WHEN ALL THE DUCKS LINE UP: CASE STUDIES ON HITS AND VERY NEAR MISSES

Paper Presented by:

Leanne Wells

Author:

Leanne Wells, *Compliance Officer,*

Department of Health

75th Annual Water Industry Engineers and Operators' Conference
Bendigo Exhibition Centre
4 to 6 September, 2012

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Leanne Wells, *Compliance Officer*, Department of Health

ABSTRACT

Victoria's *Safe Drinking Water Act 2003* (the Act) came into effect 1 July 2004. The Act sets out the responsibilities and legal requirements for the Victorian water industry in relation to the provision of safe drinking water. Since the commencement of the Act, there have been many notifications to the Department of Health of known or suspected contamination of drinking water relating to system failures. Whilst many of these have been minor in nature, there have been notifications where customers have potentially been supplied with unsafe drinking water. Issues beyond the control of the water business have caused many of these system failures, but, there have been several cases where underlying causes of the system failure were foreseeable and preventable. This paper highlights three case studies where the system failures could have been prevented.

KEY WORDS

Drinking water, safety, risk management, incident management.

1.0 INTRODUCTION

The provision of safe drinking water is one of the most 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 have been minor in nature but unfortunately, over the years there have been 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 underlying system failure contributed and therefore these events should have been foreseeable and preventable.

This paper highlights three case studies where the system failures were foreseeable and preventable. 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.

The three case studies described below have been chosen to demonstrate different types of failures of risk identification and incident management practices.

2.0 CASE STUDIES

2.1 Case Study 1

The first case study relates to a town with an approximate population of 5000. The raw water source for the town is an irrigation channel, from which water is taken and then stored in an off-stream raw water storage basin. The water treatment for the supply includes coagulation, flocculation, dissolved air flotation and filtration, and disinfection is with chlorine. The treated water is pumped to a clear water storage and then to a water tower in the town.

Prior to the incident the water business had issues with a particular type of chlorine analyser which had been installed at the water treatment plant. The analyser was found to be giving unreliable results. At the time of the incident they were no longer using this instrument for monitoring purposes. As a temporary measure, alternative chlorine monitoring had been installed at the outlet of both the clear water storage and water tower. Both of these monitoring points were alarmed via SCADA (Supervisory Control and Data Acquisition), but were not critical control point (CCP) alarms. A disinfection CCP alarm was still to be installed at the water treatment plant.

Friday evening: SCADA activated a low low level chlorine alarm for the clear water storage outlet and tower outlet at 7:18pm and 8:52pm, respectively. The Customer Service Duty Officer acknowledged these alarms at 10:40pm, but no further action was taken.

Saturday morning: the next rostered Customer Service Duty Officer acknowledged the low low level chlorine SCADA alarm during a routine alarm review and immediately initiated incident response procedures. This Customer Service Duty Officer contacted the Water Treatment Duty Officer at 8:57am, who immediately crashed the water treatment plant remotely via SCADA. The Water Treatment Duty Officer arrived on site at 9:30am and identified that the chlorine cylinder changeover had failed. The Water Treatment Duty Officer then began slug dosing the clear water storage with sodium hypochlorite.

The water treatment plant was restarted with an increased chlorine dose rate. The Water Treatment Duty Officer notified the District Manager of the incident at 10:11am, who then contacted other staff to assist with the response. The District Manager escalated the incident and advised the Process and Water Quality Coordinator of the incident via email at 11:33am.

The Process and Water Quality Coordinator received and responded to the email at 12:06pm. As per the drinking water quality emergency response procedures he directed staff to commence flushing and sampling the reticulation and notified the Operations Manager and the Department of Health of the incident by phone at 12:30 and 12:40pm, respectively.

It took four hours to draw chlorinated drinking water through the reticulation system and obtain a satisfactory chlorine residual throughout the system.

It is estimated that the treatment plant ran without disinfection for approximately 10 hours and that 2.5 ML of untreated water was pumped into the clear water storage from water treatment plant after the chlorination changeover failed. There were no reported cases of illness associated with the incident discussed in this case study.

2.2 Case Study 2

The second case study relates to a city with an approximate population of 31,000. The raw water source for the city is from surface water from an unprotected catchment. The water is extracted from the source water and stored in an off-stream raw water storage basin. The water treatment for the supply includes flocculation, dissolved air flotation and filtration, and disinfection is with chloramination. The treated water is then pumped to the clear water storage located on site.

The water treatment plant is a relatively large plant, with seven individual filters. The plant does not have a filter-to-waste mode of operation and requires the treatment plant to be operating to backwash the filters.

The raw water storage had been taken off-line for annual maintenance and cleaning. The raw water was being extracted directly from the raw water source, by-passing the off-stream storage basin and being fed directly to the water treatment plant. To minimise the risk to the treated water supply whilst the storage basin was off-line, the raw water alarm had been tightened and the backwashing of the filters had been reduced to 8 hours instead of the normal 24 hours. The updated procedures for the period of the storage basin maintenance did not address risk management considerations with respect to drinking water quality.

Friday: It had been raining for the few days prior to the Friday, with an estimated rainfall of 55mm. As a result of the rain the raw water turbidity had increased to 50 Nephelometric Turbidity Units (NTU). Historically, this was a high turbidity level for the raw water supply; however, the water treatment plant had been working well, producing safe drinking water at these turbidity levels.

A large forecasted storm event occurred on the Friday, with the local area receiving 36.5mm of rain. This storm event was underestimated by operations staff and resulted in a significant increase in the turbidity of the raw water overnight, from 18 NTU to 100 NTU. A raw water turbidity of 100 NTU for this system was unprecedented.

Key water treatment and distribution staff were on leave on the day of the storm event. The Treatment Team leader had left written instructions for the operation of the plant. It was also the first time that the Weekend Duty Manager had been on call.

Saturday: the plant alarmed and shut down at 4:00am due to the change in raw water turbidity. There was a 15 minute time delay before the plant shut down that caused filter loading, resulting in the filters becoming blocked. Turbidity breakthrough in the filters was on the brink of activating the CCP alarm, but this alarm did not activate because the raw water alarm had already been triggered.

The Weekend Duty Officer had visited the site and recorded that the clear water storage was at 60% capacity then commenced visits to other sites. On return to the plant the Duty Officer realised that the treatment plant was not operating.

He restarted the plant manually to get a raw water sample for jar testing, noted the increase in turbidity and shut the plant down again.

All the filters were blocked. The combined turbidity of the filtered water from all the individual filters was 33 NTU. The clear water storage was now at 47% capacity, and at 43% capacity there is a risk of air getting into the pipes so it was necessary to start producing water from the plant to put more water into the clear water storage.

All the filters had to be backwashed. During this process, some of the filtrate reached the clear water storage, contaminating the already treated drinking water in storage. It took 2 hours to backwash the filters and it was estimated that 2.8ML of water, with a turbidity of greater than 5 NTU, entered the clear water storage. Jar testing found that the water chemistry was incorrect and changes to the alum dosing were required, as the Dissolved Air Flotation (DAF) float was sinking.

By 1:30pm the plant was treating water to 4 NTU (still not within normal plant operating specifications) and the turbidity in the clear water storage was 13-20 NTU. Water was being discarded from the clear water storage to shandy the better quality water being produced from the treatment plant. Disinfection residuals were being maintained. The plant appeared to be back under control by 1:50pm.

At 7:40pm the filters had started breaking though again producing water at 7 NTU. Staff began backwashing the filters which were still being backwashed 2 hours later. The plant began having difficulties again with the DAF float not floating and the filters overloading. By 11:50pm the turbidity in the clear water storage was 1.7 NTU.

Sunday: The raw water basin had been reconfigured by 8:30am. Plant and reticulation system checks revealed that the turbidity of the drinking water was below 1 NTU except at the entry point. The reticulation system continued to be flushed during the day with an occasional dirty sample being recorded.

The Department of Health was advised of the incident at 11:50am on Sunday morning. The water treatment plant was back to normal operations by 3:30pm. There were no reported cases of illness associated with the incident discussed in this case study.

2.3 Case Study 3

The third case study relates to a town with an approximate population of 60. This town receives treated drinking water via a pipeline from a nearby larger town. This water is supplied directly into the drinking water reticulation system, but it also pumped into a clear water storage basin, which then feeds back into the town's reticulation system.

A booster chlorination system also formed part of the drinking water system for this town. It consisted of a break tank that was slowly filled from the clear water storage basin and when the tank was full it started a pump which pumped the water through a gas chlorinator and back into the storage basin. The booster chlorinator was triggered by a level float situated within the break tank. This system was set up in response to repeated *Escherichia coli* (*E. coli*) detections and was intended to be an interim system, until the construction of a new elevated storage and booster chlorinator. This site did not have SCADA and was not alarmed in the event of a system failure.

External contractors operate the water treatment plants owned by this water business. The contractors had determined that the chlorinator at this site was a risk and had decided that it was to be manually checked by operations staff twice a week.

The contractor received a phone call from a customer complaining about a strong chlorine taste and odour in the drinking water. On investigation it was established that there were chlorine levels of 11mg/L in both the clear water storage basin and the town's reticulation system. This equated to approximately 5kg of chlorine being present in the clear water storage. The health-based guideline value for chlorine in drinking water in the 2011 *Australian Drinking Water Guidelines* (ADWG) is 5mg/L.

The contractors advised the water business of the elevated chlorine levels and the Department of Health was advised of the incident shortly after.

The Department of Health received reports of illness from the affected community. At least three young children, including an eleven week old baby, were reported to be displaying health affects associated with consuming the affected water. A health impact assessment conducted by the department identified that there were unlikely to be any lasting adverse health affects.

The elevated chlorine levels were the result of the float in the break tank failing in the on position. The break tank continued filling, triggering the pump to continuously pump water through the chlorinator and back into the storage basin, resulting in more chlorine being dosed back into the system. This system was decommissioned in response to this incident.

In the 18 months prior to this incident there were many documented events that should have initiated prompt remedial action, or at the very least a thorough risk assessment and replacement of repeatedly malfunctioning equipment. There were six results that were at, or exceeded, the health-based guideline value for chlorine in ADWG and the contractor reported only one of these to the water business. Four of these six elevated results were recorded within the four months prior to this incident. There were nine occasions where the pump, chlorinator or float had issues requiring maintenance, or repairs requiring the pump to be restarted, and on some occasions the pump had to be restarted more than once a day. There had been no preventive maintenance conducted on the chlorinator for twelve months. There were seven separate occasions where the frequency of site visits did not meet requirements determined by contractor's risk assessment.

There were many instances where results had not been recorded by the contracting staff. One disconcerting example of this was where a chlorine level of 8.8mg/L was recorded by the contractor, with no further results recorded for the following 21 days and the chlorinator had been turned off for eight days during this period. With no results recorded during this time, it is not possible to determine what the chlorine levels were, or whether they exceeded the guideline value in ADWG.

3.0 DISCUSSION

The incidents discussed in these three case studies were preventable, and in hindsight, most likely foreseeable.

In ***Case Study 1***, processes were in place to enable staff to effectively respond to drinking water quality incidents. Although staff had been trained in these processes, some of the emergency response procedures were not followed by some staff. The most obvious of these was the lack of action taken in response to the initial low chlorine alarms. Although alternative chlorine monitoring had been put in place as an interim measure, and this was alarmed with SCADA, there was unease that there was no CCP chlorine alarm at the water treatment plant. Given the seriousness and the potential public health impacts of this incident it was concerning that it took 3 hours to escalate this incident to senior management and the method by which it was escalated.

Case Study 2 highlights the importance of preplanning to identify all foreseeable risks when changing or modifying normal day-to-day water treatment operations. Although some risk planning and management had been undertaken prior to the basin being taken off-line, the assessment of risks to drinking water quality should be automatically included as part of assessment processes when any works or changes are made to a water treatment system. Whilst the escalation of the incident internally worked well, the Department of Health was not notified of the incident until 24 hours after the incident occurred, when operations were nearly back to normal, despite the fact that potentially unsafe water had been supplied to customers.

The issues raised by ***Case Study 3*** speak for themselves. The warning signs of a potentially serious drinking water incident occurring were ignored on many occasions, over an extended period of time. As a result, a Victorian community was exposed to an unaccepted risk on a number of occasions. The continual failure of, or poor performance of treatment systems and monitoring equipment should not be ignored. All treatment failures should be investigated and, where possible, resolved promptly so as to reduce the risk of a catastrophic failure occurring. The pump, chlorinator and float issues should have been resolved after the first major malfunction. It should not have taken 18 months, and a serious drinking water incident, to have the issues properly addressed.

4.0 CONCLUSION

These three case studies were chosen to demonstrate how important it is for operators to know and understand their water treatment systems, to ensure that appropriate and detailed planning and risk assessments are conducted prior to any changes being made to a system and for operators to be involved in these processes. It is essential to consider where in a water supply system things might go wrong and the potential impacts that changes to a supply system can have on the safety of drinking water being supplied to customers. These case studies clearly identify foreseeable risks that were missed, overlooked or ignored, which led to serious public health consequences. These case studies also reinforce the importance of having good emergency management response procedures in place, with all staff adequately trained in the execution of these procedures, including the importance of early escalation.