WATER RESOURCE MANAGEMENT
TINDAL LIMESTONE AQUIFER
KATHERINE TO MATARANKA

FINAL REPORT
October 1999

LANDS PLANNING ENVIRONMENT
Northern Territory Government

and
WATSON RESOURCE CONSULTING
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References

<table>
<thead>
<tr>
<th>No</th>
<th>Report No</th>
<th>Title</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>10/1983</td>
<td>Preliminary Appraisal of the Hydrogeology of the North Mataranka Area. H Qureshi</td>
</tr>
<tr>
<td>3</td>
<td>9/1985</td>
<td>Tindal Limestone Aquifer. Development Potential in the Katherine Area. A D McQueen</td>
</tr>
<tr>
<td>4</td>
<td>25/1983</td>
<td>Venn Groundwater Investigation. R Britten</td>
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<tr>
<td>6</td>
<td></td>
<td>Development of a cotton industry in the Northern Territory. DPIF J Peart</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>Water Resource capabilities of Stylo Station, Mataranka. DLPE M Jamieson</td>
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<tr>
<td>9</td>
<td>63/1993</td>
<td>Speleological Assessment of Karst Aquifers developed within the Tindal Limestone Katherine NT. Stein-Erik Lauritsen and Danuta Karp</td>
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WATER RESOURCE MANAGEMENT
TINDAL LIMESTONE - KATHERINE TO MATARANKA

1. PURPOSE OF REPORT

The purpose of this interim report is to:

- make a preliminary assessment of the water resource development potential of this segment of the Tindal limestone aquifer;
- identify the issues and approach to be taken in ongoing sustainable management of the resource;
- compile information which can be used to report to the interdepartmental Land Resources Coordination Group; the Office of Resource Development; and promote further discussion within relevant agencies; and
- provide the basis for compilation of a draft management strategy, which can be subsequently finalised through discussion, and involvement of the full range of stakeholders.

2. REGIONAL MANAGEMENT AREA

The water resource of interest is that section of the Tindal limestone aquifer outcropping between the Katherine River in the northwest and the Roper River in the southeast. The strike of the aquifer generally straddles the Stuart Highway, with an average width of about 15 kilometres over a length of about 120 kilometres.

Groundwater discharges to the Katherine River and the Roper River, and is recharged by direct rainfall, together with shallow groundwater discharge from cretaceous sediments in the vicinity of the King River. Some minor recharge from the Waterhouse River and Beswick Creek may occur.

Map 1 shows the extent of the aquifer and broader management area, including part of the connected surface water catchments.

3. ASSESSED NATURAL RESOURCES

3.1 Surface Water
The Katherine River is primarily dependent on groundwater discharge from the Tindal limestone in the vicinity of Katherine to maintain dry season flows. The upper reaches of the Katherine River are excised into the sandstone escarpment country of Nitmiluk National Park, and the sandstone plateau of Kakadu National Park and Arnhem Land.

The Roper River is also primarily dependent on groundwater discharge from the Tindal limestone in the vicinity of the Elsey National Park, to maintain dry season flows. The Elsey Creek catchment to the south drains most of the flat, lower rainfall areas of the Sturt Plateau, and does not offer any surface water development potential.
The northern catchments, Waterhouse River, Beswick Creek, Roper Creek and King River, drain country of greater relief and higher rainfall. With the exception of the King River, contribution to groundwater recharge of the Tindal limestone has not been assessed.

Map 2 shows the location of relevant gauging stations. Surface water flows are summarised in Table 3.1 below.

**Table 3.1: Surface Water Flows**

<table>
<thead>
<tr>
<th>Waterway</th>
<th>Gauging Station (see Map)</th>
<th>Years of record</th>
<th>Catchment Area Km²</th>
<th>Mean Annual Runoff ML x 10³</th>
<th>Median Annual Runoff (50% ile) MLx10³</th>
<th>Mean Annual Min flow M³/sec</th>
<th>Min flow recorded M³/sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roper River</td>
<td>G9030176</td>
<td>38</td>
<td>6632</td>
<td>474.6</td>
<td>388.1</td>
<td>1.41</td>
<td>0.20</td>
</tr>
<tr>
<td>Waterhouse River</td>
<td>G9030089</td>
<td>27</td>
<td>3110</td>
<td>163.2</td>
<td>167.1</td>
<td>0.017</td>
<td>0.00</td>
</tr>
<tr>
<td>King River</td>
<td>G8140086</td>
<td>23</td>
<td>484</td>
<td>36.4</td>
<td>31.8</td>
<td>0.002</td>
<td>0.00</td>
</tr>
<tr>
<td>Elsey Creek</td>
<td>G9030001</td>
<td>32</td>
<td>13000</td>
<td>87.4</td>
<td>29.7</td>
<td>0.014</td>
<td>0.00</td>
</tr>
<tr>
<td>Katherine River (railway bridge)</td>
<td>G8140001</td>
<td>42</td>
<td>8640</td>
<td>1902.0</td>
<td>1600.0</td>
<td>3.68</td>
<td>0.67</td>
</tr>
</tbody>
</table>

The rating curve for this station is unreliable and minimum flows may be underestimated. The lowest flow actually gauged is 0.53 M³/sec.

Data on surface water quality is sparse, with the exception of the Katherine and Roper Rivers. Surface water quality is generally good for irrigation purposes with temporal variation strongly influenced by the interaction with groundwater.
### Table 3.2: Surface Water Quality

<table>
<thead>
<tr>
<th>Location</th>
<th>Typical values mg/L</th>
<th>TDS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hardness (Ca CO$_2$ eq)</td>
<td></td>
</tr>
<tr>
<td><strong>KATHERINE RIVER</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(low level) G8145222</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry October</td>
<td>307</td>
<td>258</td>
</tr>
<tr>
<td>Wet February</td>
<td>13</td>
<td>85</td>
</tr>
<tr>
<td><strong>KING RIVER</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G8140086</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry</td>
<td>No data</td>
<td>No data</td>
</tr>
<tr>
<td>Wet February</td>
<td>6</td>
<td>41</td>
</tr>
<tr>
<td><strong>ROPER RIVER</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mataranka Homestead G9035085</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry October</td>
<td>No data</td>
<td>No data</td>
</tr>
<tr>
<td>Wet March</td>
<td>36</td>
<td>87</td>
</tr>
<tr>
<td><strong>Upstream of Elsey Creek</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G9030176</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry November</td>
<td>516</td>
<td>1060</td>
</tr>
<tr>
<td>Wet January</td>
<td>194</td>
<td>387</td>
</tr>
<tr>
<td><strong>Downstream of Elsey Creek</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G9030013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry October</td>
<td>560</td>
<td>1010</td>
</tr>
<tr>
<td>Wet March</td>
<td>595</td>
<td>No data</td>
</tr>
<tr>
<td><strong>WATERHOUSE RIVER</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G9035128</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry August</td>
<td>620</td>
<td>1180</td>
</tr>
<tr>
<td>Wet</td>
<td>No data</td>
<td>No data</td>
</tr>
<tr>
<td><strong>ROPER CREEK</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G9035027</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry November</td>
<td>No data</td>
<td>No data</td>
</tr>
<tr>
<td>Wet February</td>
<td>56</td>
<td>111</td>
</tr>
<tr>
<td><strong>ELSEY CREEK (at spring)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G9035124</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry August</td>
<td>496</td>
<td>880</td>
</tr>
<tr>
<td>Wet</td>
<td>No data</td>
<td>No data</td>
</tr>
<tr>
<td><strong>TINDAL LIMESTONE GROUNDWATER</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>West of King River</td>
<td>350</td>
<td>400</td>
</tr>
<tr>
<td>Near Mataranka</td>
<td>560</td>
<td>1000</td>
</tr>
</tbody>
</table>

As the table shows, the quality of dry season flow in the Katherine and Roper Rivers is indicative of the adjacent groundwater quality.
Roper River data upstream and downstream of Elsey Creek shows that Elsey Creek has little influence on the quality of low flow.

Whilst there is data in the vicinity of Mataranka to establish that the local groundwater has higher levels of hardness and total salts than generally within the Tindal limestone, there is insufficient data to plot the spatial variance through the aquifer east of the King River.

It is suspected that there is a deterioration in the quality of water in the Tindal limestone between the King River and Mataranka as a consequence of a greater extent and depth of Cretaceous cover.

All surface water gauging stations are listed at Attachment 1.

3.2 Groundwater
The regional aquifers are shown on Map 1, and are described in various reports (Refs 1 to 5). The segment of the Tindal limestone outcropping between Katherine and Mataranka is to be assessed for irrigation potential.

The geological sequence of the Katherine area was summarised by McQueen (Ref 3), and is shown below:

<table>
<thead>
<tr>
<th>Table 3.3: Geological sequence of the Katherine area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cretaceous</td>
</tr>
<tr>
<td>Middle Cambrian (Daly River Group)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Lower Cambrian</td>
</tr>
<tr>
<td>Upper and lower Proterozoic</td>
</tr>
</tbody>
</table>

This sequence is folded to form what is commonly known as the Daly Basin, and the segment of the Tindal limestone aquifer of interest forms the north eastern edge of the Basin.

Whilst the Map indicates Tindal limestone in outcrop, there are areas where the Tindal limestone is overlain by Cretaceous cover. This Cretaceous cover, shown on the Map as sandstone plateau aquifers, extends north within the catchment of the King River, and plays a significant role in recharging the Tindal limestone. Yin Foo (Ref 2),
studied the potential of these sediments to provide a “non carbonate” source of water for Katherine town supply.

He concluded that whilst there was some loss of groundwater to the base of the scarp on the northwestern edge of the formation, the bulk of the groundwater flows towards the King River and southwards. Base flow in the headwaters of the King River is derived from the sediments, and “between the Stuart Highway and the gauging station (G8140086), the King River becomes influent, losing approximately two thirds of its flow to the underlying Tindal limestone formation.”

Yin Foo estimated the throughput of the shallow sandstone plateau aquifers into the Tindal limestone, to be 40 ML/day, with this water substantially lower in carbonate hardness, and total salts, than the Tindal limestone water.

Recharge of the Tindal limestone therefore consists of direct recharge from rainfall over the area of outcrop, and the contribution of 40 ML/day estimated by Yin Foo from the sandstone plateau aquifers.

Leakage from the Tindal limestone to the adjacent Jinduckin formation is considered to the negligible. West of the King River, groundwater movement is to the west-northwest, with subsequent discharge to the Katherine River. East of the King River, groundwater movement is to the east-southeast, with subsequent discharge to the Roper River.

Several reports (Refs 1,2,3,4,5,7) include summary data on groundwater quality. No regional study of the spatial and temporal variation of water quality within the aquifers has been undertaken, however, from site specific studies it would seem that the general level of bicarbonate hardness west of the King River is in the order of 350mg/l with average total salts around 400mg/l and chloride concentrations of 6 to 8 mg/l. At the eastern extremity, however, the total salts in the Mataranka water supply vary from 800 to 1,000 mg/l, with hardness in the order of 550mg/l and chloride concentrations of more than 200 mg/l. Similar quality occurs on Stylo Station.

The recharge water from the King River, and adjacent cretaceous sediments, is much better quality with TDS around 50 mg/l and hardness around 30mg/l. The typical Tindal limestone water quality will therefore be improved in the vicinity of the King River and will gradually deteriorate to the west and east.

In all parts of the aquifer, water quality is suitable for both primary production and domestic purposes.

3.3 Water Balance Model
As already identified, there is strong interconnection between the Tindal limestone groundwater and the perennial flows of the Katherine and Roper Rivers. Water balance modelling for the Katherine and Daly Rivers has been addressed by M.Jamieson, and his calculations for contribution to the Katherine River from the Tindal limestone have been adopted. The Jamieson model has been extended to
incorporate the Tindal limestone east of the King River, and is shown at Attachment 2.

Inputs to the model are recharge from the sandstone plateau (cretaceous) aquifers and direct recharge from rainfall over the area of Tindal limestone outcrop. Yin Foo (Ref 2), has estimated average through flow of 40ML/day from the sandstone plateau recharging to the Tindal limestone through shallow sediments, including effluent flow of 13ML/day from the King River. Estimates of rainfall recharge take account of the variation in average annual rainfall from about 1000mm at Katherine, to 800mm at Mataranka.

The major assumption in Yin Foo’s calculations is the selection of an infiltration factor of 7.5%, as proposed by Williams and Coventry (Ref 8). This factor is dependent primarily on soil type and surface slopes. For the aquifer west of the King River, a factor of at least this magnitude is probably sound due to the predominance of limestone outcrop (including sinkholes). Jamieson’s estimates indicate a factor of 6.7%, which equates to a mean annual recharge rate of 25000ML (70ML/day). This would appear to be conservative, however some allowance may have been made for evapotranspiration and other losses.

For the eastern portion of the aquifer, there are sufficient indicators to adopt a lower figure. The reasons for this are:

- a majority of the Tindal limestone is overlain by either Cretaceous sediments, or the Jinduckin formation which are less preferential to infiltration (Leach Lagoon is indicative);
- there is significantly few data to examine, however the higher salinity of the Mataranka water supply, and the bores on Stylo Station, are indicators of less favourable direct recharge;
- low flow water quality data in the Roper River is inferior to the low flow water quality in the Katherine River, indicating other influences west of the groundwater divide of the King River;
- there is a significant difference (>20m), in elevation between the well encised Katherine River and the smaller channel of the Roper River, and hence a lower gradient, and slower rate of travel, for groundwater flow in the easterly direction.

Chloride (Cl) levels in the groundwater of the limestone aquifers can be an indicator of the rate of direct infiltration. Less preferential recharge results in higher chloride concentrations.

The rainfall, and wet season runoff in this region, generally has a Cl concentration between 1 and 2 mg/l. The Cl concentration of the groundwater west of the King River is 6 to 8 mg/l and east of the King River 30-50mg/l (in excess of 200mg/l in the vicinity of Mataranka).

Using Cl as the basis for estimating recharge, the rate east of the King River (by direct proportion of chloride concentration) would be in the order of 12% to 26% of the rate west of the King River. 20% has been adopted for the purpose of further testing the water balance model.
Average daily recharge west of the King river is 70ML/day based on an infiltration rate of 6.7%. The estimated average daily recharge east of the King River, based on an infiltration rate of 20% of this, is therefore 32ML/day. With additional recharge from the King River, and shallow groundwater discharge from the sandstone plateau aquifers (total 40ML/day average), the recharge and throughflow to the west is 93ML/day and to the east is 49ML/day.

3.4 Testing the Model
Flow records at G8140001 (Katherine River at the Railway Bridge), and G9030176 (Roper River at Mataranka homestead) show mean minimum flow figures of 3.68m$^3$/sec and 1.41m$^3$/sec respectively. Minimum ever-recorded flows are 0.67m$^3$/sec for the Katherine, and 0.20m$^3$/sec for the Roper.

The Katherine River railway bridge record is not considered to be indicative of total groundwater inflow and an examination of daily gauging at G8140301 (Galloping Jacks), which is near the Springvale Homestead, and close to the downstream extent of outcropping Tindal limestone, shows a relationship of 1.69 between the two sites. The mean minimum low month (October), flow in the Katherine River, is therefore estimated at 1.42 x 1.69 = 2.40 m$^3$/second, which is 207ML/day.

The total groundwater inflow to the Katherine River, estimated in the Jamieson model, is 115.5 ML/day (average), including the contribution from the west bank. This is considered a reasonable check on the validity of the model, however flow data indicates a high likelihood of contribution to low flow in the river from upstream of the Tindal limestone, otherwise there are conservative assumptions in the groundwater model.

The minimum recorded flow of 0.67m$^3$/sec at the railway bridge, converts to a flow of 1.13m$^3$/second at Galloping Jacks, and a daily discharge of 97.6ML, compared with the estimated average groundwater inflow of 115.5 ML/day.

The Roper River at Mataranka has a mean minimum low flow of 1.40m$^3$/second in November. This becomes 121 ML/day and compares with the modelled groundwater flow of 49ML/day. Lowest recorded flow (from the rating curve) is 0.2m $^3$/sec (17ML/day) with lowest actual gauging of 0.53m$^3$/sec (46 ML/day). Limited data also makes it difficult to assess the extent (if any) of contributions to the Roper River low flows from other than Tindal Limestone.

3.5 Soils
The soils over the area are largely sandy red earths and loamy red earths. The sandy red earths are massive and well drained with surface textures of sand and loamy sand increasing to sandy clay loam and light clay at depth. The loam red earths have heavier surface textures of sandy clay loam and clay loam increasing to light and medium clay at depth. Yellow and brown variations of these soils also occur, usually in situations where drainage is impeded. Some grey-brown cracking clays are associated with alluvial flood plains. The red earth soils are generally considered to have the most potential for agricultural production.
Within the area of Tindal limestone outcrop, and the land extending 10km south of it, there is approximately 45000 ha of soils suitable for irrigation and 130000 ha marginally suitable. Map 3 shows the soils in the area of Tindal limestone outcrop and immediately south of it where economic bores may still be drilled to intersect the Tindal limestone aquifer.

3.6 Pollution risk
Weathering of the Tindal limestone has led to considerable fracturing and cavernous development. Consequently, any contaminants entering the system have potential to pollute other groundwater supplies, and ultimately river flows.

Particular risks exist in the Katherine area due to the extent of urban development in close proximity to the river. This will be an important matter to address in a water resource management plan. The longer term, and widespread risk associated with more intensive agricultural development, is also important.

The movement of pollutants (agricultural chemicals or other) into, and through an aquifer, depends on a number of physical processes including oxidation, filtration, absorption, ion exchange, and dispersion/dilution. The Tindal limestone characteristics of minimal soil cover, surface cavities, and high permeability, mitigate against many of the processes above, and hence pollutants can be transmitted readily into and through preferred permeability zones in the aquifer.

On the one hand, favourable circumstances for rapid migration of pollutants may exist, whereas on the other hand concentrations can be rapidly reduced through diffusion and dispersion.

Any management plan will need to incorporate monitoring and other measures to ensure the aquifer remains clean and all beneficial uses are protected. Any isolated or accidental pollution incident should only be a concern if the volume of the contaminant is large (relative to its toxicity), and if it occurs in close proximity to a river or domestic water source.

4. BENEFICIAL USE PLANNING

4.1 Current Use
Land tenure is shown on Map 2, and is a mix of urban, conservation, special purpose lease, and pastoral land. Natural rainfall varies from 1000mm/annum average at Katherine, to 800mm/annum at Mataranka, and is generally reliable on a seasonal basis.
Current extraction of groundwater from the Tindal limestone, based on available records, is shown in Table 4.1 below:

### Table 4.1: Current Water Use

<table>
<thead>
<tr>
<th>Beneficial Use</th>
<th>Estimated average annual extraction ML/annum</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agriculture (irrigation)</strong></td>
<td></td>
<td>Mainly dry season extraction. When current plantings of mangoes and citrus mature in 2 to 5 years, water use will increase significantly to 6500ML/annum.</td>
</tr>
<tr>
<td>. Venn farms</td>
<td>2100</td>
<td></td>
</tr>
<tr>
<td>. Tindal (oval and golf course)</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>. Other</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Public water supply</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>. Katherine (including Tindal RAAF)</td>
<td>1000</td>
<td>Groundwater component only of Katherine supply</td>
</tr>
<tr>
<td>. Mataranka</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td><strong>Environment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>. Cutta Cutta Caves</td>
<td>Not</td>
<td>No consumptive use but it is necessary to manage water levels (and possibility quality)</td>
</tr>
<tr>
<td>. Elsey National Park</td>
<td>Yet</td>
<td></td>
</tr>
<tr>
<td>. River flora &amp; fauna</td>
<td>determined</td>
<td></td>
</tr>
<tr>
<td><strong>Cultural</strong></td>
<td>N/A</td>
<td>Environmental allocations provide for recreation/ aesthetics and biological needs</td>
</tr>
<tr>
<td><strong>Manufacturing industry</strong></td>
<td>N/A</td>
<td>Minimal and included in town supply</td>
</tr>
<tr>
<td><strong>Riparian (estimated)</strong></td>
<td>180</td>
<td></td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>Nil</td>
<td></td>
</tr>
</tbody>
</table>

i) **Agriculture (irrigation)**

The Venn farms were originally subdivided in the mid 1980’s and several farms are now operating commercially, with approximately 950 ha under irrigation. Crops grown are:

- Mangoes 510 ha
- Citrus 300 ha
- Cucurbits 120 ha
- Asparagus 12 ha
- Other 8 ha
Water application is by a combination of dripper, sprinkler and centre pivot systems and application rates vary from 4 ML/ha/annum (mangoes) to 14 ML/ha/annum (Cucurbits)

It should be noted that 45,000 young mangoe and 3,000 young citrus trees will mature within the next 2 to 5 years, with a contingent demand on water which will significantly increase current usage from 2,100 to 6,500 ML/annum. This is without allowance for planting of any further crops in this timeframe.

All water is pumped directly from the Tindal limestone, with recharge in the Venn area strongly influenced by the sandstone plateau aquifers in the north.

Other irrigation use includes intermittent pumping by the Department of Primary Industry and Fisheries at the Katherine Research station, watering of an oval and small golf course on the Tindal RAAF base, and irrigation of a small planting of citrus at Mataranka.

ii) Public Water Supply
Katherine supply uses about 1,000 ML/annum pumped from groundwater. Catchment runoff easily satisfies town demand during the wet season. The Tindal limestone groundwater does not contribute to the source of water supply (Donkey camp pool), in the dry season. Sustained recession flows into the pool continue to meet most of the demand, however groundwater is used to make up any dry season deficiency, and to balance water quality. All domestic water for the Tindal (RAAF) base is supplied directly from the town system.

Bores pumping directly from the Tindal limestone supply Mataranka township.

iii) Environment
There are four significant environmental issues related to long term management of the Tindal limestone aquifer.

The Katherine/Daly and Roper River systems are the two most significant perennial river systems in the Northern Territory, and as already discussed, the maintenance of permanent dry season flows is directly dependent on their connection with the Tindal limestone aquifer.

Water resource management policy and planning processes now require recognition of environmental values, and formal allocation of water to the environment to maintain health of aquatic flora and fauna. This requirement will soon be reinforced in legislation.

The scientific knowledge of what is the minimum flow, and the necessary flow regime, in individual river systems is not yet available, however scientific work is commencing in this field. In the interim, a precautionary approach is necessary to ensure environmental values are protected. For the initial broad planning required in this study, it is proposed that the minimum flow to be maintained in the long term, for both the Katherine and Roper Rivers should be 50% of the average minimum flow of
the critical dry season month (October for the Katherine River, and November for the Roper River).

In both cases, 50% of the average (over the years of record), will still be greater than the minimum recorded flow for these rivers, as indicated in Table 4.2 below.

<table>
<thead>
<tr>
<th>River</th>
<th>Mean minimum for low month</th>
<th>50% of mean</th>
<th>Lowest recorded (years record)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Katherine (Galloping Jacks)</td>
<td>2.40 m³/sec (Oct) (207 MI/day)</td>
<td>1.20 m³/sec</td>
<td>1.13 m³/sec (43)</td>
</tr>
<tr>
<td>Roper</td>
<td>1.40 m³/sec (Nov) (121 MI/day)</td>
<td>0.70 m³/sec</td>
<td>0.20 m³/sec (38)</td>
</tr>
</tbody>
</table>

Donkey Camp pool outflow gaugings were examined to establish whether there is a component of the October low flow contributed from upstream of the Tindal limestone. It appears that this is the case, however, gaugings of the Donkey Camp outflow are erratic, and highly influenced by day to day pumping to Katherine water supply.

As a guide, October data on the outflow from Donkey Camp has been averaged at about 0.10 m³/sec which contributes only marginally to the total low flow situation.

As already demonstrated, dry season river flow is almost entirely groundwater from the Tindal limestone, hence the minimum influent flow to the rivers should be maintained at no less than 50% of the modelled average daily groundwater throughput.

The other environmental values relate to the limestone caves at Cutta Cutta, and springs within the Elsey National Park. Both are well-established tourism and recreation features and directly linked to the management of Tindal limestone groundwater.

The water balance model (Attachment 2) does not account for groundwater recharge east of Mataranka, including the whole area of the Elsey National Park. Any water resource management plan will need to ensure controls on extraction in or near the Park, and provide for ongoing monitoring of spring flows and water levels.

iv) **Cultural**
This beneficial use is primarily for recreation and aesthetic needs, and these are provided for in (iii) above.

v) **Riparian**
Land owners and users have an entitlement to water for stock and domestic purposes. There are approximately 50 bores drawing water from the Tindal limestone for these purposes, and average usage of 10,000kl/day has been assumed.
4.2 Development Potential

Katherine (including Tindal), is expected to grow in population at an average rate of about 2% per annum. The only significant escalation in demand on the groundwater will be for irrigated agriculture. Given the assumptions previously discussed, Table 4.3 below gives an indication of water availability for future agricultural development.

**Table 4.3: Water Availability for Future Development**

<table>
<thead>
<tr>
<th>Water Use</th>
<th>West of King River Average Ml/day</th>
<th>East of King River Average Ml/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total throughflow (from model)</td>
<td>93</td>
<td>49</td>
</tr>
<tr>
<td>Currently used for</td>
<td></td>
<td></td>
</tr>
<tr>
<td>. town supply</td>
<td>2.7 (Katherine)</td>
<td>0.3 (Mataranka)</td>
</tr>
<tr>
<td>. agriculture</td>
<td>5.8 (Venn)</td>
<td></td>
</tr>
<tr>
<td>. riparian</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>. other irrigation</td>
<td>0.1 (RAAF)</td>
<td></td>
</tr>
<tr>
<td>Future allocation to the environment (50%)</td>
<td>47</td>
<td>24.5</td>
</tr>
<tr>
<td>Remainder available to support increases in town supply and irrigated agriculture</td>
<td>37.1*</td>
<td>23.9</td>
</tr>
</tbody>
</table>

*This figures reduces to 25.1 ML/day if an adjustment is made to allow for increased water usage for trees already planted at Venn (See 4.1).*

Once domestic, environmental and riparian needs are met, irrigated agriculture can expand in the study area in accordance with the principles of ecologically sustainable development.

In the long term, the development potential for irrigated agriculture using Tindal limestone groundwater is set out in Table 4.4 below:

**Table 4.4 Development Potential for Future Irrigated Agriculture Using Tindal limestone Groundwater**

<table>
<thead>
<tr>
<th></th>
<th>West of King River</th>
<th>East of King River</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water available</td>
<td>25.1 Ml/day</td>
<td>23.9 Ml/day</td>
<td>49.0 Ml/day</td>
</tr>
<tr>
<td></td>
<td>9.2 x 10^3 Ml/annum</td>
<td>8.7 x 10^3 Ml/annum</td>
<td>17.9 x 10^3 Ml/annum</td>
</tr>
<tr>
<td>New area irrigable</td>
<td>920 ha</td>
<td>870 ha</td>
<td>1790 ha</td>
</tr>
<tr>
<td>(based on 10Ml/ha/annum)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extraction available for unit area of land for agriculture</td>
<td>Approximately 0.23 Ml/ha/annum</td>
<td>Approximately 0.085 Ml/ha/annum</td>
<td></td>
</tr>
</tbody>
</table>
To put the above in perspective, there is potential for ongoing irrigated agriculture to expand (depending on crop type and water use), by about a further 1800 ha in the study area, which is nearly double the area currently utilised.

About 1.8% of the total land area (or any individual parcel of land) could be irrigated. Ideally, water use would be distributed evenly; however, in practice this is rarely the case. Where land is subdivided for irrigated agriculture, care is required to ensure neighbouring properties are not adversely impacted by local drawdown of the aquifer.

A management plan for the aquifer will need to be developed in conjunction with key stakeholders to address, inter alia, the following:
- water available for consumptive use;
- formal allocation to beneficial uses, including the environment;
- dispersion of water use and licensing of individual users, including water entitlements and licence conditions;
- ongoing studies to improve knowledge of the water balance model and potential environmental impacts of increased usage;
- monitoring and other obligations of water users.

Whilst the assumptions made in the initial model may, in time, prove to be conservative, there is sufficient confidence in the current data and understanding of the aquifer behaviour to say there is scope for ongoing development.

Development must however proceed within the context of an agreed plan after consultation, and with provision for ongoing data collection, and the ability to make adjustments as further data is assessed, so as to ensure long term environmental and economic sustainability is achieved.

Clearly the allocation of 50% throughflow to the environment is the most significant constraint to ongoing development potential. The 50% figure is linked to low flow data in the rivers, but is still arbitrary and subject to more detailed scientific study.

The sensitivity of this figure in terms of the impact on water availability for irrigation, and hence irrigable area, is shown in Table 4.5 below:

<table>
<thead>
<tr>
<th>Allocation to the environment (as % of modelled groundwater throughflow)</th>
<th>West of King River Av ML/day</th>
<th>East of King River Av ML/day</th>
<th>Water available for additional irrigation Av ML/day</th>
<th>Additional area irrigable ha (based on 10 ML/ha/annum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25%</td>
<td>23</td>
<td>12.3</td>
<td>(49.1 + 35.9) 85</td>
<td>3103</td>
</tr>
<tr>
<td>50%</td>
<td>47</td>
<td>24.5</td>
<td>(25.1 + 23.9) 49</td>
<td>1789</td>
</tr>
<tr>
<td>75%</td>
<td>70</td>
<td>36.8</td>
<td>(2.1 + 11.6) 13.7</td>
<td>500</td>
</tr>
</tbody>
</table>
4.3 Irrigation Costs

Whilst groundwater is clearly available, experience in the Venn subdivision and elsewhere in similar karstic environments, is that irrigation bores can be expensive to construct and develop.

The potential to intersect major fractures and construct high yielding bores is reasonably good. Financial planning however should be based on three bores being drilled (on average) to obtain one with high yield suitable for final construction. The value of expert contractors, with past experience of the aquifer conditions, should not be underestimated.

Bores with recommended safe yields of less than 20 litres per second are unlikely to be satisfactory for centre pivot irrigation. Standing water levels throughout the aquifer vary from 10m to 70m, and indicative costs of drilling successful bores, in the formation is shown in Table 4.6 below. A 30 l/sec bore should be satisfactory for irrigation of about 25 ha.

Table 4.6: Capital Costs of Irrigation Development

<table>
<thead>
<tr>
<th>Depth of bore</th>
<th>Indicative cost $ x 1000</th>
<th>Cost of irrigation development Based on</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bore construction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 metres</td>
<td>40</td>
<td>200mm cased bore. 3 attempts with construction and testing of one bore yielding 30 l/sec minimum</td>
</tr>
<tr>
<td>70 metres</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>100 metres</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Pump and motor</td>
<td>28</td>
<td>Submersible</td>
</tr>
<tr>
<td>motor</td>
<td></td>
<td>Diesel</td>
</tr>
<tr>
<td>Centre pivot</td>
<td>85</td>
<td>To irrigate an area of 25 hectares</td>
</tr>
<tr>
<td>irrigator</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>Sprinkler irrigation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Hence, to irrigate 25 hectares from a single 200mm bore drilled to 70 metres, pumping at 30 l/sec, the capital cost of irrigation infrastructure would be in the order of $178,000 at $7,100/ha for centre pivot irrigation, or $126,000 at $5,000/ha for sprinkler irrigation.

Operational costs will vary with pump head, pump rate, power source and water application. For a 30 l/sec pump rate, the hours pumped to irrigate 25 ha (at an application rate of 10 Ml/ha/annum) are 2,300, and Table 4.7 below gives the indicative operating costs for both electric and diesel pumping over a range of heads. For a 100 metre pump head, the cost of diesel pumping (power/fuel only), would be in the order of $5,750/annum or $230/ha/annum.
Table 4.7 Operational Costs of Irrigation

<table>
<thead>
<tr>
<th>Pump head (metres)</th>
<th>Pump rate</th>
<th>Required horse power (kw)</th>
<th>Running cost per hour $</th>
<th>Hours pumped</th>
<th>Cost operating $</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>30 l/sec</td>
<td>18</td>
<td>Electric 2.80  1.80</td>
<td>2300</td>
<td>6440  4140</td>
</tr>
<tr>
<td>100</td>
<td>30 l/sec</td>
<td>25</td>
<td>3.90  2.50</td>
<td>2300</td>
<td>8970  5750</td>
</tr>
<tr>
<td>130</td>
<td>30 l/sec</td>
<td>32</td>
<td>5.00  3.20</td>
<td>2300</td>
<td>11500  7360</td>
</tr>
</tbody>
</table>

The figures quoted in Tables 4.6 and 4.7 above are at best indicative. There are many variables to take into account, and each enterprise will have an optimum design dependent on the crop to be grown, its water application, and other physical characteristics of the site, and must be costed in detail.

In general, unit costs will be lower for larger enterprises due to the economies of scale. Whilst diesel motors are reliable, particularly when run continuously, total maintenance and capital costs are higher than electric motors, which are generally the better option where power is available, particularly for centre pivot operation.

4.4 The Planning Framework
Currently, land use planning and natural resource planning is not well integrated. Whilst the preparation of land use objectives is conducted at a regional scale, and mapping of natural resource attributes is also being undertaken at a regional scale, decision making on the development of resources is more often made at the property, or subregional, level.

In relation to water resource management, this approach poses risks including
- overexploitation of the resource in terms of its ongoing sustainability;
- potential adverse impact on the environment;
- over use on one property impacting on neighbouring property;
- water use which is incompatible with the most appropriate land use;
- landholders and community stakeholders generally being excluded from decisions which may impact on their long term interests.

A model has previously been put forward (Ref 10) to integrate land use planning and natural resource management planning, with Natural Resource Management Plans (NRMP) being adopted as the ultimate planning tool. These could be formally incorporated into the NT Planning Scheme (see Attachment 3). Natural Resource Management Plans would be finalised in conjunction with a Water Advisory Committee appointed by the Minister.
In the case of the Tindal limestone aquifer between Katherine and Mataranka, a NRMP should be prepared with the key element of it being a Water Allocation Plan.

5. WATER RESOURCE REGULATION

5.1 Extraction Licences
Water use (beyond stock and domestic requirements), is generally required to be licensed for any surface water extraction, or any groundwater extraction from bores pumping in excess of 15 litres per second. Where Water Control Districts (WCD), have been declared, further restrictions and/or conditions can be imposed to address the particular water resource management issues. A WCD is in place for the immediate Katherine region. Boundaries are shown on the Map. The Venn subdivision, and Cutta Cutta Caves, are within the WCD.

Within the WCD the groundwater users are required to install a meter on their irrigation bores (regardless of capacity), and report water usage as a condition of licence. At present, the Controller of Water Resources is not receiving this data.

Clearly, for such an important groundwater resource, the rights conferred on water users, and their obligations to respect those rights and the conditions attached to them, must be taken seriously. This will increase in importance as further development occurs.

It is proposed that water use regulation should be undertaken within the context of a Water Allocation Plan, which may ultimately be an important component of a Natural Resource Management Plan. Proposed changes to the Water Act will provide for Water Allocation Plans to be declared as statutory instruments with water use licences issued for longer periods (than at present), and in a form where water entitlements under the licence can be traded.

The rules regarding water use will be developed in consultation with a local Water Advisory Committee. Conditions of licensing will be clearly stated and penalties for non-conformance with conditions should be rigorously applied.

5.2 Waste Discharge Licences
The only component of the water resources of the study area currently in need of waste discharge controls is the Katherine River.

A planning process is in place and has been operating across the Northern Territory, to protect water quality in accordance with the National Water Quality Management Strategy. This process requires the declaration of Beneficial Uses of natural water resources, as a prerequisite to water quality planning and waste discharge licensing.

Beneficial Uses are derived through a community consultation process and set the water use values that are desired by the community, and supported by Government. Several declarations have been made in the Katherine region. Attachment 4 describes the Beneficial Uses for the Katherine River, Katherine River tributaries, and
groundwaters of the Katherine region, with Attachments 5, 6 and 7 showing the location of these declarations.

It should be noted that the groundwaters have been declared for drinking water, agriculture and industrial uses. Obviously, drinking water will represent the most restrictive water quality criteria, and ongoing monitoring will be necessary to ensure the application of agricultural chemicals does not compromise this Beneficial Use. Extraction licences include a condition prohibiting the connection of chemical feeder systems to pump suction lines.

Where the quality of a waste stream is clearly outside the range of acceptable criteria for the declared Beneficial Use of a receiving water, a Waste Discharge Licence is required to control and monitor the discharge.

No Waste Discharge Licences are currently in place in the study area. It is suggested that effluent disposal from the PAWA sewerage ponds should be subject to a Waste Discharge Licence.

5.3 Other Regulatory Controls
The Water Act is the appropriate law to manage the use and protection of natural water resources in the NT. As previously described, there needs to be closer links to the land use planning process, as provided under the Planning Act.

There are several laws which should complement the powers under the Water Act to manage water resources, but no detailed examination of the consistency of these linkages has been undertaken at this stage. Legislation which comes to mind include:

- law governing the use of agricultural chemicals
- law relating to NT Parks and Reserves
- local government law relating to waste management etc, in declared town areas.

6. RESOURCE MANAGEMENT POLICY

The appropriate development of land within the area of the Tindal limestone outcrop between Katherine and Mataranka, is closely linked to the understanding and management of the important water resources of the Tindal limestone aquifer.

6.1 Planning Process
A planning process is required to develop a Regional Water Resources (or Natural Resources) Management Plan, which incorporates a Water Allocation Plan as a statutory tool for the sustainable management of water resources.

The broad process should include the following major steps:

- finalise and document an assessment of the water resources and water balance for the study area;
- prepare an issues/discussion paper for community consultation and feedback;
- appoint a Water Advisory Committee (WAC);
• in consultation with the WAC finalise a Water Allocation Plan (and subsequently a Water Resource Management Plan).
• seek broader community approval
• declare and implement.

6.2 **Ongoing Studies**
The Water Resource Management Plan will identify a range of ongoing studies required to better quantify the resources of the study area and the requirements for their ongoing management. Probable needs identified at this stage are:

• water balance modelling for the Katherine River from upstream of Donkey Camp to downstream of the Tindal limestone outcrop;
• scientific study of the minimum flow requirements for both the Katherine and Roper Rivers (with or without extrapolation from other study areas);
• assessment of the appropriate infiltration factors to be used in the study area and their variance east and west of the King River;
• more detailed assessment of the impact of surface water catchment inflows to the Tindal limestone east of the King River and their influence on water quality;
• local study of the impact (if any) intensive water use in the Venn subdivision is having on the Cutta Cutta Caves;
• more comprehensive monitoring of water level and quality responses to increased extraction as it occurs.

7. **SUMMARY**

Modelling shows that the mean minimum dry season flows in both the Katherine and Roper Rivers are in the order of double the estimated Tindal limestone contribution. Notwithstanding that there is almost certainly some contribution to low flows from sources other than the Tindal limestone, there could be an argument that the groundwater recharge estimates are conservative, and that the irrigation potential could be up to double that proposed.

Given also that the environmental flow allowance is totally arbitrary, and subject to ongoing scientific review, there may be a further case to argue for an even higher level of development.

If the groundwater infiltration factors were doubled (to equate more closely with streamflow), and 25% of mean low flow was proven to satisfy environmental requirements, the ultimate potential for new irrigation could be as high as 6000 hectares.

The level of study undertaken however cannot support figures other than those summarised below for ongoing planning purposes.
More extensive analysis, in conjunction with supplementary studies and the development of a management plan, may allow less conservative estimates to be made in due course.

The main conclusions and recommendations arising from this interim report are therefore:

- the Tindal limestone aquifer is primarily responsible for maintaining perennial low flows in the Katherine and Roper Rivers;
- total annual recharge to the aquifer (between Katherine and Mataranka), is in the order of 52 x 10^3 ML (142ML/day);
- the environmental health of the Katherine and Roper Rivers is dependent on low flow maintenance and hence controlled groundwater extraction;
- an arbitrary allowance for environmental flow of 50% of the average minimum flow in the lowest flow month should be adopted;
- to maintain this flow from effluent groundwater, 50% of the estimated recharge (average daily throughflow) needs to be preserved for environmental Beneficial Uses;
- Venn irrigation currently represents the major extraction from the aquifer at 5.8ML/day (average), increasing to about 18 ML/day within 4 to 5 years as already planted trees mature;
- there is still significant capacity for further agricultural (irrigation) development;
- additional extraction in the order of 49 ML/day permitting a further 1800 ha of irrigation, could be confidently allowed (after 50% provision for the environment and allowance for increased water use as current plantings mature);
- irrigable area increases to 3103ha if a 25% allocation is made for the environment, and reduces to 500ha for a 75% allocation;
- approximately 45000 ha of suitable soils exist in the extended study area, which includes the 10km strip of land immediately south of the Tindal limestone outcrop (Ref Map 3);
- indicative capital costs of irrigation infrastructure range from $5000/ha to $7100/ha;
- indicative operating costs of irrigation range from $230/ha to $360/ha;
- irrigation extraction needs to be dispersed throughout the aquifer with approximately 1.8% of the total area of the Tindal limestone outcrop available for irrigation;
- a Water Resource Management Plan (or Natural Resource Management Plan), should be prepared for the region. Changes proposed to the Water Act will enable this as a statutory process;
- future decisions on water use and conditions for extraction, should be made within the context of a declared Plan, and in consultation with a Water Advisory Committee appointed by the Minister.
- the shallow dip (approximately 1%) of the units in the Tindal limestone sequence means that economical bores could be drilled through the Jinduckin formation for up to 10 kilometres beyond the periphery of the Tindal outcrop to the south.
### GAUGING STATIONS

<table>
<thead>
<tr>
<th>Station</th>
<th>Automatic River Height</th>
<th>Flow Gaugings</th>
<th>Water Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roper River downstream of Mataranka Homestead</td>
<td>G9030176</td>
<td></td>
<td></td>
</tr>
<tr>
<td>King River downstream of Stuart Highway</td>
<td>G8140086</td>
<td></td>
<td>G8140086</td>
</tr>
<tr>
<td>Katherine River at Galloping Jacks</td>
<td></td>
<td></td>
<td>G8140301</td>
</tr>
<tr>
<td>Katherine River at Railway Bridge</td>
<td>G8140001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Katherine River at Donkey Camp inflow</td>
<td>G8140027</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Katherine River at Donkey Camp outflow</td>
<td>G8140012</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roper River at Mataranka Homestead</td>
<td></td>
<td></td>
<td>G9035085</td>
</tr>
<tr>
<td>Roper River downstream of Elsey Creek</td>
<td>G9030013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little Roper</td>
<td></td>
<td></td>
<td>G9035027</td>
</tr>
<tr>
<td>Roper River upstream of Elsey Creek</td>
<td>G9030176</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Katherine River at low level crossing</td>
<td></td>
<td></td>
<td>G8145222</td>
</tr>
<tr>
<td>Waterhouse River at road bridge</td>
<td>G9030089</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elsey Creek at Warlock Ponds</td>
<td>G9030001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elsey Creek at spring</td>
<td></td>
<td></td>
<td>G9035124</td>
</tr>
</tbody>
</table>
TINDAL AQUIFER - KATHERINE TO MATARANKA
WATER BALANCE MODEL

Area of outcrop 400km²

Area of outcrop 1020km²

Assumptions:
- Infiltration factors
  - Sandstone Plateau Aquifers: 7.5%
  - Tindal Aquifer (west): 6.7%
  - Tindal Aquifer (east): 1.34%
- No recharge from the upper tributaries of the
  - Roper River
  - Waterhouse River
  - Beswick Creek
  - Roper Creek
- No leakage southwards to the Jinduckin formation
PROPOSED PLANNING MODEL

Government Policy → Identify planning priorities → Natural Resource Management Planning

LRGC → Identify issues and stakeholders → Internal data information and liaison (including land capability assessment) → Appoint Advisory Committee (AC)

State Advisory Committee (if appointed) → Consultation based on issues paper → Draft proposed Planning Scheme amendments and obtain Ministerial approval → Prepare draft Natural Resource Management Plan and finalise in conjunction with Advisory Committee

NT Planning Scheme

Identify issues and stakeholders

Draft proposed Planning Scheme amendments and obtain Ministerial approval

Statutory exhibition

Finalise Planning Scheme Amendments and Minister "makes" under Planning Act

Implementation and development applications

Incorporate into the NT Planning Scheme

Implement and monitor
Katherine River

Aquatic Ecosystem Protection and Recreational Water Quality and Aesthetics
(Upstream of river's intersection with Zone 53 Australian Map Grid line 220500E (source 1:50,000 Topo Map Series R722, Sheet 5369 - II, Edition 1 - AAS)

Aquatic Ecosystem Protection and Raw Water for Drinking Water supply
(Between the point where river intersects with Zone 53 Australian Map Grid line 220500E and the point where river intersects with Zone 53 Australian Map Grid line 211100E (source 1:50,000 Topo Map Series R722, Sheet 5369 - II, Edition 1 - AAS)
Signed 25 February 1997

Katherine River Tributaries

Aquatic Ecosystem Protection and Recreation Water Quality & Aesthetics
Maud Creek

Aquatic Ecosystem Protection, Recreational Water Quality & Aesthetics and Agricultural Water Use
Dry River

Aquatic Ecosystem Protection
McAddens Creek
Seventeen Mile Creek
All other Tributaries
Signed 1 October 1998

Groundwaters of the Katherine Region

Raw Water for Drinking water, Raw water for Agriculture and Raw water for Industrial purposes
Signed 10 May 1999
Above Donkey Camp Pool
- Aquatic Ecosystem Protection
- Recreational Water Quality and Aesthetics

Donkey Camp Pool
- Aquatic Ecosystem Protection
- Raw Water for Drinking Water Supply

Below Donkey Camp Pool
- Aquatic Ecosystem Protection
- Recreational Water Quality and Aesthetics
- Agriculture Water Use

Notes:
1; For declaration and description see Northern Territory Government Gazette No. G9, 5 March 1997.
2; Prepared by Natural Resources Division, September 1999.

Declaration of Beneficial Uses and Objectives of Water
Katherine River
Notes:
1; Beneficial Uses are raw water for drinking water, raw water for agriculture, and raw water for industrial purposes.
2; For declaration and description see Northern Territory Government Gazette No. G22, 9 June 1999.
3; Prepared by Natural Resources Division, September 1999.