MANAGEMENT CHALLENGES FOR DRINKING WATER BREAKPOINT CHLORINATION IN SEQ

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ABSTRACT

In early 2014, a breakpoint chlorination project was undertaken to improve water quality in a supply zone at the end of the supply network. There were known water quality issues due to nitrification and low chloramine residuals in the upstream supply. This was compounded by problematic/complex disinfection stations along the supply path to this area. In addition, planned mains cleaning had not been performed in the area for some time due to the millennium drought.

The area had a high frequency of dirty water events. A 'proof of concept' was initiated to address these water quality concerns through breakpoint conversion of the zone's drinking water from chloramine to free chlorine using a portable dosing station. The pilot project was successful and has provided valuable long term benefits in future applications. An additional benefit has been the development of a chemical dosing philosophy to maximise the effectiveness of a chloramine residual and minimise the occurrence of nitrification.

1.0 INTRODUCTION

Water quality in the target area had a history of poor performance and persistent customer enquiries. The root cause of the poor performance was nitrification of the network, a process whereby bacteria are able to break down the chloramine disinfectant residual to utilise the ammonia component as a food source. As a result of nitrification, persistent detections of microbial indicators were observed with little or no disinfectant residual.

Mains cleaning in this supply zone had not been undertaken for many years as a consequence of the 8 year drought in early 2000. From data gathered both recent and historical, it is known that the area had a high sedimentation risk; a contributing factor to the poor water quality performance observed. Additionally, historic data and experience showed a high likelihood of impacting customers through dirty water.

When performing water quality improvement projects, comprehensive mitigation measures such as pre-emptive mains cleaning (pigging or swabbing) and significant upgrades of dosing facility capabilities are typically undertaken. However in this instance such measures were not feasible for Unitywater due to financial and operational limits. This challenge is faced by many utilities in delivering a product within the Australian Drinking Water Guidelines (ADWG) under operational and financial drivers. As a compromise, minimal mains' cleaning was performed with a scaled back flushing program focusing on 'end of line' to minimise impacts on customers. This was initiated as a mitigation measure for dirty water events by flushing out sediment build up and drawing through fresh water.

Bulk water is treated and supplied to Unitywater by the SEQ Bulk Water Authority, known as Seqwater. It was not possible to change the secondary disinfection at the Water Treatment Plant due to supply constraints encountered by Seqwater. As a consequence, Unitywater had to identify options within our own network to conduct breakpoint chlorination as a means to improve water quality.

A portable dosing 'skid' was placed at the reservoir bulk storage point of the target supply zone. This was a temporary solution to replace the existing dosing system and enable chlorine breakpoint, until a longer term solution was put in place.

Over the breakpoint chlorination period, water quality performance was monitored through four approaches; (1) an increase in long term monitoring sites, (2) pre and post conversion short term water quality monitoring programs, (3) deployment of continuous real time field monitoring equipment and (4) external validation by a contracted service providing 'snap-shots' of the system from a water quality monitoring van. This information provided an in depth understanding of water quality in the network in response to operational changes.

Prior to the chlorine conversion, total chlorine residual (as chloramine) was detectable at approximately half of the long term monitoring sites; at low levels of 0.2-0.4 mg/L. Chloramine measurements (as total chlorine) after the project ended, were on average 1-1.2 mg/L at extremity sites reflecting source water chloramine penetrating into the network where it did not before. Customer enquiries during this period represented a typical bell shaped curve with peak enquiries observed at weeks 4-6, with 64 complaints in total (see Figure 2).

Additional challenges arose from the portable skid configuration and automated control. The full 10 week breakpoint chlorination period started in mid-May and finished end of July 2014.

2.0 DISCUSSION – THE CHALLENGES

2.1 Source Water Nitrification

Observations from data showed that the source water into the distribution reservoir contained nitrifying bacteria, which had implications for re-seeding of the network with nitrifying bacteria and encouraging biofilm growth. A long term solution to improve source water quality has been identified. Unable to control nitrification entering the network, a suitable location for breakpoint chlorination was identified to control/manage water quality.

2.2 Stakeholder Engagement

Large organisations can often experience difficulties in project headway through communication blockages. Due to the size of the project and configuration of the network, the solution was complex and involved many stakeholders. Persistent reinforcement around definition and scoping of responsibilities was necessary to create clarity and project direction. In addition, changes in management structure, roles and responsibilities contributed to the need to define roles and responsibilities.

2.3 Dosing Skid Configuration

The existing chloramination dosing system was problematic and complex. A portable dosing skid was purchased and deployed as a proof of concept in its ability to conduct successful breakpoint chlorination with the justification of reduced operational expenditure. Additional challenges arose with the skid analysers and configuration.

This included non-representative analyser sample water (mixed reservoir water compared to

water at the sample off take location), automated control using skid analysers via SCADA and technical difficulties with analyser probe calibrations which resulted in drifting trends.

Further challenges arose on the discovery of inadequate mixing even with a reservoir mixer in place and extended chemistry reaction times resulting in a time lag for analyser trends.

2.4 Overdose Mitigation Measures

An outcome of the risk assessment showed a high risk of a chemical overdose in the breakpoint reservoir. Mitigation measures were put in place to prevent over chlorinated water reaching customers. To achieve this, downstream reservoirs were topped up to provide an extra 2 day's supply (providing extra time for decay in the breakpoint reservoir). Additionally the breakpoint reservoir was only filled to 80% to allow room for dilution.

There was one instance of overdose and one close call where the mitigation measures of dilution and decay over time were necessary before water was released to customers. This was one reason the site was chosen for breakpoint as there was good control to manage overdosed water within the reservoir, and therefore no over chlorinated water reached customers.

2.5 Impact on Customers

There were 64 registered water quality complaints from the start of the project to two weeks after the dosing skid was turned off (Figure 2). The average number of enquiries for Unitywater's entire supply area is 1 enquiry per 973 customers. Over the project the average customer enquiry ratio was 1 per 415 customers. The elevated number of enquiries was most likely due to the sediment deposition in the network and negligible mains cleaning in the area historically. Of the total customer enquiries received 78% were for dirty/milky and 22% for taste/odour.

Figure 1: ***Oxidised Biofilm in Water Sample taken from a Customer's House***

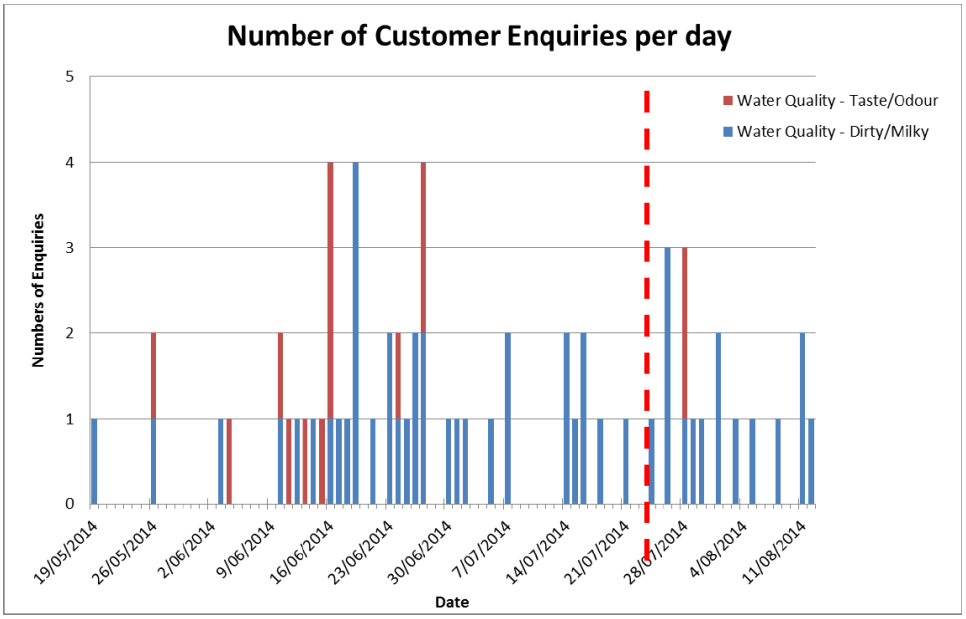

Figure 2: ***Frequency and Number of Customer Enquiries Per Day***
(The dashed line represents when the chlorine dosing was turned off at the reservoir.)

2.6 Reduce Cost

The portable dosing skid was purchased with the understanding it would be utilized at other sites maximising its usage to increase efficiency and reduce cost. Once the water quality improvements were demonstrated using breakpoint chlorination within Unitywater, breakpoint chlorination would be applied under similar circumstances. As a result, only minimal water quality monitoring will be required in future monitoring programs leading to further savings. The total costs for the pilot project are outlined in Table 1.

Table 1: ***Costs Associated with the Breakpoint Chlorine Project***

Item	Cost	Comments
Dosing Skid	$70,000	Purchase and installation/electrical
Internal water quality monitoring	$65,743	Background and intensive
External water quality verification	$24,420	Pre and during project WQ monitoring
Mains Flushing end of line	$14,318	Labour ($7K) 1400kL 'pre-flush'; 976kL reactive flush $3.08 per kL (bulk water $ + lost revenue)
Hypochlorite chemical	$8,500	48 cents per litre
Media Advertising	$668	1 x 4x3 advertisement
Reactive response to customer enquiry	$6,780	$60 avg. callout cost x 121(minus 8 background) WO
Planned maintenance for chemical dosing operations	$4,560	$ 60 avg. WO cost x 151 (minus 75 background) WO generated
Staff time	$3,000	All not captured under work orders. Est. 50hrs @ $60/hr (incl. overheads)
Contractor	$10,500	Project management
Total*	**$208,489**	

***This does not include items such as the mixer, customer enquiries, electricity use, prior consultant's report etc.**

Water quality in the supply zone was a known problem compounded by existing re-dosing station issues. This approach proved to be an effective proof of concept before outlay of large financial expenditure on capital project solutions to redesign the existing system and network. It demonstrated there were other options to achieve consistent water quality outcomes throughout the yearly temperature cycles. Additionally, this project is expected to result in operational savings due to rectification of the underlying nitrification and dosing station reliability issues.

This pilot project provided the understanding and justification for future capital expenditure at this site and gave re-assurance that Unitywater was investing in the right solution to improve network water quality.

3.0 CONCLUSION

3.1 Water Quality Outcomes

Improvement in water quality performance was observed immediately after breakpoint chlorination started, and continued after the project finished for 5-6 weeks (Figure 3). During the project bacteriological detections ceased almost entirely and free chlorine disinfectant was detected on average at 0.5 mg/L at extremity sites. Once dosing was ceased, penetration of chloramine disinfectant as total chlorine was observed with an average of 1-1.2 mg/L at extremity sites, which historically were not exposed to a disinfectant residual all year round. Water temperature increased 5-6 weeks after project completion, and chloramine residual in the source water was observed to decay significantly. The combination of low disinfection residual and nitrified source water led to the re-emergence of bacteriological indicators.

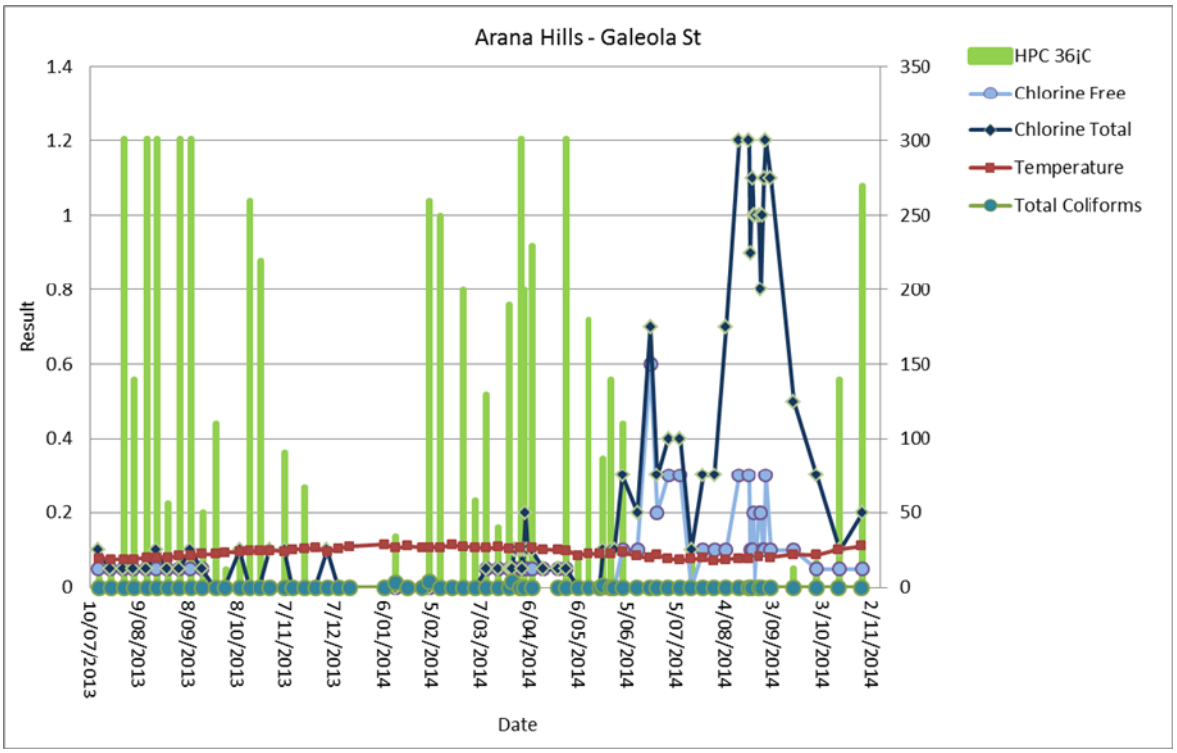

Figure 3: ***Water Quality Trends at an Extremity Site During Breakpoint Chlorination***

3.2. Dosing Control Philosophy

Future chlorine conversions in this supply zone will be initiated when source water disinfection residuals are not adequate to penetrate into the network extremities. This is typically observed during the summer months when water temperatures are warmer and chloramine decay is significant. When source water residuals are adequate to penetrate into the network extremity, the addition of chlorine is not recommended. This has typically been observed during winter when water temperatures are cooler. In shoulder periods when the chloramine starts to decay, trickle dosing with chlorine is recommended for 'mop-up' of chloramine decay products to extend the life of chloramine downstream when the scenario presents. The dosing philosophy is outlined in Table 2.

Table 2: ***Breakpoint Reservoir Dosing Philosophy***

	Breakpoint Reservoir Outlet			**Downstream reservoirs**
MODE	Philosophy	Rule		Philosophy
1 WINTER	Adequate chloramine residuals carrying through reservoir and into extremities	IF ⇨^{out} >2.0 mg/L total THEN no dose		IF downstream reservoir total chlorine is <1.0 mg/L over 2 consecutive tests more than 48 hours apart THEN breakpoint
2 Shoulder	Chloramine starting to decay	IF ⇨^{out} <2.0 mg/L AND >0.5 mg/L total THEN trickle dose to mop up		
3 SUMMER	Chloramine residual is insufficient and does not penetrate network extremities	IF ⇨^{out} <0.5 mg/L total THEN Cl2 breakpoint dose		If reservoir total chlorine is less than 0.5 mg/L total chlorine THEN dose top up chlorine

3.3 Was It Worth It?

The cost versus benefit comparison of the breakpoint chlorination pilot project was proven to be worthwhile. A process for regular maintenance of the distribution system to combat nitrification was identified and a successful solution was demonstrated. The project provided valuable information for chemical dosing station operation and configuration for future locations, with proven water quality chemistry application and experience for operators and staff. Breakpoint chlorination demonstrated immediate water quality improvements and provided confidence to operators to competently undertake breakpoint chlorination at future sites.

4.0 ACKNOWLEDGMENTS

To Unitywater staff in the Operations Centre, Civil Maintenance South, Engineering Operations and Water Quality sections who worked towards this outcome.

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