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Factoring in palaeo-climate analysis and future climate changes to catchment hydrology and assessments of salinity hazard in Australia

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Since the 1970's there has been a net decrease in precipitation over the SW of Western Australia of the order of 20%. This decrease in winter rain is associated with a southward displacement of the air mass systems that bring winter rainfall to southern Australia (Pittock, 2003). Predictions of future climate change in southern Australia point to a significant warming, a further decrease in precipitation and increase in evaporation in many areas of Australia over the next century (Pittock, 2003; Hennessy, 2003; Hennessy *et al*., 2004). The best climate predictions for 2030 point to a probable 20% decrease in winter rain over SW and S central Australia, increasing to a possible 60% decrease by 2070 (Hennesy, 2003). Recent climate warming has been attributed to global increases in CO_2 levels (IPCC, 2001), and this event is superimposed on a post-1840 dry cycle in Australia, the previous Holocene climate record being generally wetter in Australia (Williams, 2001).

These recent climate changes in parts of Australia have already affected many physical and biological systems, with significant impacts on stream runoff, salinities and groundwater levels (Mayer *et al.*, 2004; Reid, 2004). This 'hot and dry' event is likely to have further significant impacts on human and natural systems (Hennesy, 2003; Hennesy *et al*., 2004), and also likely to impact on salinity hazard and risk predictions, as these are currently weighted towards present-day climate data (NLWRA, 2000).

The recent 6-7 year drought in Victoria has highlighted the need to resolve the relative contribution of climate change to measured and predicted changes to water table levels, and predicted salinity discharge and hazard. The issue is not easy to resolve, as the NLWRA (2000) salinity hazard maps in Victoria are based largely on simple linear extrapolation of (pre-drought) hydrograph trends, with no errors calculated, and trend analysis performed on records monitored for less than 25 years (Reid, 2004). Furthermore, pre-European water table levels are not recorded, despite some historical records suggesting some significant water table rises (>20m) in regional flow systems in Victoria over the last 100 years (Macumber, 1991). Further complications arise because some aquifers are also utilized as groundwater resources (Reid, 2004), and other factors such as regolith composition and architecture may also influence rates of change to water table levels and water quality (Lawrie & Williams, 2004).

The lack of long-term monitoring of piezometers, and patchy rainfall records for the first century of European settlement, and the other factors listed above, significantly complicate predictions of water table rise and salinity discharge. This generally means that temporal analysis and estimates of rates of change of water tables are not well constrained, and must rely on historical records and/or biophysical proxies and/or models. Also, the impacts of episodic recharge events may lead to significant abrupt changes in water table rise (Macumber, 1991), and the periodicity and spatial extent of these events is largely unknown.

The predicted climate differs significantly from the Late Pleistocene in Australia, which although generally drier, was also colder (Williams, 2001). Palaeo-climatic evidence suggests that previous climate events associated with significant drying of the continent and salinity discharge in wetland and riverine environments in SE Australia were cold arid events (Bowler, 1981). Both the temperature *maxima* predicted in the climate change models and the rates of change may be particularly important in looking for analogues in the geological record and in modelling future responses of natural systems. The rates of temperature increase predicted for the coming century, always assuming a doubling of CO_2, and assuming equilibrium, could amount to up to 6 degrees within 50-100 years (Hennesy, 2003; Hennesy *et al*., 2004). This rate of change is fast, but possibly not unprecedented from the Quaternary record, at least in high latitudes. However, the temperature maxima may be more extreme than experienced in the late Quaternary. The rates of change and the ability of our natural systems to respond to these changes remain problematic.

It is argued that the climate corrections for climate suggested herein are essential to improve the reliability of salinity and water table hazard predictions in Australia. It is also suggested that palaeo-climate analysis may have an important role to play in assessing the economic and environmental sustainability of many regions.

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