

## Discussion and recommendations

### ***Sources of the springs***

In September 2005, most of the springs had dried up (Table 4), except Hudson Creek, Melacca Creek, Banka Spring, Berry Springs and Parsons Spring (Figure 8). Palm Creek at Holmes Jungle, Hollands Creek at Black Jungle, Litchfield Creek and Acacia Spring are reported to naturally dry up at the end of the dry season (Tickell 2000).

Palm Creek and Hudson Creek flow from Palmerston Dolomite (Tickell unpublished). The typical high conductivity of approximately  $300 \mu\text{Scm}^{-1}$  recorded in the tributaries to the Elizabeth River (Table 1; Figure 20), and the location of the bores drilled in dolomite along the Elizabeth River (Figure 5) imply a possible dolomite origin of the stream water. The extent of the dolomite aquifer probably exists further south in the Elizabeth River catchment.

Howard Springs, Melacca Spring and Banka Spring flow from Koolpinyah Dolomite (Pietsch 1985). Modelling of different development scenarios concluded that land use has minimal impact on Melacca Spring and Banka Spring (Yinfoo 2004). However, rural development and extreme seasonal conditions such as low rainfall are reported to adversely impact Howard Springs dry season flows, the springs actually ceased to flow more often (Yinfoo 2004).

The springs at Black Jungle Swamp also originate from Koolpinyah Dolomite. The typical high conductivity of approximately  $300 \mu\text{Scm}^{-1}$  recorded in Litchfield Creek at Humpty Doo Station (Table 1; Figure 19) and the presence of bores drilled in dolomite in the vicinity of the spring imply a possible dolomite origin of the stream water. The extent of the dolomite aquifer could include Humpty Doo Station.

Berry Springs and Parson Spring flow from Berry Springs Dolomite (Verma 1994) and retain a substantial discharge throughout the dry season. However, the aquifers have been highly exploited mainly for horticulture and measures to protect the groundwater are currently under investigation.

Upstream of Manton Dam, Manton River flows from Coomalie Dolomite (Pietsch 1985) and has typical dolomite water quality (Table 4). Downstream of Manton Dam, Manton River flows along the quartzite Daly Range and the electrical conductivity becomes fresher (Figure 24). Downstream of the confluence with Acacia Creek at Acacia Gap, Manton River's electrical conductivity reflects the dolomite origin of Acacia Springs (Table 4). Acacia Springs sources from Coomalie Dolomite aquifer at Larrakia Community (Tickell 2000).

Springs in Cox Peninsula flow from Cretaceous Sandstone and electrical conductivity reflects the fresh origin of stream water quality (Table 1).

### ***Difference in water quality in different dolomite aquifers***

Water quality of bores from Koolpinyah Dolomite, Palmerston dolomite, and Berry Springs Dolomite have been listed (Appendix B). Principal component analysis was performed (StatSoft 1984-2005) to evaluate relationships among the chemical components and the dolomite aquifer. Two eigenvalues were greater than 1 and explained 50% of the total variance (Table 7). Factor 1 explained 36% of the variance among the elements and represented electrical conductivity, alkalinity, bicarbonate, hardness, total dissolved solids and magnesium. Factor 2 explained 15% of the variance and accounted for chloride, nitrate and sodium (Table 8).

Table 7. Eigenvalues extracted from principal component analysis

	Eigenvalues	% total variance	Cumulative eigenvalues	Cumulative %
1	6.05	35.6	6.05	35.6
2	2.48	14.6	8.53	50.2

Table 8. Summary of factor analysis. The factor loadings represent the correlation coefficients between the original variables and the newly derived factor.

Factor names and the high-loading variables	Factor loadings
<u>Factor 1</u>	
Electrical conductivity	0.97
Alkalinity	0.95
Bicarbonate	0.94
Hardness	0.98
Total dissolved solids	0.92
Magnesium	0.77
<u>Factor 2</u>	
Chloride	-0.87
Nitrate	-0.90
Sodium	-0.90

### ***Influence of deep aquifer springs on stream water quality in the dry season***

Data recorded in HYDSTRA reflect three different behaviours of surface and groundwater quality in the wet season. According to geological location, the streams and bores at the proximity of the coastline show a significant increase in electrical conductivity in the order of several thousand  $\mu\text{Scm}^{-1}$  and significantly high chloride concentration of several hundred  $\text{mgL}^{-1}$ . The streams receiving substantial runoff show a significant decrease in electrical conductivity (less than  $50 \mu\text{Scm}^{-1}$ ) due to rainwater dilution. Some bores and streams water quality (for example Berry Springs, Howard Springs, Manton River) remains the same with electrical conductivity of approximately  $300 \mu\text{Scm}^{-1}$ .

In the dry season, due to the absence of rainfall, the effects of saltwater intrusion and rainwater dilution disappear. As the dry season progresses, static water level and stream flow decrease. During this period baseflow is maintained by groundwater discharge, with electrical conductivity and ionic composition of streams reflecting the dolomite origin of the deep aquifer (Table 3).

### ***Change in stream water quality with distance***

Data collected in Darwin River, Manton River and Howard River at different distances upstream and downstream of the groundwater input show a significant difference in electrical conductivity (Figure 24). This reflects the influence of the

regional lithology on the stream water quality. The dolomite aquifer influences the high electrical conductivity and amounts of bicarbonate, calcium and magnesium in the rivers. Sandstone and quartzite aquifers bring fresher electrical conductivity to the streams.

### **Recommendations**

- \* Monitoring bore water levels as well as surface water gauging is needed to better understand the groundwater – surface water interaction and the recharge – discharge process.
- \* Additional water sampling, and modelling is required to evaluate the impact of dolomite springs on stream water quality downstream of the discharge point.
- \* The extent of dolomite aquifer has been determined using bore data (Figure 5). More investigation is needed to determine the extent of the dolomite aquifer in the Elizabeth River catchment and Litchfield Creek at Humpty Doo Station.

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