OPINION ON
GROUNDWATER AVAILABILITY
LOT 26
LTO 62/4 HUNDRED OF BRAY
COX PENINSULA AREA

Water Resources Group
Darwin
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1. INTRODUCTION

A proposal to subdivide Lot 26 of Section 7 LTO 62/4 Hundred of Bray Cox Peninsula into eleven blocks of approximately four hectare (Figure (1a)) was refused by the Northern Territory Planning Authority in June 1987. One of the criteria for this refusal was that:

"information available indicated that there is low yields of potable water in this area and that the shallow aquifer is marginal. The Authority is also concerned about the fragile nature of this borefield. The Authority is therefore mindful of the affect that further bores in this area would have on existing residents who rely on the already limited supply of underground water to supplement their rainwater tanks."

The developer has subsequently drilled two bores and airlifted an existing bore (old army bore) on Lot 26 (see Figure 1(b)) to determine whether potable groundwater supplies are available for subdivisional development. The three bores at sites 25497 "A", 25498 "G" and 25499 "D" were airlifted for one hour by the drilling contractor and reportedly yielded 1-2 L/s, 0.5 L/s and 1.0 L/s respectively. Water quality samples were taken. The bores have not been test pumped to determine their long term yields. Bores 25498 and 25499 are cased.

The proposed subdivision on Lot 26 is bounded by twenty-seven lots of approximately 4040 m² (0.4 ha) along the foreshore (Lots 1-25, 27,28, Section 7) and along the western boundary by a subdivision of approximately 224 blocks on part of Section 8.
Approximately ten blocks along the foreshore fronting Lot 26 have had bores sunk and used for potable water supplies. Approximately 15 Lots out of a possible thirty-four along the foreshore of Section 8 have had bores sunk for potable water supplies. As a condition of sale bore drilling or extraction permits have not been allowed for the remaining 190 (0.4 ha) blocks on Section 8.
2. HYDROGEOLOGY

2.1 Geology

Pietsch (Reference 1) defined Cox Peninsula in the proposed subdivision area as consisting of Proterozoic Aged metamorphic rocks (quartz-feldspar-mica schist, in places granitised, possibly equivalent to Burrell Creek Formation in part). This is overlain by up to 40 m of the Cretaceous Aged Darwin Member of the Bathurst Island Formation which consist generally of siliceous claystone, sandy claystone, quartz sandstone and basal conglomerate.

In the Darwin Rural Area it is common to strike low yields of 0.2 L/s-1.0 L/s in these Cretaceous Sediments. This is often struck in the basal conglomerate and in the top weathered zone of the underlying formation. Verma (Reference 2) defined the shallow aquifer on Cox Peninsula as being this type. The aquifer depth varies generally between 10 m and 46 m depending on the thickness of the Cretaceous Sediments with the thickness of the aquifer depending on the depth of weathering in the underlying formation.

The Cretaceous Sediments in the Darwin region have relatively low transmissivity (ability to transmit water) but have a relatively high storage capacity. It is this storage in the Cretaceous Sediments that usually enable aquifers in the weathered zone of the underlying formation to maintain groundwater yields throughout the dry season.
2.2 Geology Lot 26

An interpretative cross-section of the geology through Lot 26 (see Figure 2) shows that the depth of Cretaceous Sediments overlying this area is relatively thin. In the southern part of the Lot (bore site A) it is virtually non-existent where the top of the Proterozoic Metamorphic rock has been laterised. The laterite profile is better developed in the vicinity of bore site 25498 where it is approximately 9 m thick. Laterite is generally reasonably transmissive but has a low storage potential. The only reasonable thickness of Cretaceous Sediments is in the vicinity of the foreshore blocks where it is approximately 18 m thick.

2.3 Aquifer Parameters

The bores in the proposed subdivision in Lot 26 and along the foreshore have not been test pumped. Test pump results taken from the pumped bores 4647, 5094 and 5209 at the Radio Australia Receiver Station indicate transmissivities in the order of 0.8 m²/d. The bores were able to be pumped for one hour at rates of 0.5 L/s before the water level dropped below the pump intake. The water level in the bores recovered to their pre-pumping level after one hour.

Test pump results from bore 4696 in Section 414 which supplies Mandorah gave a similar transmissivity value. The short duration test pump indicates the bore could be capable of a continuous yield of approximately 0.2 L/s (17 kL/d). This estimate corresponds to the results from the Radio Australia bores if pumped intermittently for twelve hours per day. These areas are however overlain by up to 30 m of Cretaceous Sediments.
Test pumping of bores 23122 and 23132 at Delisaville gave transmissivity valued in the range of 34-63 m²/d. Observation bore data suggested a storage coefficient value of between (0.6-1.6) x 10⁻³.

Due to the lower transmissivity values estimated for the shallow aquifer elsewhere over Cox Peninsula, the lack of Cretaceous Sediment over Lot 26 (proposed subdivision) and the lack of hydraulic data in the area, a storage coefficient value of 5 x 10⁻⁴ has been adopted for the aquifer in the vicinity of Lot 26. The transmissivity value adopted for the aquifer in the vicinity of Lot 26 was 1 m²/d.

2.4 Groundwater Movement and Storage

Groundwater throughflow at the end of the dry season has been estimated using two techniques:

(i) It is postulated that the direction of throughflow is towards the coast in the general direction of the land surface gradient. Across the subdivision this is from the south western corner towards the foreshore. A regional discharge point occurs at Imaluk Creek where the discharge is approximately 0.2 L/s (17 KL/d) at the end of the dry season. For a regional aquifer transmissivity of 1 m²/d and an aquifer width of 1 km contributing to the discharge point, this discharge can be calculated by assuming a hydraulic gradient equivalent to the natural ground surface gradient. A second discharge point probably occurs into the creek system on the eastern boundary of Lot 26. Discharge into this system is masked by its regular inundation by salt water at high tide.
The water table gradient through Lot 26 was estimated from standing water levels taken when bores 25497 "A" and 25498 "C" were drilled and bore 25499 "D" was airlifted. These levels, measured at the end of the dry season gave gradients of 0.6:100 and 0.2:100. If the water table was considered to follow the natural ground surface a regional gradient of 1.0:100 would result. From these figures an average gradient of 0.6:100 was adopted. By taking the width of the subdivision as 700 m and the regional transmissivity of 1 m²/d, throughflow through the subdivision equates to 4.2 kL/d. This is calculated using the formula:

\[ Q = TIW \]

where
- \( T \): Transmissivity (m²/d)
- \( I \): hydraulic gradient
- \( W \): aquifer width (metres)

(ii) Verma (Reference 2) identified a seasonal fluctuation of approximately 4.5 m in the water level in the shallow aquifer on Cox Peninsula. The water level profile in Figure 2 at the end of the dry season indicates the water level at the foreshore blocks will be at or just below mean sea level. This will depend on the degree the Cretaceous Sediment confines the aquifer in this area and the groundwater extraction from the foreshore blocks. Water quality analyses (Chapter 3) from the foreshore blocks indicate an increase in salinity, though still potable, over the dry season which decreases again with wet season recharge.
The volume of water which is dissipated during the dry season from the aquifer in the vicinity of Lot 26 under natural recession due to evapotranspiration and groundwater throughflow can be estimated by the equation:

\[ V = S_y \times h \times A \]

where
- \( V \): volume of water dissipated in kL/d
- \( S_y \): specific yield which in this case has been estimated to be \( 5 \times 10^{-4} \)
- \( h \): the annual decline in the water level 4.5 m
- \( A \): Area of aquifer under consideration 47 hectares

This recession calculated to be 1100 kL, usually occurs from May through to mid December which equates to approximately 4.8 kL/d which is in reasonable agreement with the estimated throughflow at the end of the dry season. The actual release from storage may be slightly higher to allow for evapotranspiration losses and the typical recession curve in the northern region of the NT where the majority of the recession occurs by July-August with a slower decline to the end of the dry season. This estimate equates to approximately 0.4 kL/d per four hectare block.

In the foreshore area Lots 1-25, 27, 28 the thicker Cretaceous sequence may provide greater storage capacity. A typical Specific yield value around 1.5% (1.5 \( \times 10^{-2} \)) has been adopted for this sequence in other areas. In this case the annual volume of water released would be in the order of 7350 kL. This would equate to approximately 33.4 kL/d or 1.2 kL/d per block. However, due to the current decline in water quality during the dry season this estimate probably should be reduced to around 0.4 kL/d.
3. WATER QUALITY

There are no major quality concerns with the water coming from the existing bores located on the foreshore adjacent to this subdivision.

A water quality characteristic that could become a problem with uncontrolled extraction of groundwater from the sub division, especially for the existing blocks on the foreshore, is the sodium chloride levels due to salt water intrusion.

Water quality to date from these foreshore bores show that sodium chloride is present in the groundwater but not in levels to make the water unpotable. Conductance levels at the end of the wet season recharge period, range from 100 microsiemens/cm to 200 microsiemens/cm. These rise to levels ranging between 500 to 1000 microsiemens/cm at the end of the dry season. From the limited amount of data to date there is no indication that sodium chloride levels are increasing other than seasonally.

Two bores, RN 7029 and RN 7030 to the south of the sub-division have been abandoned due to excessive sodium chloride levels. This could cause concern for blocks No. 6 and 7 which although not in the same area as the two bores, are adjacent to the same area of tidal salt water inundation.

The conductivity values in early December 1987 from Bores 25497 "A", 25498 "G" and 25499 "D" were low indicating the water is potable. The conductivity values were 100, 196 and 100 microsiemens/cm.
4. DEMAND

A daily per capita consumption figure of 200 litres is being used as the basis for determining the demand for the existing adjacent subdivision on Section 8. This is sufficient to meet domestic needs (in-house) only. Using this figure and assuming a base population of four persons per block the weekly demand equates to 5.6 kL/block for a permanent residence and 1.6 kL/block for a weekend only residence. In either case the daily requirement of 0.8 kL/block could be met by pumping at a rate of approximately 0.26 L/s for one hour into a storage tank.

The length of time each year that groundwater is relied upon will depend upon the size of the storage tank utilised. The Northern Territory Planning Authority was concerned that water stored for lengthy periods in rainwater tanks could pose health problems. Practically, the maximum sized tank for a permanent residence of four people is 45 kL and for a weekender 13 kL. The annual groundwater demand will vary with the type of development and storage tank capacities. These demands are tabulated below.
<table>
<thead>
<tr>
<th>Permanent (four people/block)</th>
<th>Rainwater Tank Storage Capacity</th>
<th>Permanent (one person/block)</th>
<th>Weekender (four people/block)</th>
<th>Weekender (one person/block)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr-Dec</td>
<td>Apr-Dec</td>
<td>May-Dec</td>
<td>Apr-Dec</td>
<td>June-Dec</td>
</tr>
<tr>
<td>216</td>
<td>200</td>
<td>192</td>
<td>58</td>
<td>45</td>
</tr>
<tr>
<td>(one person/block)</td>
<td></td>
<td></td>
<td>(one person/block)</td>
<td></td>
</tr>
<tr>
<td>54</td>
<td></td>
<td></td>
<td>15</td>
<td>11</td>
</tr>
</tbody>
</table>

NOTE: Rainfall period January-March

Currently, of the foreshore Lots 1-25, 27, 28, three are occupied permanently by single residents. This would give a continuous extraction during the dry season of around 0.6 - 1.8 kL/d depending on garden development. Approximately seven blocks are used for weekenders.
5. RESULTS AND CONCLUSIONS

1. Although data available is sparse, an assessment has been made to give an opinion on the possible groundwater availability at Lot 26. The assessment has used data from all sources across Cox Peninsula and experience in similar geologic formations elsewhere in the Darwin Region.

2. The analysis assumes no groundwater extraction occurs from the subdivision development on Section 8 bordering the western side of Lot 26.

3. Cretaceous sediments which typically occur over much of the Darwin region and provide groundwater storage throughout the dry season do not exist over most of Lot 26. The aquifer development here is in the weathered zone of the underlying metamorphic rock. Hence a lower storage parameter value has been assigned to the aquifer in this area.

4. Some Cretaceous Sediments do overlay the foreshore blocks 1-25, 27, 28 to which a higher storage parameter value has been assigned. Based on the estimated groundwater throughflow and the natural groundwater recession during the dry season following wet season recharge, the maximum extractable yield from Lot 26 (47 ha) is 4.8 kL/d. This equates to a maximum extraction of approximately 0.4 kL/d per four hectare block. Based on the data available this would utilise the available groundwater resource. Extraction in excess of this amount may induce increased salinity along the foreshore blocks and/or the blocks in the eastern end of Lot 26 bordering the tidal creek.
5. This extraction would support only domestic (in-house) water usage of one to two permanent residents per block at a consumption rate of 200 litres per person per day.

6. The resource could potentially support domestic weekender usage of four to five people.

7. There is no guarantee that sufficient yields would be obtained from bores on each individual block. Yields from individual bores can be expected to vary significantly as demonstrated from the three bores 25497 "A", 25498 "G" and 25499 "D". Drilling would be required on each block to confirm groundwater extraction is possible on each block.

8. The conductivity (salinity) of the water from the bores for the foreshore blocks increases during the dry season to between 500-1000 microsiemens/cm and declines to around 100-200 microsiemens/cm with wet season recharge, and presumably lower extraction during the wet season.

9. The conductivity in early December 1987 from bores 25497 "A", 25498 "G" and 25499 "D" in Lot 26 were 100, 196 and 100 microsiemens/cm respectively. These values are low and hence potable. The value from bore 25498 "G" is marginally higher than the other two bores. This bore is closer to the foreshore than the other two bores.

10. Bores 7029 and 7030 south-east of Lot 26 were abandoned due to high salinity. (Conductivity 15,000 microsiemens/cm). With groundwater
extraction, blocks 6 and 7 of the proposed four hectare subdivision on Lot 26 may also be prone to same threat of high salinity. This threat cannot be quantified on the available data.

11. The proposed subdivision of eleven (four hectare) blocks should be the maximum density of development considered at this stage for Lot 26 for the following reasons.

(i) the lack of Cretaceous Sediments overlying Lot 26.

(ii) the saltwater intrusion threat to the twenty-seven 0.4 hectare foreshore blocks fronting Lot 26, if excessive groundwater extraction occurs.

(iii) the additional threat posed by the tidal creek on the eastern boundary of Lot 26.

12. Proposals for developments on Cox Peninsula should be accompanied by an assessment of the groundwater availability from a recognised, practicing Professional Groundwater Consultant.
6. REFERENCES

Pietsch, B.A.  1:100 000 Geoclogical Map Series, Darwin 5073; Northern Territory Geological Survey; Department of Mines and Energy 1983.

Verma, M.N.  Cox Peninsula Hydrogeology; Report No.8/ 1982; Water Division; Department of Transport and Works 1982.