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# The use of environmental tracers to determine focused recharge from a saline disposal basin and irrigation channels in a semiarid environment in Southeastern Australia

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SUMMARY

Lake Tutchewop in southeastern Australia is a former ephemeral wetland that has been used as a saline disposal basin since 1968, forming part of the salinity management of the Murray River. The extent of saline focused recharge from Lake Tutchewop and fresh recharge from nearby unlined irrigation channels was determined using pore water and groundwater stable isotope and major ion chemistry, which were able to separate the influence of lake water, irrigation water and regional groundwater. In ~45 years, saline water from Lake Tutchewop has infiltrated only up to 165 m from the lake edge in most directions, due to the underlying relatively impermeable clay-rich sediments, and a maximum of 700 m due to preferential groundwater flow along a sandy palaeochannel. The saline leakage has had limited, if any, impact on surrounding agricultural land use. Fresh water leakage from unlined irrigation channels extends up to 10 m deep, validating the current program to replace these channels with pipelines. This study demonstrates that focused recharge from different sources can be positively identified where the recharge waters have distinctive compositions, and that underlying clay-rich sediments restrict the extent of seepage. Therefore, management of focused recharge sources, particularly those that could decrease groundwater quality, requires a detailed knowledge of both the groundwater composition around the site and the underlying geology.



## 1. Introduction

Groundwater recharge can be diffuse (distributed over large areas) or focused (concentrated at a point e.g. topographic depression, stream, or lakes) (Scanlon et al., 2002, 2006). Focused recharge is common in semi-arid environments, where episodic and/or seasonal rainfall patterns mean that the majority of streams are ephemeral and typically lose flow to groundwater (Dean et al., 2015). This leads to highly variable recharge rates on a regional scale and results in difficulties in quantifying recharge in these environments (Allison et al., 1994; Wood and Sanford, 1995; Scanlon et al., 2002), where changing land use and climate change are predicted to increase stresses on aquifers in terms of both water quantity and quality (e.g. Sophocleous, 2004; Green et al., 2011). It is particularly important to manage focused recharge sources that could potentially decrease the groundwater quality, e.g. saline disposal basins (Chambers et al., 1992, 1996; Simmons et al., 2002; Lamontagne et al., 2009) and wastewater treatment ponds (e.g. Asano and Cotruvo, 2004).

These concerns are especially relevant to the Murray–Darling Basin in southeastern Australia, which occupies about one-seventh of the country's land area and provides one-third of Australia's food supply, worth \$18.6 billion dollars to the economy in 2011–12. The Murray River is an important irrigation and potable water source in the semi-arid/arid climate of the basin, and to ensure that the salinity of the river water does not rise above a threshold electrical conductivity (EC) value (800 μS/cm at Morgan, South Australia), saline groundwater and surface water inputs into the river are intercepted at several points (Evans, 1989; Simmons et al., 2002). The saline water is disposed into 'saline disposal basins' along the river, which are natural landscape features such as lakes or meander cutoffs (Simmons and Narayan, 1998). The use of these basins for saline disposal can potentially lead to focused recharge of saline groundwater (Chambers et al., 1992, 1996; Simmons et al., 2002; Lamontagne et al., 2009), impacting the surrounding groundwater environment and nearby land use. It is important to monitor and investigate any impacts in order to determine the future sustainability of these basins.

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One such saline disposal basin is Lake Tutchewop, in the southern part of the Murray–Darling Basin between Kerang and Swan Hill in northwestern Victoria (Fig. 1). It was formerly an ephemeral wetland that was intermittently filled during flooding of the Avoca River, but since 1968 has been used as a saline disposal basin, receiving an estimated 980,000–1,090,000 tonnes of salt from the Barr Creek Drainage Disposal Scheme (Aquaterra, 2011b). Lake Tutchewop is surrounded by farms and a network of unlined irrigation channels, and the possibility of saline leakage (i.e. focused recharge) from the lake impacting on local groundwater and agricultural land use was raised by Macumber (2007), and a major drilling program combined with extensive groundwater analysis was conducted in 2008 to investigate this question (Aquaterra, 2011a, 2011b). The data obtained in these investigations have been reanalysed in the present study, along with long term monitoring data and additional targeted sampling, in order to determine the extent of focused recharge, both from Lake Tutchewop and the surrounding irrigation channels. The resulting conceptual understanding can be applied to other saline disposal basins within the Murray–Darling Basin and in similar environments around the world.

## 2. Geology and geomorphology of Lake Tutchewop

Lake Tutchewop is situated on a flat plain at ~70 m AHD (metres above Australian Height Datum). To the west and south are the low rises of the fault-bounded Cannie and Gredgwin Ridges respectively, rising 120–125 m AHD at their highest points (Macumber, 1991; Robson and Webb, 2011).

Lake Tutchewop forms part of the Kerang Lakes, which consist of over 50 permanent and temporary, fresh water to hypersaline lakes, marshes and swamps. Lunettes along the eastern edges of many of these lakes form an extensive system which acts as the western confinement of the Loddon River and eastern confinement of the Avoca River in this area. The Avoca River flows southwest of Lake Tutchewop, but the lake lies towards the end of an old course of the river (Avoca Floodway) that is still active during large floods; these floods filled Lake Tutchewop until a levee was built in 1970 on the western side of the lake (Macumber, 2007).

Lake Tutchewop is located within the western part of the Murray Basin, a broad downwarp containing up to 600 m of Paleocene to Holocene, mostly siliciclastic sediments (Brown and Stevenson, 1991). The lake is underlain by, in stratigraphic order, Loxton Sand, Shepparton Formation, Coonambidgal Formation and Yamba Formation. The Miocene–Pliocene Loxton Sand comprises largely shallow marine and beach dune sediments (Robson and Webb, 2011) deposited on a regressive strandplain (Roy et al., 2000). The overlying Pliocene to Holocene Shepparton Formation consists of complex interbedded floodplain sediments (mottled grey/brown/red clay) and palaeochannel deposits (sandy/silty lenses) up to 30 m thick (Australian Geological Survey Organisation, 1997; Page et al., 2009), deposited by prior courses of the Loddon and Avoca Rivers ("prior streams"; Butler, 1950). Lithological and gamma logs obtained during the present study from boreholes around Lake Tutchewop identified a palaeochannel sand within the Shepparton

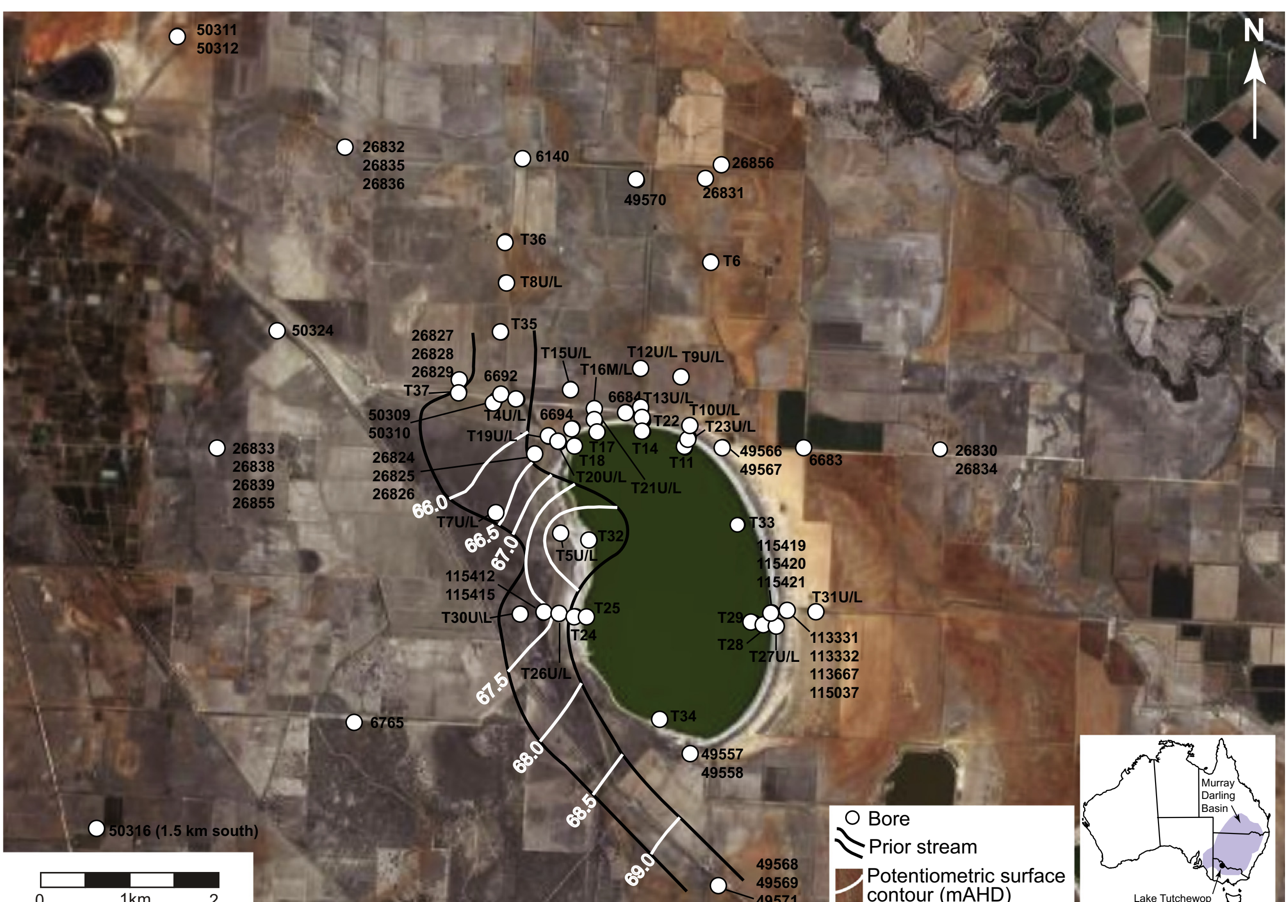


**Fig. 1.** Lake Tutchewop, showing locations of nearby bores (multiple bore numbers at a single site indicate a nested site) and adjacent palaeochannel (prior stream), with potentiometric surface for August 2010 (Google Earth Image, 1 February 2007, Digital Globe).