Appendix 20: Cyanotoxin Treatment

1. Introduction

Some reaches of the Waikato River downstream of Lake Karaapiro are susceptible to blue-green algal blooms. If the nutrient load (nitrogen and phosphorus) to the river continues to rise, it is likely that these blooms will occur more frequently. The blooms pose a risk to public (human and animal health) as the chemicals (cyanotoxins) released into the water when the cyanobacteria (blue-green algae) die are toxic. If nothing is done to improve the nutrient loading of the Waikato River, community water treatment plants (WTPs) may need to upgrade their treatment processes to deal with the increased frequency and intensity of algal blooms.

This appendix considers the possibility of cyanotoxin treatment at any location where water is taken from the Waikato River and the water is used for drinking or food processing purposes. There is no historic evidence of algal blooms occurring in the Waipa River – therefore water takes from this river are not considered. Water extracted from tributaries for drinking-water has also not been evaluated.

WTPs and other businesses that draw water from the Waikato River have been identified from the Register of Community Drinking Water Supplies and the Resource Consents for the Waikato area. A total of 14 water takes from the Waikato River have been identified. Two of these water takes, Wairakei Resort and NZ Prawns Ltd, are located just downstream of Huka Falls. Blue-green algae levels very occasionally exceed 'trigger' levels in Lake Taupoo but this is thought to occur as a result of wind concentration. The risk to these water intakes is considered small and, as such, they have been excluded from the cost estimate.

Of the remaining 12 water takes, 10 are for community drinking-water supplies and two, Fonterra Te Raapa and the AFFCO Meatworks, are industrial. Both are primary processing industries and the water may be used in the production of food. Although both these operations have treatment systems, neither have processes suitable for the removal of cyanotoxins.

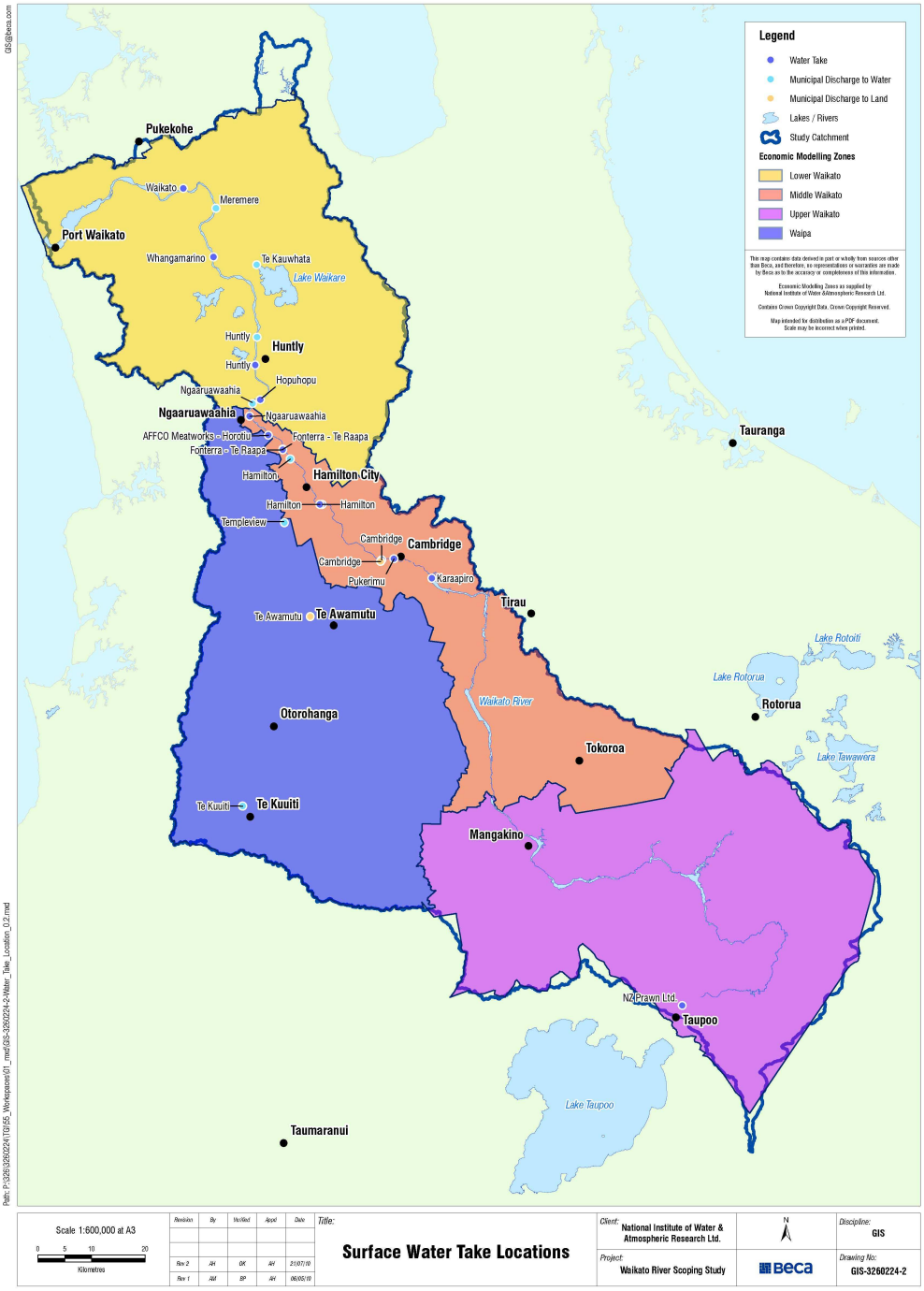

Figure 1: Locations of water takes from the Waikato River which are used for drinking-water supply or food processing.

2. Goals

The purpose of this paper is to generate an estimated cost for the increased level of treatment that may be required at community and industrial WTPs at risk from more frequent and severe algal blooms in the Waikato River should nutrient levels in the river continue to rise.

3. Actions

Algal blooms have a number of effects on drinking-water. The cyanotoxins released by the algae are toxic to human and animal life, and also impart an unpalatable taste and odour to the water. Treatment for algal blooms should include processes to remove the entire cells, and treat the water for removal of cyanotoxins, taste and odour.

Under the Drinking Water Standards for New Zealand 2005 (revised 2008) (DWSNZ), water suppliers do not currently need to provide treatment to remove cyanobacteria but they do need to comply with the Chemical MAV (Maximum Acceptable Value) limits for cyanobacteria.

Regardless of whether a water source is able to treat for cyanotoxins or not, in areas where source water has previously experienced algal blooms the water supplier must implement a monitoring programme for cyanotoxins and develop a management protocol that specifies the actions to be taken should cyanotoxin levels reach a potentially hazardous level. The protocol will be site specific and will outline what steps are to be taken to provide safe drinking-water in the event of an algal bloom. It will take into consideration factors such as whether the water supply is the sole supply for the community, the size of the community and whether alternative source water can be used. For some supplies it may be possible to stand down the WTP until the bloom is over. For others, installation of either a temporary or permanent treatment process may be the only solution.

If the cyanotoxin levels exceed 50 percent of the maximum acceptable value (MAV), more frequent monitoring must be implemented and the Drinking-Water Assessor (DWA) informed. If the MAV is exceeded, the DWA and consumers must be informed. An alternative source of water must be used until levels drop below 50 percent of the MAV.

In conjunction with monitoring cyanotoxin levels, cyanobacterial cell counts may also be routinely monitored by authorities with water takes in water bodies at risk from blue-green algae blooms. The following table outlines some of the cyanobacterial cell

count trigger levels, and the recommended actions (by the Ministry of Health) to be taken by local authorities in the event the trigger level is exceeded.

Table 1: Guideline values for a drinking-water source and recommended actions (Kouzminov et al., 2007).

Guideline Value	Threshold Level	Actions by Local Authorities
Vigilance Level	2,000 cells/mL, or 0.2 mm^3/L biovolume, or 10 µg/L chlorophyll a.	Continue regular monitoring of raw and treated water to ensure adequate system performance and consider analysis (bioassay test) of the treated water to confirm the absence of toxins.
Alert Level 1	20,000 cells/mL, or 2 mm^3/L biovolume, or 10 µg/L chlorophyll a.	Prepare to implement water supply contingency plan, use an alternative source of water, or use water treatment processes capable of removing cells or toxin, or provide drinking-water by tanker or bottles.
Alert Level 2	50,000 cells/mL, or 5 mm^3/L bio-volume, or 25 µg/L chlorophyll or toxin concentrations exceeds MAV.	Monitoring frequency should be increased to at least twice weekly (preferably daily), the water body should be closed temporarily and a contingency plant should be activated, including advanced treatment process.

It is important to note that cyanobacterial cell counts in excess of vigilance or alert levels do not necessarily mean that cyanotoxin levels will also exceed MAV values. Routine monitoring of cell counts is not part of DWSNZ, but is a best practice measure that provides an early warning of bloom conditions. The two largest water supplies extracting from the Waikato River have some degree of permanently installed treatment for cyanotoxins.

Three upgrade options have been reviewed. Option 1 assumes that the river nutrient levels stay the same or decrease from the current situation. Option 2 would apply if algal bloom frequency showed a moderate increase (i.e., an event every one to three years). Option 3 would apply if the algal bloom frequency increased to, say, an annual basis.

Table 2: Options for the treatment of algal blooms (cyanotoxins).

Upgrading Option	Upgrade Required	Description
Option 1	No new treatment.	Blooms are managed under the existing Public Health Risk Management Plan and there is no additional cost.
Option 2	For plants with existing conventional filters, convert to Biological Activated Carbon (BAC). Where no existing filters install new BAC filters.	The filters remove algae cells while the biological media is able to adsorb toxins, taste and odour. The bacteria are grown on granulated activated carbon (GAC) media and will take some time to adjust to bloom conditions. Conversion of existing filters includes: • Replacement of sand media with GAC. • Combined air/water scour for backwash. • Non-chlorinated backwash, including new tanks. • Modifications to filters to increase bed depth. • Automation of backwash procedure.
Option 3	Option 2 plus: • Powdered activated carbon (PAC) dosing for small plants. • Ozone or UV-peroxide oxidation for large plants.	For the case where blooming is very frequent and additional treatment is required. Large plants are those with population greater than 10,000. PAC is able to adsorb the toxins. Ozone and UV-peroxide oxidation work by degrading the chemical structure of the toxins.

Suppliers were approached for costs for both Option 2 and Option 3. Due to the increased complexity of the treatment process for Option 3 it was not possible to provide a reasonable cost estimate; however, costs are anticipated to be significantly more than Option 2. The economic modelling scenarios are therefore based on the treatment plants upgrading to Option 2. The following three options have been selected for modelling:

Option 1: No changes to installed treatment.

Option 2: Supplies greater than 10 MLD install Option 2 level of treatment permanently.

Option 3: All suppliers install Option 2 treatment.

Three of the WTPs already had BAC treatment in place (Waikato, Waiora Tce, Hamilton and Whangamarino). Hence these WTPs were excluded from possibly

requiring upgrades under Option 2. The following table summarises the water takes identified as being at risk of being affected by algal blooms.

Table 3: Water takes considered at risk of algal blooms.

Water Take	Design Flow (ML/day)	Population [1]	Upgrading Options	
			Option 2	Option 3
Waikato (serves Auckland city)	75	956,800	Nothing required	Add ozone/UV-oxidation
Mercer Country Stop	0.06	200	Add BAC filter	Add PAC dosing
Alpha St. Cambridge	16.8	13,400	_	Add ozone/UV-oxidation
Karaapiro	20.5	13,500	_	Add ozone/UV-oxidation
Parallel Rd, Pukerimu	7.8	3,700	_	_
Waiora Tce, Hamilton	94	132,200	Nothing required	Add ozone/UV-oxidation
Ngaaruawaahia	7	5,700	_	_
Hopuhopu	0.8	660	_	_
Huntly	7	7,410	_	_
Whangamarino	3.1	1,700	Nothing required	Add ozone/UV-oxidation
Fonterra Te Raapa	28	NA - Industrial	Convert to BAC filter	Add ozone/UV-oxidation
AFFCO Meatworks	29	NA - Industrial	Convert to BAC filter	Add ozone/UV-oxidation

4. Desired outcome

The risk of illness caused by accidental consumption of cyanobacteria from drinking-water is reduced.

5. Risks and probability of success

The biological media in BAC filters takes some time to adjust to algal bloom conditions. There is, therefore, a lapse in time before the bloom starts and treatment begins. Processes such as PAC, ozone and UV-oxidation are effective as soon as they are started.

[1] Source: Water Information New Zealand, as extracted from the National WINZ database on 3 May 2010 and rounded to the nearest 100.

If nothing is done to prevent the increased nutrient levels in the river, the frequency and intensity of algal blooms will continue to increase. This will mean that the treatment process may not be adequate in the future, or under unanticipated bloom conditions.

At present, the cyanobacterial monitoring data collected by the various local authorities in the Waikato region is collected and collated by Environment Waikato. This information is publicly available. This is an important source of information and could be used as a tool for identifying and tracking the development and extent of algal blooms conditions.

6. Costs and timelines

The following table summarises the upgrade costs necessary to install treatment for cyanotoxins under Option 2. Costs for Option 3 have not been determined at this time. They are anticipated to be significantly more than Option 2.

The upgrade works would be implemented by the water suppliers and the costs ultimately passed on to the communities in the form of increased property or water rates.

It will take three to six months to design and tender the WTP upgrade. A further 6 months to two years should be allowed for procurement, construction and commissioning. This may seem like a long timeframe, but for some WTPs the construction and commissioning may need to be staged or sequenced in such a way to ensure that there is a sufficient quantity and quality of water supplied at all times.

Projects would be implemented on a case by case basis and potentially could have programme overlaps.

Table 4: Cost estimates for cyanotoxin treatment – Option 2.

Water Take	River reach	Capital cost $	Annual operating cost $	Preliminary and general	Consenting and investigations	Design and supervision	Contingency	Capital cost total $
Waikato	Lower	-	-	-	-	-	-	-
Mercer Country Stop	Lower	19,000	10,500	2,280	2,128	2,341	7,725	30,000
Hopuhopu	Lower	-	-	-	-	-	-	-
Huntly	Lower	-	-	-	-	-	-	-
Whangamarino	Lower	-	-	-	-	-	-	-
Alpha St. Cambridge	Middle	-	-	-	-	-	-	-
Karaapiro	Middle	-	-	-	-	-	-	-
Parallel Rd, Pukerimu	Middle	-	-	-	-	-	-	-
Waiora Tce, Hamilton	Middle	-	-	-	-	-	-	-
Ngaaruawaahia	Middle	-	-	-	-	-	-	-
Fonterra Te Raapa	Middle	1,127,000	22,600	135,240	126,224	138,846	458,193	1,990,000
AFFCO Meatworks	Middle	1,145,000	23,400	137,400	128,240	141,064	465,511	2,020,000
Total		**$2,291,000**	**$56,500**	**$274,920**	**$256,592**	**$282,251**	**$931,429**	**$4,040,000**

7. References

Kouzminov, A.; Ruck, J.; Wood, S. (2007). New Zealand Risk Management Approach for Toxic Cyanobacteria in Drinking Water. *Australian and New Zealand Journal of Public Health Vol. 31 No. 3.*