Groundwater residence time in the Kulnura-Mangrove Mountain Plateau (Gosford, NSW, Australia)

Dioni I. Cendón [a*], Stuart Hankin [a], John P. Williams [b], Chris Dimovski [a], Karina T. Meredith [a], Cath E. Hughes [a], Suzanne E. Hollins [a]

[a] *Australian Nuclear Science and Technology Organisation, Institute for Environmental Research, PMB 1, Menai NSW 2234, AUSTRALIA (* corresponding author: dce@ansto.gov.au)*
[b] Department of Water and Energy, NSW, Australia

The Kulnura-Mangrove Mountain plateau consists of the catchments of Mangrove, Narara, Mooney Mooney, and Ourimbah Creeks, and Wyong River. Groundwater plays a key role in sustaining stream flow within these catchments. Estimates indicate up to 50% of annual stream flow is derived from baseflow.

The local community water supply relies on the groundwater within the elevated Hawkesbury-Narrabeen sandstone plateau. Furthermore, the Gosford-Wyong Councils' Water Authority (WSA) is the third largest in NSW and utilises many of the streams flowing from the sandstone plateau for municipal water supply. It is anticipated that the WSA will provide municipal water for 319 000 persons by the year 2010. The increasing volumes of groundwater being extracted and changing land use have the potential to cause damage to the fresh water aquifer through contamination and aquifer depletion.

A hydrogeochemical survey (2006-2009) has been conducted in NSW Dept of Water and Energy (DWE) monitoring wells across the plateau in order to determine groundwater residence times. Groundwater was analysed for major ions, minor and trace elements, H_2O $\delta^{18}O$ and δ^2H, $\delta^{13}C_{DIC}$, $^{87}Sr/^{86}Sr$, $^{14}C_{DIC}$, and ^3H, and complemented with mineralogical and isotopic information obtained from soil and drill chips collected during well construction. Water stable isotopes confirm the meteoric origin of the groundwater with most values plotting on the local meteoric water line. Localised evaporative trends suggest recharge with evaporated groundwater stored in ponds.
Shallow groundwaters have ^3H and ^{14}C activities consistent with modern recharge (Fig 1). Carbon "bomb pulse" signatures of up to 116.8 pmC are found in the central areas of the plateau. The thin soils, lack of carbonates in the intensely weathered near-surface Hawkesbury sandstone, and the shallow depth of the water samples is consistent with the ^3H results measured, suggesting minimal dilution of the original ^{14}C. Input of this data into a southern hemisphere bomb pulse model [1] suggest potential recharge during the 1990´s, coinciding with sustained wet conditions and above average rainfalls experienced during this period.

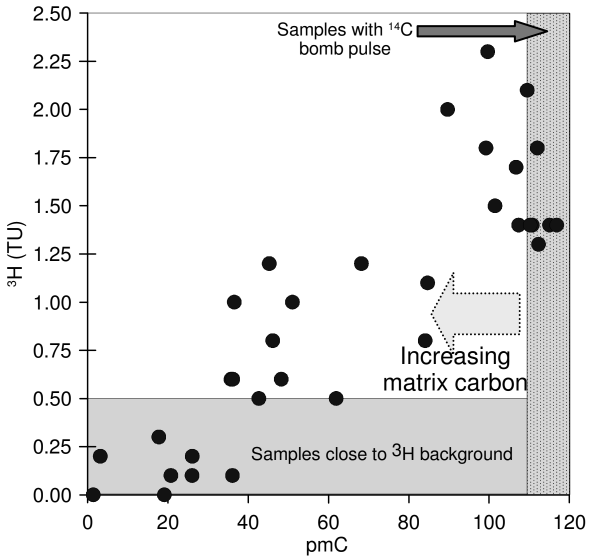

Fig. 1. ^{14}C vs ^3H plot of groundwater samples in the Kulnura-Mangrove Mountain Plateau

Deeper groundwaters have lower ^{14}C and ^3H activities in some cases close to background level (Fig. 1). The quantifiable ^3H suggests residence times of <70 a. However, non-corrected ^{14}C residence times are sub-modern (>500 a). This apparent discrepancy can be explained by either mixing with older waters or dissolution of carbonates. The good correlation of total dissolved inorganic carbon (TDIC) and Ca (R^2=0.8), $\delta^{13}C_{TDIC}$ in groundwater and mineralogy results from drill chips suggest that dissolution of dispersed carbonates is taking place.

The deepest groundwaters show the most difference in residence time across the study area. The eastern and western plateaus yield old groundwater with ^{14}C corrected residence times of around 9 ka and 4 ka respectively. However, the groundwater at equivalent depths in the central plateau was found to be considerably younger with residence times of <70 a.

References

[1] Reimer P.J., Brown T.A. and Reimer R.W. (2004). Radiocarbon 46, pp. 1299-1304.