Alice Springs Soil Aquifer Treatment Scheme: Investigation for Demonstration Production Bores, AZRI

Report 24/2006A

John Wischusen
NT – NRETA
Water Resources Branch
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Introduction

Extraction bores capable of high yields are an essential component of the Soil Aquifer Treatment Project (SAT) associated with the joint Power Water Corporation and Department of Primary Industries and Mines Alice Springs Water Reuse Scheme. A drilling investigation program was conducted by the Land and Water Division of Natural Resources, Environment and The Arts during May and June, 2006 with the intention of siting and constructing high yielding demonstration production bores on the Arid Zone Research Institute (AZRI) property. This work is part of the ongoing proposal to artificially recharge and store treated Alice Springs effluent water underground and utilise the water resources for horticulture (Knapton, et al. 2004).

The previous attempts at production bore construction on the AZRI block yielded 5 litres per second or less (Knapton and Lennartz, 2005). Higher yields have, however been obtained previously from bores drilled in similar strata in the Town and Outer Farm basins of Alice Springs further to the north (Berry, 1985). The yield from production bores, constructed using a similar technique to that employed for these higher yielding bores, drilled on the AZRI block are reported here.

Production bore drilling

The previous drilling on the AZRI block has shown air lift yield and lithology to be variable over relatively short distances. Consequently several exploratory holes were air drilled south and south east of the proposed Saturated Aquifer Treatment (SAT) ponds on the AZRI block. This strategy was adopted as a means to identify likely areas of high yield for optimum production bore location. A test production hole was first constructed near a known high yielding, high water table area, along the north eastern section of the AZRI block (RN 18247). This provided a test of the proposed construction method with the higher water tables expected to exist once the SAT scheme is operational. The location of the three production bores drilled is shown in figure 1.
Details of the lithology, construction, and test pumping results for these bores are detailed in the attached Appendix. The results of drilling are summarised in Table 1 below.

Table 1 Production bore details

<table>
<thead>
<tr>
<th>BORE</th>
<th>Depth (m)</th>
<th>24hr tested yield (L/s)</th>
<th>Transmissivity (straight line est.) (m²/day)</th>
<th>Conductivity (µS/cm)</th>
<th>SWL may 2006 (mbgl)</th>
<th>Recommended Yield @ May 2006 SWL</th>
</tr>
</thead>
<tbody>
<tr>
<td>18247</td>
<td>30.6</td>
<td>10</td>
<td>225</td>
<td>1531</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>18248</td>
<td>34</td>
<td>15</td>
<td>365</td>
<td>3310</td>
<td>17.7</td>
<td>4</td>
</tr>
<tr>
<td>18249</td>
<td>32</td>
<td>n/a</td>
<td>n/a</td>
<td>2520</td>
<td>17.85</td>
<td>none</td>
</tr>
</tbody>
</table>

The production bores were constructed using the same technique employed for RN15889 at Blatherskite Park. This bore, which produced 30L/s with only 3 metres drawdown after a 24 hour test, is analysed and discussed in the report by Berry (1991). The method of construction is detailed more fully in the drillers log sheets included in the Bore Record file held in the NRETA Alice Springs Library. Basically the construction technique involves setting 200 mm diameter steel casing just above the aquifer zone and then telescoping 150 mm diameter stainless steel screens into the aquifer below. This construction method reduces the chance of finer grain material above the aquifer zone being drawn into the bore during pumping and has the added advantage of ensuring only clean drilling mud (any fines settled out during casing operation) is used when drilling through the aquifer zone.
**Production bore testing**

**Recommended yields**

On examination of Table 1 it can be seen that the bore RN 18249 has no recommended yield, this is because very little yield was obtained when tested.

It can also be seen that bore RN 18248 while pump tested at 16 L/s is only recommended to be pumped at 4 L/s. The reason for this is disparity is explained on examination of the bore construction diagram shown in the Appendix. Standard practise for long term bore operation is to place the pump intake above the screens to limit the chance of sand ingestion through the screens jamming the pump in the hole – which ultimately can jeopardise the usefulness of the bore itself. When tested at 16 L/s the pump intake was set at 26.5 metres below ground level (mbgl). For continued safe operation, however, a pump setting above the top of the screens (at 19m) is assumed and thus the recommended rate of extraction is lowered to reflect the reduced available drawdown. Similar considerations were employed for the setting the recommended yield below that tested for bore RN 18427.

**Aquifer characteristics**

The transmissivities (T) calculated from the pump tests are included in Table 1. These data are calculated from the early stage of the pump tests as the drawdown response at both bores (see Appendix; drawdown gradient increases with time for the constant rate tests) indicates a classic boundary effect – a not unexpected situation in channel deposits such as the gravel aquifers encountered here. By way of comparison the T value calculated from the early stage (around first 100 minutes, drawdown data from Berry, 1991) response of the 30 L/s constant rate test conducted for bore RN15699 is 1000 m²/day. The average T reported for presumably similar sediments in the Alice Springs Town Basin in 1969 (Quinlan and Woolley, 1969) was 310 m²/day. If the high yield and T at RN 15899 is regarded as a rarity, then it can be assumed, from comparison with the Town Basin that aquifer characteristics determined for these two
successful production bores reflect the true nature of the hydraulic properties of sediments drilled at the AZRI block.

**Yield potential AZRI block**

The yields obtained from the two successful production bores drilled show that significant yields may be obtained from shallow depths from some bores drilled on the AZRI block. The lack of success at bore RN 18249 illustrates that due to rapid changes in lithology yield is not guaranteed at any particular site. The bore closest to potential new horticulture blocks (RN18248) is capable of high yields but due to lack of available drawdown above the screens only a modest yield of 4 L/s is currently recommended. With the expected significant raising of the watertable when the waste water reuse scheme becomes operational it is expected that a yield of 10 L/s will be safely available from a pump setting above the screens in this bore. If for some reason a greater yield is desired at this location prior to when artificial recharge raises the water table then a larger diameter bore with screens set adjacent to the bottom half of the aquifer (29.5 – 26m) is likely to be able to supply 10L/s with the current water table. The method of large diameter bore construction used for irrigation in the Alice Springs Town Basin (Matthews and Rooke, 1991) could probably also be used a template for bore construction in this situation.

**Drilling lessons**

From this drilling program there are a number of lessons. Initially it was thought airlift yield might be the way to prove potential production bore sites. The failure of RN 18249 drilled adjacent to the highest yielding air drilled hole in the vicinity (RN 18127; 3.5 L/s) demonstrates that airlift yield alone is an unreliable marker of good production bore yield. Whereas the drilling of RN 18248, drilled adjacent RN 18246 which encountered a thick gravel intersection but only yielded 3 L/s, shows that lithology is the best indicator of a successful production bore in this area.
Given these problems of obtaining an accurate indicator of both yield and lithology in the shallow unconsolidated Quaternary sediments underlying the AZRI block it is recommended all future production bore drilling programs seek favourable aquifer lithology by careful (i.e. geological supervision of drilling and 1m sample interval collection and gamma logging) mud drilling investigation or pilot holes.

The lack of yield from RN 18249 even though two metres of gravel were screened is of interest. The results indicate that either; a gravel of very limited extent has been tapped and dewatered; or, perhaps more likely, the 6 m of clay below the 200mm casing (See Appendix) drilled prior to intersecting the gravel contaminated the drilling mud and led to aquifer deterioration by introduction of suspended clay.

**Conclusions**

Given favourable geology and the right construction method high yielding production bores can be installed on the AZRI block near the proposed SAT ponds.

Installation of production bores should be preceded by mud drilled investigation or pilot holes. Air drilled holes do not provide reliable indication of potential yield and aquifer lithology in the shallow unconsolidated sediments underlying the AZRI block.

The long term available yield of bores in these shallow aquifers will be increased when the water table is artificially raised by the significant waste water infiltration proposed as part of the SAT scheme.

Great effort should be made to ensure that main aquifer is only drilled with clean mud; this can seemingly be easily achieved when drilling mud is left to settle for 24 hours while waiting for upper hole casing cement to set.
References


Figure 1 May 2006 Production Bore locations
Appendix

Note:

Bore test reports, constant rate drawdown graphs and long term pumping extrapolation plots were all compiled by Bob Setchell, the NRETA officer responsible for conducting pump tests. On the constant rate drawdown graphs the x plot points, labelled with the discharge rate, show response to pumping while the dot points, labelled $1/t$, show the recovery response on cessation of pumping.

Lithological logs of the holes could be improved by cross reference with the gamma logging to produce an interpretative lithological column. The 1m sampling interval, however, gives a good representation of actual lithology at the scale these log diagrams are presented here.
RN18247

Lithological Description

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Sandy silt, medium, some gravel</td>
</tr>
<tr>
<td>2</td>
<td>Clay, brown, gravel and occasional sand of quartz and fine gravel</td>
</tr>
<tr>
<td>4</td>
<td>Clay, dark brown, plasticine-like, fine gravel and occasional sand, characteristic of a clayey mud</td>
</tr>
<tr>
<td>6</td>
<td>Clay, dark brown, plasticine-like, fine gravel and occasional sand, characteristic of a clayey mud</td>
</tr>
<tr>
<td>8</td>
<td>Clay, dark brown, plasticine-like, fine gravel and occasional sand, characteristic of a clayey mud</td>
</tr>
<tr>
<td>10</td>
<td>Clay, dark brown, mottled, with rare gravel piece</td>
</tr>
<tr>
<td>12</td>
<td>Clay, brown, grey, silty, sticky with 10% gravel</td>
</tr>
<tr>
<td>14</td>
<td>Clay, brown, grey, silty, 40% gravel, angular and angular to sub-rounded quartz and fine gravel, characteristic of a clayey mud</td>
</tr>
<tr>
<td>16</td>
<td>Clay, brown, grey, silty, 40% gravel, angular and angular to sub-rounded quartz and fine gravel, characteristic of a clayey mud</td>
</tr>
<tr>
<td>18</td>
<td>Clay, brown, grey, silty, 40% gravel, angular and angular to sub-rounded quartz and fine gravel, characteristic of a clayey mud</td>
</tr>
<tr>
<td>20</td>
<td>Sand, grey, few mm (0.5 to 2 mm) sand, angular to sub-rounded, characteristic of a clayey mud</td>
</tr>
<tr>
<td>22</td>
<td>Gravel, pale orange to brown, angular to sub-rounded, characteristic of a clayey mud</td>
</tr>
<tr>
<td>24</td>
<td>Gravel, orange to brown, angular to sub-rounded, characteristic of a clayey mud</td>
</tr>
<tr>
<td>26</td>
<td>Gravel, orange to brown, angular to sub-rounded, characteristic of a clayey mud</td>
</tr>
<tr>
<td>28</td>
<td>Gravel, orange to brown, angular to sub-rounded, characteristic of a clayey mud</td>
</tr>
<tr>
<td>30</td>
<td>Gravel, orange to brown, angular to sub-rounded, characteristic of a clayey mud</td>
</tr>
<tr>
<td>32</td>
<td>Gravel, orange to brown, angular to sub-rounded, characteristic of a clayey mud</td>
</tr>
<tr>
<td>34</td>
<td>Gravel, orange to brown, angular to sub-rounded, characteristic of a clayey mud</td>
</tr>
<tr>
<td>36</td>
<td>Gravel, orange to brown, angular to sub-rounded, characteristic of a clayey mud</td>
</tr>
<tr>
<td>38</td>
<td>Gravel, orange to brown, angular to sub-rounded, characteristic of a clayey mud</td>
</tr>
</tbody>
</table>

Bore Completion Details

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>SWL (June 2006)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

NRETA Land and Water Division

Alice Springs SAT scheme; Investigation for demonstration production bores, AZRI block.
NATURAL RESOURCES DIVISION
TEST REPORT – RN 18247.

Bore Location: ARID ZONE RESEARCH INSTITUTE.
Map: Alice Springs 1:100,000 Sheet 5650.
Grid Reference: AGD 84 53K 0386371 – 7371866.

RECOMMENDATIONS: Pumping Rate: 7 L/s.
For alternative pumping rates or settings contact:
General recommendations are on reverse side.
In all correspondence please quote RN 18247.

Bore Data:
Finished depth: 30.0 m. Completion date: 15.5.06.
Standing Water Level: 12.12 m on 17.6.06.

Construction Details:

<table>
<thead>
<tr>
<th>Interval</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 5.70 m</td>
<td>254 mm ID steel casing – grouted</td>
</tr>
<tr>
<td>0 - 20.37 m</td>
<td>203 mm ID steel casing</td>
</tr>
<tr>
<td>19.95 - 20.58 m</td>
<td>152 mm ID steel casing</td>
</tr>
<tr>
<td>20.58 - 28.58 m</td>
<td>152 mm ID stainless steel screens – 1 mm apertures</td>
</tr>
<tr>
<td>28.58 - 30.09 m</td>
<td>152 mm ID steel casing</td>
</tr>
</tbody>
</table>

Notes: 1. Top of casing when tested was 0.30 m above ground.
2. All depths measured from natural ground level unless stated otherwise.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 152 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 203 mm.

COMMMENTS:
1. The above recommendations are based on a step test and a constant rate test at 10 L/s for 24 hours and assume that hydrological conditions remain constant.
2. It is recommended that provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.
3. SWL should be monitored to ascertain seasonal variation.

WATER ANALYSIS: Lab register -
Prepared by: Bob Setchell
20.6.06

Northern Territory Government
Department of Natural Resources, Environment and the Arts

Alice Springs SAT scheme; Investigation for demonstration production bores, AZRI block.
Drawdown in Metres

LONG TERM PUMPING EXTRAPOLATION
17.6.06

Q = 4 L/s
Q = 6 L/s
Q = 10 L/s

CAG = 0.30 m
SWL = 12.12 m
TD = 30.05 m
PS = 24.40 m
AD = 5.58 m

1 Day
1 Year
2 Years

AZRI RN 18247
CONSTANT DISCHARGE TEST

Drawdown in Metres

CAG = 0.30 m
SWL = 12.20 m
RD = 20.60 m
AD = 25.00 m
Q = 101.4 l/s
Alice Springs SAT scheme; Investigation for demonstration production bores, AZRI block.

Bore Location: ARID ZONE RESEARCH INSTITUTE. Client: Natural Resources.
Map: Alice Springs 1:100,000 Sheet: 5650. Purpose: Investigation.

RECOMMENDATIONS: Pumping Rate: 4 L/s. Pump Setting: 19 m.
For alternative pumping rates or settings contact: NRETA Natural Resources.
General recommendations are on reverse side. PO Box 1120.
In all correspondence please quote RN 18248. Alice Springs NT 0870.

Bore Data:
Finished depth: 31.2 m. Completion date: 18.5.06.
Standing Water Level: 17.70 m on 14.6.06.
Construction Details:

<table>
<thead>
<tr>
<th>Interval</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 5.7 m</td>
<td>254 mm ID steel casing – grouted</td>
</tr>
<tr>
<td>0 - 20.4 m</td>
<td>203 mm ID steel casing</td>
</tr>
<tr>
<td>19.7 - 21.5 m</td>
<td>152 mm ID steel casing</td>
</tr>
<tr>
<td>21.5 - 29.4 m</td>
<td>152 mm ID stainless steel screens – 1 mm apertures</td>
</tr>
<tr>
<td>29.4 - 31.2 m</td>
<td>152 mm ID steel casing</td>
</tr>
</tbody>
</table>

Notes:
1. Top of casing when tested was 0.30 m above ground.
2. All depths measured from natural ground level unless stated otherwise.
3. Test rates do not necessarily indicate a sustainable yield for production pumping.

WARNING: MINIMUM INTERNAL BORE DIAMETER IS 152 mm.
MINIMUM INTERNAL BORE DIAMETER TO RECOMMENDED PUMP SETTING IS 152 mm.

COMMENTS:
1. The above recommendations are based on a step test and a constant rate test at 15 L/s for 24 hours and assume that hydrological conditions remain constant.
2. It is recommended that provision to monitor water levels and obtain water samples while pumping should be incorporated when bore is equipped.
3. SWL should be monitored to ascertain seasonal variation.
4. Bore construction limits pumping rate and pump setting.

WATER ANALYSIS: Lab register -
Prepared by: Bob Setchell
17.6.06
Checked by:
LONG TERM PUMPING EXTRAPOLATION
15.6.06

Q = 4 L/s
Q = 6 L/s
Q = 10 L/s
Q = 16 L/s

CAG = 0.30 m
SWL = 17.70 m
TD = 31.20 m
PS = 26.55 m
AD = 5.85 m

AZRI
RN 18248
Lithological Description

RN18249

0
silty sand, bluish grey

2
sandy gravel: 4 cm to gravel, sb ang., Qz, some lithic frag, sb looks similar to gravel's seen at depth in area

4
clay, brownish to red, sticky; 20% gravel, silty

6
sandy gravel: il brn, 1 mm to 10 mm, predm 1-3 mm, ang- sb ang, Qz + fsp + lithics, clean loose.

8
clay, brownish to red, some gravel cavities?

10
silty clay, brownish to red, ooc 1 cm gravels

12
sandy gravel, brn fr (<1 cm) to f gravel (>3 mm), sb ang, Qz + fsp + lithics

14
sand and gravel, alba silt over to 1 cm predm 2-5 mm, 5% dk gry pieces of small size rock also f gr and Qz or gravels, orange tops: clay, pale gry, sam e as bagged at other holes in area as marker for near top of main aquifer

16
clay, silt, 15% orange gry

18
clay-orange, brn to gry

20
clay, alba

22
clay, alba

24
clay, alba

26
clay, alba: more orange, mica flakes and fsp gr.

28
clay, alba on brn, alba

30
gravel, pale gry, >3 mm Qtz w/ orange/yellow same Qzfrags of large >1 cm pebbles, 10% clay, alba

32
gravel, alba but coarser, dk gry lithics, 20% clay, alba

34
clay, brick red and pale gry, taken as top Tertiary

36
clay, red/yell gry

38

40

NRETA Land and Water Division