WHEN THE DUCKS CONTINUE TO LINE UP: DRINKING WATER QUALITY NEAR MISSES AND THE ISSUES THAT LEAD TO THEM

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76th Annual WIOA Victorian Water Industry Operations Conference and Exhibition
Bendigo Exhibition Centre
3 to 5 September, 2013

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ABSTRACT

Each year, under Victoria's *Safe Drinking Water Act 2003*, notifications are made to the Department of Health on known or suspected contamination of drinking water that are the result of system failures. Following on from last year's paper, *When all the Ducks Line up: Case Studies on Hits and Very Near Misses,* this paper presents two more case studies where system failures could have been prevented, as well as providing an overview of some of the common themes and issues that can lead to drinking water quality incidents.

1.0 INTRODUCTION

The provision of safe drinking water is one of the fundamental elements of public health. When Victorians turn on the drinking water taps in their homes, their expectation, without question, is that the water supplied will be safe to drink. To ensure that this community expectation is met, Victoria introduced the *Safe Drinking Water Act 2003* (the Act), which commenced on 1 July 2004.

It is acknowledged that it is not possible to eliminate all risks associated with the provision of safe drinking water. The Act addresses this by requiring all Victorian water businesses to identify and manage risks associated with the provision of safe drinking water. This is achieved by each business developing, implementing, reviewing and maintaining a risk management plan for each drinking water supply that they manage.

The legislation also requires any known or suspected contamination of drinking water to be reported immediately to the Department of Health. The vast majority of these notifications are minor in nature, but, unfortunately, each year there are several notifications to the department of system failures where customers have potentially been exposed to unsafe drinking water.

Whilst many of these system failures have been caused by issues beyond the control of the water business, there have been several cases where the underlying issues that led to the system failure should have been foreseeable and preventable. This paper highlights two case studies where the system failures were foreseeable and preventable.

This paper also contains a discussion on common themes and issues related to the foreseeable and preventable system failures. As with last year's paper, the case studies have been de-identified, as the intention of this paper is not to highlight particular water businesses or apportion blame.

The case studies are intended to be used as a learning tool to assist the water industry to identify precursors to serious incidents, develop systematic approaches to prevent similar incidents from occurring in the future and to review incident management processes, including escalation procedures.

2.0 COMMON THEMES AND ISSUES

Whilst there are numerous reasons why incidents occur and systems fail, there are some common themes and issues. These common themes and issues are described below.

2.1 Most incidents are preceded by a change in conditions

Most incidents are preceded by a change in conditions. Some of the obvious sources of change are:

- Bushfires
- Floods
- Severe storms

There are also less noticeable sources of changed conditions, that can precede incidents, such as:

- Plant upgrades
- Changes to processes
- Change in raw source
- Changes in staff

Most of these changes will alter the risk profile for a water treatment plant.

When a major change in conditions occurs it requires extra vigilance on the part of water treatment staff. Major incidents tend not to occur when the raw water quality is stable and water treatment plants are operating normally. The challenge for the management of water businesses is avoiding complacency as incidents occur rarely.

2.2 Major incidents occur when two or more issues line up

Whilst it is not always true, in most cases major incidents occur when two or more issues line up. This is the so-called “lining up of the ducks”. Examples are:

- Plant maintenance occurring right before a major storm event
- Heavy rainfall and a chlorinator failing at the same time
- Both the filtration system and the disinfection system having problems at the same time
- Key staff going on holiday before a flood

In many instances, it cannot be predicted that high risk activities will line up, but staff need to respond to the early warning signals.

In some cases it is likely to be foreseeable:

- Changing to a different source water in a week when heavy rain is predicted
- Changing the type of coagulant that is used whilst also undertaking maintenance work on the filter
- Undertaking major process changes whilst key staff are on leave

The main points here are that:

- Consideration should be given to the downstream impact of upstream changes
- Even minor changes to plant processes or operation can have a major impact if they line up with some other event

2.3 Capability and appropriateness of treatment barriers

Whilst operational staff are often not in a position to influence the treatment processes that are used, it is important to note that the number and capability of treatment barriers must be appropriate to the range hazards and the severity of the associated risk faced by the water supply system.

What it is required, though, is a thorough understanding of the water supply system, both in terms of the capabilities of treatment barriers and the nature of the hazards and risks. When treatment barriers are allowed to become dysfunctional, even to a minor degree, then the capability of those treatment barriers is no longer appropriate to the threats facing the system

2.4 Most incidents usually involve some level of human error

Human error usually cannot be avoided, but the consequences of such errors can be minimised. Common human errors should not be capable of causing disastrous outcomes; if they can, the system is flawed and needs to be reviewed.

Water businesses need to learn from the mistakes that occur. If a mistake occurs once it is unlucky; twice it is careless; three times and it is potentially negligent.

2.5 A failure of a particular type of equipment should lead to an investigation of other similar equipment

Risk management is about being pro-active. If a failure occurs in a particular piece of equipment (e.g. pump, analyser) it should lead to an investigation of all similar equipment owned by the business. This may avoid similar failures in the future. This is of particular relevance if the mode of failure is unusual.

2.6 A failure of a particular type of equipment should lead to an investigation of other similar equipment

Debriefs are an important learning tool. For all major incidents, a debrief should be undertaken. The debrief helps identify why the incident occurred and how similar issues can be avoided in the future.

It is important to note that no two incidents are exactly the same, but the key is to recognise from the debrief the potential for such failures to occur in other systems, and what the signals for such failures would be. You must not look for why these cases could not happen to you, rather, look for how they could happen in your system.

Finally, the debrief is only of use if the identified actions are implemented.

3.0 CASE STUDIES

3.1 Case Study 1

The first case study relates to a town with a population of approximately 3600. The raw water source is surface water, drawn from an unprotected catchment, with an off-stream raw water storage basin. The available treatment at the town's water treatment plant is coagulation, flocculation, and clarification, followed by disinfection using chlorination.

The treated water is pumped to a clear water storage and then distributed through the town's reticulation system.

Prior to the incident, the water business had noted that the flocculation (floc) blanket in the clarifier had a habit of flipping over, not only, but typically, during periods of hot weather. The incident occurred during the first period of hot weather of the summer, so a higher volume of water was being used by customers.

Thursday afternoon: At around 12:30pm, during a site inspection at the water treatment plant, a water treatment operator at the plant noticed that the floc blanket of the clarifier had flipped over. The water treatment operators on the site met and decided to crash the plant to allow the floc blanket to settle. Operators did not advise the customers service centre that the plant had been shut down. At the time of plant shutdown the clear water storage was at 80% of capacity.

At around 4:45pm on the Thursday afternoon the water treatment plant was restarted. The clear water storage was now at 66% of capacity.

Thursday evening: At around 7:30pm, the High High CCP SCADA alarm activated for both filter 1 and filter 2. The post-filter turbidity for filter 1 was recorded as being 1.06 NTU, and for filter 2 as 0.92 NTU. Ten minutes later, the post-filter turbidity for both filter 1 and filter 2 was recorded as being greater than 5 NTU, but the exact figure is unknown, as the SCADA scale only goes to 5 NTU.

At 9:00pm, the High High CCP SCADA alarm was acknowledged by a customer service centre staff member. Customer service centre staff member spoke to the on-call water treatment operator. Ten minutes later the water treatment plant was crashed remotely by a staff member at the customer services centre. At the time the plant was crashed the clear water storage was at 48% of capacity.

Ten minutes after the plant was crashed, the water treatment operator contacted and advised the Area Manager of issues at the plant, and the Area Manager contacted the Operations Manager and advised them of the issue, as per business' emergency response protocols.

At 10:00pm, the operator arrived on site at the water treatment plant. They found a large volume of sludge on top of the filter media in both filters. The filters were drained via the bottom under-drain scours, in preparation to do a backwash. Filter 1 and 2 were backwashed via manual control. The clarifier drain was opened, and no heavy sludge observed.

At 11:17pm, the water treatment plant restarted in normal operation. The clear water storage was at 26% of capacity.

Friday morning: At 11:00am on the Friday morning, the water business' water quality team is advised of the previous night's incident. At 2:00pm on the Friday, the Operations Manager advised the Department of Health of the incident.

3.2 Case Study 2

The second case study relates to a town with population of approximately 180. The raw water source is bore water.

The available treatment at the town's water treatment plant is clarification, filtration and iron-sorption, followed by disinfection with chlorination. Treated water is pumped to clear water storage, and then to a high level tank in town.

Monday morning: At 11:00am a water treatment operator conducted a chemical drawdown on the chlorine dosing pump at the water treatment plant. The operator found the chemical dosing pump flow rate calculated from the chemical drawdown was out by greater than 10% in relation to the dose that it was set at. In response to this, the operator calibrated the dosing pump. To do this, they switched the pump from "auto" to "manual" and then performed the calibration. The operator conducted a final drawdown to confirm the accuracy of the calibration. Once the final drawdown had been completed, the operator continued other duties, not realising the pump was still on "manual" mode.

Monday afternoon: At about 1:35pm, the operator received a chlorine residual low alarm. The alarm did not indicate what the chlorine residual was. Chlorine is dosed at two points at the treatment plant – at the bore, as an oxidant, and prior to the high level tank, for disinfection, and chlorine residual is monitored at three points (downstream of bore, before clarifier, after high level tank).

The chlorine dosing pump at the bore is frequently affected by gas bubbles forming in the dose line. Gas bubbles cause erratic readings on the analyser (usually as "low chlorine residual" alarms). As the operator was present at the plant shortly before receiving notification of the alarm, and the treated water chlorine residual at the plant was fine, they assumed that it was the bore chlorinator alarming due to gas bubbles. The alarm was acknowledged and no further action was taken.

Tuesday morning: At 9:00am, a different operator was conducting routine chlorine tests in the town's reticulation system. The chlorine residual at the outlet of the high level tank was found to be very high (10mg/L). This exceeded both the HACCP limit and health-based guideline value in the Australian Drinking Water Guidelines (ADWG) of 5 mg/L.

The operator confirmed the residual with another test. The operator then investigated the cause of the high residual and found the chlorine pump was on "manual" and turned off the dosing pump. The chlorine dosing pump had continued to dose while in manual mode, even when the treatment plant was not operating.

The incident was reported to the district coordinator and escalated within the business, as per the business' CCP plan. Chlorine residuals were checked at the first reticulation point after the high level tank to see if it was above the ADWG health-based guideline value (5mg/L). If above the health-based guideline value, then the incident would be required to be reported to the Department of Health. The results were above 5 mg/L, and the issue was duly reported to the department.

As per their CCP plan, flushing was conducted to reduce chlorine residuals to below 5mg/L. The flushing was completed by 3:00pm. When another operator was trying to get the water treatment plant back to normal operation, another alarm was observed. The alarm tag name was: "filtered CL2 dosing fault". No one had a proper understanding of what this alarm referred to, but it was believed that it referred to a fault that no longer applied to the plant. Operator noted that this alarm had to be reset to operate the plant.

Thursday: Residents were notified of the incident by posting notices in public places, as advised by the Department of Health.

Friday: A root cause analysis of the incident was undertaken.

4.0 DISCUSSION

In **Case Study 1**, as the clear water storage was getting very low there was an understandable focus on producing water, but, with the raw water sourced from an unprotected catchment, and the filters producing water above 5 NTU for 1.5 hours, the question "***is safe water being produced?***" was not asked at the time. Additionally, whilst the internal escalation procedure worked well during the incident, the Department of Health was not advised until well after the incident had passed.

Whilst water businesses have an obligation to ensure the continuity of supply of drinking water, they also have an obligation to provide safe drinking water. In hindsight, a boil water advisory should have been seriously considered by the business for this supply system.

In **Case Study 2**, the major findings of the root cause analysis were:

- The low level alarm was incorrect; it should have been a high chlorine residual alarm
- Alarms should show the actual chlorine residual
- The chlorine dosing pump continued to operate in manual mode, even when the treatment plant was not operating
- The other alarm was the result of old wiring connected to the new pumps, but the alarm tags had not been changed
- No analyser on the inlet to the high level tank to detect high chlorine residuals entering the tank

In both cases, the affected water businesses undertook debriefs on the incidents. The findings of the debriefs have been implemented by the businesses.

There were no reports received of any illness associated with either incident.

5.0 CONCLUSION

The two presented case studies were chosen to demonstrate how important it is for operators to know and understand their water supply systems, to understand how the treatment equipment and associated meters they use work, and to have an appreciation of the hazard and risks faced by the supply system. These case studies clearly identify foreseeable risks and warning signs that were missed, overlooked or ignored, which led to potentially serious public health consequences.

Whilst the post incident responses undertaken by the two water businesses were appropriate and comprehensive, these case studies highlight that risk management should be proactive, rather than reactive, to be effective.

6.0 ACKNOWLEDGEMENTS

Steve E. Hrudey, FRSC, FSRA, IWAF, DSc(Eng), PhD, Professor Emeritus, Analytical & Environmental Toxicology, Faculty of Medicine & Dentistry, University of Alberta, Canada, who reviewed and provided feedback on the common themes and issues section.

The two water businesses who generously allowed us to use their incidents as case studies.