FLUORIDATION: THE GLEAMING WHITE TOOTH ABOUT COST

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ABSTRACT

The addition of fluoride to drinking-water is a method of reducing dental caries, supported by the World Health Organisation and the World Dental Federation. Currently, there is no legislation in New Zealand requiring fluoride addition to water supplies; therefore fluoridation is undertaken at the discretion of the drinking-water supplier. However, if the proposed Health (Fluoridation of Drinking-Water) Amendment Bill is passed, the responsibility for adding fluoride into drinking-water supplies would shift from local government to District Health Boards (DHBs) and many Councils are likely to be required to fluoridate their supplies.

A study by the Sapere Research Group in 2015, with fluoridation cost inputs by Beca, evaluated the benefits and costs of water fluoridation in New Zealand. This study was summarised in the 2016 Water NZ paper titled *Cost and Benefits of Drinking-water Fluoridation*. It found that for water treatment plants (WTPs) supplying populations over 500, introduction of fluoride to drinking water could provide a net discounted saving over 20 years of $1,401 million. Despite the potential savings in dental treatment, addition of fluoride to drinking-water is likely to come at significant cost for drinking-water suppliers with multiple smaller WTPs.

This study uses Waimakariri District Council as a case study. These WTPs serve population equivalents of between 100 and 18,000 people and, if mandated by the DHB, would be upgraded to meet the best practice requirements outlined in the *Code of Practice for Fluoridation of Drinking-water Supplies*. The likely capital and operational costs of upgrading 13 WTPs to include fluoridation is compared to the Sapere study costs and commentary on the likelihood of realising the benefits is made.

KEYWORDS

drinking-water, fluoridation, cost-benefit

PRESENTER PROFILE

Lisa is a Process Engineer with five years' experience in the water industry. She was involved in drafting the Code of Practice for Fluoridation of Drinking-water Supplies in New Zealand which included industry consultation. She has since completed numerous water treatment plant fluoridation audits for the Victorian Department of Health and Human Services.

1 INTRODUCTION

Increasing the naturally occurring level of fluoride in drinking-water is a method of reducing dental caries. Approximately half of the New Zealand population have access to fluoridated drinking-water, however it is more common in the North Island than the South Island. Fluoridation has been proven to be an effective method for reducing dental

carries; however there is an increased cost involved in the additional equipment (capital) and operating costs at the water treatment plants (WTPs).

This paper summarises what drinking-water fluoridation is, how prevalent it is in New Zealand and it reviews the benefits and costs. Waimakariri District Council (WDC) is used as a case study.

2 FLUORIDATION OF DRINKING WATER

Fluoridation is the process of adding the trace element fluorine to drinking-water (in the form of the fluoride ion) to raise the concentration of fluoride in the water above the level which occurs naturally in the water supply. The natural fluoride content of water depends on the geology of the area and the type of water (surface water or groundwater). Groundwaters (wells, bores and springs) tend to have higher naturally-occurring fluoride concentrations than surface waters (rivers, streams and lakes). New Zealand waters tend to have relatively low levels of natural fluoride.

Fluoride is added to the water at a controlled rate relative to the flow through the treatment plant to achieve a target concentration in the treated water. The fluoride concentration in the water that leaves the treatment plant is monitored by regular sampling and/or online analytical instruments. There are three chemicals used for the fluoridation of drinking water. These are:

- Fluorosilicic acid (FSA) – formerly known as hydrofluorosilicic/hydrofluosilicic acid (HFA), and also known as hexafluorosilicic acid
- Sodium fluoride
- Sodium fluorosilicate (SFS) – also known as sodium silicofluoride

FSA is not currently available in the South Island but it is likely that it would be made available if there was demand.

Sodium fluoride can be a good choice for smaller water supplies as the capital set up costs are generally lower and the systems are relatively simple to operate. It is better suited to smaller water supplies as the chemical supply cost is relatively expensive.

SFS is the lowest cost chemical and so is commonly used for larger supplies.

3 FLUORIDATION HEALTH EFFECTS

The main beneficial effect of fluoridated drinking water supplies is the reduction of dental caries (tooth decay or cavities) in both pre-eruptive tooth formation and at the tooth surface after it has erupted.

The Royal Society of New Zealand and the Office of the Prime Minister's Chief Science Advisor (2014) carried out a review of scientific evidence relating to water fluoridation. This review included an extensive review of the literature on the subject and input from a panel of experts across the relevant disciplines.

The main findings of this investigation were that there is compelling evidence that fluoridation of water at the established and recommended levels produces broad benefits for the dental health of New Zealanders. The only scientifically established side effect of fluoridation at levels typically used in drinking water fluoridation is minimal fluorosis (discolouration of tooth enamel) which is of minor cosmetic significance. No reported cases of disfiguring fluorosis associated with the levels used for fluoridating water supplies in New Zealand have been found.

The review found that the issues raised by those opposed to fluoridation are not supported by the evidence. It was concluded that it is appropriate, from a scientific perspective, that fluoridation be expanded to assist those New Zealand communities that currently do not benefit from this public health measure.

4 FLUORIDATION IN NEW ZEALAND

4.1 CODE OF PRACTICE FOR FLUORIDATION OF DRINKING WATER SUPPLIES

In December 2014, Water New Zealand published the *Code of Practice for Fluoridation of Drinking-water Supplies in New Zealand* (the Code of Practice). This document was based on best practice around the world, particularly in Victoria, Australia and was produced in consultation with the water supply industry. Currently, there is no legal requirement to comply with the Code of Practice but it has been written to assist water suppliers in the design and operation of fluoridation equipment and maintenance activities associated with fluoride dosing.

The Code of Practice covers:

- Design Criteria
  - Operating targets
  - Control requirements and alarms
  - Dose monitoring including Independent Checks (discussed below)
- Chemical Delivery, Handling and Storage
- Chemical Mixing and Dosing
- Process and Control Instrumentation
- Plant Security
- Operation and Maintenance
- Documentation
- Reporting and Auditing

The three Independent Checks included in the Code of Practice are key to minimising the risk of excessive fluoride concentrations. For water supply systems that serve more than 10,000 people, at least two of the three following independent checks are required. If the water supply system serves 10,000 or fewer people, then at least one of the three independent checks is required.

- **Independent Check 1:** Use of a day tank that can only be filled once a day and is equipped with an online device to measure its contents.
- **Independent Check 2:** Use of a fluoride measuring flow meter on the fluoride dosing line before the dosing point.
- **Independent Check 3:** Use of a fluoride concentration analyser on the drinking-water line after the dosing point.

Water New Zealand also published a Good Practice Guide for the Supply of Fluoride for Use in Water Treatment in May 2014 (the Guide). This document outlines best practice for chemical quality and delivery.

4.2 FLUORIDATED SUPPLIES

There are currently 49 water treatment plants in New Zealand that add fluoride to the water supply, and these plants supply 2,296,782 people with fluoridated water (ESR, 2018). This means that approximately 59.7% of people in New Zealand on networked or specified self-supplies have access to fluoridated water.

Table 1 summarises the fluoridation status of a number of communities in New Zealand. Communities have been selected because they are large or because there have been

recent changes in the use of fluoride. The communities selected for the table are not intended to reflect all the councils that fluoridate.

Table 1: Summary of fluoridated supplies in New Zealand

Local Authority	**Status**	**Comments**
Auckland City Council Auckland	Currently fluoridated	A public referendum was held before the super-city amalgamation.
Central Hawke's Bay District Council Waipukarau	Fluoridation ceased in 2012	In response to submissions during their 2012-2022 Long Term Plan process, the Council voted to cease fluoridation.
Hamilton City Council: Hamilton City	Currently fluoridated	Fluoridation ceased in June 2013 after Council voted 7 – 1 to cease fluoridation. However, when a referendum on the issue was held in conjunction with the October 2013 local body election, just under 70% of the voters supported the addition of fluoride. In March 2014, Council voted to restart fluoridation.
Hastings District Council: Hastings	Currently fluoridated	In response to presentations to Council from an international anti-fluoride campaigner, and the District Health Board (in support of continuing fluoridation), a binding referendum was held in conjunction with the 2013 election. 63% voted in favour of fluoridation. Fluoridation ceased for two years following the Havelock North gastro-outbreak.
Hutt City Council: Lower Hutt excluding Petone and parts of Korokoro	Currently fluoridated	In response to submissions to Council, and presentations from an international anti-fluoride campaigner, and the District Health Board (in support of continuing fluoridation), the Council has voted to continue fluoridation.
New Plymouth District Council: New Plymouth, Waitara, Lepperton & Urenui	Fluoridation ceased in 2011	Fluoridation ceased in 2011 following a tribunal hearing. The fluoridation budget now being used to fund a community dental health education programme throughout the District.
Ruapehu District Council: Taumaranui	Fluoridation ceased in 2011	Responses to submissions on the draft 2011-2012 Annual Plan were 16 for and 18 opposed. During the Council hearings the majority of Councillors were in favour as was the Council management, but after an impassioned plea from one Councillor the Council voted to discontinue fluoridation.
Thames Coromandel District Council: Thames	Currently fluoridated	In response to submissions during their 2012-2022 Long Term Plan process and after extensive community consultation the Council voted to continue fluoridation.
Whakatane District Council: Whakatane &	Currently fluoridated	A decision was made in a district-wide non-binding referendum to be held in conjunction with the 2013 local body election in response to submissions during

Ohope		the Annual Plan process. About 60% voted in favour of fluoridation.

4.3 FLUORIDATION BILL

Currently, there is no legislation in New Zealand that requires the addition of fluoride to a water supply and therefore fluoridation is undertaken by drinking-water suppliers at their discretion. However, if the proposed Health (Fluoridation of Drinking-Water) Amendment Bill is passed, the responsibility for adding fluoride into drinking-water supplies would shift from local government to District Health Boards (DHBs). The bill has come back from the Select Committee and is scheduled for its second reading – it could pass into law some time in 2018.

In June 2017 the Government announced it would make subsidies available over a ten year period to provide capital assistance for fluoridation of local authority drinking-water supplies in support of the impending legislation. The subsidy will support local authority-owned water suppliers who have been directed to fluoridate by their local DHB. Fluoridation dosing systems funded by the subsidy will be expected to comply with the requirements of the Code of Practice for Fluoridation of Drinking-water Supplies in New Zealand, and procure chemicals from sources that comply with the Good Practice Guide for the Supply of Fluoride for Use in Water Treatment.

The government expects that by transferring the responsibility for fluoridation decisions onto DHBs, and providing this subsidy to councils, it will extend fluoridation coverage leading to improvements in the oral health status of the population.

5 BENEFITS AND COST

5.1 SAPERE/BECA STUDY

A review completed by Sapere (2015), with cost inputs from Beca, was carried out to examine the national cost-effectiveness and cost-benefit of fluoridation. A Water NZ paper titled *Costs and Benefits of Drinking-Water Fluoridation* (2016) was published to summarise this study. The review compared the 'burden' of the disease from dental decay by determining that it is equivalent to three-quarters of that of prostate cancer and two-fifths of that of breast cancer in New Zealand. This burden exists despite the provision of dental services for children and the common use of fluoride toothpastes.

The study also summarised the strong body of evidence that confirms the benefits of water fluoridation. It stated that there is a large bogy of epidemiological evidence over 60 years that confirms that fluoridation of drinking-water reduces dental decay over a lifespan. However, it is difficult to accurately quantify the precise amount of reduction because of the continuing improvements in dental treatments.

It was found that children and adolescents living in fluoridated areas could expect a 40% lower lifetime incidence of dental decay compared to those without fluoridated water. In addition, a 48% reduction in the hospitalisation of children due to treatment of tooth decay is expected. Benefits for adults were estimated to be a 21% reduction for those aged between 18 and 44, and a 30% reduction for those over 45.

The study found that adding fluoride to New Zealand's water treatment plants serving above 5,000 people would result in an overall cost savings. The report also found that fluoridation of minor water treatment plants (supplying more than 500 people) would *likely* result in cost savings. It was estimated that the net discounted savings over 20 years for minor and larger plants would be $1,401 million. These savings consist of a $177 million cost for fluoridation and a $1,578 million cost offset for the reduction in dental decay. This results in an estimated 20-year discounted net saving of water

fluoridation of $334 per person, made up of $42 for the cost of fluoridation and $376 savings in reduced dental care.

This study did state that the costs for councils will differ for site-specific reasons. The importance of individual council appraisal was recommended so that the correct benefit profile can be assigned to the specific situation at the council.

5.2 CASE STUDY: WAIMAKARIRI DISTRICT

Waimakariri District Council (WDC) owns and operates 13 WTPs that each serve population equivalents of between 100 and 18,000 people. Historically, fluoridation has not occurred at any of these locations.

A study was carried out to estimate the cost of fluoridation of all WDC supplies so that, if mandated, the Council would have a reasonable idea of the likely investment required. It is important to note that the costs presented in this paper were prepared based on a concept level of design and so they are considered accurate to ±30%.

The Code of Practice includes three Independent Checks. Independent Check 3 (use of a fluoride concentration analyser on the drinking-water line after the dosing point) was included in all designs. Independent Check 2 (use of a fluoride measuring flow meter on the fluoride dosing line before the dosing point) was used for Rangiora and Kaiapoi as they serve more than 10,000 people and two Independent Checks are required for supplies of this size.

SFS was assumed as the fluoridation chemical for Rangiora and Kaiapoi as it is the most economical chemical for large supplies. For smaller supplies where fluoride chemical usage will be low, sodium fluoride was assumed. Although this chemical is more expensive, it is easier to handle and both chemicals are in powder form rather than liquid. This means that the delivery area does not need to be fully bunded and spill kits can be provided as an alternative. This also means that the fluoridation operation is similar for the two chemical types.

Canisters containing 5 kg of compound were considered as an alternative to 25 kg bags. Canister systems greatly reduce the risk of spill and dust inhalation; however, the operational cost is much higher and could not be justified.

Table 2 summarises the capital and operational cost estimates included in Tables 3 and 4 of the 2016 Water NZ paper (the Sapere/Beca study) compared to those found in the WDC study. As can be seen, the WDC case study costs were higher than those from the Sapere/Beca study. The reasons for these discrepancies are:

- **Mid-range Fluoridation Systems** – The cost estimates prepared for the Sapere/Beca study included "low cost" and "high cost" estimates and the values presented in the report are roughly halfway in-between the two. The "low cost" option may require higher operator input, maintenance and have less robust control checks. The "high cost" option allows for a more robust system with better equipment, safety and controls. For the WDC case study, the concept designs were more in line with the "high cost" option as this would reduce operator and maintenance staff input as well as better ensure full compliance with the Code of Practice.
- **Site Specific Considerations** – For the WDC study, all sites were visited so that any site-specific considerations could be identified. In some cases, a new chemical delivery access road was required (not included in the Sapere/Beca estimates). For some of the sites, treated water storage was included so that fluoride could be dosed before this buffer volume (also not included in the Sapere/Beca estimates). Although it is a Code of Practice requirement to dose before treated water storage to minimise the consequences of fluoride overdosing, the Sapere/Beca estimates assumed that treated water storage already existed. We would note that there are broader benefits for the

operation of the supply from these improvements that extend beyond those attributed to fluoridation.

- **Buildings** – Almost all of the WDC sites required new buildings with estimated costs ranging from $40,000 to $60,000 which was higher than assumed for the Sapere/Beca study. These buildings costs were higher as the size of the included a chemical storage area, generally for one pallet of chemical, which was excluded from the Sapere/Beca study.
- **Chemical Assumptions** – There were some differences in the fluoridation chemical assumptions between the Sapere/Beca study and the WDC study which may account for some of the capital and operational cost differences. For the WDC study, SFS was assumed for the larger supplies while sodium fluoride was assumed for the smaller supplies. The Sapere/Beca study assumed FSA for medium sized supplies but this was not used for the WDC study.
- **Inflation** – Costs, including the equipment supply costs, have increased from 2015 to 2018.
- **Minor Inclusion** – The WDC study included a number of minor items, such as water softeners in case required and personal protective equipment, that were specifically excluded from the Sapere/Beca study.
- **Operational Costs** – A higher operational allowance has been made for the WDC case study. This includes building maintenance, chemical costs and electrical maintenance.

Table 2: Summary of capital and operational cost estimate

Supply Size	**Range of Capital Costs**		**Range of Operational Costs (Year 1)**	
	Sapere/Beca Study	**WDC Case Study**	**Sapere/Beca Study**	**WDC Case Study**
Neighbourhood (<100)	$65,000 – $160,000	n/a	$6,800	n/a
Small (101-500)	$75,000 – $160,000	$240,000 - $270,000	$7,600	$11,000 - $12,000
Minor (501-5,000)	$80,000 - $260,000	$290,000 - $350,000	$11,700	$14,000 - $18,000
Medium (5,001-10,000)	$145,000 - $260,000	$380,000 - $390,000	$13,200	$15,000 - $16,000
Large (>10,000)	$400,000 - $2,250,000	$380,000	n/a	$20,000

Table 3 shows the net present value (NPV) of water fluoridation by plant size specifically for the WDC case study. This table is an updated version of the analysis included in Table 8 in 2016 Water NZ Paper (Watson, et al., 2016). Despite capital and operational cost

estimates for the WDC case study being higher than was assumed for the Sapere/Beca study, the same conclusions can be drawn:

- For small plants, the cost of fluoridation is higher than the estimated offset from the reduced dental costs.
- For minor, medium and large WTPs, the cost offsets are greater than the cost of fluoridation which results in a net cost saving.
- WDC does not have any WTPs that fit into the neighbourhood category, so a comment cannot be made.

Table 3: Net present value of water fluoridation by plant size for WDC case study

Supply Size	**Population used for Estimate**	**Fluoridation Cost (NPV)***	**Dental Care Cost Savings (NPV)***	**Net Cost (a negative is a net saving)***
Neighbourhood (<100)	50	-	$19,000	-
Small (101-500)	250	$404,264	$94,000	$310,264
Minor (501-5,000)	2,500	$528,848	$939,000	-$410,152
Medium (5,001-10,000)	7,500	$584,785	$2,818,000	-$2,233,215
Large (>10,000)	50,000	$641,736	$18,785,000	-$18,143,264

*Over 20 years, discounted at a rate of 3.5%

6 CONCLUSIONS

It was found that the estimates prepared for the WDC case study were above the upper end of the range of values included in the 2016 Water NZ paper. The cost figures used in the Sapere/Beca study were based on the average of the range, and also do not take into account site specific considerations. This analysis shows that these site-specific considerations can have a substantial effect on the overall cost estimate.

Despite these capital and operational variations in cost, the conclusions drawn in the Sapere/Beca analysis still apply to the WDC case study. Water fluoridation is more expensive per person in smaller areas. For WDC, it is unlikely that there will be cost savings associated with small supplies, but there is likely to be substantial cost savings associated with minor, medium and large supplies. It is noted that the costs would be borne by WDC (potentially with subsidies, if available) and that the savings are mostly seen in private expenditure with a smaller benefit to the national health budget.

This study highlights the importance of site-specific estimates for determining the cost benefit of fluoridation for a supply.

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