Investigation and Development of Groundwater Irrigation Source for Lot 3252, Venn Horticultural Subdivision
INVESTIGATION AND DEVELOPMENT
OF GROUNDWATER IRRIGATION
SOURCE FOR LOT 3252, VENN
HORTICULTURAL SUBDIVISION

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Water Resources Group
Darwin
July 1987
SYNOPSIS

As a result of drilling three bores on Lot 3252 of the Venn Horticultural subdivision, bore RN 25089 was successfully completed to meet an irrigation demand. This bore has a maximum recommended pumping rate of 35 L/s for year round continuous pumping at a pump intake setting of 77.0 metres below ground level.

Supplies of up to 50 L/s can be expected through-out the subdivision with higher supplies being possible at specific locations. Future production drilling at this location should target the L7 and L8 units of the Tindal Limestone for supply development. This is generally at a depth of 90 to 130 metres below ground level.

The static head for any production bore development in this subdivision will be between 65 and 75 metres.

A strategy to enhance drilling procedures in this subdivision is contained in the report.

The indicative cost to site, drill, and complete a bore with 203 mm interval diameter casing and screens for yields up to 50 L/s at this subdivision is expected to be approximately $35 000 in 1987 dollar value terms.
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1. **INTRODUCTION**

The Industries Assistance Branch of the Department of Industries and Development, formerly the Agricultural Development and Marketing Authority, engaged the Water Resources Group of the Water Directorate to drill and construct an irrigation bore at Lot 3252 of the Venn Horticultural Subdivision, 20 km south east of Katherine (see Figure 1).

All bores in this report are referred to by their registered number (RN). All casing diameters in this report are stated in terms of inside diameter (ID).

An irrigation supply of approximately 30 - 40 L/s was requested to meet requirements of the proposed horticultural development at the location.

The work was conducted during April and May of 1987. Because of difficulties with bore construction at this location, a five week drilling programme was needed to obtain a single irrigation bore. Drilling conditions were similar to those experienced during previous groundwater drilling in the cavernous limestones of the Venn area by Britten (Reference 1).

This report documents the procedures and results of the irrigation bore drilling. It also examines the geological and drilling conditions in relation to procedures for further irrigation bore drilling at this subdivision.
2. **HYDROGEOLOGY**

The regional geological setting has been documented by Britten (Reference 1), in his reporting of a groundwater investigation in 1983, in the vicinity of the now abandoned Venn Airstrip. That description also applies in the area of the Venn Horticultural Subdivision. The regional geology is shown by Figure 2(a).

The geological setting varies from the Antrim Plateau Volcanics outcropping north of the subdivision to the Cretaceous exposures in the King River area (Reference 2). A shallow thickness of alluvium and soil overlies the Tindal Limestone in the Venn area.

Previous investigations have correlated the stratigraphy of the Tindal Limestone in the Venn area to the interval from 227 to 404 metres of the diamond drill hole CCVH No. 1 (Figure 2(b) Reference 3).

Major groundwater supplies are generally encountered in the fractured limestone units L4 to L7. The major limiting factor in regard to supply prospects in the Venn area, is the extent of these units development below the watertable. Due to topographic relief and strata dip, the watertable was expected to be within the lower levels of the L4 to L7 units in the area of the Venn Horticultural Subdivision. The previous drilling in the Venn area indicated that supplies of up to 40 L/s could be sustained with less than 10 metres drawdown. It was considered that these supplies originated from the L4 and L5 units of the Tindal Limestone. In the horticultural subdivision area the major supplies were expected to occur in the L6 and L7 units due the deeper water table at this site.
GEOLOGY OF THE VENN REGION

Legend

- Antrim Plateau Volcanics
- Jurassic Beds - medium/coarse sandstone claystone
- Alluvium and Soil
- Tindal Limestone
- Bore
### DESCRIPTION OF CORE

<table>
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<th>LOG</th>
<th>CORE RECOVERY %</th>
<th>WATER DATA</th>
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<td>L1</td>
<td>70.5%</td>
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<tr>
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<td>L2</td>
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<tr>
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LIMESTONE, light grey, fine crystalline, fine vugs (clim diam.); abundant patches cream, coarse crystalline, coarser vugs (av. diam. 7cm), highly porous and permeable: calcite 7 shell fragments at 233.16m; fractured at 230.45m at 25° to core axis.

LIMESTONE, light grey with patches of brown, abundant stylolites, scattered nearly vertical fractures, more massive rock than above.

MUDSTONE, dark grey, scattered 7 shell fragments pyritic in part.

LIMESTONE, as interval 261.33-261.55m: trilobite sections (unverified) 1-2cm dimensions at 291.55m; breccia at 292.35m; interbedded brown, porous near base of interval; discoid vugs probably after gypsum.

MUDSTONE, grey grading red.

MUDSTONE, dark grey; interbeds 2-7cm thick, LIMESTONE, brown; very finely crystalline, finely vuggy.

LIMESTONE, cream, grading brown at 318.80m; very finely crystalline, similar to cream limestone above; scattered vugs 2-4cm diam.

LIMESTONE, brown, grading to cream at 337.20m, grading to brown at 337.20m, medium crystalline, vugs from fine in brown to coarser (av. diam. 1cm) in cream, highly porous and permeable.

LIMESTONE, interbedded light grey and cream, fine crystalline, stylolitic; solution enlarged fractures at 45-60° to core axis, lined with calcite crystals up to 5cm.

LIMESTONE, light grey and light brown patches, 3-4cm vugs at 344cm, coarse calcite crystals infilling scattered stylolites.

LIMESTONE, cream patched brown, stylolites abundant (1-3cm spacing), less broken and less vuggy than preceding interval except in interval 361.41-361.81m where vugs to 1cm diam. common.

MUDSTONE, dark grey, scattered white calcite crystals, minor black interbedded silt and cream LIMESTONE, brown, CHERT in interval 347.35-350.95m.

LIMESTONE, light brown patched light grey; contorted black laminae at 4-5mm intervals; vugs to 1cm diam. one interbed CHERT. In interval 366.69-366.78m; vertical solution enlarged fracture in interval 367.94-368.84m; wavy black SHALE interbeds to 1cm thick, interval 379.90-392.10m; scattered vugs to 1cm diam. interval 399.49-392.10m.

MUDSTONE, red; minor buff and grey limestone, and grey mudstone.

BASALT, dark grey; red brown weathered basalt in top 5m of interval.

### NOTE

L1 through to L8 are units of TINDAL LIMESTONE

### GEOLOGICAL LOG OF DRILL HOLE

**CCVH No. 1**

**INTERVAL 227m - 404m**

**Fig. 2(b)**
3. RESULTS

This chapter documents the results of the drilling and test pumping activities, together with a discussion of both water quality and long-term pumpage considerations.

3.1 Drilling

The successful completion drilling of a single production bore site for Lot 3252 of the Venn Horticultural Subdivision entailed the drilling of three bores 25060, 25061 and 25089. Bore 25089 was subsequently deepened to obtain greater supplies. The location of these bores is shown in Figure 4.

The lithology of these bores is described in Appendix 2. Each bore was drilled through the cavernous and broken L4 to L7 units of the Tindal Limestone. However, due to the existence of a significant interval of cavities above the water table, major problems in maintaining hole stability were experienced at each site.

Bore 25060 was drilled to a total depth of 104.8 m. This bore intersected brittle broken grey limestone from six metres depth. From approximately 18 metres, injection of foam was required to reduce bit bogging when changing drill rods. Broken grey/brown limestone continued to be intersected to approximately 30 metres where problems were experienced in maintaining circulation. The running of 203 mm diameter casing to 38 metres and the use of foam enabled spasmodic lifting of cuttings to the surface until approximately 66 metres depth. From 66 to 104.8 metres the only interval over which circulation was regained was from 75.0 to 75.5 metres. Firm drilling was experienced from 86 to 104.8 metres.
Due to formation instability the hole collapsed to approximately 68 metres at the cessation of drilling. An attempt to gamma-log the hole shortly afterwards indicated a major obstruction at approximately 55 metres. It was thus not possible to correlate with logs from holes drilled by Britten (Reference 1).

Because of the use of foam during drilling, it was not possible to determine a water level, despite the water level probe being run to 68 metres. Due to the absence of a detectable water level and the presence of firm drilling from 86 to 104.8 metres, it was postulated that the major cavity zone unit, L4 to L7 encountered in bore 25060 were above or just at the water table. This would provide insufficient pump submergence to obtain a significant supply.

A second drill site was selected with the objective of increasing the probability of intersecting cavities below the water table. This site was estimated to be 10 metres lower topographically than bore 25060, and one kilometre down dip from 25060.

Bore 25061 was drilled at this site to a total depth of 96.3 metres. Again drilling encountered highly unstable broken limestone this time from 48 to 88 metres. The existence of red, clayey sands to about 30 metres necessitated the running of 203 mm diameter casing to this depth to enable further drilling. Circulation was lost at 56 metres depth in a very broken soft limestone. Due to the hole stability problems, several attempts at hole clearing and heavy foam injection were required at each rod change to prevent hole collapse.

Again the lack of circulation made stratigraphic correlation with previous drilling impossible. An attempt to place 50 mm diameter galvanised water pipe to enable gamma-logging for stratigraphic correlation and collection of a water level met with only limited
success. The pipe was run to 60 metres depth only. No water level was directly evident. Correlation of the gamma-logs suggested the existence of up to 50 metres of broken limestone below 50 metres depth. To confirm this, an attempt was made to clear the hole to the total depth and jet 50mm galvanised pipe to 96 metres using an Ingersol Rand TH60 (top head drive) rig. This attempt met with limited success, however, it was possible to jet the pipe to 70 metres. This was sufficient depth to confirm the L4 to L7 units could extend from 48 metres to about 90 metres depth.

As a result of the additional data gained from bore 25061, it was considered that the prospects for a water supply at the first location (desired by the landholder) were good. This was despite an estimated depth to the standing water level of greater than 60 metres.

Bore 25089 was sited about 20 metres west of 25060 and was drilled to a total depth of 114.8 metres. To overcome hole stability problems, 355mm diameter casing was run to 15 metres to case-off the red-brown, sandy clays (refer to Appendix 1 for construction details). Stiff foam (Bariod polymer quick mud, foam and water mixture) injection during drilling was used. Stability and circulation problems at 40 metres necessitated the placement of 254 mm diameter casing. Due to the broken material the hole was drilled with a slight deviation; as a result the casing jammed at approximately 34 metres during its placement. Using maximum drill string stabilisation, a 165mm diameter hole was drilled to 111 metres depth. Circulation was lost from about 46 metres. Generally soft broken material was encountered from 46 to 86 metres with a cavity at approximately 80 to 81 metres. Firm, even drilling continued to 111 metres, but without drilling returns.
The SWL was measured as 65.5 metres below ground level, through the drill pipe. On retreat of the drill string, it was found that the plum weight would run to a depth of 109 metres and so a gamma-log was run to that depth. Based upon interpretation of the gamma-log and correlation with the other holes it was decided to target the interval 80 to 88 metres for water supply. This interval was correlated to the L7 unit of the Tindal Limestone sequence. Bore 25089 was then reamed to 78 metres using a rock-roller with maximum stabilization and stiff foam. Casing of 203mm diameter was successfully run to 78.4 metres. Drilling continued with the 203mm diameter hammer-button bit. From 78.0 metres to 114.4 metres circulation was maintained, with an increase in airlifted yield from 4 L/s at 78 metres to in excess of 30 L/s at 108 metres.

The increase in water supply was incorrectly ascribed to the increase in submergence over the major cavity zone to 88 metres. As drilling continued beyond 100 metres it was increasingly difficult to clear the bit and maintain full circulation. Drilling ceased at 114.7 metres depth. The hole fell back to 102.5 metres after the drill string was removed. A caliper log from 75 to 102 metres confirmed major fractures and cavities between 80 and 86 metres. This interval was screened however test pumping indicated that less than 10 L/s could be produced from this zone.

Re-analysis of the information indicated that the higher airlift yield would have originated from a fractured and cavernous zone between 101 and 107 metres. This sequence correlated to the top at the L8 unit of the Tindal Limestone. Subsequently, the hole was re-worked, cleaning it out to 114 metres and running a 152 mm diameter liner and sump with screens in the interval from 101 to 107 metres (refer to Appendix 1 for final bore construction details). A yield of about 30 L/s was airlifted on completion.

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3.2 Test Pumping

Only bore 25089 was test pumped. Following reconstruction of the bore with screens set between 101 and 107 metres, a 24 hour test pump was conducted at 33 L/s. The maximum drawdown over that period was about 3.3 metres.

The minimal drawdown of the water table in response to this pumping indicates that yields higher than 33 L/s are possible from this bore. The bore's construction limits the maximum depth to which a pump can be placed to 77.0 metres (the internal diameter reduces from 203mm to 152mm). With a SWL of approximately 66 metres, this limits the maximum short term pumping rate from this bore to about 50 L/s.

3.3 Long Term Production Estimates

Bores in the area may be developed to provide a pumping rate in excess of 50 L/s. However, bore 25089 is limited to a long term continuous supply rate of 35 L/s due to it's construction which provides for a maximum available drawdown of 11 metres. At this rate the water level decline over a year of continuous pumping should not exceed 9 metres. This analysis allows for pump vortex effects, likely interference from other future production bores in this subdivision and extreme seasonal water level declines.

In recognition that a 24 hour pump duty cycle may not suit the user, an analysis of pumping under a 12 hour duty cycle was made. Using the criteria of a maximum available drawdown of 9 metres, a 12 hour pumping rate of 40 L/s should provide year-round production at that rate.
Dependant upon the existing pump manufacture technology, rates of 45 to 50 L/s may be possible for a bore pump placed at 77.0 metres. Year-round pumping at such rates cannot be assured. It is likely that such supply rates would not be possible from the bore late in the dry season.

These analyses are based on existing information. The regular collection of information including pumping rate, pumping duration and standing water level (after pumping) will provide further information to facilitate a more accurate assessment of the production potential of bore 25089. It is therefore recommended that regular monitoring and recording of pumping rate, pumping duration and standing water level become the responsibility of the bore operator, and that this data be reviewed after two years of production pumping and data collection.

3.4 Water Quality

Due to the problems of circulation loss during drilling, water samples were only collected from 25089 after the casing was run to 78 metres.

There were two water supplies of significance intersected during the drilling and construction of bore 25089. The first supply intersected did not provide sufficient yields to sustain irrigation development and was cased off in order to obtain the higher yielding lower supply.

Generally the water conductivity of 600 to 650 $\mu$S/cm is considered typical of waters found in limestone systems, and is termed 'very hard'. The hardness of this water is due to the presence of carbonates and bicarbonates which indicates that this water is scale
forming under temperature elevation. This may produce some problems within the long-term sprinkler and irrigation jets operation. These problems would be similar to those currently being experienced by groups irrigating from similar water sources.

The complete analysis of the supplied water is given in Appendix I.
4. IMPLICATIONS FOR FURTHER PRODUCTION DRILLING IN THE VENN AREA

As bore 25089 is the first production bore to be drilled in this horticultural subdivision, it provides a reference point for planning further production drilling in the area. Consideration of the bore construction difficulties will also lead to significant savings during future production bore drilling for the remaining lots of this subdivision.

The initial consideration of any attempt to construct a bore in this area is the hydrogeology. As was stated in Chapter 2, it was previously considered that the L4 to L7 units were the most prospective strata of the Tinda Limestone for a water supply. However, this work indicates that the L8 unit produced the target supply. At the base of these sequences, a conformal red-brown mudstone exists that separates the limestone sequences and the underlying basalt. Most successful bores in the Tinda Limestone intersect the cavernous and fractured limestone interval that occurs from approximately 90 metres above the red-brown mudstone to the mudstone. The greater the depth of the cavernous limestone that exists below the water table, the better the prospects are for a significant groundwater supply.

To assist the assessment of the likely depths to the mudstone/basalt contact, interpreted contour levels in Australian Height Datum (AHD) for both the water table and the mudstone/basalt contact have been mapped on Figure 4. This Figure has been compiled by interpretation and extrapolation of existing bore data. Therefore caution must be exercised in extrapolating this information beyond the area shown.
CONTOURS OF WATER LEVELS
AND MUDSTONE/BASALT CONTACT - VENN AREA
Figure 4 shows that in the area of the Venn Horticultural Subdivision, 50 to 70 metres of cavernous limestone exists below the water table. This occurrence indicates that good prospects should exist for the development of significant water supplies, notwithstanding the local extent of cavernous development and possible construction difficulties. The pumping performance of bore 25089 and others drilled in this area indicate that the cavernous development is quite extensive. Most bores intersecting the cavernous sequences of the Tindal Limestone produce water supplies of 20 to 50 L/s with drawdowns of three to five metres.

On the basis of the hydrogeology and previous drilling experiences in the region, production drilling in the subdivision should realise supplies in excess of 20 L/s. It is not unreasonable to expect that appropriately designed and constructed bores could yield supplies as high as 100 L/s. However, the existence of such potential may not be widespread and will depend on the extent of cavernous development at each site.

With regard to the supply potential away from the subdivision, the following analysis has been made on the basis of Figure 4 and previous drilling experience. North and northwest of the subdivision, supply prospects are poorer due to the reduced thickness of cavernous limestone beneath the water table. Supply prospects are expected to be as good as or better than for the subdivision south and south west of the subdivision, due to the increased submergence of the cavernous limestone and the relatively level water table surface. This analysis cannot be extended beyond the mapped contact of the Tindal and Jinduckin formations without investigation drilling.
It is noteworthy that while good production supply prospects exist throughout the subdivision pumping heads will be of at least 65 to 75 metres, and bores of between 110 and 130 metres total depth will be required.

The target units for production drilling at this subdivision are the L7 and L8 units of the Tindal Limestone sequence. While only a limited supply of 10 L/s was produced in the L7 unit during current drilling, this may not be the case throughout the area. Hence the inclusion of this unit in the specification of the target units.

The second consideration when constructing a bore in this area is the highly cavernous and broken nature of the lower sequences of the Tindal Limestone. While this produces an excellent aquifer, it can cause significant problems during production bore drilling due to the extreme formation instability.

This is compounded by the existence of significant cavities up to 40 metres above the water table which causes difficulty in maintaining the complete circulation of air and cuttings during drilling.

The general strategy recommended to efficiently drill and construct a production bore in this geological environment is to select as the initial target the top of the L7 unit. This is generally 50 metres above the mudstone/basalt contact mapped in Figure 4. This will represent a depth of 20 to 30 metres below the water table and a depth of about 80 to 90 metres below ground level. As much of the initial drilling will be without circulation and in highly unstable material, the
use of a stiff foam (polymer mud, drilling foam and water) is recommended. This will also require the casing of any clay/sands above the limestone. The diameter of the drilled hole will be dependant on the desired production pumpage, however, a minimum drilled diameter suitable to place 203mm diameter steel casing is recommended for a supply from 20 to 40 L/s.

Once casing is seated at the target depth, drilling should continue while suitable drilling conditions exist and not beyond the depth that would intersect the red mudstone band at the base of the L8 unit (Figure 2 (b)). Generally circulation will be maintained while drilling below the casing. Reasonable indications of supply potential will be gained from the observation of drill rod penetration and airlifted yield. Depending on borehole stability, a caliper-log run to total depth will assist in the selection of the interval to screen. Water supplies will generally be realised after 20 to 30 metres drilling from the top of the L7 unit.

Upon selection of the target zone for screening, the initial casing should be withdrawn and the hole reamed to the bottom of the target zone. Once the hole is reamed to the total depth, the screen and casing string is to be installed paying particular attention to joint welding for straightness. Screens should be placed to minimise the likely pumping of drill cuttings and to stabilise the aquifer formation. In the event of any difficulties in removing the initial casing string, a smaller diameter casing and screened string should be packed back from the initial casing to the target zone.

Due to the current limitations of commercial pump technology, casing diameters in excess of 203 mm are recommended for supplies above 50 L/s.
The alternative to running, withdrawing and rerunning the final casing is to drill an oversize hole to the top of the L7 unit, 20 to 25 metres below the water table, run casing, drill on and place the final diameter casing and screened string packed from base of initial casing string to the target zone. This alternative represents considerable material costs particularly where high yield (greater than 50 L/s) bores are sought. This method should only be considered upon failure of the earlier recommended strategy.

The indicative cost of siting, drilling, constructing and completing a bore with 203 mm casing and screens in order to obtain a supply up to 50 L/s is expected to be approximately $35 000 in 1987 dollar value terms.

The cost is based upon the work being conducted by commercial drilling contractors, professionally supervised and commercial test pumping at bore completion. These costs do not include costs of bore equipping.
5. CONCLUSIONS AND RECOMMENDATIONS

The maximum depth recommended to set the pump intake in RN 25089 is 77.0 metres below ground level.

For a year round continuous duty cycle (24 hour), a maximum pumping rate of 35 L/s is recommended for RN 25089.

For a 12 hour duty cycle, a maximum pumping rate of 40 L/s is recommended for RN 25089.

The standing water level and the duration of production pumpage should be regularly monitored (fortnightly) by the bore operator.

The production performance of RN 25089 should be reviewed after two years of production pumpage and regular collection of water level and pumpage data has taken place.

Future production drilling in this Venn Horticultural Subdivision area should target the L7 and L8 units of the Tindal Limestone. The drilling strategy described in Chapter 4 should be observed until such time as further drilling indicates a revised strategy is needed.

The design of future bores at the Venn Horticultural Subdivision should be based on an expected total depth of 120 to 130 metres, and pumping head of at least 65 to 75 metres static lift.
Individual production supplies of up to 50 L/s can be expected throughout the subdivision with higher supplies being possible at sites where suitable geological environments exist. Indicative cost for the construction of a bore at the subdivision to yield up to 50 L/s using 203 mm casing is expected to be approximately $35 000 in 1987 dollar value.
6. REFERENCE

1. Britten, R. - *Venn Groundwater Investigation 1983*
   Report 25/1983
   Department of Transport and Works,

2. Yin Foo, D. - *Katherine Groundwater Investigations*
   1984 Cretaceous Sediments near the
   King River. Department of Mines and
   Energy, Water Resources Division.
   Report 3/1985

3. Lau, J.E. - *Daly River Basin Data Record, Logs of*
   *Stratigraphic Diamond Drill*
   Holes KRUH - 1, CCVH -1
   Department of Mines and Energy.
   Technical Report GS 81/29
   (Unpublished).
APPENDIX 1

- Bore Test Report RN 25089
- Composite Log of RN 25089
- Water Quality Analysis of RN 25089
Bore location:
Lot 3252 Venn Horticultural Subdivision, Katherine
Map: 1:100 000 Manbulloo 5368
Grid reference: 237.933

Client/owner: Terry Williams ADMA
Client’s reference: Purpose of supply: Irrigation

RECOMMENDATIONS
Pumping rate: 35 L/s. Pump setting: 77 m below ground level
General recommendations are given on the reverse side.
The aquifer and bore can/cannot sustain higher pumping rates with deeper pump settings or for short periods in favourable seasons. Further advice can be obtained from:
(In all correspondence refer to the bore’s RN number). Water Directorate, PAWA

BORE DATA
Finished depth: 114.7 m Completion date: 12/6/87 Test date: 13/6/87
Standing water level 65.5 m on June 1987 Test rates: 33
Construction details: Test duration 24 hrs

Interval (m) Description
0 - 13.5 356mm ID Blank steel casing (Cemented)
0 - 34.0 234mm ID Blank steel casing
0 - 78.0 203mm ID Blank steel casing
78 - 78.3 152mm ID Packer
78.3- 100.9 152mm ID Blank Steel casing
100.9- 107.0 152mm ID 1.0mm aperture stainless steel screens
107.0- 114.7 152mm ID Blank steel casing sump

Notes: 1. Top of casing as constructed was 0.6 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 203 mm to 78.0 metres

COMMENTS
This bore may be able to sustain a slightly higher yield than that recommended. However, due to the limitations of the available data, yields above 35 L/s cannot be recommended at this stage. Monitoring of the bore’s performance and future analysis may result in a revision of the recommended pumping rate.

A means of measuring standing water level and duration of pumpage should be installed to enable appraisal of bores performance.

WATER QUALITY
See water laboratory report (Analysis No. 87/88/0164)
**WATER ANALYSIS**

Department of Transport & Works
Water Division, Darwin N.T.

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**Location and Details**

Venn Airstrip Katherine R/N 25089 Depth 76.16m

BSC 33 L/8 Temp 34.8°C pH 7.09 Cond 654 MAP 5368 G.R. 228420

Proposed water use:- Domestic, Stock, Irrigation, other (specify) 8872-180 P/F N° 7542 RSP 1572

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**Analysis - Physical**

- pH: 7.4
- Specific Conductance (microsiemens/cm at 25°C): 700
- Total Dissolved Solids (mg/L - by evaporation at 180°C): 110
- Turbidity (NTU's):
- Colour (Hazen units):
- Suspended solids (mg/L):

**Analysis - Chemical** (mg/L)

- Sodium, Na: 4
- Chloride, Cl: 6
- Potassium, K: 2
- Sulphate, SO₄: 12
- Calcium, Ca: 9
- Nitrate, NO₃: 7
- Magnesium, Mg: 40
- Bicarbonate, HCO₃: 17
- Total Hardness (as CaCO₃): 389
- Carbonate, CO₃: 390
- Total Alkalinity (as CaCO₃): 0.2
- Iron, (total) Fe: <0.1
- Orthophosphate, PO₄: 27
- Silica, SiO₂: 27
- Fluoride, F: 1
- Sodium Chloride (calc. from chloride):

**Analysis - Additional** (mg/L)

- Copper, Cu:
- Lead, Pb:
- Arsenic, As:
- Manganese, Mn:
- Zinc, Zn:
- Cadmium, Cd:
- Nickel, Ni:
- Cobalt, Co:

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The Sample as analysed complies/does not comply with Northern Territory Drinking Water Standards as recommended by the Northern Territory Department of Health.

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This Laboratory is registered by the National Association of Testing Authorities, Australia. The results reported herein have been performed in accordance with the terms of registration. This document shall not be reproduced except in full.

Analysed By: 19/10/81

Boxes marked thus ☐ indicate levels considered undesirable for drinking water by the National Association of Testing Authorities, Australia.
APPENDIX 2

- Lithology for Bores 25060, 25061 and 25089.

- Composite logs for 25060 and 25061
## APPENDIX 2

### LITHOLOGY FOR BORES 25060, 25061 AND 25089

<table>
<thead>
<tr>
<th>BORE RN</th>
<th>TOTAL DEPTH (m)</th>
<th>INTERVAL (m)</th>
<th>LITHOLOGICAL DESCRIPTION</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>25060</td>
<td>104.8</td>
<td>0.0-6.9</td>
<td>Red brown clayey sands</td>
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<tr>
<td></td>
<td></td>
<td>6.9-32.0</td>
<td>Soft brown vuggy grey/brown limestone</td>
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<tr>
<td></td>
<td></td>
<td>32.0-37.6</td>
<td>Very broken limestone chert &amp; calcite</td>
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<tr>
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<td>37.6-39.0</td>
<td>Grey brown limestone with thin bands of red/brown mudstone</td>
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<td>39.0-48.5</td>
<td>Grey brown broken limestone and chert</td>
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<td>48.5-54.5</td>
<td>Grey/brown limestone/chert. Very soft drilling.</td>
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<td>54.5-66.0</td>
<td>Highly broken grey limestone &amp; chert</td>
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<td>66.0-67.8</td>
<td>Cavity</td>
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<td>67.8-104.8</td>
<td>?</td>
<td>Lost circulation Firm drilling 86m - 104.8m</td>
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<tr>
<td>25061</td>
<td>96.3</td>
<td>0-9.0</td>
<td>Red/brown clays &amp; lateritic pebbles</td>
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<td>9.0-28.0</td>
<td>Red/brown clayey sands</td>
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<td>28.0-31.5</td>
<td>Grey limestone and chert</td>
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<td>31.5-47.5</td>
<td>Yellow brown clay mudstone and soft limestone chips</td>
<td>Top L4 Tindal unit at approx 48m</td>
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<td></td>
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<td>47.5-56.1</td>
<td>Very broken grey limestone</td>
<td>Firm Drilling 86.6 - 96.3 SWL approx 60.0</td>
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<td>56.1-96.3</td>
<td>?</td>
<td>Lost circulation</td>
</tr>
<tr>
<td>BORE RN</td>
<td>TOTAL DEPTH (m)</td>
<td>INTERVAL (m)</td>
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<td>COMMENTS</td>
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<tr>
<td>25089</td>
<td>114.7</td>
<td>0-6.8</td>
<td>Red/brown sandy clay</td>
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<td>6.8-14.6</td>
<td>Brown/yellow sandy clay &amp; limestone chips</td>
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<td>14.6-27.0</td>
<td>Vuggy porous brown limestone and chert</td>
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<td>Broken, soft limestone and chert</td>
<td>Top L4 Tindal unit at approx 52m</td>
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<td>41.5-47.4</td>
<td>Grey limestone chert &amp; thin laminae of yellow/brown mudstone</td>
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<td>47.4-78.4</td>
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<td>78.4-98.0</td>
<td>Brown/grey limestone and chert</td>
<td>Standing Water Level 65.5m through drill pipe</td>
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<td>98.0-100.0</td>
<td>Soft dark grey mudstone</td>
<td>4L/s @ 78.0m 10L/s @ 90.5m 20L/s @ 102.5m 30L/s @ 108.0m</td>
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<td>Fresh blue grey fractured limestone and chert</td>
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<td>104.5-114.7</td>
<td>Broken brown/grey limestone and chert</td>
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COMPOSITE LOG OF BORE 25060
COMPOSITE LOG OF BORE 25061