WATER QUALITY AND DISTRIBUTION SYSTEMS – WHERE DO WE BEGIN?

Paper Presented by:

Patricia Rokahr

Author:

Patricia Rokahr, *Water Quality Officer,*

North East Water

78th Annual WIOA Victorian Water Industry Operations Conference and Exhibition
Bendigo Exhibition Centre
1 to 3 September, 2015

WATER QUALITY AND DISTRIBUTION SYSTEMS – WHERE DO WE BEGIN?

Patricia Rokahr, *Water Quality Officer,* North East Water

ABSTRACT

However effective treatment processes are in eliminating contamination of drinking water they cannot totally eliminate the build-up of sediment and the formation of biofilms in the distribution system. Taste and odour issues can occur due to a build-up of biofilm and other events occur that can potentially affect reticulation water quality, including: burst mains, replacement works, deteriorating old mains, irregular tank cleaning programs and flow/pressure variations that all contribute to sediment build up, water discolouration and microbiological growth within supply systems. As the distribution system represents the final barrier before delivery of drinking water to consumers, it is important that there is adequate management of this system. The purpose of this work was to develop strategies for improving water quality in our distribution systems.

A number of strategies have been put in place or are in the process of being put in place to reduce the risks identified, however the optimisation of our distribution systems will be an ongoing process that develops and matures over time.

1.0 INTRODUCTION

The Safe Drinking Water Act (2011) and the Australian Drinking Water Guidelines (2011) require the use of an integrated risk management framework, extending from catchment to consumer to deal with water quality risks to drinking water. In recent years attention has been given to dealing with the potential for contamination of drinking water from source waters and the proper selection and operation of treatment processes. The application of this framework has been successful in reducing waterborne outbreaks associated with inadequate treatment, but there are still outbreaks occurring that are associated with distribution systems, this suggests that more attention needs to be paid to the sound management and optimisation of distribution systems.

In recent years North East Water has made water quality improvements across its water treatment systems to meet quality objectives. The improvements to treatment processes, however beneficial to water quality, cannot totally eliminate water quality issues from occurring in the distribution system. Passage through the distribution system provides opportunity for microbial contamination and proliferation that is not easily managed.

Other physical and chemical processes can also occur in distribution systems, such as the build-up of sediment and formation of biofilms. Other events affecting reticulation water quality include: burst mains, replacement works, deteriorating old mains, irregular tank cleaning programs and flow/pressure variations which all contribute to sediment build-up, water discolouration and microbiological growth within supply systems.

1.1 Water Quality Issues in Distribution Systems

As is widely known most water quality issues in reticulated water systems are aesthetic (taste and odour) but there is also the potential for contamination causing serious health issues. According to Hrudey and Hrudey (2004), between 1995 and 1998 in the United States, 45% of all outbreaks in community water systems were attributed to deficiencies in distribution systems.

Some common hazards in distribution systems consist of:

- Pathogens (bacteria, viruses and protozoans);
- Chemical contaminants (from contaminated source waters, water treatment chemicals, backflow);
- Turbidity
- Natural organic matter (which may indicate microbial contamination, increase chlorine demand and provide nutrients for biofilm organisms);
- Algae:
    - Blue-green algae (BGA) toxins;
    - Aesthetic taste and/or odour issues produced by algae, bacteria or fungi; and

1.2 Optimisation of Water Quality in Distribution Systems

The optimisation of physical and operational conditions in the distribution system has the potential to achieve the following:

- Reduce disinfection by-products;
- Minimise microbial events;
- Improve disinfection residuals;
- Minimise the leaching of metals;
- Minimise biofilm growth;
- Reduce corrosion and minimise scale deposition;
- Minimise taste and odour complaints;
- Reduce overall customer complaints; and
- Reduce water detention times.

1.3 Main Objective

North East Water is at an early stage of an ongoing process of improving the management of water quality in our distribution systems. This paper is about showing what we did to begin the process of distribution optimisation and where we would like to go from here.

2.0 DISCUSSION

Before planning or undertaking improvements in the reticulation, it was necessary to understand what water quality risks were present, which were the greater risks and which were the risks that the Corporation could improve. A number of activities were undertaken to obtain this information and are described as follows.

2.1 An Operational Survey

An operational survey was given to each team working in distribution to determine what their current practices were. The survey was used to determine if the Corporation's current practices were adequate and consistent across all teams in regard to water quality and the following activities:

- Mains cleaning (flushing, scouring and pigging);
- Hygiene and sanitation during mains repairs and maintenance;
- Commissioning of new infrastructure;
- Treated water storages (inspections, seasonal tank levels);
- Cross connections;
- Backflow protection; and
- Areas of low pressure.

The survey results showed gaps in the way some routine distribution activities were carried out and that there is potential to improve and standardise distribution activities across the business.

A review of current literature produced a large amount of information on optimising distribution systems to improve water quality. Some information from the literature review provided practical strategies to reduce risk and were incorporated in the rapid risk assessment (see Section 2.3), and much of the remaining information was placed in a reference document. As improving water quality in the distribution will be an ongoing objective, this stored information will be useful for future reference.

2.2 Total / Free Chlorine Sampling

Free Chlorine / Total Chlorine ratios were measured weekly for one month by North East Water's contracted laboratory during routine verification monitoring. This took place for one month from October to November 2014. The reason for this testing was to determine if Free Chlorine decay was occurring in the reticulation with the resulting formation of distribution by-products that could be responsible for taste and odour issues. Ratios ≥ 0.9 indicate that most of the residual chlorine is in the form of Free Chlorine with little to no formation of by-products. Results < 0.8 can be seen in Table 2 below.

Table 2: ***Free/Total Chlorine Distribution Sampling Results < 0.8***

Location	No. samples taken	Values < 0.9
Beechworth	9	0.6, 0.7, 0.8, 0.8, 0.8
Mt Beauty/ Tawonga	11	0.6,0.7,0.8, 0.8
Porepunkah	4	0.7
Rutherglen/ Wahgunyah	9	0.8, 0.8, 0.8, 0.7
Corryong	8	0.7
Wangaratta	14	0.7, 0.7, 0.8,
Goorambat	4	0.6, 0.6, 0.8

The above data shows ratio values < 0.8 indicating that there may be some decay of free chlorine at these sites and the formation chlorine by-products. However, verification monitoring by the contracted laboratory has not returned any exceedances due to chlorine by- products, suggesting that by product formation is not a health issue but may contribute to taste and odour issues. Further investigation will be conducted to attempt to determine the cause of free chlorine decay in these systems. As this sampling was only conducted for a short period of time, more extensive sampling needs to be done before making any further generalisations.

2.3 Rapid Risk Assessment

A rapid risk assessment was conducted on each water distribution system in relation to the identified risks to determine where and what the greatest risks were across North East Water's distribution systems (Figure 1 below).

The list of potential risks to water quality grew quickly and it was decided to limit the number of identified risks in this initial investigation so that the risk assessment did not become too large and slow down the process of developing strategies and optimising processes to improve distribution water quality.

Low or No Risk - 3
Medium Risk - 2
High Risk - 1

Entry Point to Customer / Reticulation Rapid Assessments	Barnawartha	Beechworth	Bellbridge	Benalla	Bright	Baranduda /Ebden	Bundalong	Chiltern	Corryong	Dartmouth	St James / Devenish	Eskdale	Glenrowan	Goorambat	Harrietville	Mt Beauty	Moyhu	Myrtleford	Oxley	Springhurst	Tallangatta	Tungamah	Wahgunyaha	Walwa	Wangaratta	Whitfield	Wodonga	Yackandandah	Yarrawonga
WQ - Fe / Mn / Colour	2	3	1	1	1	2	2	2	2	2	2	3	2	3	3	3	2	2	2	3	1	2	2	3	1	2	2	3	1
WQ - Taste and Odour (MIB / Geosmin)	2	3	1	3	1	2	2	2	2	3	2	3	2	3	3	2	1	3	1	2	1	2	2	3	2	2	2	3	2
WQ Retic - Free Chlorine < 0.20 mg/L [1] (< 4% = L, ≥ 4% and ≤ 10% = M, > 10% = H)	3	3	3	2	3	3	3	3	2	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	1	3	2	3
WQ - pH > 8.5 [2] (< 4% = L, ≥ 4% and < 10% = M, ≥ 10% = H)	3	3	3	3	3	3	2	3	3	2	3	3	3	3	3	1	3	3	3	1	3	3	3	3	3	1	3	2	3
Retic pipe material [4]	3	2	2	3	3	3	3	1	1	2	3	3	3	2	3	1	2	3	3	2	3	3	3	2	1	2	1	3	3
Tanks / CWS - age, condition, common inlet/outlet, mixer /baffle present, tank WQ data	2	1	2	3	1	2	3	2	2	3	2	3	1	3	2	3	3	3	3	2	2	2	2	2	1	3	1	3	2
Comercial customers (Base reporting data for % commercial customers)	3	3	3	1	2	1	3	3	2	3	3	3	3	3	3	3	3	2	3	3	3	3	2	3	1	3	1	3	1
3rd pipe and urban recycled water sysems	3	3	3	3	3	3	1	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	1	2	3	3	1	3	3
Backflow (Casey's % high and HH risk sites per retic)	3	2	3	1	1	3	3	3	2	3	3	3	3	3	3	2	3	1	3	3	2	3	2	3	1	3	1	2	1
Hydrants (Operator informed % ball type hydrants)	3	2	3	1	2	3	3	3	2	3	3	3	3	3	3	2	3	2	3	3	3	3	2	3	1	3	1	3	1
Air Valves (% in potable water retic)	3	3	3	1	3	3	2	3	1	3	1	3	2	3	3	3	3	2	3	3	3	1	3	3	1	3	1	3	1
Seasonal demand / Tourism	3	2	2	2	1	3	2	3	3	3	3	3	3	3	2	3	3	2	3	3	3	3	2	3	1	3	1	3	1

1 Based on the percentage of sample results for Free Cl_2 in the retic ≤ 0.25 mg/L between 1/7/2012 and 5/01/15.
2 Based on the percentage of sample results for pH in the retic < 6.5 and > 8.5 between 1/7/2012 and 5/01/15. NOTE: All exceding results are > 8.5 pH units (not < 6.5 pH values).
4 If %age Good pipe material ≥ 50 and %age bad pipe material < 1, then risk rating is low (green).
If %age Bad pipe material ≥ 1, then risk rating is high (red).
Anything in between these is a medium risk rating (amber).

Figure 2: ***Risk Assessment of Factors Causing Water Quality Issues Across Our Systems***

2.4 Flushing and Scouring Plans

Flushing and scouring plans have been developed for some systems and are continuing to be developed for each remaining system, with the objective of removing excessive build-up of sediment and biofilm, which in turn should reduce customer dirty water related contact as well as other aesthetic issues that can occur due to biofilm and sediment.

The flushing and scouring plans will be developed uniquely for each system. These plans identify valves and/or hydrants that need to be operated during flushing on the Graphical Imaging System (GIS), so that flushing is unidirectional from the water treatment plant to the end of the system or end of a zone, depending on the size of the reticulation network. Written instructions and comments will also be supplied. The goal is for these plans to supply an Operator enough information to be able to flush a system or a zone within a system successfully.

2.5 Minimum Chlorine Residual in the Reticulation

A minimum free chlorine residual concentration of 0.2 mg/L has been prescribed for all North East Water distribution systems. Potential response actions will also be recorded to guide Operators when a free chlorine residual < 0.2 mg/L should occur.

The *Australian Drinking Water Guidelines* (2011) do not have a recommended minimum free chlorine residual concentration for chlorinated distribution systems, but other national and international organisations, such as the United States Environmental Protection Authority (US EPA) and the Australian Water Industry Operators Association of Australia (WIOA) do have recommended guidance values for free chlorine residual concentration in chlorinated distribution systems. The US EPA requires a minimum free chlorine residual of 0.2 mg/L in water entering a chlorinated distribution system, whereas WIOA recommends a target of 0.2 mg/L of free chlorine be maintained throughout all chlorinated distribution systems.

2.6 Mains Repairs and Maintenance

A working group has been developed within the Corporation to look at further areas where water quality can be improved in the distribution. This working group will be meeting for the first time next week to look at a number of initiatives to reduce risk to water quality in the distribution.

One of these initiatives is to create guidelines on correct sanitation and hygiene practices during mains repairs or maintenance. Many Operations Teams at North East Water work in both Water Treatment and Distribution, including both potable water and wastewater systems. In these cases there is always the risk of cross contamination when equipment is used in servicing both systems. This includes: pumps, hoses, Jetvacs, shovels, boots, etc. It is easy to prevent cross contamination as long as the risk is recognised and procedures put in place to reduce these risks. This will be one of the strategies to improve water quality in the distribution that the working group will consider.

2.7 Other Areas of Optimisation

There are a number of other initiatives that the working group will consider in a strategy to improve water quality in the distribution.

This includes the development of a consistent method for verifying chlorine residual after mains repair, embedding refresher training for staff for the commissioning of new infrastructure, and the development of a Corporation wide system for storage of pipes and pest control. Operators also need to have additional training on the importance of water quality in distribution systems. They need to know that their work and actions are important in maintaining good water quality.

3.0 CONCLUSION

In recent years it has been demonstrated that distribution systems have a significant impact on drinking water quality. Similarly, the amount of research focusing of improving water quality in distribution systems is increasing. For these reasons and more, it is important that water utilities evaluate the impacts of their distribution systems on the water quality they provide to their customers, and when possible make physical or operational improvements to minimise water degradation in the distribution. This paper is about what North East Water has done to risk assess our distribution systems in regards to water quality and about how we are going about the development of strategies to improve water quality in our distribution systems. This will be an ongoing program of distribution optimisation with the aim of embedding into our Drinking Water Quality Management System.

4.0 REFERENCES

Australian Government, National Health and Medical Research Council. *Australian Drinking Water Guidelines* (2011) https://www.nhmrc.gov.au/guidelines-publications/eh52

Hrudey E and Hrudey J. *Safe drinking water: Lessons from recent outbreaks in affluent nations.* IWA Publishing, London UK (2004)

Chow C, Cook D and Mussared A. *Guidance manual for the maintenance of chlorine and chloramine residuals Research Project 1064,* Water Research Australia, Australian Water Quality Centre, SA Water (2014)

Cooperative Research Centre for Water Quality and Treatment. *Biofilms: understanding the impact on water quality and water treatment processes* Cooperative Research Centre for Water Quality and Treatment, Salisbury SA

Mosse P and Deere D. *Practical guide to the operation and optimisation of distribution systems.* Water Industry Operators Association of Australia, Shepparton VIC (2009)

Nadebaum P, Chapman M, Morden R and Rizak S. *A guide to hazard identification & risk assessment for drinking water supplies.* Cooperative Research Centre for Water Quality and Treatment, Salisbury SA (2004)

World Health Organisation. *Water safety in distribution systems: public health, environmental and social determinants Water, sanitation hygiene and health IWHO/FWC/WSH/14.03.* World Health Organisation, Geneva Switzerland (2014)