water e-journal
Online Journal of the Australian Water Association
ISSN 2206-1991
Volume 1 No 2 2016
http://dx.doi.org/10.21139/wej.2016.018

ECOLOGICAL RISK ASSESSMENT OF WASTEWATER DISCHARGES

INFORMING SENSIBLE OUTCOMES

A Laidlaw, J Day, J Mullins

ABSTRACT

In 2008, North East Water implemented an ecological risk assessment (ERA) program for wastewater treatment plants (WWTPs) that discharge to waterways. The aim of an ERA is to use science to determine the level of risk that a wastewater discharge may pose to a receiving waterway. This evidence is then used to inform management decisions, such as treatment upgrades or amendments to discharge licences. An ERA was conducted for North East Water's Beechworth WWTP and is summarised here as a case study of a successful ERA.

North East Water's Beechworth WWTP discharges treated wastewater to a nearby waterway and has historically breached the discharge licence limits set by the Victorian environmental regulator. A major infrastructure upgrade was planned to meet discharge compliance when North East Water was invited by the regulator to participate in a pilot ERA in 2008. Catchment stakeholders were engaged at each stage of the process. Data was collected over a number of years and the eventual findings indicated that the discharge had minimal impact on the values of the receiving waterway.

North East Water worked closely with the regulator to utilise the outcomes of the ERA to amend the discharge licence and commit to continual environmental improvement. The outcome has resulted in the WWTP meeting discharge compliance for the first time in 40 years. The ERA process was unprecedented and at times challenging, but demonstrated that an evidence-based approach can achieve an outcome that is agreeable to all parties including the environment and North East Water's customers.

Keywords: Ecological risk assessment, wastewater discharge, wastewater treatment, environmental regulation.

INTRODUCTION

In Victoria, smaller towns have commonly been serviced by lagoons for sewage treatment. North East Water operates 20 WWTPs, with 18 of them utilising lagoon-based treatment processes. The Environment Protection Authority (EPA), Victoria's environmental regulator, licenses each WWTP that discharges to a waterway. Licence conditions include stringent discharge limits for various physical, chemical and microbiological parameters, which has driven a change towards full land-based agricultural reuse. North East Water has eight remaining licensed WWTPs that discharge to waterways. Two of these are biological nutrient reduction processes that meet strict nutrient limits, with six being lagoon-based systems. Chemical-assisted sedimentation is generally utilised for phosphorus and suspended solids removal, but nitrogen removal is limited.

Beechworth is a small tourist town with a resident population of 3,680 located in sub-alpine north-east Victoria, Australia. The Beechworth WWTP is a lagoon-based system and consists of the following components:

- Two primary lagoons in series
- Six secondary lagoons in series
- Polishing lagoon
- Chemically-assisted sedimentation (CAS)
- Discharge outfall to waterway
- 28 ha of agricultural reuse irrigation.

Figure 1 shows the treatment process in schematic format.

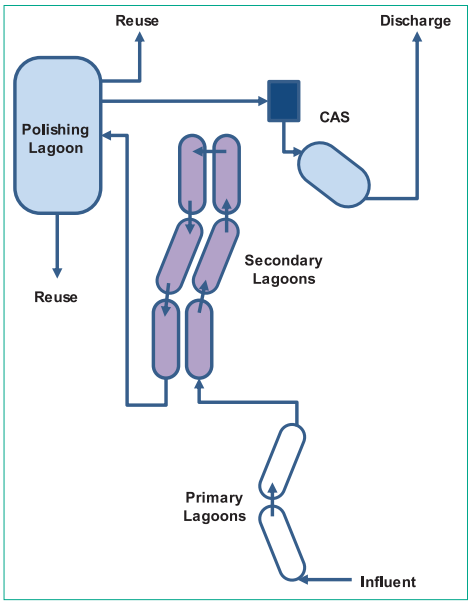

Figure 1. Beechworth WWTP process schematic.

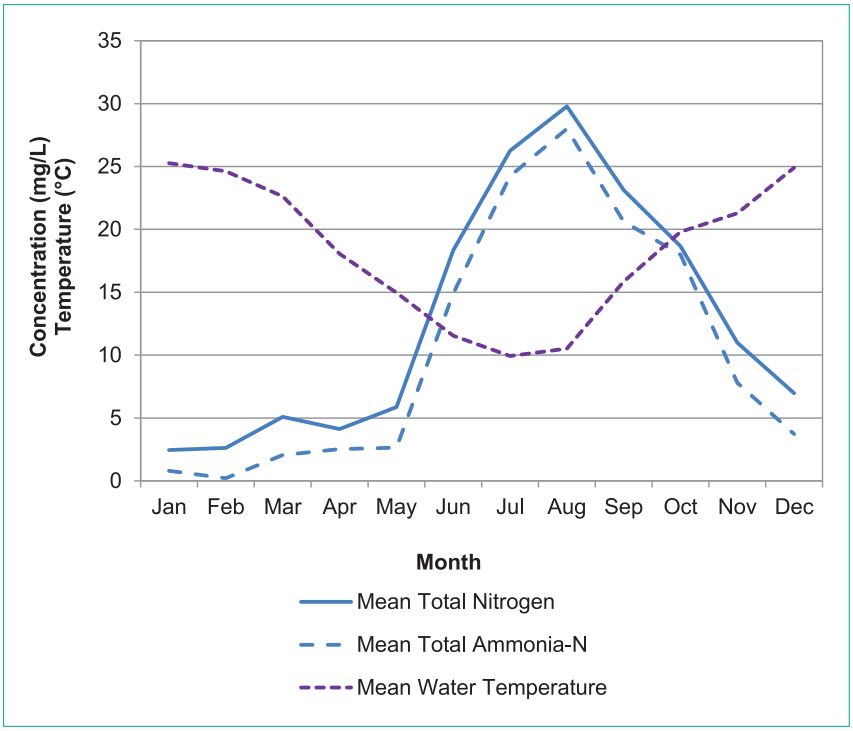

Figure 2. Mean total nitrogen and total ammonia-N concentrations in the discharge with mean lagoon water temperature (2003–2013).

The Beechworth WWTP experiences cold, wet winters and hot, dry summers. Discharge typically occurs during the cooler months of the year when nitrification in the lagoons is limited. No ammonia-nitrogen is removed when the lagoons reach a temperature of 15°C or less (Jeffrey, 2008). The average winter temperature in the lagoons is just 10.7°C, which results in elevated total ammonia-nitrogen concentrations from the months of May through November (Figure 2). Ammonia-nitrogen makes up a large proportion of total nitrogen.

The discharge licence for Beechworth WWTP was issued by EPA in 1975 to the then Beechworth Sewer Authority. In 1997, the licence was transferred to the newly formed North East Water along with 18 other WWTP licences. North East Water typically complied with all parameters on the licence except for total nitrogen and total ammonia-nitrogen, which had annual median limits of 20 mg/L and 5 mg/L respectively.

The WWTP has historically failed to meet EPA licence compliance. Despite a number of process improvements, the effluent discharged from the WWTP contains elevated total ammonia-nitrogen during the cooler months due to limited biological activity within the lagoons. There is no capacity for urban reuse and very limited capacity for agricultural reuse due to high rainfall and unsuitable local topography and geology.

The licence limits were arbitrary, unchanged since 1975, and had never matched the actual performance of the WWTP or considered the receiving waterways. The annual median value is calculated for each parameter at the end of the year at monthly intervals and must be lower than the limits listed in the discharge licence to be compliant. This presented a problem for the Beechworth WWTP licence, as discharge did not occur each month and, when it did occur, total nitrogen and ammonia-nitrogen concentrations were generally elevated.

Discharge typically occurs from April to October at a rate of up to 1.2 ML/day. Discharge is to the small Spring Creek, which subsequently flows into the larger, perennial Reedy Creek just downstream of the WWTP. The discharge was non-compliant almost every year for total ammonia-nitrogen and in some years for total nitrogen. The compliance limits were in place to protect the environment, but the level of protection provided or required was uncertain.

North East Water had been in discussions with the EPA for nearly a decade to resolve issues relating to the Beechworth WWTP discharge non-compliance. These conversations were steering towards an expensive mechanical plant solution. Both waterways have been extensively modified by historical mining activities, including sluicing and dredging, and their natural courses have been realigned. Spring Creek also receives the bulk of stormwater from the Beechworth township and monitoring of background conditions indicates that poor water quality events occur regularly. The discharge period coincides with elevated total ammonia-nitrogen concentrations in the lagoon and, as a result, the Beechworth WWTP has been generally non-compliant with discharge licence limits.

A biological nutrient reduction (BNR) plant was designed during 2007 as a solution to the compliance challenges. Budget estimates and approaches to market indicated that this solution was not financially viable in terms of capital (approximately $6 million) or operating expenditure. It was agreed with the EPA that the Beechworth WWTP upgrade would be deferred until the risk to the environment was assessed.

METHOD

North East Water was invited by the EPA to conduct a pilot ERA for the Beechworth WWTP under EPA's *Draft Guidelines for Risk Assessment of Wastewater Discharges to Waterways* (EPA, 2008). North East Water accepted, but it was unclear at the time how the evidence-based findings would ultimately be utilised by North East Water or the EPA. The EPA's risk assessment framework consists of four key stages:

1. Problem formulation
2. Risk analysis
3. Risk characterisation
4. Decision-making and risk management.

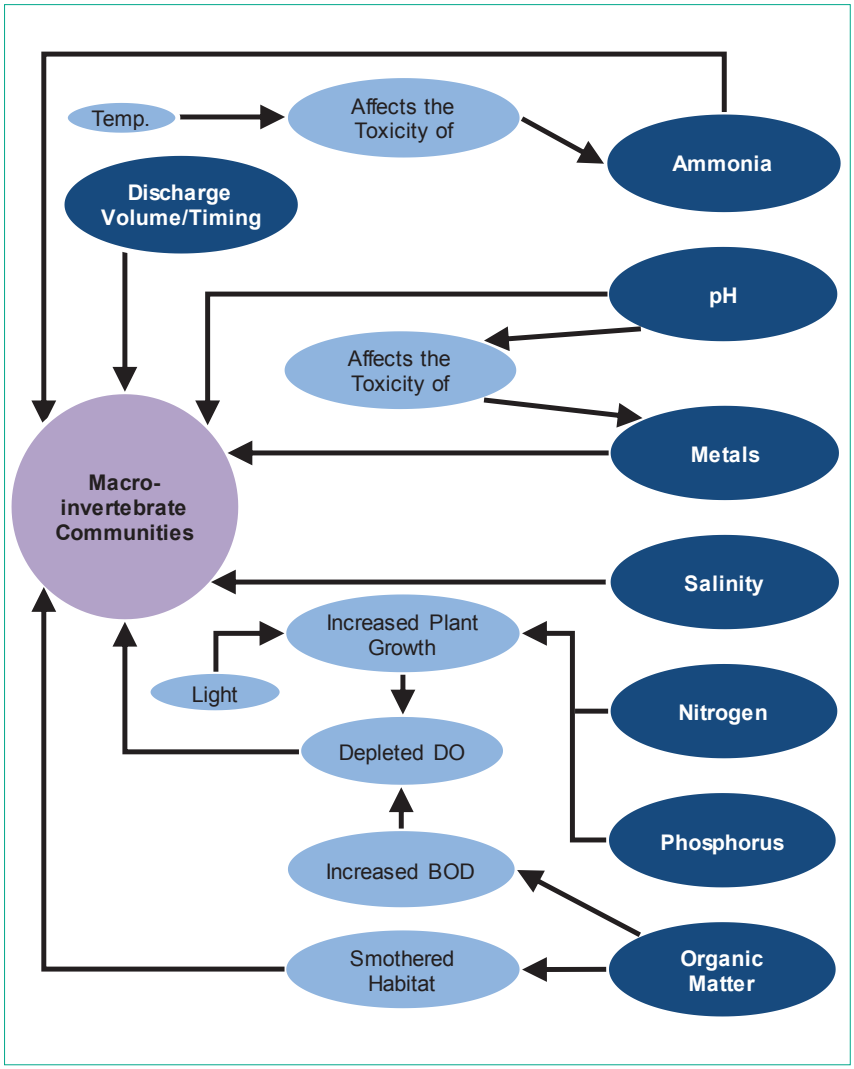

Figure 3. Conceptual model for macroinvertebrate communities.

These stages are generally approached sequentially, but may be revisited during the progress of the ERA.

Problem Formulation

A problem formulation workshop was held with stakeholders in March 2008 to determine the scope of the ERA. The group included members of the EPA, the local Catchment Management Authority, local government and community stakeholders. The group identified key beneficial uses and values of the waterway. These are aspects of the water environment that the community wants to protect and can include not only ecological values, but also social, health, cultural and economic values. Stressors contained in the discharge and their interactions with these values were also identified. This initial risk screening was used to develop conceptual models, which are tools used to simplify these often complex relationships. As an example, Figure 3 sets out a conceptual model for macroinvertebrate communities. The outcome from this stage of the ERA was a Risk Analysis Plan that set out the actions required to quantify the potential risk.

Risk Analysis

North East Water had been collecting water quality data in the receiving waterways since 2006, but more specific monitoring programs were required to focus on key risks as part of the risk analysis stage of the ERA. This included additional water quality monitoring, biological assessment and algae (chlorophyll) monitoring. These programs were conducted over a two-year period towards the end of the Millennium Drought – one of the worst droughts experienced in south-eastern Australia.

Risk Characterisation

This is the evaluation and reporting stage of the ERA. Data collected in monitoring programs (assessment endpoints) were compared with environmental objectives (measurement endpoints). Water quality and biological objectives set out in the State Environment Protection Policy (Waters of Victoria) (EPA, 2003) were used as the measurement endpoints. Figure 4 sets out biological monitoring data for the two receiving waterways in comparison with environmental objectives. This data was used to gain an understanding of background and impact conditions in the receiving waterways, as well as other waterways in the catchment, including reference waterways. It was found that background and impact sites in Spring Creek (the receiving waterway) failed to meet the SEPP (WoV) objectives. This indicated that the receiving waterway was in poor condition upstream and downstream of the discharge point. Nearby Reedy Creek, which Spring Creek flows into, just downstream of the discharge point, was found to be in a healthy condition.

The impact of the discharge on fish species was then investigated through a study on ammonia. Total ammonia-nitrogen comprises two ammonia species: un-ionised ammonia NH_3 and the ionised ammonium ion NH_4^+. Ammonia toxicity increases as pH and temperature increase due to the existence of more un-ionised NH_3. While ammonia concentrations in the discharge are at their highest at low temperatures, less un-ionised NH_3 exists at these temperatures and, consequently, ammonia toxicity is lower. At sufficiently high pH levels, un-ionised NH_3 forms a large portion of total ammonia and dominates toxicity. Hence, un-ionised NH_3 can be used to represent ammonia toxicity (USEPA, 2013). Figure 5 sets out the percentage of un-ionised

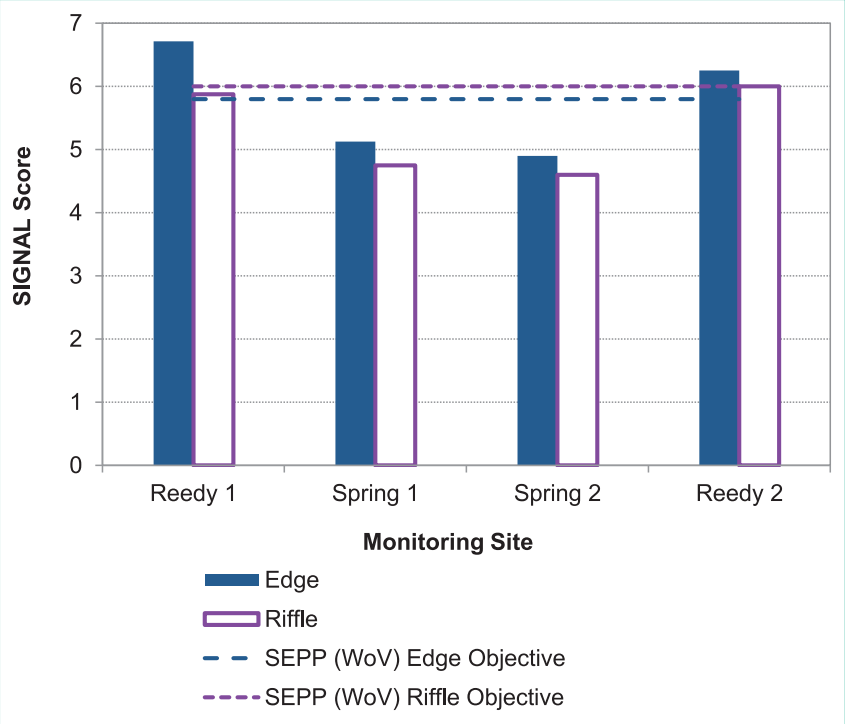

Figure 4. Biological monitoring data and environmental objectives.

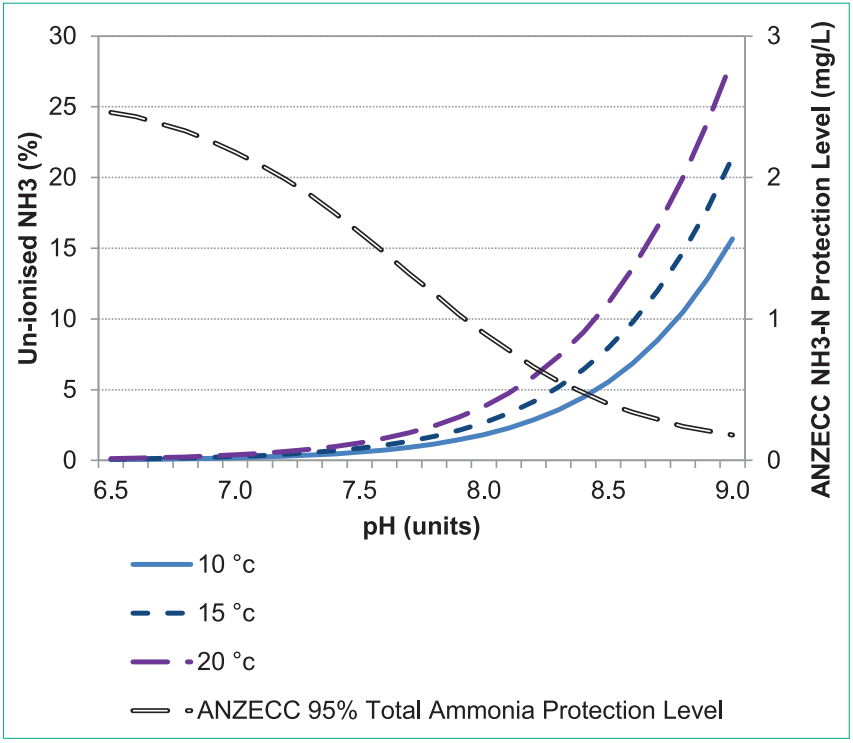

Figure 5. Effect of pH and temperature on ammonia toxicity.

NH_3 present at different pH levels and a range of temperatures on the primary vertical axis in comparison to the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ, 2000) 95% protection level.

It can be seen that at lower temperatures when discharge generally occurs, there is less un-ionised NH_3 present at a neutral pH and, hence, the impact on fish species is lower to negligible. This information, combined with the absence of native or recreational fish species in Spring Creek, was used to prove that there was negligible impact on fish species in Spring Creek. However, in nearby Reedy Creek, Mountain Galaxias and Southern Pygmy Perch had historically been recorded. While research and expert advice indicated that neither of these species were likely to inhabit the waterway, total ammonia-nitrogen data was used to assess the likely impact to these fish species if they were to occur there.

A historical maximum total ammonia-nitrogen concentration of 0.8 mg/L was recorded in Reedy Creek downstream of the discharge, which was only marginally higher than background conditions that appeared to be influenced by other catchment inputs. By monitoring the pH, temperature and total ammonia-nitrogen concentration, an understanding of the toxicity effects is possible in comparison to Figure 5.

In addition to other data collected, the biological and ammonia toxicity studies were used to provide a better understanding of the conditions in the receiving waterways. From here, a risk assessment was conducted to score and rate the risks to each value. A Risk Characterisation Report was developed by North East Water in 2010 that summarised all of the ERA findings and the subsequent risk posed to values of the waterway.

The ERA found that the key beneficial values of the waterway at risk from the discharge were:

- Ephemeral stream habitat;
- Appearance of plant and algae communities;
- Macroinvertebrate communities;
- Native fish populations.

The key interactions that posed a risk to these values were nutrient enrichment (nitrogen, phosphorus) and toxicity (total ammonia-nitrogen).

The ERA found that the discharge posed some risk to beneficial values under drought conditions due to low passing flows and decreased dilution. However, under normal operating conditions the discharge posed a

low risk to all beneficial values of the receiving waterway.

Decision-Making And Risk Management

This is the final stage of the EPA's ERA process. The EPA had agreed with the results of the ERA and findings of the Risk Characterisation Report, but there were still some gaps largely related to data collected under drought conditions that occurred during the ERA. These conditions were a significant influencing factor on the risk posed to beneficial values. North East Water agreed to address these uncertainties by continuing with more refined monitoring programs.

North East Water had now essentially completed the ERA, but there was little guidance from EPA or elsewhere on how to utilise the findings to bring about a change, or what that change may be.

Figure 6. Secondary lagoons with fixed media visible on right.

Results And Discussion

North East Water worked through potential options to meet discharge compliance. This included licence amendments, storage augmentation, irrigation expansion, seasonal licence limits and combinations of each. Options assessments indicated that storage augmentation was not possible due to the geology, and irrigation expansion was not feasible due to nil irrigation demand and the cost of acquiring more land (up to $12 million). With evidence indicating a low risk to the environment, North East Water and the EPA agreed to commence with an amendment of the licence limits as part of the compliance solution.

A licence amendment using the findings of an ERA as the basis was unprecedented in Victoria, and initially there was no clear pathway. The EPA and North East Water worked together to develop a way to accommodate this new type of amendment. This was a lengthy process and involved further information exchange between both parties and, more broadly, within the EPA. It was eventually agreed that the EPA's existing provisions for licence amendment would be adapted to provide a pathway.

North East Water was proposing discharge limits for total nitrogen and total ammonia-nitrogen of 25 mg/L and 20 mg/L respectively. These were marked limit increases (particularly so for total ammonia-nitrogen) and supporting justification would prove to be important to contextualise them.

Now that North East Water and EPA shared an understanding of the way forward in terms of the licence amendment, the next stage was to communicate the proposed changes to catchment stakeholders. The EPA convened a stakeholder meeting with representatives from the local Catchment Management Authority, local government, Parks Victoria and the bulk water supplier. This provided an opportunity for the stakeholders to revisit the Beechworth WWTP ERA and provide feedback to North East Water on the proposed changes. The outcome was a level of comfort among the group and agreement that the proposed changes were appropriate.

North East Water submitted a licence amendment application proposing discharge limits for total nitrogen and total ammonia-nitrogen of 25 mg/L and 20 mg/L respectively to the EPA. Supporting documentation including a number of ERA reports was also provided to the EPA. This application represented the instrument to formalise the licence changes. In August 2013, the EPA issued North

East Water with a draft discharge licence for review, which incorporated the proposed changes. North East Water approved the draft licence and in November 2013, five years after commencing the ERA, the amendment was completed when the EPA issued an updated discharge licence.

The licence amendment has been effective in improving compliance at Beechworth WWTP and all EPA annual discharge licence limits were met for the first time in 2013–2014 and have been met continually since.

Ongoing Environmental Improvement

With discharge compliance challenges largely met via the licence amendment, North East Water increased the focus on providing benefit to the environment.

A staged upgrade strategy was put in place to deliver incremental environmental improvement over the coming years. The first stage was completed in 2013 and involved the installation of fixed media with aeration in one secondary lagoon to increase biological activity in the cooler months and improve nitrogen removal (Figure 6).

This upgrade has resulted in the additional removal of approximately 6 mg/L total ammonia-nitrogen across the process.

North East Water has committed to ongoing performance monitoring of the WWTP and monitoring of the receiving waterways to verify that the level of risk posed to beneficial uses does not increase.

CONCLUSION

The EPA's ERA process provided the opportunity to scientifically assess the impact of a wastewater discharge on the environment.

North East Water's experience working with the EPA has been positive and highlighted each party's commitment to work through complex challenges. Importantly, North East Water is confident that the approach refined in the Beechworth ERA will provide a platform for assessing other similar WWTPs. Involving stakeholders at each stage of the ERA process and beyond provided them with ownership of the process and an understanding of the eventual changes to the discharge licence. This open and transparent approach not only helped to develop the ERA, but also the relationship between agencies. This is particularly important in a process that can span a number of years. It is fundamental to the ERA process that stakeholders understand the problems and their solutions.

By using the ERA process to inform a discharge licence amendment based on science, the Beechworth WWTP is now able to meet discharge compliance. This negated the need for investment of approximately $6 million in intensive mechanical treatment technology, which would ultimately have been paid for by North East Water's customers. More focused investment is now occurring to provide incremental environmental improvement.

North East Water has since completed ERAs for seven of the eight WWTPs that discharge to waterways. Outcomes from these include licence amendments and planned capital upgrades. Additionally, ERAs have also commenced for WWTPs that may discharge during periods of wet weather. These will assist to inform arrangements for emergency discharges or application for discharge licences. North East Water is continuing to work with the EPA to utilise the ERA findings and deliver sensible outcomes to both the environment and customers.

ACKNOWLEDGEMENTS

The Authors would like to thank the Environmental Protection Authority Victoria, North East Office for its hard work and assistance over a number of years; staff at the Environmental Protection Authority Victoria, Melbourne Office who assisted along the way; the various catchment stakeholders who contributed throughout the various ERAs; and North East Water's Environment and Wastewater team.

THE AUTHORS

Alister Laidlaw (email: alaidlaw@newater.com.au) is the Water Systems Coordinator at North East Water. Alister has been part of North East Water for eight years, initially working on the Ecological Risk Assessment program before moving into the areas of drinking water quality, water resource management and drought response.

John Day (email: jday@newater.com.au) is the Executive Manager Operations at North East Water. John oversees the critical functions of water and wastewater treatment and delivery. This includes playing a key role in the delivery of the Ecological Risk Assessment Program.

Jason Mullins (email: jmullins@newater.com.au) is the Manager Systems Optimisation at North East Water. Jason has spent 11 years with North East Water focusing on process improvements and maturing key management systems, including both environmental and drinking water quality. Jason has been involved with the Ecological Risk Assessment Program at North East Water since 2008.

REFERENCES

ANZECC/ARMCANZ (2000): *Australian and New Zealand Water Quality Guidelines*, Australia and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

EPA Victoria (2008): Draft Guidelines for Risk Assessment of Wastewater Discharges to Waterways, *Publication Number 1209*, Environment Protection Authority, Melbourne.

EPA Victoria (2003) Variation of State Environment Protection Policy (Waters of Victoria). *Government Gazette No. S107*, Environment Protection Authority, Melbourne.

Jeffrey GC (2008): Temperature and the Nitrification Process at Beechworth WWTP, BSc Hons Thesis, La Trobe University, Wodonga.

USEPA (2013): Aquatic Life Ambient Water Quality Criteria For Ammonia – Freshwater, EPA 822-R-13-001, United States Environmental Protection Authority, Washington.