IMANPA
RECONSTRUCTION OF MONITORING
AND PRODUCTION BORES
1992

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1. INTRODUCTION

1.1 Background

Rooke (1990), apart from describing the hydrogeology of and the water source development for Imanpa Aboriginal Community and environs, recommended several options for aquifer management and future exploitation. Specifically, in order to achieve the former, reconstruction of certain monitoring bores was necessary and for the latter, new drilling and reconstruction of existing bores to production status was scheduled. These bores would be properly constructed to minimise the danger of saline contamination of drinking quality water drawn from the major aquifer, namely the Stairway Sandstone. They would supplement the sole production bore RN 15142 capable of yielding good quality water.

1.2 Original Terms of Reference

Technical Support Branch (TSB), PAWA Alice Springs, having reviewed Rooke's (1990) report, for strategic/financial planning reasons (Beyer, Pers Comm, 1991) opted to:

* commission/convert bores RN 15535 and 15573 to production status for augmentation of the domestic water supply. These bores would intercept the Stairway Sandstone.

* drill a new production bore to water recreational facilities via a separate reticulation system. This bore would intercept a saline aquifer, namely the Carmichael Sandstone. It would be drilled in the vicinity of the power station;
reconstruct monitoring bores RN 15572, 15573 and 15575. These bores would be slotted against the Stairway Sandstone and sealed off from overlying strata to isolate them from interaquifer flow. They would act as piezometers to gauge hydraulic heads and water quality within the main aquifer.

The total cost to meet the scope of works as defined above was estimated to be $94,000-.

1.3 Terms of Reference

Upon instructions from the client, owing to budget limitations, plans to construct a new production bore described above were abandoned. Instead, an existing production bore, RN 11927, which yields saline water from the Carmichael Sandstone would continue to be used for no-potable purposes. (Details of RN 11927 can be found in Rooke (1990)). Additionally plans to test pump RN 15535 on an 'as is' basis, prior to its proposed reconstruction were abandoned.

The terms of reference and scope of works were amended accordingly at an estimated cost of $73,000-.

1.4 Scope of Works

A construction and testing programme for the project follows:

**BORE RN 15535**

* Retrieve 150 mm casing string (total depth, TD 110 m). (A casing protector was left in the sump after the initial construction upon which the drill rods could be threaded for ease of retrieval).

* Leave 6 m of 273 mm OD surface collar in ground.
* Leave 75 m of 219 mm OD Steel casing in ground. (It was originally cemented in at bottom).

* Drill out hole to TD using a 200 mm (7 7/8") rock roller bit.

* Geophysically log.

* Backfill hole to about 100 m.

* Run 168 mm OD steel casing to TD.

* Seal bottom of hole with a bentonite plug.

* Pressure cement annulus to ground level.

* Drill on through concrete plug to about 170 m using a 150 mm (5 7/8") rock roller bit.

* Geophysically log.

* Line aquifer with about 60 m of 125 mm NB (141 mm OD) Class 12 PVC pipe, factory slotted (1 mm aperture).

* Acceptance test pump for 24 hours at a rate of $\geq 1 \text{ L/s}$ with water quality monitoring.

**BORE RN 15573**

* Retrieve 50 mm NB Class 12 PVC pipe if possible; if not drill out using a blade bit.
* Ream to about 100 m if hole collapsed in; otherwise continue to TD at 133 m if hole has remained open, using a 216 mm (8½") rock roller bit.

* Geophysically log.

* Backfill open hole (if necessary) to about 100 m.

* Run in 150 mm NB (168 mm OD) steel casing to about 100 m.

* Seal bottom with bentonite plug.

* Pressure cement annulus to ground level.

* Drill through concrete plug and drill through backfill to about 125 m.

* Geophysically log.

BORES RN 15572, 15574 AND 15575

* Retrieve 50 mm NB Class 12 PVC pipe if possible; if not drill out using blade bit.

* Drill out holes to TD using a 194 mm (7 5/8") rock roller bit.

* In the case of RN 15572, drill on approximately 40 m using the 194 mm bit to intercept the Stairway / Winnall Formations' unconformity.

* Geophysically log.
Run in 100 mm NB (115 mm OD) Class 9 PVC pipe, appropriately slotted with 1 mm apertures to TD and fitted with end caps.

Gravel pack between about 100 m and 120 m using ¾" tremie GWP.

Tremie bentonite pellets to form a seal on top of the gravel pack.

Grout with cement to 6 m above the bentonite seal using ¾" tremie pipe.

Short term airlift test to establish their hydraulic interaction with the aquifer (and to determine permeability values for modelling).
2. RECONSTRUCTION OF MONITORING BORES

2.1 Introduction

Rooke (1990) revealed that four of the monitoring bores, RNs 15572 to 15575 had been constructed against the Stokes Siltstone. Due to the nature of their construction they provided only integrated piezometric levels and water quality samples, i.e., a mixture of Stokes Siltstone and Stairway Sandstone Aquifers. In particular RN 15572 was giving erroneous SWL readings. The original construction of these bores is shown in Appendix A.3.3 of Rooke (1990). Their amended constructions (except RN 15573; refer Section 3.2) are shown as Figures 2a, b and c in this report.

2.2 RN 15572

Reconstruction of this bore commenced on 22nd April 1992. TD was measured at 72.1 m and the 50 mm PVC pipe was pulled out of the hole without incident. The hole was cleared to its original drilled depth of 91.9 m with swelling clay encountered between 69.5 m and 72.6 m BGL. Subsequently, this depth interval (down to 80 m) proved to be a problem to keep open with the hole repeatedly bridging off especially after being left overnight. (This condition was exacerbated by an overtime ban in force during this project, which invariably resulted in an inability to condition the hole and insert PVC casing strings in one day).

The hole was deepened from 91.9 m to 134.2 m BGL using a 190 mm (7½"") hammer bit. The base of the Stairway Sandstone was encountered at 128 m. The rig moved site on 25th April. Open hole was then geophysically logged to a depth of only 79 m, where it had bridged. The sole tool run was the temperature sonde.
The rig returned to RN 15572 on 6th May whence the hole had bridged at 66m. Although, it was cleaned out using a 187 mm (7 3/8") rock roller bit with heavy foam and liquid polymer continual bridging occurred. Consequently, it was decided to case the hole temporarily to a depth of 84 m using 150 mm NB steel casing. A 140 mm (5½") rock roller bit was used to clear the hole and 100 mm NB PVC pipe was run into the hole to TD at 128 m. The depth within the annulus between steel and PVC was tagged at 107 m. As the bottom of the slotted zone of the PVC was at 127 m, gravel pack could not be emplaced fully within the aquifer zone. After gravel packing, depth tagging indicated the hole had bridged yet again, at 80 m. The rig was moved off RN 15572 and on to RN 15535 on 8th May, whilst 13 mm GWP was ordered from town.

Work on RN 15572 resumed on 20th May when compressed air, via 84.5 m of 13 mm GWP, was applied to clear the annulus. Bentonite pellets were then allowed to "free-fall" down the annulus to seal off the top of the gravel pack. Cement slurry was then injected via the GWP to form a final seal above the aquifer. Finally, the 150 mm casing string was withdrawn from the hole and a locking cap fitted to the surface collar.

### 2.3 RN 15574

Reconstruction of this commenced on 22nd April 1992. TD was measured at 111.7 m BGL and the 50 mm PVC pipe was retrieved without incident. The hole was cleared to its original drilled depth of 157 m. Problems occurred with hole stability with a bridge repeatedly forming at 111 m BGL.

Open hole was geophysically logged to a depth of 111.7 m BGL on 24th April 1992. Tools run were the caliper and temperature logs.

The Rig was moved off site and returned on 2nd June 1992. The surface casing (6 m x 200 mm NB collar) was pulled out and the hole reamed to 2.7 m using a 311 mm (12½") blade and reamer. 2 m of 355 mm NB surface casing was inserted and the hole was reamed to 116 m using a 279 mm (11") reamer with
heavy foam and mud injection to hold the hole open. Temporary casing (200 mm NB) was run into the hole to a depth of 115.6 m. A 187 mm (7 3/8") rock roller bit cleaned the hole using foam/water injection to a TD of 147 m BTOC. 100 mm NB PVC pipe was run into the hole to a TD 142.5 m. The annular space was gravel packed by 'free-fall' to 119.9 m BTOC. 4.5 L of bentonite pellets were then introduced down the annulus in a similar manner. 110 m of 19 mm GWP was then placed in the hole and cement slurry injected down it to form a final seal above the aquifer. Finally the 200 mm casing string was withdrawn from the hole, the 355 mm surface casing removed and replaced with a 200 mm section with locking cap.

2.4 RN 15575

Reconstruction of RN 15575 commenced on 23rd April 1992. TD was measured at 98.2 m BGL and the total 90 m of 50 mm PVC pipe was retrieved from the hole. The hole was cleared to its original drilled depth of 151.5 m.

Open hole was geophysically logged to 142.3 m BGL. Several tools were run, namely temperature, caliper, electric (SP and SPR) and natural gamma. The hole remained open for the duration of this logging.

The rig was moved off site (to retrieve PVC in other bores) and returned over the bore on 28th April 1992. By this time the hole had closed at 99 m BGL (ie at the Stokes Siltstone/Stairway Sandstone's contact). The hole was then cleared to TD using a 187 mm rock roller bit with regular airlift. Through the section 97 m to 116 m the bit became clogged with clay and had to be withdrawn for cleaning. Otherwise, unlike RN's 15572 and 4, this hole remained relatively stable, hence a temporary casing string was not needed. The hole was backfilled from 142 m to 131 m BGL and the 100 mm NB PVC pipe string was inserted. 1200 L of gravel pack was poured down the annulus to 91.1 m BGL and 9 L of bentonite pellets was introduced above the gravel to seal it off. Whilst checking the annular depth it was noticed that a bridge had formed at 65 m whilst inserting the pellets. 89 m of 19 mm GWP was introduced down
the annulus and air blasted through it to clear the blockage. Thereafter the bulk of the pellets (another 16 L) were emplaced through the GWP using water displacement (with a tee piece at the top of the GWP, one end connected to the water tanker the other a funnel through which the pellets were poured). A definitive seal was made on top of the bentonite (above the aquifer) by pumping a cement slurry down the GWP. The remaining annular space was backfilled to ground level using local sand.
3. RECONSTRUCTION OF PRODUCTION BORES

3.1 Introduction

The original construction of bores RN 15535 and 15573 is detailed in Appendices A 3.2 and A 3.3 respectively of Rooke (1990). Their amended construction details are shown as Figures 2d and 2e in this report.

3.2 RN 15535

Reconstruction of this bore commenced on 8th May 1992. The bore had silted up to the level of its packer (74 m BGL). It was cleared by airlifting through the drill rods to TD whence the rods were rotated to couple onto an existing casing protector and the total casing string was pulled out.

Next day TD was checked at 93.1 m BGL. 100 m of 150 mm NB steel casing was hung within the hole using casing clamps. Gravel fill was then emplaced from 102.6 m to 100.4 m. Bentonite pellets were poured through the casing on top of the gravel to form a 0.25 m plug. 39 bags of SR cement were then mixed and the slurry pumped down inside the casing and a wooden formwork plug with rubber gaskets inserted in the casing. A "tight head" was welded on the surface casing and water pumped into the hole to force the slurry down the casing and back up the annulus. After a build up of excessive pressure with the top of the plug at 57.3 m the tight head was removed. No returns of cement occurred from the annulus at the surface. The casing was filled with water overnight to avoid any back pressure allowing cement contamination. Checking of depths on 12th May 1992 revealed that the top of the cement had set in the annulus at 75 m BGL. 28 bags of cement were then mixed and pumped down this annular space, volume being calculated to effect complete sealing.
A 143 mm (5 5/8") rock roller bit was used to drill cement out of the casing to depth of 99.6 m BGL. The rig was then relocated and returned to this site on 15th May 1992. The inside of the casing was then "smoothed" of cement using a 150 mm (5 7/8") rock roller bit and drilling continued through the bentonite seal, with fresh hole made below 110 m with regular airlift yield and quality (EC and pH) measurements taken until EOH at 130.7 m BGL.

The bore was then geophysically logged (on 18th May 1992) using the temperature, caliper, gamma and electric sondes. Only the gamma was logged through the casing as well as open hole.

The next day it was discovered that the hole had a ledge at 111 m and blockage at 115 m (the latter with a small boulder) which was drilled out. After backfilling, with TD at 129.7 m the 125 mm NB PVC pipe string was run into the hole with its sump weighted by a few sample bags of cement. The pre-slotted PVC pipe was lowered on a sand-line. Unfortunately it would not go beyond the casing bottom and was gently pushed into place by one length of suspended drill pipe. After successful emplacement of the PVC production casing, drill rods were run into the hole and the bore airlifted 1.1 L/s from 90 m BGL with an EC of 1449 µS/cm.

3.3 RN 15573

The 50 mm PVC pipe string was retrieved from this bore on 23rd April 1992 with TD measured at 81.2 m BGL.

Reconstruction of this hole got underway on 13th May 1992. The hole was cleared to its original drilled depth of 133 m using air/foam. 150 mm NB steel casing was run into the bore to a depth of 93 m BGL. After natural collapse the hole was backfilled with gravel from 107.2 m back to 93.1 m BGL. 4 L of bentonite pellets were poured down inside the casing on top of the gravel to form a seal. A mix using 36 bags of SR cement was then introduced to seal the annular space using the same technique as employed in RN 15535. The
The depth to the top of the cement in the annulus was 35.2 m BGL. The void space above this was filled from the surface using a mix prepared from 13 bags of cement to completely seal the annulus. The depth inside the casing was 92.5 m BGL. This was drilled out using a 150 mm (5\7/8") rock roller bit and drilling continued through the bentonite seal and backfill material. Whilst airlifting from 102 m to 115 m only a seepage was produced with an EC of 6690 \( \mu\text{s/cm} \) and pH 12.4; cement had contaminated the aquifer through improper setting and possible infiltration into rock fractures. The bore was left dormant for ten days whilst work continued elsewhere to allow the cement to dry.

The rig was re-established over the hole on 26th May 1992, and the hole was drilled out again to TD at 133.2 m BGL. Drilling resumed into fresh rock to ascertain definitively the permeability of the Winnall Beds underlying the Stairway Sandstone Aquifer. Drilling terminated at 137.2 m. Cement continued to contaminate the formation water with pH measured at more than 11 units, and lower yielding, higher EC supplies than anticipated \((Q = 0.3 \text{ L/s}; EC = 2200 \ \mu\text{s/cm})\).

No supplies were obtained above 100 m with only a seepage between 100 and 109 m. It was concluded that the cement had infiltrated the backfill material from 93 to 107 m, and several attempts were made to clear the bore of cement slurry using foam and water injection over an eight hour period.

It was then decided to do a slug test by filling the bore with water until the surface and measuring its head decay for a time period until resumption of SWL conditions (4 hours). This was proceeded by surging and jetting via the drill stem with water injection (four loads, 10 KL each) at depth intervals between 94 m and 115 m BGL. After 3\1/2 hours the formation water had lowered its pH and EC to 8.9 and 1680 \( \mu\text{s/cm} \) respectively, whereupon another slug test was performed on 28th May 1992. This showed little improvement in permeability and the bore was then airlifted through a rock roller bit for two hours whereupon the yield was measured at approximately 0.4 L/s, EC = 1660 \( \mu\text{s/cm} \)
and pH = 8.6. A third and final slug test was done on 29th May whereafter the decision was made to complete the bore with production casing.

The hole was then conditioned using a 150 mm (5 7/8") rock roller bit with heavy foam injection to maintain open hole through and unstable zone at 107 m and 112.5 to 117 m.
The pre-slotted PVC production casing was inserted on a sand-line with the assistance of airlifting from within it using 104 m of 19 mm GWP to seat it correctly.

After completion the bore when airlifted from 89.5 m BGL yielded 1.4 L/s increasing to 1.9 L/s with an EC of 1620 μs/cm and pH = 8.35.
4. TEST PUMPING

4.1 RN 15535

Test pumping was performed using a "640 Mono" helical rotor pump powered by a three cylinder Lister diesel engine. Various discharges were measured using an appropriately sized orifice plate coupled to a manometer tube. During pumping, field pH, EC, temperature and visual records of turbidity were kept intermittently of the discharging water. The pump was set at 93.5 m BGL, that is above the packer within the 150 mm steel casing. This setting gave an available drawdown of approximately 53 m, with a SWL of 40.2 m BGL.

4.1.1 Step Drawdown Test

A four step drawdown test was carried out on 9th July 1992. The rates used were 0.5, 1, 1.5, and 2 L/s, each step 100 minutes in duration, except for the fourth where the bore forked after 40 minutes. A light brown discolouration of the discharging water cleared after the first two steps.

4.1.2 Constant Rate Test

A constant rate test commenced on 15th July 1992 at a rate of 1 L/s for a duration of 1500 minutes, followed by 180 minutes monitoring the recovery. Water levels were also observed in monitoring bores RN 14349, 15572 and 15576 and production bore RN 15573. Of these observation bores only RN 14349 and 15576 responded with nil drawdown in the others.

Measurements of TD of the bore prior to and after test pumping indicated that RN 15535's sump was clean with negligible ingress of sediment through the slotted pipe.
4.2 RN 15573

Test pumping was performed using a "520 Mono" helical rotor pump powered by the same engine as used for testing RN 15535. The same suite of records were acquired as those taken for RN 15535. The pump was set at 83.1 m BGL, that is almost 6 m above the packer inside the 150 mm steel casing, giving an available drawdown of approximately 39 m, with a SWL of 43.8 m BGL.

4.2.1 Step Drawdown Test

A four step drawdown test was carried out on 10th July 1992. The rates used were the same as those used in the testing of RN 15535. The bore did not fork at the highest rate and the discharging water was clean and clear throughout testing.

4.2.2 Constant Rate Test

A constant rate test commenced on 13th July 1992 at a rate of 1 L/s for a duration of 1500 minutes, followed by 180 minutes of recovery. Water levels were also observed in monitoring bores RN 15572, 15574 and 15577 and production bore RN 15535. Only RN 15572 and 15574 responded, the others having nil drawdown.

TD measurements taken before and after testing showed that the sump was clean with negligible ingress of sediment through the slotted pipe.

4.3 Analyses

The time-drawdown graphs pertaining to these suite of pump tests appear as WHIP (1988) plots in Appendix A. Recovery plots are given, also, for the production bores’ data only. Simple parametric analysis using WHIP (1988) gave values for T and S which are given adjacent to the graphs. These values may
be considered as representative of the regional aquifer as they include analyses of the observation drawdowns.

Drawdown results from step and constant rate tests of both production bores were analysed using a modification of Linnox's (1955) method to provide a theoretical drawdown/yield/time relationship. The analytical results are shown on graphs as Figures 3a and 3b for RN 15535 and RN 15573, respectively. Based upon these graphs, pump rates and settings have been recommended, for each bore, on the Test Report forms given as Appendix B. (The reader's attention is drawn to the "Comments" section of each of the Test Reports, particularly item No 5 which addresses the issue of resource conservation. This issue is discussed in detail in Rooke, 1990).

Aquifer parameters derived from the test pumping data and their application to local drawdown analysis in the production bores and regional aquifer is discussed in a hydrogeological context in Section 5.3 below.
5. REFINEMENT OF HYDROGEOLOGY

5.1 Drilling

The author's presence on site during the deepening of holes RN 15535 and 15572 through the Stairway Sandstone, with drilling terminating in underlying Winnall Beds has indicated, definitively, that the Winnall Beds are dry and impermeable. The conclusion in Rooke (1990) that the Stairway/Winnall unconformable contact is potentially a higher yielding zone than the Stairway Sandstone has proven to be a fallacy. In drill chip samples the contact zone is remarkably sharp with a 2 m unit of dark red-brown, soft silty sandstone overlying a purple, hard, fine-grained arkose marking the top of the Winnall Beds. A further 3.9 m of hole made in RN 15573 through the Winnall Beds also proved their hardness and impermeability. The rate of drilling penetration slowed markedly once into Winnall Beds.

In bores RN 15535 and 15572 the Stairway/Winnall contact occurs at depths of 122.4 m and 128 m BGL, respectively. Re-logging of drill chip samples from RN 15573 has resulted in a re-interpretation of the contact depth in this hole. It occurs at 127 m BGL and not 112 m as previously indicated in Rooke (1990).

Individual yields from the Stairway Sandstone vary from hole to hole and within stratigraphic horizons. They appear to vary depending upon the degree of fracturing and cleaness of the sandstone units.

5.2 Geophysical Logging

Borehole geophysical logging complemented drilling information in extending the hydrogeological knowledge of the aquifer. It also aided screen placement in production bores RN 15535 and 15573, as well as the monitoring bore reconstructions.
The complete suite of logs for each bore can be seen in Appendix C. They include caliper, natural gamma, single point resistance (SPR), self potential and absolute temperature (differential temperature channel was unavailable). Extension of the natural gamma logs for RN's 15535, 15572, 15573 and 15575 has been plotted on Figure 4; (RN 15574 was logged to its total drilled depth during its original construction in November 1989).

Only in RN 15575 did the hole remain open to almost total drilled depth to enable a complete suite of logs to be run. The other holes had to be logged below temporary casing in the case of RN's 15572 and 15575 and below permanent steel casing (prior to insertion of the production casing) in the production bores.

The most noticeable aspects of the logs showed the relative competencies of units within the Stairway Sandstone. Intercalations of clay are seen as wider hole diameter of the caliper logs sometimes correlated with gamma spikes. In RN 15573 the generally cleaner, fractured sandstone beds correlate with a remarkably uniform gamma count as compared with the other bores. In RN 15535 clay bands of the upper Stairway Sandstone are absent below 110 m where the lower Stairway is tight.

The temperature log of RN 15574 indicates a significant inflow of groundwater at a depth of 99 m BGL; this correlates with the base of a pure dolomite horizon underlain by silty dolomite (both Stokes Siltstone). The temperature log of RN 15575 indicates an inflow of groundwater at 93 m BGL, that is just above the Stokes Siltstone/Stairway Sandstone contact. This emphasises the need to cement off this poor quality, abundant groundwater within the Stokes Siltstone.

5.3 Aquifer Parameters

Values for aquifer parameters given in Appendix A are in broad agreement with those values previously analysed for other bores tapping the Stairway Sandstone Aquifer (Section 3.7.2 and Appendix A.5 of Rooke, 1990). These indicated that
transmissivity is higher in the vicinity of production bores RN 15142 and 15573 than production bore RN 15535 and ex-production bore RN 14349. This is confirmed by this study.

The data is summarised below in Table 1.

TABLE 1

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<th>BORE RN</th>
<th>T (m²/d)</th>
<th>T (m²/d) RECOVERY</th>
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The Jacob analyses used to produce the drawdown-yield graphs (Figures 3a and 3b) are in agreement with those produced by WHIP (1988).

The semi-confined values for S justify the use of a specific yield value in the resources assessment (Rooke, 1990).

The absence of any drawdown in observation bore RN 15577 (whilst RN's 15572 and 15574 responded) during the pumping of RN 15573 indicates the highly stratified nature of the Stairway Sandstone Aquifer and its strip like geometry (west-east).
5.4 Water Quality

Major ion chemical analyses of water samples taken from bores RN 15535 and 15573 are given as Appendix D. These samples were taken whilst drilling, after bore completion (samples retrieved by airlift and immediately prior to cessation of pumping (24 hours).

NHMRC drinking water quality guidelines are reproduced for comparative purposes. According to this guideline, bore RN 15573 has water of marginal quality, however, it lies within the potable water range (TDS < 1500 mg/L) as defined in the terms of reference laid down by AES; (Section 1.1, Rooke, 1990 refers). They are also comparable with the TDS and nitrate (NO₃) levels within pre-existing production bore, RN 15142 of 965 mg/L and 32 mg/L, respectively (sampled October, 1990).

The highly stratified nature of the Stairway Sandstone in terms of water quality (as well as yield) was highlighted in this study by a careful examination of EC values measured whilst deepening monitoring bore RN 15572 (the bore deepened the most in the re-construction works). Here the EC decreased from approximately 2800 μS/cm in the Stokes Siltstone to 1900 μS/cm at the top of the Stairway Sandstone. However, careful measurements whilst drilling the Stairway Sandstone Aquifer indicated that there was a degree of fluctuation in quality with a marked increase to above 2800 μS/cm at the base of the Stairway Sandstone.

There are relatively high NO₃ values in RN 15573 (and RN 15142) compared with a negligible concentration in RN 15535. Interestingly, bores RN 15573 and 15142 are proximal to outcrop of the aquifer, and hence to a possible path for recharge. The relationship between possible preferential recharge of bores close to outcrop with seemingly high NO₃ surface waters (of high NO₃ concentration - water hole analysis; Appendix D) merits investigation. Comparison of hydrographic records of SWLs in monitoring bores in the vicinity with surface
and groundwater chemistry and rainfall data might be made to ascertain any relationship.

5.5 Structural Control

During the latest drilling operations the author examined outcrops of the Carmichael and Stairway Sandstones and the Winnall Beds. It is believed that the cuspatate hill (immediately NE of Imanpa community) composed of Carmichael Sandstone represents the nose of an overturned fold. Within the Basedow Range the unconformity between the Stairway Sandstone and Winnall Beds is represented by thin, recessive clayey beds. The Stairway Sandstone shows signs of hiatus with convoluted bedding north of RN 15142. In a gully north of RN 15535 (just north of dud bores RN 15567 and 15568) there is recumbent folding, the fold axis striking ENE, the N limb being overturned and faulted out with a zone of mylonite; the southern limb dips more gently at about 15°. The closure is only 50 m. Again, north of RN 15575 bedding is overturned (nearly vertical dip to the north) in an isolated fault block bounded to the east by an acute fault sympathetic to the main thrust. This vertical wall of Stairway Sandstone is closely jointed with three sets of conjugate joints. It is interesting to note that RN 15575 had higher yields of poor quality water (5-6 L/s, EC = 3000 µS/cm).
6. FURTHER STUDIES

Recommendation 8.1.5 (Rooke, 1990) proposed the development of an aquifer model to use as a resource management tool. The terms of reference for this exercise has already been briefed. Prior to commencing this model further study of all available regional hydrogeological data coupled with further field geological mapping may be deemed worthwhile.
I. Bores RN 15535 and 15573 have been re-constructed as production bores to augment Imanpa Community’s domestic water supply. They have been completed to specifications which should avoid formation collapse and short-term salinisation from overlying groundwaters.

II. Monitoring bores RN 15572, 15573 and 15575 have been re-constructed (effectively as piezometers) to be open against the Stairway Sandstone Aquifer, which provides the water source for supply. They have been hydraulically isolated from the overlying Stokes Siltstone Aquifer which is saline. They have been completed with 100 mm NB PVC pipe for ease of water sampling.

III. The Winnall Beds and unconformity between the Stairway Sandstone and Winnall Beds are effectively dry and impermeable. This is contrary to the previous understanding of the hydrogeology by Rooke (1990).

IV. Individual yields from the Stairway Sandstone Aquifer vary from hole to hole and within stratigraphic horizons. Furthermore water quality within the aquifer appears to be stratified. The Stairway Sandstone may be regarded as a fractured rock aquifer.

V. Significant inflows of groundwater in the lower Stokes Siltstone, particularly emanating from dolomite units has emphasised the efficacy of sealing off this saline aquifer from the production aquifer.

VI. The transmissivity of the aquifer zone surrounding Production Bores RN 15142 and 15573 is somewhat higher than that zone around Production Bores RN 14349 (ex-production) and 15535 (8 m²/d as opposed to about 4 m²/d). The storage coefficient of 1%, however, appears to be consistent throughout the aquifer (and is half that upon which the volume of potable
groundwater stored in the Stairway Sandstone Aquifer was calculated by Rooke (1990)). This emphasises the need for resource conservation.

VII. The absence of drawdowns in certain observation bores during the testing of the production bores reinforces Conclusion No IV and attests to the "strip" geometry (west-east orientation) of the Stairway Sandstone Aquifer.

VIII. Production Bore RN 15573 during test pumping produced water of marginal quality (TDS) according to NHMRC (1987) drinking water guidelines. However its water quality lies within the guideline of less than 1500 mg/L invoked by AES (Section 1.1, Rooke (1990) refers).

IX. Production Bore RN 15535 during test pumping produced water of acceptable quality when compared with guidelines (NHMRC, 1987).

X. Relatively high nitrate concentrations of groundwater are produced from Production Bores RN 15573 and 15142. These bores are proximal to outcrop of the Aquifer; hence to a possible source of recharge (through gully run-off in southern foothills of the Basedow Range). (SWL hydrographic records might be examined to research possible correlation of this higher NO₃ groundwater with recharge events).

XI. For reticulation design purposes it should be noted that the groundwater is mildly corrosive (Appendix B).
8. RECOMMENDATIONS

I. Production Bore RN 15535 may be pumped at a maximum rate of 1 L/s with a pump setting of 94.5 m BGL (refer Appendix B 1).

II. Production Bore RN 15573 may be pumped at a maximum rate of 1.5 L/s with a pump setting of 86.5 m BGL (refer Appendix B 2).

III. Notwithstanding Recommendations Nos I and II, ideally, for conservation of the resource a continuous pumping rate of 17 KL/d from both bores is recommended; (likewise for Production Bore RN 15142). (This issue was covered in detail in Rooke, 1990).

IV. Provision to monitor water levels and obtain water samples from Production Bores RN 15535 and 15573 should be incorporated when equipping them. Records of abstraction and monthly water levels for these bores should be collected to facilitate assessment of the Aquifer's behaviour. (Appendix B). All other monitoring requirements stand as given in Section 8.3 of Rooke (1990).

V. Further study is needed pertaining to the hydrogeology of the aquifer system at Imanpa as groundwater hydrograph, production, hydro chemical and other data comes to hand. An aquifer model should be developed to use as a resource management tool.
9. REFERENCES

<table>
<thead>
<tr>
<th>Author</th>
<th>Title</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NHMRC/AWRC, Canberra.</td>
<td></td>
</tr>
<tr>
<td>Rooke, ER, 1990</td>
<td>Imanpa - Groundwater Supply Investigation</td>
<td></td>
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<tr>
<td></td>
<td>WRB, PAWA Report No 19/1990 A.</td>
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<tr>
<td>WHIP, 1988</td>
<td>Well Hydraulics Interpretation Program, Version 3.22</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hydro Geo Chem, Inc. Tucson, Arizona, USA.</td>
<td></td>
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</tbody>
</table>
COMPOSITE LOG OF BORE

DEPTI (m) BORE CONSTRUCTION LOG GRAPHIC STRATA DESCRIPTION AQUIFERS (Water Struck)

0 0.5m 2 2m-1

10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160

91.8m 97.8m 99.3m 106.8m 127.3m 128.3m

S R Cement group (red)
St Elmo Group (blue)
Sand Pack
Gravel Pack
0.2m drill

Vertical Scale 1:1000 V = 50
Horizontal Scale 1:20 H

Ot = Stokes Siltstone
Os = Stairway Sandstone
PuW = Winnall Beds

Airlift Yield (L/s)
EC (μS/cm)

0.5 1970
0.4 2360
0.7 1925
0.8 2420
1.0 2320

For strata details refer to Rooke 1990

SWL 48.6m
30/5/92

I MANPA BORE RECONSTRUCTIONS RN 15572

FIGURE 2a
COMPOSITE LOG OF BORE

DEPT (m) CONSTRUCTION LOG STRATA DESCRIPTION AQUIFERS

For Strata Details Refer to Rooke 1990

Vertical Scale 1:1000
Horizontal Scale 1:20

DATE OF BORE COMPLETION 4/6/92

IMANPA BORE RECONSTRUCTIONS RN 15574

FIGURE 2b
POWER AND WATER RESOURCES

COMPOSITE LOG OF BORE

DEPTH (m) BORE CONSTRUCTION LOG STRATA DESCRIPTION AQUIFERS (Water Struck)

For strata details refer to Rooke 1990

Date of bore completion 1/5/92

Imanpa Bore Reconstructions RN 15575

Figure 2c
COMPOSITE LOG OF BORE

DEPTII BORE GRAPHIC CONSTRUCTION LOG STRATA DESCRIPTION AQUIFERS
(m) CONSTRUCTION LOG STRATA DESCRIPTION (Water Struck)

FOR STRATA DETAILS REFER TO ROOKE 1990

V SWL 40.2m
9/7/92

Ot
Os

Gy.brown v.hard s.f. SANDSTONE band at 114.5m
Lt brown fractured SILTSTONE
Lt to red brown SANDSTONE well fractured 117.7 - 118.4m
Hard red brown SANDSTONE

0.3m thick
Soft dark red brown silty SANDSTONE
Red purple silty SDST soft-hard

Vertical Scale 1:1000  \( \frac{V}{H} = 50 \)
Horizontal Scale 1:20

DATE OF BORE COMPLETION 20/5/92

IMANPA BORE RECONSTRUCTIONS RN 15535

* AFTER DEEPENING BORE BELOW ITS ORIGINAL TD

FIGURE 2d
### COMPOSITE LOG OF BORE

<table>
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<tr>
<th>DEPTH (m)</th>
<th>BORE CONSTRUCTION LOG</th>
<th>GRAPHIC LOG</th>
<th>STRATA DESCRIPTION</th>
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<tbody>
<tr>
<td>0</td>
<td></td>
<td>2.66m -</td>
<td></td>
</tr>
<tr>
<td>0.71m</td>
<td></td>
<td>1.9m</td>
<td></td>
</tr>
<tr>
<td>28.8m</td>
<td></td>
<td>24.9m O.G.</td>
<td></td>
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<tr>
<td>33.0m</td>
<td></td>
<td>24.2m O.G.</td>
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</tr>
<tr>
<td>60.3m</td>
<td></td>
<td>12mm O.G.</td>
<td></td>
</tr>
<tr>
<td>112.3m</td>
<td></td>
<td>TD</td>
<td></td>
</tr>
<tr>
<td>137.2m</td>
<td></td>
<td>E.G.H.</td>
<td></td>
</tr>
<tr>
<td>140m</td>
<td></td>
<td>12mm O.G.</td>
<td></td>
</tr>
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</table>

**AERIALS**
- Yield EC (L/s) (μS/cm)

- **For Strata Details Refer to Rooke 1990 and Detailed Log. Appendix 2**

**SWL 43.8m**

**DATE OF BORE COMPLETION 2/6/92**

**IMANPA BORE RECONSTRUCTIONS RN 15573**

- * After deepening bore below its original TD
- + After setting slotted pipe (bore completion)
These curves are based on a one day pumping test at a discharge of 1.0 litres per second. They assume that hydrological conditions will not change for other pumping rates and periods.

**IMANPA RN 15535**

**DRAWDOWN-YIELD RELATIONSHIP**

FIGURE 3a
Date Tested 13/7/92

These curves are based on a one day pumping test at a discharge of 1.0 litres per second. They assume that hydrological conditions will not change for other pumping rates and periods.

**IMANPA RN 15573**

**DRAWDOWN-YIELD RELATIONSHIP**

*FIGURE 3b*
APPENDIX A

Analyses of Pumping Tests
APPENDIX A.1

DRAWDOWN (METERS)

+ Measured Drawdown
- Theoretical Drawdown

TIME (MINS)

1.E+00
1.E+01
1.E+02
1.E+03
1.E+04

DRAWDOWN (METERS)

1.E+00
1.E+01
1.E+02
1.E+03
1.E+04

15.0
20.0
25.0
30.0

T = 28.96 m
d = 40 cm
S = 0.02

RN 15535 PUMPED BORE Q = 1 L/s 15 JULY 92

APPENDIX A.1
APPENDIX A.2

RN 15535 PUMPED BORE Q= 1 L/s 15 JULY 92

T = 3m²/d
S = 0.01
D = 40m

APPENDIX A.2
RN 15573 PUMPED BORE Q= 1 L/s 13 JULY 92

\[ T = 6.5 \text{m}^2/\text{d} \]
\[ S = 0.008 \]
\[ D = 30 \text{m} \]
APPENDIX A.4

RN 15535 PUMPED Q=1 L/s 16.7.92 RECOVERY

- $T = 2.8m^2/d$
- $T = 3.5m^2/d$

(S = 0.02)
D = 40m
APPENDIX A.5

RN 15573 PUMPED BORE Q = 1 L/s 14 JULY 92

RECOVERY

--- T = 6.5m²/d
--- T = 10m²/d
(S = 0.008)
APPENDIX B

Test Reports:

RN 15535 and RN 15573
WATER RESOURCES DIVISION

TEST REPORT — BORE RN.15535

Bore Location: Imanpa
Client: TSR/NTCA
Reference: 116.1c
Purpose: Domestic

Map: SG53-5 Kulgera 1:250,000
Grid Reference: 255211E 7220521N

RECOMMENDATIONS.

Pumping Rate: 1 L/s
Pump Setting: 94.5m below Ground Level.

General recommendations are given on the reverse side. The aquifer and bore cannot sustain higher pumping rates with deeper pump settings or for short periods in favourable seasons. Further advice can be obtained from Water Resources Branch (In all correspondence please refer to bore’s RN number)
Stuart Hwy
ALICE SPRINGS NT.

BORE DATA.

AQUIFER TEST.

Finished depth: 119.7m
Completion Date: 20.5.92
Test Date: 15.7.92
Standing Water Level: 40.2m on 9.7.92
Test Rate: 1.0 L/s
Test Duration: 24 hrs

Construction details:

Interval (m) Description
0 - 6.00 m 273 mm OD steel casing
0 - 75.00 m 219 mm OD steel casing
0 - 100.00 m 152 mm ID steel casing
96.00 - 119.70 m 122 mm ID Class 12 PVC pipe
with 1.2 mm slots

top of adaptor set @ 96.0m

Notes:
1. Top of casing as constructed was 0.74 m above ground.
2. All depths are measured from natural ground level.
3. Test rates are not indicative of safe long term pumping rates

WARNING: Minimum internal bore diameter is 152mm above adaptor.

COMMENTS.

1. The above recommendations are based on a constant rate test at 1.0 L/s
   for 24 hours and assume hydrological conditions remain constant.
2. Provision to monitor water levels and obtain water samples should be
incorporated when equipping this bore.

3. Records for extraction and monthly water levels would be valuable for long term aquifer assessment.

4. For rates up to 1.0 L/s, with a pumping cycle of 6 hours per day, pump may be set at 75.00 m.

5. Ideally, for conservation of resource (maintain integrity of fresh water in the aquifer) a continuous 24 hour rate the equivalent of 17 KL/d should not be exceeded.

***********************************************************************

WATER ANALYSIS

Total dissolved solids of production zone is approx. 900mg/l.

The groundwater is mildly corrosive.

See water laboratory report Analysis No. 92/93/0056.

WATER RESOURCES DIVISION

TEST REPORT — BORE RN. 15573

Bore Location: Imanpa

Client: TSB\NTCA

Reference: 116.1c

Purpose: Domestic

Map: SG53-5 Kulgera 1:250,000

Grid Reference: 253457E 7220616N

*******************************************************************************

RECOMMENDATIONS.

Pumping Rate: 1.5 L/s  Pump Setting: 86.5 m below Ground Level. General recommendations are given on the reverse side. The aquifer and bore cannot sustain higher pumping rates with deeper pump settings or for short periods in favourable seasons. Further advice can be obtained from: Water Resources Branch (In all correspondence please refer to bore's RN number) Stuart Hwy., ALICE SPRINGS NT.

*******************************************************************************

BORE DATA. AQUIFER TEST.

Finished depth: 112.3 m Completion Date: 2.6.92 Test Date: 13.7.92
Standing Water Level: 43.82m on 10.7.92 Test Rate: 1.0 L/s
Construction details: Test Duration: 24 hrs.

<table>
<thead>
<tr>
<th>Interval (m)</th>
<th>Description</th>
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<tr>
<td>0 – 2.65 m</td>
<td>219 mm OD steel casing</td>
</tr>
<tr>
<td>0 – 93.00 m</td>
<td>152 mm ID steel casing</td>
</tr>
<tr>
<td>88.80 – 112.30 m</td>
<td>122 mm ID Class 12 PVC pipe</td>
</tr>
<tr>
<td></td>
<td>with 1.2 mm slots</td>
</tr>
</tbody>
</table>

Top of adaptor set @ 88.8 m

Notes:
1. Top of casing as constructed was 0.71 m above ground.
2. All depths are measured from natural ground level.
3. Test rates are not indicative of safe long term pumping rates

WARNING: Minimum internal bore diameter is 152 mm above adaptor.

*******************************************************************************

COMMENTS.

1. The above recommendations are based on a constant rate test at 1.0 L/s for 24 hours and assume hydrological conditions remain constant.
2. Provision to monitor water levels and obtain water samples should be incorporated when equipping this bore.
3. Records for extraction and monthly water levels would be valuable for bore data.

*******************************************************************************

APPENDIX B.2
long term aquifer assessment.

4. For rates up to 1.5 L/s, with a pumping cycle of 6 hours per day, pump may be set at 75.00 m.

5. Ideally, for conservation of resource (maintain integrity of fresh water in the aquifer) a continuous 24 hour rate the equivalent of 17 KL/d should not be exceeded.

WATER ANALYSIS

Total dissolved solids of production zone is approx. 1000 mg/l.

The groundwater is mildly corrosive.

See water laboratory report Analysis No. 92/93/0055.

APPENDIX C

Borehole Geophysical Logs
RN 15535

Ot = STOKES SILTSTONE
Os = STAIRWAY SANDSTONE
Euw = WINNALL BEDS

APPENDIX C.1
LOG STARTS AT: 50.00m.

hole bridged on logging run

Ot

Os

LOG ENDS AT: 128.60m.

RN 15572

APPENDIX C.2
Appendix C.3

RN 15573
APPENDIX C.4
1 - CALIPER
5.000 inches 15.00

2 - GYMP
5.000 cps 175.0

3 - SPR
75.00 ohms 200.0

3 - SELF POTENTIAL
50.00 mv 100.0

LOG STARTS AT: 60.04m.

75.00m.

100.00m.

125.00m.

LOG ENDS AT: 143.14m.

RN 15575

APPENDIX C.5
APPENDIX D

Water Quality Data.
## Analysis in milligrams per litre - mg/L (unless otherwise stated)

| BORE NUMBER | DATE OF SAMPLING | TDS (mg/L) | pH | Na (mg/L) | K (mg/L) | Ca (mg/L) | Mg (mg/L) | CaCO₃ (mg/L) | CaCO₂ (mg/L) | Fe (mg/L) | SiO₂ (mg/L) | Cl (mg/L) | SO₄ (mg/L) | NO₃ (mg/L) | HCO₃ (mg/L) | F (mg/L) | NaCl (mg/L) | COMMENTS |
|-------------|------------------|------------|----|----------|---------|---------|---------|-----------|-----------|---------|-----------|---------|---------|---------|---------|---------|---------|
| RN 15535    | 15.5.92          | 1355       | 795| 8.7      | 165    | 26     | 50     | 33        | 260       | 44      | -         | 11      | 238     | 242     | 1       | 47      | 0.3      | 392     | Airlift, drilling at 114m |
| RN 15535    | 20.5.92          | 1450       | 850| 7.2      | 165    | 24     | 51     | 29        | 239       | 49      | -         | 12      | 250     | 259     | 1       | 60      | 0.3      | 412     | Airlift, 1.1 L/s from 90m after bore completion |
| RN 15535    | 16.7.92          | 1545       | 920| 6.1      | 186    | 26     | 55     | 38        | 294       | 58      | -         | 14      | 277     | 289     | 1       | 71      | 0.3      | 457     | Test pumping at 1 L/s after 1500min |
| RN 15573    | 29.5.92          | 1845       | 1100| 7.5     | 212    | 29     | 86     | 40        | 343       | 115     | -         | 8       | 330     | 268     | 27      | 140     | 1.6      | 544     | Airlift, drilling at 115m |
| RN 15573    | 2.6.92           | 1655       | 995| 7.8      | 185    | 28     | 71     | 38        | 327       | 157     | -         | 31      | 291     | 201     | 33      | 191     | 1.0      | 480     | Airlift 1.0 L/s from 60m after bore completion |
| RN 15573    | 14.7.92          | 1655       | 1020| 7.1     | 197    | 30     | 67     | 39        | 228       | 172     | 0.1       | 36      | 292     | 194     | 35      | 210     | 0.9      | 481     | Test pumping at 1 L/s after 1600min |
|             | 23.4.92          | 405        | 300| 6.4      | 21     | 24     | 22     | 7         | 84        | 65      | 1.4       | 13      | -       | 36      | 64      | 80      | 0.1      | -       | Water hole on Stairway S/d, outcrop, gully north of RN 15142 |

### NHMRC GUIDELINES

|  | 1500 | 8.5 - 8.5 | 500 | 0.3 | 400 | 400 | 45 | 1.7 | Maxima except pH range |

## WATER QUALITY DATA

**IMANPA**

APPENDIX D