MANAGING WATER QUALITY IN THE HUNTER

Paper Presented by:

Darren Bailey

Authors:

Darren Bailey, *Manager Treatment Operations,*
David Turner, *Manager Operations Support*

Hunter Water Australia

7^{th} Annual WIOA NSW Water Industry Operations Conference and Exhibition
Exhibition Park in Canberra (EPIC),
9 to 11 April, 2013

MANAGING WATER QUALITY IN THE HUNTER

Darren Bailey, *Manager Treatment Operations,* Hunter Water Australia
David Turner, *Manager Operations Support,* Hunter Water Australia

ABSTRACT

Hunter Water Australia (HWA) is a subsidiary company of Hunter Water Corporation (HWC), a public utility providing water and wastewater services to around half a million customers in the lower Hunter region of NSW. HWA has been contracted since 1998 to operate HWC's water and wastewater treatment plants. Supplying a safe, reliable and aesthetic product is a critically important function of a water supply utility. Hunter Water's performance is regulated by the NSW Independent Pricing and Regulatory Tribunal (IPART) via an operating licence, and performance is audited annually. The operating licence is aligned with the Australian Drinking Water Guidelines and the 'Framework' embedded within the guidelines.

Significant effort has been applied by Hunter Water towards implementing and continuously improving performance against all of the Framework elements. This has included comprehensive risk assessments for each supply system from catchment through to customer and management of Critical Control Points (CCP) throughout each supply system. A strong continuous improvement culture has allowed refinement of infrastructure and systems to maximise the utility of existing assets, which has deferred the need for major upgrades. Emerging water quality risks and more stringent performance standards have driven developments in monitoring and control. Tightening water quality targets, such as the latest ADWG revision to filtered water turbidity limits, have focused attention on accuracy, precision and reliability of monitoring. Using existing infrastructure to achieve a higher performance standard also inevitably reduces tolerance for process deviations, which has driven improvements in data and information management, automation and contingency planning. The aim of this paper is to provide an overview of Hunter Water's approach to managing drinking water quality and to provide examples of strategies employed to achieve regulatory compliance, improve performance and reduce risk.

1.0 INTRODUCTION

Hunter Water Australia (HWA) has been contracted since 1998 to operate and maintain six water treatment plants in the lower Hunter region of NSW. These plants supply approximately 70 GL of drinking water each year and service around half a million customers in six local government areas. The majority of supply is derived from surface water sources in well-protected catchments with low to moderate microbiological, organic and inorganic risks. High quality water is also sourced from shallow sand aquifers. The level of treatment is tailored to each water source and includes aeration, direct filtration, 2-stage filtration, conventional treatment, and membrane filtration processes. An overview of the main elements for managing drinking water quality within Hunter Water is shown in Figure 1.

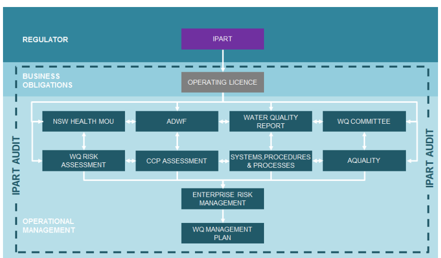

Figure 1: ***Main elements for managing drinking water quality***

Performance and pricing is regulated by the NSW Independent Pricing and Regulatory Tribunal (IPART) via an operating licence and performance is audited annually. The operating licence is aligned with the Australian Drinking Water Guidelines and the Framework for Managing Drinking Water Quality (the Framework) within the guidelines.

Hunter Water has a Memorandum of Understanding (MOU) with the NSW Department of Health. This document defines the roles and responsibilities of each agency with regard to protecting public health and covers areas including water quality monitoring, information exchange, access rights, incident notification, incident response and rectification, and regulatory reporting. The two agencies also hold regular liaison meetings.

An internal Water Quality Committee convenes monthly and reports to senior management. The committee is comprised of management and technical representatives who have either operational or planning responsibilities for catchment, treatment or distribution of drinking water. The key functions of the committee with respect to drinking water quality are to:

- Oversee and review performance against the Operating Licence and ADWG
- Review the quality of raw water and treated water supplied to customers
- Review current and planned operational changes
- Review current and emerging issues and regulatory changes
- Verify that effective action is taken in response to variations and exceptions
- Operate as a core knowledge management centre.

1.1 Framework for Managing Drinking Water Quality

The ADWG Framework consists of the 12 elements shown in
Figure 5. The brevity of this paper does not allow detailed discussion of all components. Instead, attention will be focussed on the elements 2, 3, 4 and 12, which relate to risk identification, risk assessment and continuous improvement.

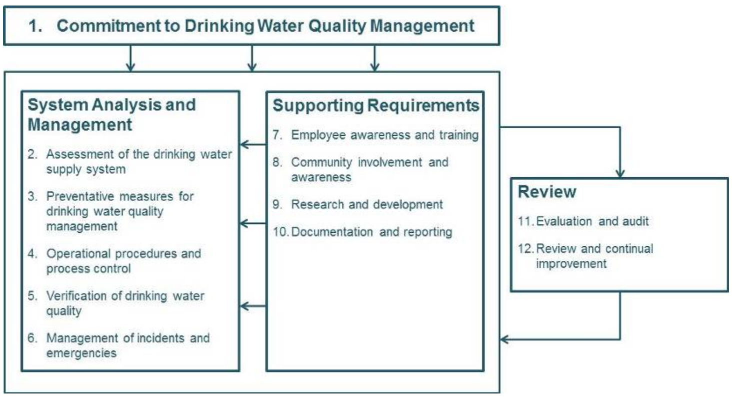

Figure 5: ***Elements of the ADWG Framework***

1.2 Risk Assessment

The ADWG Framework advocates risk-based approach from catchment to tap for managing drinking water quality. To this end, for each supply source a systematic process was undertaken to identify and assess risks. This process involved a series of workshops with participants selected on the basis of expertise and area of responsibility. Risk assessment workshops were conducted for the catchment, treatment and distribution components of each water supply source. As a key stakeholder, NSW Health also participated in some of these workshops.
The first step involved preparing a simple 'system diagram' such as shown in Figure 3.

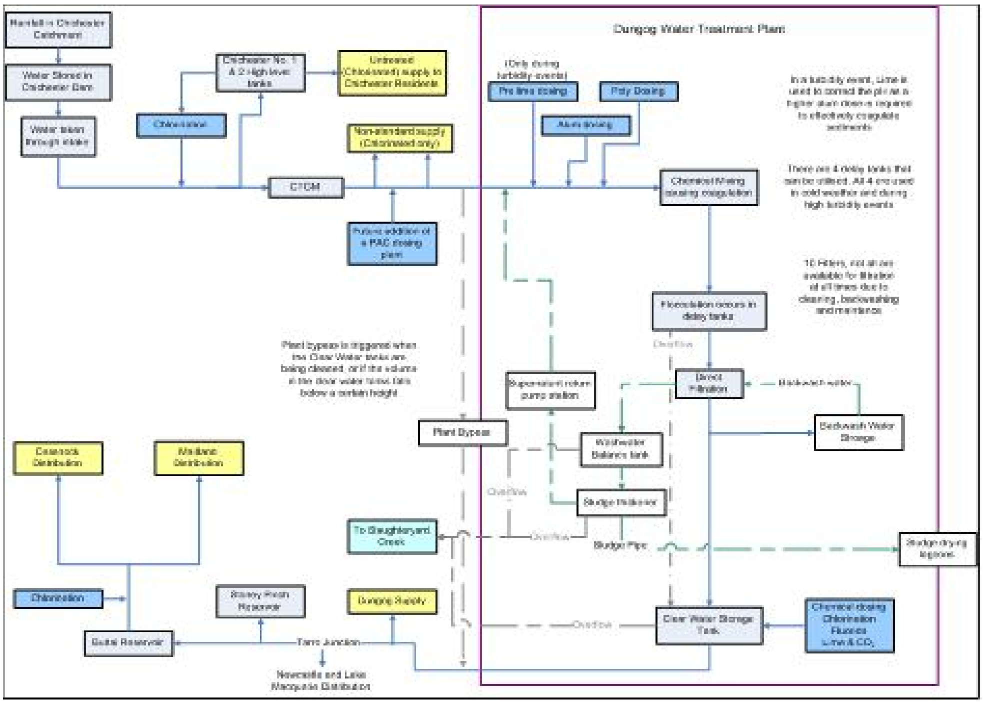

Figure 3: ***Example 'system diagram' used to assist with risk assessments***

The risk assessment process then involved:

- Identifying water quality hazards and potential sources of these hazards
- Identifying existing hazard control measures
- Determining residual risks through a standard likelihood and consequence assessment
- Identifying possible actions to improve water quality or reduce risk

This risk assessment methodology was applied for five separate water supply sources and six treatment plants. Each risk assessment is now revisited following any significant changes and at least once every five years. The output from the risk assessments was a highly detailed understanding of the hazards and risks for each water supply system, as well as a prioritised list of potential improvements and risk mitigation strategies.

1.3 Critical Control Points

The ADWG Framework defines a critical control point (CCP) as "*an activity, procedure or process at which control can be applied and which is essential to prevent a hazard or reduce it to an acceptable level*".

Critical control point assessment involved the following steps:

- Identifying water quality hazards
- Identifying CCPs for each supply system
- Identifying existing hazard controls
- Identifying CCP monitoring measures, target values, and exception/critical limits
- Developing effective CCP excursion response processes and procedures
- Validating CCP monitoring and response processes
- Documenting the CCP assessment process.

This methodology was applied for each water supply source. A snapshot of an example CCP summary report is shown in Figure 4.

Chichester Supply System - Critical Control Points for Management of Drinking Water Quality								Date: 10/11/08 - Revised 22/09/11
CCP	Activity / Process	Hazard(s)	Parameters	Target Limits	Critical Limit	Monitoring	Corrective Actions	Verification
2	***Protected & Monitored Dam Storage***	Pathogens (bacteria, viruses, protozoa), Turbidity, Pesticides, Chemical/Feul spills	Pathogens (bacteria, viruses, protozoa), Turbidity, Pesticides, Chemical/Feul spills	Water Treatment Contract raw water limits Zero presence for other parameters	Water Treatment Contract raw water limits ADWG limits for other parameters	Weekly sampling & analysis of Dam Ranger patrols include inpsection of Dam Public reporting of any spills	Source substitution PAC treatment Remediation of contaminant Containment of contaminant using booms Emergency response protocol	Grahamstown raw water quality monitoring data Treatment & Distribution data Complaints data
3	***Destratification of water storage***	Manganese, Iron, Blue Green Algae	DO %	Dissolved oxygen concentrations less than 85% of saturation for 2 consecutive weeks for any dam profile sample (except bottom sample which may be inconsistent).	80% DO saturation between Apr - Oct, and >60% Nov - Mar	Weekly sampling & analysis of Dam profile	Optimisation, adjustment and/or repair of destratification equipment	Dungog raw water quality monitoring data (Dam Data)
			Soluble manganese (Mn)	Soluble manganese concentration >0.025mg/L for any dam profile sample	Soluble manganese concentration >0.025mg/L for any dam profile sample			
			Temperature (℃)	Temperature gradient does not exceed 3℃	Temperature gradient does not exceed 3℃			
4	***Dam Chlorination***	Pathogens (bacteria, viruses, giardia, algal toxins), soluble Mn	Chlorine (mg/L)	Target = 0.9mg/L	0.5mg/L (low) to 1.5mg/L (high), with 1 hour delay	Continuous online monitoring, equipment calibration, daily inspection of chlorination equipment by care takers, daily grab sample at down stream site (Dusodie).	Optimisation and/or repair of equipment, Optimisation of Dungog WTP post-filtration disinfection	Calibration and maintenance of equipment, grab samples for chlorine residual, and mircobiological quality, algal toxin monitoring (in the event of toxicity being detected in raw water)
5	***PAC dosing facility (temporary)***	Taste & Odour (Geosmin & MIB), Algal toxins	Geosmin (ng/L)	Geosmin <20ng/L	Failure in dosing of nominated dose rate of PAC for removal of Geosmin & MIB or toxins	Turbidity of Dungog WTP raw water as surrogate for PAC concentration, supervision & records of batching kept from dosing pump operation	Optimisation and/or repair of equipment	Taste & Odour monitoring (MIB & Geosmin), Algal toxin monitoring, Customer complaints, daily taste testing
			Microcystin (ug/L)	Microcystin <1.3ug/L				
			MIB (ng/L)	MIB <5ng/L				
6	***Coagulation & Filtration***	Pathogens (bacteria, viruses, protozoa), Turbidity	Turbidity (NTU)	<0.3NTU at all times	Filter turbidity <0.5NTU 95% of time, MAX 5NTU, Alum & Poly system availability	Continuous online monitoring and daily grab sample, SCADA priority 1 alarms[1] 0.5NTU after 40mins, pH 6.7 high & low pH 5.5 after 30mins	Backwash filters, pre-lime dose, adjust alum/polymer dose, adjust flocculation time, adjust alum/polymer lag, adjust Dam chlorination, check equipment (mixing, dosing, control, monitoring), adjust backwash parameters, check media condition	Calibration and maintenance of equipment, NATA accredited Drinking water quality monitoring, Customer satisfaction, Evaluation and audit, WTP lab testing, HWAL lab testing
			Coagulation (pH)	Coagulation pH 5.8-6.5	Coagulation pH >5.5 & <7.5			
7	***Dungog WTP Post-Filtration Disinfection***	Pathogens (bacteria, viruses, giardia), Algal toxins	CWT outlet pH	pH 6.5 - 8.5 (Target pH 7.6)	>pH8.5 for > 1 hour	Continuous online monitoring, and daily grab sample, SCADA priority 1	Adjust chlorine dose (at Dam or WTP), turbidity (check filtration), check	Calibration and maintenance of equipment, NATA accredited Drinking

Figure 4: *Example Critical Control Point summary*

1.4 Risk Mitigation Framework

Water utilities have many responsibilities, and options to reduce water quality risk need to be weighed against other competing areas such as safety, supply continuity and environmental risks. Available resources are finite, so all competing risks and opportunities need to be normalised and prioritised to ensure that available resources are allocated most effectively. Hunter Water uses an 'Enterprise Risk Management' tool to prioritise activities and allocate resources. This is a risk ranking tool that assesses consequence and likelihood to quantify and rank risks in context with other issues across the organisation. Available resources can then be applied to address the highest risk items.

2.0 DISCUSSION

The output of the various risk assessment processes described above is a prioritised list of corrective (or improvement) actions to reduce water quality risk. A register of actions is maintained to monitor progress on implementing these actions. Again, the brevity of this paper doesn't allow a detailed discussion of all improvement actions. However, some general trends are discussed further below.

2.1 Continuous monitoring

The risk-based approach in ADWG has resulted in more parameters being monitored at more locations and there has also been a trend of monitoring earlier in the water supply sequence.

2.2 Backup equipment

A greater emphasis on risk management has highlighted the need to have backup equipment for all critical processes. This backup is normally provided in the form of 'hot-standby' equipment. Significant effort has also been applied to maximise the flexibility of equipment to act as a common backup across processes and between plants.

Because contemporary treatment plants are so heavily reliant on automation, a lot of work has been done to ensure that core control systems including PLC hardware are robust and that failure of a single component doesn't result in failure of the whole plant.

2.3 Backup and 'inferential' monitoring

Online monitoring isn't effective unless it provides a true and reliable indication of the parameter being monitored. There has been a trend towards having backup analysers for all critical parameters. This is often for water quality but has increasingly been applied to level, flow and other critical monitoring parameters. In general, wherever the output from an instrument is used as the input for controlling a critical system, some form of backup monitoring should be in place. Otherwise, a situation could arise where an instrument reading incorrectly isn't detected before a serious problem develops. Backup monitoring is typically setup with a discrepancy alarm in place that activates if independent measurements of the same parameter deviate by more than a specified amount.

Backup monitoring may also be achieved by inference. Based on the characteristics of a dosing pump or a dosing control valve, the output can be inferred based on the speed of the pump or the position of the valve. This inferred dosing output can, in combination with a flow reading, be used to infer a dose rate. An alarm can be set to activate if the inferred dose rate deviates from what is expected.

2.4 Operational Data and Information Management

Collecting, assessing and responding to data is an important part of a drinking water quality management plan. Significant improvements have been made in the management of data and information. For operating data manually recorded at treatment plants, such as water quality and chemical dosing data, systems have been implemented to perform a range of statistical tests to automatically flag to operators when data points or trends are abnormal. Emails are also automatically generated and sent to supervisors which list all of these data 'exceptions' as well as the corrective actions recorded by the operators. This has proven to be an efficient and effective way to keep supervisors informed and allow them to get involved quickly when needed.

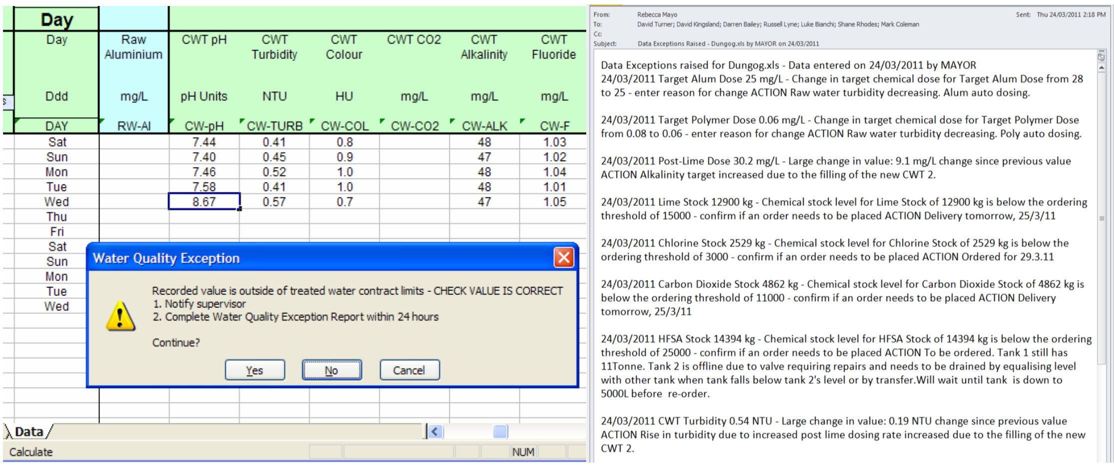

Figure 5: ***Plant data management system interface and example 'exception' email***

The effectiveness of workgroups is affected by how and where effort is applied. A challenge for operational workgroups is that available resources can be consumed by day to day imperatives. 'Crisis' issues typically have a high profile. Formal and informal reward systems are often biased towards recognising individuals who are good at 'putting out fires'. Strategic efforts applied to reducing risk and improving performance can be less tangible and can therefore be undervalued. To maximise effectiveness of HWA operations teams, details of all significant incidents and issues are recorded in a central register.

Each issue is assessed to identify root cause(s) and quantify risks before identifying options to reduce risk to an acceptable level.

Responsibility for implementing changes is assigned by a team leader or manager and prioritised on the basis of the risk-reduction/benefit achieved compared to effort/cost applied.

2.5 Automatic response

Reduced tolerance of water quality risks has resulted in more automation to ensure that any water quality problems are quickly contained and downstream impacts are avoided. Automatic isolation provides protection against poor water quality reaching customers and further tightening of standards will result in ever increasing reliance on automatic systems. However, each time this type of control logic activates it reduces production availability, which may bring forward the need for capacity upgrades.

2.6 Monitoring Validation

All measurement involves error and uncertainty. It is important that the total magnitude of measurement error is small compared to the magnitude of the parameter being measured. As water quality regulations become more stringent the accuracy and precision of monitoring equipment increases, as does the need to validate that the measurement is representative of what is occurring in the process being monitored.

2.7 Contingencies

Even with monitoring systems that detect and alarm water quality problems and control systems that isolate supply, contingencies are needed to allow supply of safe water to continue while problems are fixed. The risk based approach in the ADWG framework helps to identify weaknesses and options to address these weaknesses.

3.0 CONCLUSIONS

Water quality regulation in Australia will likely continue to become more stringent in line with community expectations of higher quality and reduced tolerance to risk. The potential loss of trust caused by a single water quality ‘incident’ could be irrevocably damaging to the reputation of a water utility. In some cases existing treatment assets won’t be able to achieve future performance standards, and there will be pressure to upgrade or build new plants. However, while technology solutions are available, funding sources will continue to be limited. Innovation will be needed to get the best possible performance from existing assets. Using better monitoring, controls and automatic response systems can help reduce water quality risks at relatively low cost. Effective systems for managing data and information are also fundamental to achieving continuous improvement. The ADWG provides a robust framework that can be used to manage water quality risks. However, effective application of this framework requires adequate resourcing and ongoing commitment.

4.0 ACKNOWLEDGEMENTS

Managing water quality requires the dedicated and concerted effort of a range of personnel in both Hunter Water Corporation and Hunter Water Australia. The authors gratefully acknowledge this contribution. Special appreciation is extended to Water Quality Engineer, Pam O’Donoghue and Water Quality Scientist, Bruce Cole.