IMPLEMENTING COMMUNITY ACCEPTABLE MEANS OF DISINFECTING WATER SUPPLIES FOR SMALL TOWNS IN NORTH EAST VICTORIA

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IMPLEMENTING COMMUNITY ACCEPTABLE MEANS OF DISINFECTING WATER SUPPLIES FOR SMALL TOWNS IN NORTH EAST VICTORIA

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ABSTRACT

North East Region Water Authority (NERWA) has signed a Memorandum of Understanding (MoU) with the Victorian Government that includes a requirement to provide drinking water supplies that meet World Health Organisation (WHO) guidelines (1984). Complying with the microbiological parameters (faecal coliforms and coliforms) means that drinking water supplies must be disinfected.

Traditionally, chlorination has been the preferred method for disinfecting water supplies because it is an effective disinfectant, both initially and as a residual, and because it is inexpensive. However, several North East Victorian communities accustomed to drinking untreated water supplies are generally opposed to disinfection by chlorination. In these cases, NERWA has consulted with community groups to install various alternative means of disinfection including ozonation, ultraviolet irradiation and chlorine dioxide systems. This paper discusses the process involved in selecting the disinfection methods with the community, briefly describes the disinfection process selected, and discusses the challenges involved in commissioning the new Ozone/GAC/UV plant at Myrtleford, the first of its kind in Australia.

KEYWORDS

Disinfection, Ozone, UV, Chlorine Dioxide, Potable Water, Residual.

1.0 INTRODUCTION

North East Region Water Authority (NERWA) has signed a Memorandum of Understanding (MoU) with the Victorian Government that includes a requirement to provide drinking water supplies that meet World Health Organisation (WHO) guidelines (1984). The Department of Human Services has also issued a directive to NERWA to disinfect town water supplies that continue to fall below WHO bacteriological compliance levels.

Consequently, NERWA was charged with the responsibility of installing disinfection facilities for the townships of Myrtleford, Mt Beauty (including Tawonga and Tawonga South), Corryong, Barnawartha and Whitfield. Residents from these towns have been drinking water fed from mountain sources without any form of conventional treatment or disinfection for many years. The raw water consistently meets both physical and chemical WHO guidelines, but falls well short of biological guidelines.

NERWA has a preference for providing chlorine disinfection. Several communities in North East Victoria used to very pure water are strongly opposed to the addition of any chemical to its water supply. In order to implement the disinfection projects, NERWA has undertaken an extensive community consultation processes to determine the most acceptable means for disinfecting these towns' water supplies. The result has been that NERWA is now in the process of implementing many forms of water disinfection including; ozone by UV lamps, Ozone by electric corona discharge, UV irradiation (utilising low and medium pressure lamps), chlorine dioxide, and chlorine gas.

This paper discusses the process involved in selecting the disinfection methods with the community, briefly describes the disinfection process selected, and discusses the challenges involved in commissioning the new Ozone/GAC/UV plant at Myrtleford.

2.0 DISINFECTION PREFERENCES

2.1 NERWA's Disinfection Preference

Chlorine has had a long and successful history as the disinfectant of choice for most Water Supply Authorities to protect the consumer against water borne diseases present in drinking water supplied to the tap. The reasons for chlorine's status as a widely accepted and used disinfectant for drinking water include the following;

- ♦ Chlorine is a strong oxidant capable of inactivating most pathogenic bacteria including E.Coli and Coliforms.
- ♦ A residual can be maintained into the reticulation network protecting against potential recontamination.
- ♦ Chlorine systems are cost effective to install and maintain.

A former president of the American Public Health Association and former chairman of the National Water Resources Board has said of the use of chlorine in potable water supplies that "Chlorine should be noted as perhaps saving more lives throughout the world than any other chemical" (Abel Wolman 1994).

The Australian Drinking Water Guidelines 1996 state that "it is vital to maintain a disinfection residual throughout the distribution system" (p18). Current industry practice is to use chlorine or chloramine for this purpose, although chlorine dioxide and other residuals are put forward as alternatives. If chlorine facilities are provided to maintain a residual, it is cost effective to also use these facilities to provide the initial disinfection.

In view of the widely accepted use of chlorine in water supply systems and its ability to provide a residual, NERWA presented to the community its preference for the use of chlorine to disinfect the town water supply.

2.2 Communities Disinfection Preference

There is a growing resistance in the general community to the use of chemicals in food and drink including tap water. The proposed use of chlorine by NERWA for non-disinfected potable water supplies presented at public meetings was met with very strong community opposition. The townships of Myrtleford, Mt Beauty, Corryong, and Whitfield have always consumed untreated water free of added chemicals and the natural water supplies are a source of town pride that many residents feel compelled to defend.

Some of the reasons cited by the community in opposition to chlorination include;

- ♦ Potential high level of taste and odour associated with the use of chlorine.
- ♦ A disbelief that water fed from mountain spring sources can be harmful.
- ♦ A belief that residents develop a regional immunity to certain pathogenic microbial organisms present in drinking water sourced from the same location.
- ♦ Questioning the WHO guidelines and their applicability to Australian communities.
- ♦ Growing human health concerns regarding the formation of chlorinous by-products such as trihalomethanes (THM's). Health studies have indicated an association between chlorinated drinking water and increased mortality from bladder cancer and possibly colon and rectal cancer (National Academy of Sciences Safe Drinking Water Committee 1980 & 1987).

Whether these reasons are valid or not is immaterial. The main point was that NERWA believed the community needed to be fully involved in the decision making processes to ensure an acceptable disinfection alternative was selected for each town.

3.0 SELECTING AN ACCEPTABLE DISINFECTANT

Due to the initial public outrage against the introduction of chlorine to the water supplies in

Myrtleford, NERWA advertised the formation of a Disinfection Community Reference Group for each town to investigate various disinfection alternatives for the water supplies in that town. The Reference Group met with technical staff and the Board representatives on a regular basis researching various disinfection alternatives available, reporting to the community through meetings and the local press.

As part of the investigations, two pilot plant trials were undertaken to assess the suitability of disinfectant alternatives. Mt Beauty and Myrtleford were trialed for a 2 month period using a portable Ozone/UV plant established for a small number of allotments (< 100). The results of the trial, shown in Table 1, were used to promote the use of the alternative disinfectant for these towns.

Table 1: ***Water quality results from Ozone/UV trials in Myrtleford and Mt Beauty***

Sample Location	Myrtleford	Mt Beauty
Water Prior to Disinfection		
Number of samples	16	13
Average Plate Count orgs/mL	360	720
Ave. Total Coliforms orgs/100mL	67	13
Ave E.Coli orgs/100mL	2.5	0.2
# samples where Coliform > 0	16 (100%)	10 (77%)
# samples where E.Coli > 0	9 (56%)	1 (8%)
Water After Disinfection		
Number of samples	16	13
Average Plate Count orgs/mL	430	2000
Ave. Total Coliforms orgs/100mL	0.7	0.6
Ave E.Coli orgs/100mL	0	0
# samples where Coliform > 0	2 (13%)	2 (15%)
# samples where E.Coli > 0	0 (0%)	0 (0%)
Water in Reticulation		
Number of samples	32	26
Average Plate Count orgs/mL	394	2890
Ave. Total Coliforms orgs/100mL	0.7	2.5
Ave E.Coli orgs/100mL	0	0
# samples where Coliform > 0	7 (22%)	7 (27%)
# samples where E.Coli > 0	0 (0%)	0 (0%)

NERWA was concerned about the higher capital costs involved with non-chlorine disinfectants, usually cited as a disadvantage when considering alternatives. NERWA and the Reference Group adopted an innovative means of overcoming the cost barrier. NERWA had a preference for chlorination and was therefore prepared to pay the full capital cost. However, if the community preferred an alternative to chlorination, then the community would pay the additional capital cost required for the disinfection alternative over and above the chlorination option.

Through an independent agency, NERWA and the Reference Group distributed disinfection survey forms that summarised the various disinfectant alternatives and the capital contribution required for each option. Now the community was empowered with the responsibility for selecting the most suitable disinfectant. It was time to see how serious the community was about the use of chemicals in drinking water supplies!

Based on the surveys undertaken, with the exception of Barnawartha, it was clear that the general community was opposed to the introduction of chlorine to their water supply, and was prepared to pay for an alternative system. The residents voted for an Ozone/Granular Activated Carbon (GAC) filter/Ultraviolet Irradiation (UV) system for Myrtleford, an Ozone/GAC system for Mt Beauty, an

UV system for Corryong, a Chlorine system for Barnawartha, and an UV/Chlorine Dioxide (ClO_2) system for Whitfield. Table 2 summarises the results from the disinfection surveys undertaken.

Table 2: ***Results from water disinfection surveys***

Township	Myrtleford	Mt Beauty	Corryong	Barnawartha	Whitfield
Population	4200	3700	2100	600	150
Households	1302	1223	687	189	69
Survey Responses Received	1094 (84%)	692 (57%)	258 (38%)	150 (79%)	36 (52%)
Chlorination (no additional charge)	87 (8%)	75 (11%)	88 (34%)	101 (67%)	7 (19%)
Alternative 1 (+ additional charge)	O_3/GAC/UV 876 (80%)	O_3/GAC 446 (64%)	O_3/GAC 37 (14%)	O_3/GAC 9 (6%)	UV/ClO_2 28 (78%)
Alternative 2 (+ additional charge)	-	UV 171 (25%)	UV 133 (52%)	UV 32 (21%)	-
Either	131 (12%)	-	-	8 (5%)	1 (3%)
Preferred Option + Capital Contrib.	O_3/GAC/UV $52/annum for 5 years	O_3/GAC $87.20/annum for 5 years	UV $18/annum for 5 years	Cl_2 Nil	UV/ClO_2 $50/annum for 5 years

NERWA has now agreed to install the disinfection systems as voted by the community on the following conditions:

- the community pay for the additional capital contribution, and
- if after a period of one year operation the disinfection process fails to meet WHO guidelines, NERWA will install a chlorination system in addition to the existing facilities to provide a disinfection residual.

4.0 IMPLEMENTING THE PROJECTS

NERWA advertised for a design and construct contract for the Ozone/GAC/UV plant for Myrtleford in February 1998. The contract included a performance guarantee that required the Contractor to "ensure that water disinfected is to comply with WHO bacteriological guidelines throughout the reticulation up to the consumers tap at all times". This limited the number of tenders received to one supplier prepared to meet the conditions of the performance guarantee.
On the basis of limited suppliers prepared to meet the conditions of the performance guarantee, the design and construct contract for the remaining sites was advertised in December 1998 in an amended format. The performance guarantee was modified to provide the same guarantee, but at the beginning of the town reticulation. Under this format a total of 7 manufacturers/distributors provided tenders for the UV and/or the ozone equipment.

5.0 DESCRIPTION OF ACCEPTED DISINFECTION PROCESSES

5.1 Myrtleford

The Ozone/GAC/UV disinfection process adopted for Myrtleford is unique to Australia. The Contractor is proposing a system that has been successful in European communities and appears to be gaining favour. The critical components of the system involve:

- process equipment under pressure with continually varying flowrate based on town consumption,

- ♦ short wavelength (184 nm) ultraviolet lamps used to photochemically convert oxygen in air to ozone (a total of 48 lamps capable of producing 340 g/hr),
- ♦ residual trim ozone dose controller that varies the number of ozone generating lamps that are on to meet an ozone residual set point measured after the ozone contact tanks,
- ♦ injecting ozone into 4 stainless steel contact tanks connected in series to provide a 5 minute detention time,
- ♦ design C.t (dose concentration x contact time) of 1.5 at maximum design flow (135 L/s),
- ♦ passing the ozonated water through 2 fibreglass GAC (coconut fibre) filters in parallel each with a 1.25 minute Empty Bed Contact Time (EBCT) to remove excess ozone,
- ♦ passing the disinfected deozonated water through flow paced low pressure UV lamps (a total of 160 lamps at peak flow) each providing 42 mWs/cm^2 at end of lamp life.

5.2 Mt Beauty

The Ozone/GAC disinfection process adopted for Mt Beauty is widely used throughout Australia for low flow disinfection applications such as in hospitals and swimming pools. There are however very few potable water ozone plants of the scale proposed for Mt Beauty.
The critical components of the system involve;

- ♦ two equal sized independent lines (duty/standby on flip/flop rotation) each capable of half the peak design flow rate,
- ♦ process equipment under pressure with fluctuating flowrate based on town consumption,
- ♦ electric corona discharge method for generating ozone with flow pace and residual trim control (total capacity 960 g/hr),
- ♦ inline hydrokinetic mixers,
- ♦ fibreglass ozone contact tanks with 5 minute detention time,
- ♦ design C.t of 5 at maximum design flow (117 L/s),
- ♦ passing the ozonated water through fibreglass GAC (coconut fibre) filters with a 1.5 min EBCT to remove excess ozone.

5.3 Corryong

The successful Contractor for the UV disinfection for Corryong is proposing to utilise medium pressure UV lamps, another example of a treatment solution unique in Australia.

Most UV systems implemented for potable water supplies utilise low pressure UV lamps that emit ultraviolet light at a frequency concentrated around the germicidal UV wavelength (88% at 253.7 nanometres). Medium pressure lamps emit ultraviolet light at all wavelengths with 27 - 44% in the germicidal wavelength range.

The advantages of medium pressure lamps over low pressure lamps for Corryong include:

- ♦ it is cheaper (at least 30% less than low pressure option for Corryong where the design flow is 64 L/s),
- ♦ there is only one lamp to maintain instead of 20 lamps,
- ♦ the control is simpler on one lamp with half lamp power provided at low flows, and
- ♦ the medium pressure lamp is less susceptible to water temperature variations (medium pressure lamps operate at 600^{o}C, low pressure at 40-50^{o}C).

Disadvantages of medium pressure lamps over low pressure lamps for Corryong include:

- ♦ higher operating costs (low pressure 2.5 kW, medium pressure 8 kW), however the power supply controller at low flows will reduce power consumption on a medium lamp,
- ♦ shorter lifespan on medium pressure lamp (200 days) than a low pressure lamp (300 - 400

days), however the number of lamps required for medium pressure is far less,

- potential by-product formation (e.g. bromate).

6.0 CHALLENGES – IMPLEMENTING MYRTLEFORD'S DISINFECTION

6.1 Maintaining microbial water quality in the distribution without a disinfectant residual

Myrtleford will be supplied with disinfected water with no residual. Maintaining the microbial water quality without a disinfectant residual will be the greatest challenge facing the success of the project.

Providing a free chlorine residual of between 0.2 – 0.5 mg/L has long been the method employed by Water Authorities to preserve the disinfection as recommended in the Australian Drinking Water Guidelines.
However, this is no guarantee of preventing recontamination. Studies have shown that regrowth can occur in water supplies that have a chlorine residual of 1 mg/L (Rice et al. 1991, Herson et al. 1991).

Water supplies can successfully meet WHO guidelines without a disinfectant residual judging by the Netherlands experience. In 1983, Amsterdam Water Supply ceased post-chlorination in response to consumer pressure. Two thirds of all Netherlands water supplies are now consuming disinfected water supplied without a residual. The water is supplied with excellent bacteriological water quality to the customer's tap providing the distribution system is regularly maintained. Maintenance involves routinely flushing, disinfecting after main breaks, and adopting a comprehensive testing program (Van der Kooij 1999).

Maintaining a good quality distribution system is important in any distribution system. Studies have shown that 15 – 30% of outbreaks of water borne diseases in water supplies are attributed to distribution system deficiencies (Wierenga 1985, Galbraith et al. 1992, Moore et al. 1994). It will be more important for Myrtleford in the absence of a residual.
These challenges face the Contractor and NERWA over the coming financial year as the Contractor will be bound by the performance guarantee and NERWA will be reluctant to impose a chlorine residual on the community.

6.2 Modifying the existing reticulation

Myrtleford's water supply is sourced from the Buffalo Creek 10 km to the south of the town. The water is pumped through the reticulation to a 400 ML storage basin on the north eastern side of the town. The reticulation had to be modified to ensure the main supply line across town was fully dedicated with no potential source of recontamination. NERWA does not trust the seals of 10 cross connection valves and propose to blank these off.

Modified flow conditions will result from passing all Myrtleford's water through the treatment plant. A number of new mains were required to take into account perceived changes in flow patterns. A computer hydraulic model was built to model these supply changes and determine size and location of the pipelines required.

NERWA investigated all meters to ensure that backflow prevention devices were fitted.

6.3 Preparing the Reticulation to receive the Disinfected Water

In order for the system to be effective the receiving water mains must be as clean as possible, to minimise the chance of bacteriological regrowth that may be pathogenic (Geldreich 1991). NERWA installed a number of hydrants and flushing points to enable all water to be cycled through the pipe network, particularly on dead-end mains. NERWA then air scoured the whole town to remove years of accumulated algae on the pipe walls. The colour of water removed during the air scouring program was black before running clear!

The Contractor proposed a unique process to disinfect the mains prior to supplying treated water to customers. The swabbing process, coined "Superozonation", was trialed in the Myrtleford reticulation over two consecutive nights. Residents were advised to turn off their supply at the meter during the swabbing. The Contractor utilised the ozone generating equipment on site to generate a maximum of 1.5 mg/L of ozone and by-passed the GAC filters and UV unit to send ozonated water into the reticulation.

The town was broken up into 20 sections and hydrants in these sections were progressively opened to direct ozonated water through every pipe in the reticulation network. As soon as an ozone residual of 0.05 mg/L was achieved, the hydrant was shut and a hydrant further downstream was opened. This process was repeated until the whole town was ozone swabbed. A total of 80 ozone residual readings were recorded.

Given the rapid decay rate of ozone and the poor quality of the reticulation, industry experts felt that the process would not be successful. However, the superozonation process recorded ozone residuals in more than 90% of the town pipelines, the best result being a point 3 km from the disinfection plant. The areas that were not successful were on lines over 3 km from the plant and in areas where cross contamination was present.

6.4 Air degassing at customers tap

When the ozone system initially supplied disinfected water to the reticulation, complaints were received by a number of residents regarding "milky" water. The ozonated air injected into the contact tanks was not being fully released to atmosphere via the 4 air release valves on top of each contact vessel. Consequently this air was passed into the distribution as micro-bubbles that would slowly rise to the surface when opened to atmosphere (a mini DAF plant in a glass!).

Following initial complaints the contractor then installed further air valves on top of the GAC filters. However this does not appear to have solved the "milky" water complaints.
The contractor has since upgraded the size of the air valves and this appears at the time of publication to have solved the degassing problems.

6.5 Testing Program

A comprehensive testing program has been developed to assess the performance of the Ozone/GAC/UV plant during the first year of operation. The program was developed by NERWA with assistance provided by Cooperative Research Centre for Water Quality and Treatment. A summary of the proposed testing program is outlined in Table 3.

Table 3: ***Proposed testing program for Myrtleford***

Test Parameter		Frequency of Sampling						
		L 1	L 2	L 3	L 4	L 5	L 6	L 7
pH		-	-	W	-	-	W	-
Temperature	°C	-	-	W	-	-	W	-
Turbidity	NTU	-	-	W	-	-	W	-
True Colour	Pt/Co	-	-	W	-	-	W	-
TOC (Total Organic Carbon)	mg/L	-	-	F	-	-	F	-
AOC (Assimilable Org. Car.)	mg/L or µg C/L	-	-	F	-	-	F	-

UV Transmission	% @ 1cm 254nm	-	-	-	-	F	-	-
Ozone Residual	mg/L	-	-	-	W	-	W	
Heterotrophic Plate Count	Count	F	F	W	W	-	W	W
E-Coli	Count	F	F	W	-	-	W	W
Coliforms	Count	F	F	W	-	-	W	W
Viable Cryptosporidium Parvum	Count	-	-	M **	-	-	M **	M **
Viable Giardia spp	Count	-	-	M **	-	-	M **	M **

~~Code:~~ Pre Disinfection L1. Raw Water in 400 ML Nil Gully Reservoir
L2. Raw Water from Buffalo Creek Weir.
L3. Raw Water inlet to the Disinfection Plant (shandy of above two sources).
During Process L4. After Ozonation but before GAC Filters
L5. After GAC Filters but before UV Lamps
Post Disinfection L6. At beginning of town reticulation
L7. Within the reticulation (various points x 4).
M – Monthly, F – Fortnightly, W – Weekly
** Giardia and Crypto testing to be undertaken at L6 and L7 if either is detected at L3. Assumes the potential for Giardia and Crypto to develop within the reticulation is extremely unlikely.

It is anticipated that the results of the testing program will be of great interest to the potable water industry.

7.0 CONCLUSIONS

Communities in north east Victoria used to drinking untreated undisinfected water sourced from mountain rivers and springs are strongly opposed to the addition of chemicals to their water supplies. The communities of Myrtleford, Mt Beauty, Corryong and Whitfield are prepared to pay an additional capital contribution to the cost of alternative disinfectant technologies such as ozone, ultraviolet irradiation and chlorine dioxide.

Implementing the projects in previously untreated water supply systems may involve numerous modifications to the existing network.

These modifications may include converting to a single pressure system, installation of flushing points and hydrants, blanking off cross connections to avoid cross contamination, new pipelines to cope with the change in flow conditions, and ensuring backflow prevention devices are fitted.

Maintaining the disinfection into the reticulation network through to the consumers tap will be the major challenge confronting the success of the alternative disinfection projects.

It is proposed to adopt a comprehensive maintenance program including regular flushing and scouring, disinfecting after main breaks, and undertaking frequent testing. It is anticipated that the results of the testing programs for Myrtleford, Mt Beauty, Corryong and Whitfield in the coming year will be observed by many with great interest.

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