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Forecasting with FLARE – predicting Lake Alexandrina water quality

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Abstract The ability to provide safe and reliable water for the community faces the challenge of operating in an uncertain environment. This paper summarises the deployment of the Forecasting Lakes and Reservoir Ecosystems (FLARE) system to Lake Alexandrina (South Australia), which was used to create prototype real-time water quality forecasts. This system automatically integrates in situ observations of key water quality parameters and regional weather and hydrological forecasts to create lake forecasts spanning 1-30 days ahead. A key management lever for the system is the operation of barrage gates to regulate water levels and downstream flows. Multiple barrage management scenarios are therefore included in the forecast to allow decision-makers to anticipate the benefit of different actions. These probabilistic forecasts of lake levels, salinity, and water temperature are displayed in a publicly available dashboard alongside data on current lake and weather conditions, a key tool for public engagement. By integrating live observations of water quality parameters into FLARE forecasts, the key information gap between recent conditions and likely future conditions is addressed to inform management decisions and potential mitigation actions.

Keywords: *Water quality, forecasting, barrage operations, environmental decision-making*

1. INTRODUCTION

Water resource managers are limited in their ability to predict and pre-emptively manage the occurrence of poor water quality events, which can often persist for months. Such events significantly compromise the water resources of the Murray-Darling Basin with impacts on water supply, ecology, recreation, and cultural values. While monitoring offers near real-time insights into some water quality parameters, the ability to forecast the environmental conditions that may lead to future water quality issues, as well as the occurrence and persistence of water quality issues in the Basin is lacking. Lake Alexandrina is particularly vulnerable as it is located at the terminus of the River Murray and experiences both imported and localised water quality issues. The lake is managed within an operating envelope with managed levels typically varying between 0.5 m AHD and 0.85 m AHD. A series of five barrages, spanning 2km, separate the downstream ocean environment from the primarily freshwater and well-mixed lake. As specified in Section 9.14 of the Basin Plan, the lake's salinity is managed to maintain levels below 1000 µS/cm. Barrage operations are the primary management lever used to respond to changing inflows to maintain water levels and water quality in the weir pool up to Lock 1. Daily timestep hydrological model inflow forecasts do not include water quality, leaving South Australia (SA) reliant on upstream reporting and monitoring to provide warnings of water quality issues.

Lake Alexandrina has a history of water quality issues with the most recent, and currently still occurring, bloom of the potentially harmful *Cylindrospermopsis* freshwater blue green algae (SA Health, July 2025). While high flow or flood events have historically imported low Dissolved Oxygen blackwater into SA and ultimately Lake Alexandrina (Goyder Institute for Water Research, 2025**)**, salinities exceeding 8,000 EC and the exposure of more than 20,000 ha of Acid Sulfate Soils were also recorded in the lake during the height of the Millennium Drought in spring 2009 (Royal Society of South Australia Inc., 2018). The ability to forecast the likely occurrence and persistence of water quality risks to the SA River Murray and Lower Lakes region would allow river managers to implement proactive and adaptive river operations to mitigate impacts. Likewise, it would allow SA Water to plan responsive River Murray pumping and water treatment regimes for the three major River Murray pipelines supplying drinking water to Adelaide and regional SA. The aim of this study was to develop a prototype forecasting platform able to demonstrate the utility of scenario-based forecasts with uncertainty quantification for assisting managers anticipate future conditions.

2. METHODOLOGY

The Forecasting Lakes and Reservoir Ecosystems (FLARE) system was employed which uses a one-dimensional GLM-AED hydrodynamic model (Hipsey et al., 2019) of Lake Alexandrina to enable efficient ensemble forecast model runs with alternate management scenarios. The model is initialised with publicly available current observed in-situ lake data from the South Australian water monitoring network. Using an iterative approach, the model evaluates previously generated forecasts (1-30 days) each day and then updates the model starting conditions and model predictions using ensemble Kalman filter (EnKF) data assimilation (Thomas et al., 2020). The model forecasts rely on forecasts for both meteorological and upstream river hydrology, and generation of an inflow forecast for the River Murray at Wellington in the prototype model presented the primary challenge for the project. Depending on flow magnitude, known travel times from the SA border to the lake permit a degree of inflow forecast certainty for between 7 – 22 days. Beyond this, Flow to SA (QSA) forecasts were generated using a random walk forecast method which adopted SA's annual Entitlement flow of 1,850 GL/y as the lower inflow bound. The upper inflow bound was defined as SA's Entitlement flow plus historical monthly average environmental water delivery. Calibrated travel times and losses under a range of flows up to 40 GL/d and climate (net evaporation) from the SA River Murray Source hydrological model were applied to the full 30-day QSA forecast period to generate the hydrograph at Wellington. Outflows were represented in the model at the barrages, which were configured as a singular outlet with a changeable crest height meaning barrage releases were represented as a crest overflow.

3. RESULTS

The prototype forecasting system was configured with two alternate barrage operation scenarios with all other inputs and parameters held constant to generate daily forecasts between 1-30 days for lake level, salinity, temperature and barrage flow resulting from each. The two barrage scenarios assumed either an increased or decreased crest outflow height (i.e., decreased or increased barrage releases, respectively) which persisted for the forecast duration. These scenarios were compared to a base case scenario assuming no change in crest outflow height for the forecast duration. These scenarios highlighted the importance of barrage releases in maintaining lake salinity levels by exporting salt, with barrage releases particularly important when inflows to the lake were lower. The modelled scenarios also demonstrated that lake levels are more sensitive to barrage releases than to variability in lake inflow. Ultimately, the FLARE forecasting system was able to successfully represent Lake Alexandrina water level, temperature, salinity, and barrage releases over ~two years across a range of hydrological conditions (Olsson et al., 2025).

4. CONCLUSIONS

The prototype deployment of the FLARE software for Lake Alexandrina highlights the potential of probabilistic scenario-based forecasting with quantified uncertainty to support management of lake water quantity and quality. These forecasts, extending to 30 days ahead, offer insights into the impacts of different barrage opening decisions on both lake levels and water quality variables, and the capacity of barrage management to manage water quality events. The presentation of the forecast data coupled with quantified uncertainty bounds in a dedicated dashboard delivers easy to interpret, informative insights for site managers and the community alike. When combined with near real-time monitoring data for the region available on Water Data SA, the key information gap between current conditions and likely future conditions is addressed.

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