

Future landscape scenarios in the lower River Murray, south-eastern Australia and their implications for river salinity and floodplain health

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Introduction

The Murray Darling Basin of South-Eastern Australia provides more than 40% of the irrigated agriculture for Australia, despite making up only one seventh of the country. The lower River Murray is located within a naturally saline groundwater system and increased recharge from agricultural practices has augmented the baseflow of saline groundwater to the river and floodplains. Combined with decreased river flow and flooding regimes due to agricultural water extractions, this irrigation has led to increased river salinity. State, Commonwealth and regional agencies have developed management strategies to reduce lower River Murray river and floodplain salinity. A challenge arises in understanding the effectiveness of such plans because the salinity effects of landscape management practices are buffered and delayed by the order of many decades due to the dynamics of the groundwater system. Thus, direct observation of outcomes is not feasible.

An alternative method is required to test the effectiveness of strategies aimed at satisfying the many salinity, biodiversity and socioeconomic targets in regional natural resource management plans. One option is futures scenario modelling of the system by combining hydrogeological, ecological and economic models into a systems framework. This approach provides a powerful tool for evaluating possible future landscapes and their impacts on the environment and local communities.

This paper briefly describes an integrated model developed to assess future scenarios for the lower River Murray region, and discusses the relevance of the scenario outcomes for policy and management.

Methodology

The River Corridor Systems Model (RCSM), integrates existing biophysical and economic models to determine the salinity, biodiversity and economic impacts of land use and management actions. The model was used to test whether variations in future land use scenarios and water management strategies would achieve salinity and biodiversity targets. The model estimates triple-bottom line impacts of land management decisions. A detailed description of the RCSM is found in Walker *et al.* (2006).

The RCSM incorporates six biophysical and socio-economic processes: basin water availability and river salinity, irrigation economics, groundwater salinity processes, floodplain health, salinity damage and salt interception, and regional socio-economic impacts. These interconnected model components allow futures scenario modelling to better understand the potential delayed outcomes from changes in future management.

Table 1 and Table 2 describe, respectively, the policy options and future climate change scenarios modelled in this study. Policy options include zoning of new irrigation development or relocating current developments to low impact areas, and improving irrigation efficiency and investing in engineering to mitigate salinity. Climate change scenarios account for the lower rainfall, river flows and water available for irrigation that is an expected outcome under human-induced climate change (Chiew, F.H.S. and McMahon, T.A. (2002).

The mitigation costs of reducing saline groundwater baseflow were estimated by modeling the reduction of river salt loads (measured by ECs at Morgan) as a result of extraction of saline groundwater at the edge of the floodplains. The level and location of such effort was assumed to optimally meet targets in the most economically efficiency manner.

Table 1 Scenario policy options.

Policy option	Short Description
Current Policy	Continuation of current NRM policy including continuing investment in salt interception to offset river salinity growth, current irrigation zoning and management policy, and current water allocation and flow management policy.
Irrigation Efficiency	Complete adoption of high efficiency irrigation practice across the region and continuation of current NRM policy as in the Baseline scenario.
Low Impact Irrigation	Reduction by 20% of irrigation in high salinity impact areas through cessation of irrigation or relocation to low impact areas. Again continuation of current NRM policy as in the Baseline scenario is assumed.

Table 2 Climate change scenarios.

	Baseline	Mild Climate Change	Moderate Climate Change	Severe Climate Change
Temperature	Historical Mean	1°C	2°C	4°C
Average Annual Rainfall	Historical Mean	5% decrease	15% decrease	25% decrease
Average Annual Basin Inflow	1975 – 2000 25 year reference sequence levels	13% decrease	38% decrease	63% decrease

Results

A key finding of this study is that salt loads in the river are expected to increase under climate change, regardless of policy. Each of the modelled policy options showed an increase of river salinity over a 50 year period (Figure 1) under the baseline climate scenario. A major source of this increase is the long groundwater system lag times, meaning that the ultimate salinity impact of historical irrigation development will reach the river in the next 100 years or more. The effects of policy changes are to reduce the rate at which salinity increases, but they are overwhelmed by the impacts from historical irrigation (Figure 1).

The climate change scenarios reduce the volume of water available for irrigation and therefore reduce the groundwater recharge that is expressed as salt loads to the river. However, lower river flows are predicted to reduce the water available to dilute the saline inflows. Under the moderate climate change scenario, the net predicted effect is higher river salt concentrations (Figure 2). Significantly higher salinities can be expected when the concentration effects of reduced flow are factored into the model. This is despite reduced groundwater baseflow.

The findings have significant implications. In the past it was possible to mitigate the increases in river salinity back to 2001 levels using salt interception. Over \$100 million has been spent since 1988 to reduce the river salinity at Morgan by over 100 EC. Morgan is the EC measurement reference location on the River Murray. Future saline baseflow can be reduced using salt interception, but the reduced river flows consistent with the moderate climate change scenario considered in this analysis would lead to rising salinity, even with large investments in salt interception. Reducing saline groundwater baseflow cannot mitigate the concentrating effects of a reduced flow.

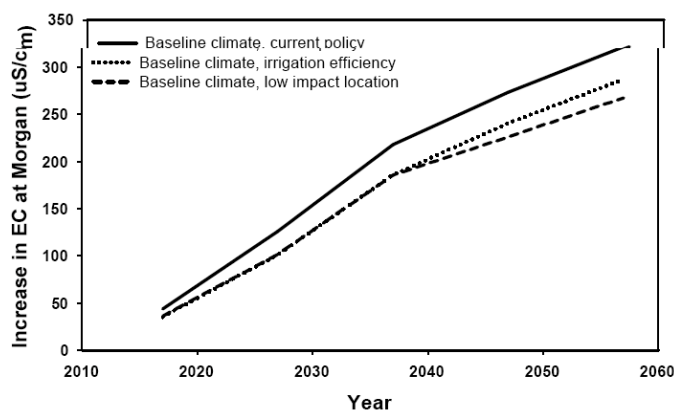


Figure 1 Predicted salinity increase at Morgan, the reference location for river salinity measurement under future scenarios defined by current policy, improved irrigation efficiency and zoning new development to low impact locations, under baseline (1975–2000) climate conditions.

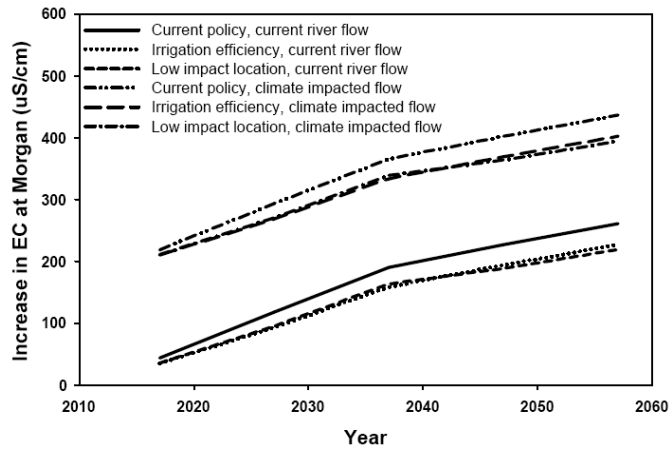


Figure 2 Predicted salinity increase at Morgan, the reference location for river salinity measurement under future scenarios defined by current policy, improved irrigation efficiency and zoning new development to low impact locations, with moderate climate change, with and without the concentrating effects of river flow reduction.

The relative timing of the impact is dependent on aquifer properties. The results show significantly different behaviour if future salt loads are disaggregated into their state of origin (South Australia or Victoria) (Figure 3). Whilst the salt loads to the river from South Australia show a consistent increase over time, those from Victoria increase until they reach a plateau in 2036 (Figure 3). This is due to the different hydrogeological properties of the two regions, namely the much lower diffusivity and greater depth to groundwater in South Australia resulting in much longer time lags than Victoria. The lower present recharge rates in the South Australian system are expected to lead to a long term reduction in salt loads beyond the period modelled.

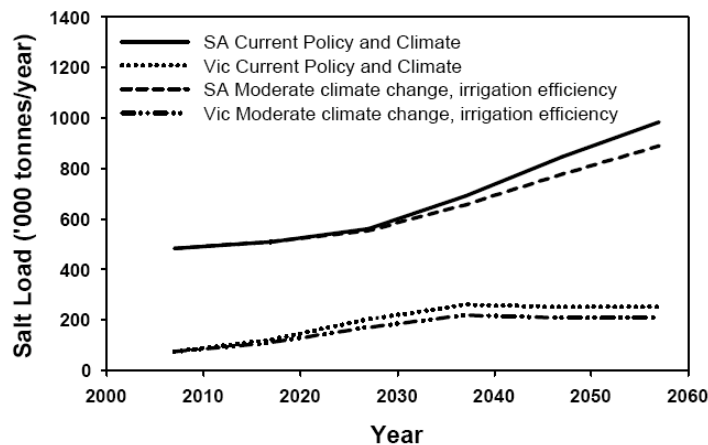


Figure 3 Expected future river salt loads for South Australia and Victoria for current policy and improving irrigation efficiency, under current (1975 – 2000) and moderate climate change conditions.

Conclusions

The RCSM aggregates several biophysical and economic model components in an integrated assessment model developed for the landscape futures project within the lower Murray Darling Basin. Climate change increases water scarcity, resulting in improvements to irrigation efficiency as water becomes more expensive. However, a net increase in river salinity is expected as a result of the reduced dilution resulting from reduced flows. The long lag times of the hydrological system in South Australia compared with Victoria were defined, and the relative merits of both mitigation and policy implementation to treat the problem at its source were highlighted. It is possible to continue to offset river salinity with additional salt interception schemes, but at a cost. Policy options to encourage irrigation efficiency and location at low impact sites may be available at less cost than salt interception. Consideration of policy or water trading solutions for maintaining or improving current river flow levels is also required.

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