year.

Thus the safe yield is

\[ 4 \times 10^5 \text{ cubic metres per year} \]

or 13 L/s.

At present the town supply demand is met by the extraction of 3.8 L/s and this is expected to increase to 7.7 L/s by the year 1991.

2. Safe Yield

As the calculations are based on the potentiometric gradients taken over the incomplete recharge period in one year only, the above safe yield can only be taken as an indication of the safe yield of the system. Additional calculations were made based on:

(1) In filtration of rainfall, and

(2) annual leakage from the fluvial surface strata.

The results are very approximate and are three times greater than calculations made based on the potentiometric gradient. Therefore, it is thought that a conservative estimate of the safe annual yield from the main aquifer system 400 000 cubic metres.