Regulating mine water releases using water quality trading

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Abstract Management of saline water release from coal mines in the Fitzroy Basin Queensland, Australia, is challenged by extreme climate variability and by the ephemeral nature of the receiving river systems. In the past decade, extended periods of drought and the floods of 2007/08 and 2010/11 have tested both strategic and operational mine water management practices, infrastructure and regulation of mine water release. Mine water release is currently regulated by the Fitzroy Model Conditions, a licence-based system which allows for increasing release rates with increasing flow in the receiving waters. The purpose of this study was to evaluate the technical feasibility of implementing a market-based cap-and-trade mechanism for managing saline mine water release into rivers of the Fitzroy basin.

Keywords mine water release regulation, environment, salinity, trading

Introduction

Water quality trading is a market-based approach to water quality regulation, intended to increase flexibility in meeting regulatory requirements with the potential to lower abatement costs. A review in 2009 identified 26 active water quality trading programs world-wide, two of which are currently operational in Australia: the Hunter River Salinity Trading Scheme (HRSTS; Fig. 1) and the South Creek Bubble Licencing Scheme (Selman *et al.* 2009). Types of water quality trading schemes include exchange markets, bilateral trades and sole-source offsets, amongst others (Selman *et al.* 2009).

The HRSTS is one of two water quality exchange markets operational worldwide and has been attributed as one of the water quality trading programs that comes closest to commoditising water quality credits (Selman *et al.* 2009). The success of the market is attributed in part to having a large number of regulated entities able to participate, creating depth and fluidity in the market space (Selman *et al.* 2009). It is also enhanced by real-time knowledge of market conditions, transparency of data and rules used to operate the system, and involvement of all stakeholders in developing operating rules.

There has been increasing interest in the potential to implement a salinity trading scheme in the Fitzroy catchment (Fig. 1) over recent years. Since 2008 Bowen Basin coal

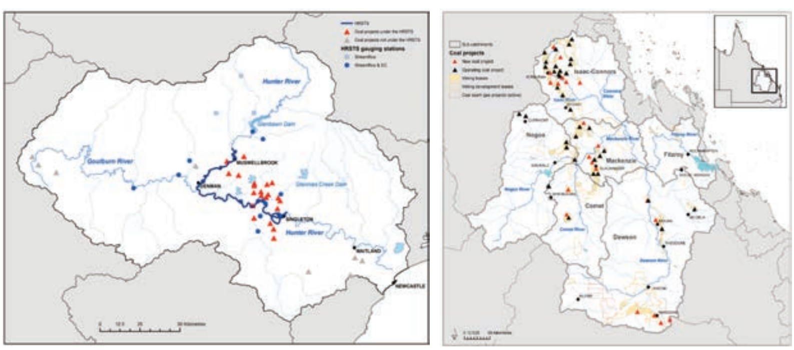

Fig. 1. a. Hunter River catchment NSW; and b. Fitzroy Catchment (Queensland).

mines have experienced consecutive wet seasons with higher than average rainfall. Excessive rainfall and tighter regulation of mine discharge in the basin has resulted in the accumulation of large volumes of water on most mine sites. It is estimated that most of this water has salinity approximately 6000 mS/cm, around 4 times higher than the end of pipe discharge criteria set in the 2009 Fitzroy Model Conditions. To assist in alleviating concerns with storages reaching their capacity and the compromise to coal production, the Department of Environment and Resource Management (DERM; now EHP) has been granting Transitional Environmental Programs (TEP) to enable discharge of excess mine water. These licences are issued in emergency or other extreme situations in order to ensure safe operation of the mines. While the conditions for release set in the TEP's is reducing the volume of water currently held on sites, there remain significant questions regarding how best to regulate and manage mine water discharge in the basin on an ongoing basis.

Overview of Hunter River Salinity Trading Scheme

In the Hunter catchment in NSW, the Hunter River Salinity Trading Scheme (HRSTS) has successfully managed saline mine release for over a decade. The scheme has been credited for the effective management of cumulative impacts of saline water release in the Hunter River, resulting in water quality objectives being achieved more frequently, whilst providing flexibility to industry. Point source saline discharges in the Hunter Valley were historically regulated by traditional 'trickle discharge' licensing strategies. The primary reason that this system was unsuccessful was that small volumes of saline water could be released at all times, irrespective of river flow or ambient salinity conditions (DoP 2005). A further criticism was that the system was unworkable for operators, being non-flexible and not allowing for licence holders to take advantages of the assimilative capacity of high flow periods.

In general the Hunter River can have naturally elevated salinity (Cameron 2010) especially where tributaries cross Permian geology. Records indicate that creeks within the upper catchment can have salinity between 4000 – 6000 µS/cm (DoP 2005). In periods of low flow, base flow of the Hunter River is fed by groundwater which typically has elevated salinity between 1000 – 3000 µS/cm (NSW OEH 2010). Conversely, in periods of high rainfall and runoff, salinity is substantially reduced , to as low as 350 µS/cm (DoP 2005). Sources of salinity to the river system include both natural, due to the marine origin of the sediments in the region, and anthropogenic sources.

Whilst it was accepted that the majority of salinity in the Hunter River system is derived from natural sources, diffuse and point discharges of saline water from agriculture and industry were recognised as significant environmental management issues in the region. These problems were particularly critical during periods of low river flow when consequences for aquatic ecosystems and other users were the most acute.

The HRSTS was developed as an alternate system for multiple point source saline discharge regulation. The scheme is a market-based cap and trade system, which uses a system of tradable salinity discharge credits to limit the total amount of salt discharged in the Hunter River system from point-source industrial activity. The scheme was developed in consultation between the NSW State Government, mining industry, electricity generators, agricultural interests and environmental groups (DoP 2005). A pilot salinity trading scheme commenced in the Hunter Catchment on 1 January 1995. Fig. 2 shows the mean monthly Electrical Conductivity at Singleton from 1980 and 2000. Prior to introduction of the pilot scheme, the 900 µS/cm target was exceeded 35 % of months. This was reduced to 4 % of months in the 5 year period of the pilot scheme (EPA 2001). In 2002, the *Protection of the Environment Operations (Hunter River*

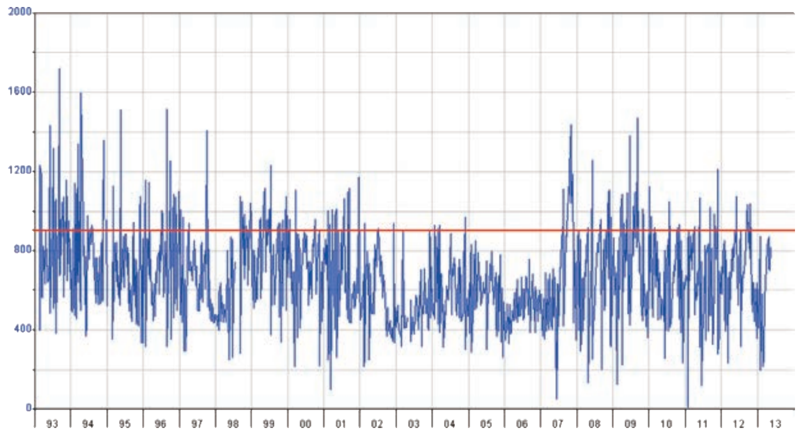

Fig. 2 *Mean monthly Electrical Conductivity at Singleton 1993 – 2013. Red line is the salinity target.*

Salinity Trading Scheme) Regulation 2002 (NSW; the Regulation) was passed which formally implemented the trading scheme.

Under the Hunter River Salinity Trading Scheme, discharges of saline water into the Hunter River are permitted only during periods when the Hunter River is considered to be in high flow or flood flow, and only by parties that hold a discharge licence and discharge credits. Allowable maximum salinity in the river during discharge events is set as 900 µS/cm at Singleton (the most downstream monitoring point of the scheme). Currently 13 mines and 3 power stations participate in the scheme. A credit entitles a discharge licence holder to discharge 0.1 % of the total allowable discharge of salt, determined on a daily (or more frequent basis) dependant on the ambient environmental river flow and salinity conditions.

The scheme involves real-time river monitoring to detect stream flow and ambient salinity conditions and load-based calculations to determine a Total Allowable Discharge (TAD) of salt, noted as the window of opportunity (Fig. 3). This method is similar to the USEPA method for calculating total daily maximum loads.

Under the scheme, mines and industry can discharge according to the number of salt discharge credits they hold. These credits are sold at auction and also traded between users to allow for the market to determine the price of credits. The HRSTS has allowed for better regulation of cumulative impacts of discharge in the Hunter River and has provided increased flexible to mines and industry.

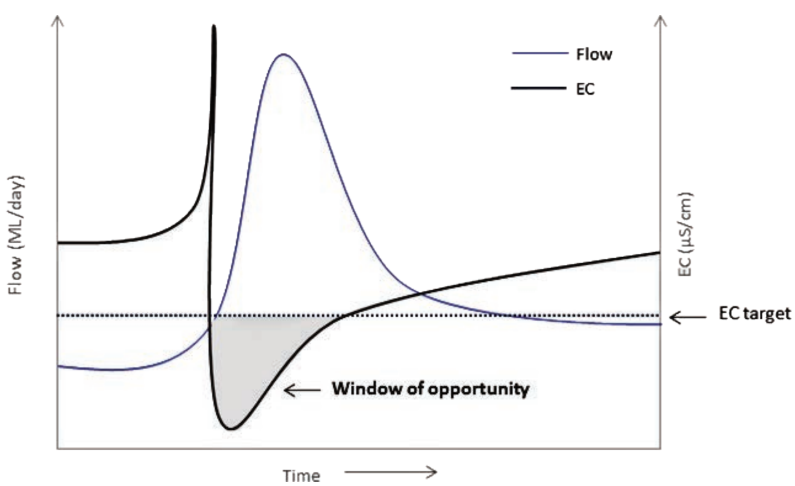

Fig. 3 *Calculation of Total Allowable Discharge is based on the repetitive decrease in salinity as flow increases.*

Regulation of Mine Water Discharge in the Fitzroy Catchment

Current discharge license conditions for mines in the Fitzroy catchment are specified in the Fitzroy Model Conditions. These conditions regulate end-of-pipe flow and salinity of mine water released to streams. These relatively conservative conditions were based on the best available data and designed to minimise impacts of mine discharge by ensuring that only water with a relatively low conductivity was discharged into streams with sufficient flow for dilution to achieve background stream salinities, typically around 300 µS cm^{-1}.

TEP’s granted to individual mines to alleviate excess water accumulation, allowed water with higher salinity (up to 6,500 µS/cm) to be released with less dilution from upstream flow. While the granting of the TEP’s is providing relief for the current situation, limited periods of stream flow, due to the ephemeral nature of the majority of streams, continues to restrict the volume of water able to be discharged. In addition there has been a considerable impost on the regulator considering TEP applications and anxiety on the part of the mines in terms of lost production and increasingly hazardous conditions of storages.

The overall objective of the work was to explore whether an alternative framework, similar to the salinity trading scheme currently used in the Hunter Valley, might be a more effective model to manage mine water release in the Fitzroy Catchment. Two sub-catchments (Isaac River and Mackenzie River) will be used as representative examples of the characteristics of streams in the Fitzroy catchment.

Comparison of hydrology and salinity relationships

Stream flow in the Fitzroy catchment is generally much larger and more variable than in the Hunter River (Fig. 4). Sub-catchment flows in the Isaac River are of similar magnitude as the Hunter River. Fig. 1b shows the ephemeral nature of the streams reflective of natural flows in the catchment. The Isaac River sub-catchment has approximately the same area as the Hunter River catchment. The ephemeral nature of stream flow in many catchments severely reduces the number of opportunities for mine discharge.

Fig. 5 shows the relationship between salinity and stream flow in the Mackenzie River. Similar relationships are found in the Isaac River. It can be seen that the largest decrease in salinity occurs during the first flow events in the system at the beginning of the wet season. Later in the season there is very little decrease in salinity with flow. In fact the largest flow events exhibited a minimal corresponding decrease in salinity. Although characterising flow/salinity patterns in the Fitzroy was challenged by data availability & mine water discharge, the reduction in salinity during flow events was more moderate and variable in the Fitzroy compared to the Hunter River resulting in an overall lower assimilative capacity.

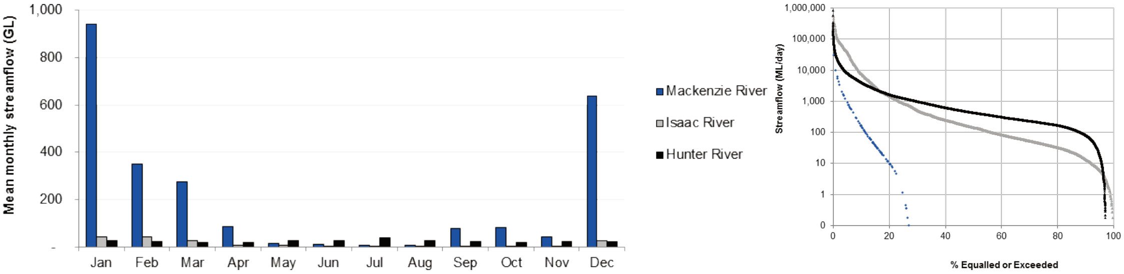

Fig. 4 *Comparison of streamflow characteristics of the Isaac and Mackenzie River sub-catchments with the Hunter River.*

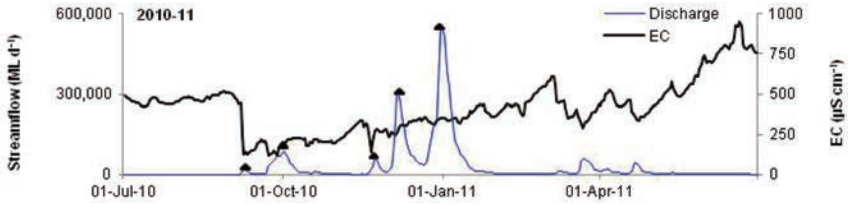

Fig. 5 *Streamflow and salinity relationships in the Mackenzie River.*

In the HRSTS, 12 hours advance notification time of an opportunity to discharge is considered the minimum degree of notice to allow sufficient time for salinity credit trading and preparation for discharge on sites. Often 24–48 hours notification can be given, particularly for the middle and lower sectors of the Hunter. Travel times for peak flows are much faster in the Fitzroy catchment. Fig. 6 shows typical travel times for flows in the Isaac River. It can be seen that mines located upstream of Goonyella would be required to prepare and trade credits within 10 hours of a stream flow event. Downstream of this point travel times increase but are still within 24 hours to Deverill. The majority of mines in this catchment are located upstream of Deverill. The implications of this is that both the mines and regulator will be required to invest in significant automated monitoring and infrastructure associated with releases. The risk is that if the monitoring/release system malfunctions the likelihood of noncompliant discharge would be increased. In addition, the current model used to predict river flow would require significant upgrades to better predict salinity- flow relationships in order to allow calculation of total allowable discharge reliably and faster. One method to achieve this is to use real time rainfall measurements to drive the model, noting that in these catchments rainfall and rainfall intensity are highly spatially variable. This would represent not only a significant advancement of catchment models generally, but increases the level of risk if it is used solely as the means of authorising discharges. However, it could be used as a ‘be prepared’ warning for discharges

There are also significant implications associated with the location of the control monitoring points where total allowable salt load is calculated in the upper Isaac River. To maintain water quality objectives within the upper Isaac River, control points should be set upstream of the confluence with the Connors River, *i.e.* upstream of Yatton (Fig. 6). Flows from the Connors River provide considerable dilution of flows in the Isaac River. Thus if the control point is located below this confluence salinity in the upper Isaac River is likely to be much greater than the water quality objective. In addition, there are some instances where the Isaac River has relatively low flow compared to the Connors River. Thus, a monitoring point located downstream of the Connors river confluence may indicate suitable flows and salinity for mine discharge to occur, when conditions in the upper Isaac River may not be suitable.

Conclusions

Balancing mine water management and regulated discharge in ephemeral streams is challenging. Opportunities for mine water releases are limited and the lack of flow and a predictable flow salinity relationship complicates planning arrangements. From the analysis given above it can be seen that the stream flow and salinity characteristics of rivers in the Fitzroy catchment have a lower assimilative capacity and significantly faster travel times than the Hunter River. The ephemeral streams, such as the Isaac River, also provide far fewer opportunities for mine water release due simply to the lack of stream flow throughout most of the dry season. In addition, careful consideration must also be given to the location of control monitoring points to ensure that sufficient flow and

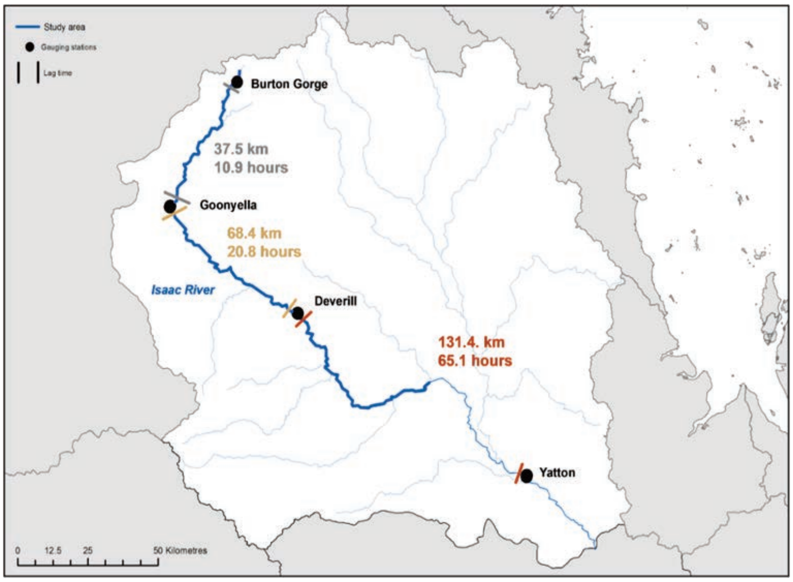

Fig. 6 *Travel times of peak flows in the Isaac River.*

salinity conditions exist in the river for mine discharge to occur.

The flow and salinity relationships in the Fitzroy catchment are not likely to allow direct translation of the Hunter River Salinity Trading Scheme as a mechanism for regulating mine water discharge management in the Fitzroy. Significantly more monitoring stations would be required to link to an automated network. In addition significant investment would be required to enhance the predictive capability of catchment models, particularly where stream flow is highly dependent on spatial rainfall characteristics. Perennial flowing streams with more predictable flow-salinity relationships may be more suited to this type of regulatory regime.

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