TRIAL IMPLEMENTATION OF HEALTH BASED TARGETS

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ABSTRACT

Health Based Targets (HBT) for microbial safety provide quantitative definitions of safe drinking water. While the Australian Drinking Water Guidelines provide values for hazardous chemicals it does not include corresponding targets for pathogenic micro-organisms such as bacteria, viruses and protozoa. The Health Based Target Manual was produced by the Water Services Association of Australia and is based on the World Health Organisation target of disability-adjusted life years. Tweed Shire Council recently participated in a trial implementation of HBTs using this manual. The manual was found to be a well structured and useful tool for assessing the pathogenic safety of drinking water and compliments the recently developed Drinking Water Management System. A number of improvements were identified that were expected and consistent with an existing improvement plan. The most significant and unexpected improvement required was the requirement for additional process steps such as UV disinfection to increase protozoan reduction.

1.0 INTRODUCTION

A guiding principle of the Australian Drinking Water Guidelines (ADWG) is that the greatest risk to consumers of drinking water is pathogenic microorganisms. However, while the ADWG includes guideline values for hazardous chemicals it does not include corresponding targets for pathogenic micro-organisms such as bacteria, viruses and protozoa. Internationally, HBTs for microbial safety are used to provide quantitative definitions of safe drinking water. These HBTs are based on risks of illness or infection and then use assessments of source water quality to determine the treatment requirements to meet the HBT. The National Health and Medical Research Council (NHRMC, 2014) recently released a discussion paper on the possible implementation of HBTs in Australia and conducted a survey of stakeholders to determine their views on the inclusion of HBTs in the ADWG. The survey found that most stakeholders are supportive of the inclusion of HBTs in the ADWG but have concerns about the costs and skills gaps of staff to implement and manage HBTs.

In 2012, the Water Services Association of Australia (WSAA) decided to form a HBT Working Group to assess the implications of introducing HBTs. This resulted in a trial of HBTs by several large water utilities. Using their experience WSAA developed a manual for the application of HBTs (HBT Manual, 2014) and invited a number of water utilities to participate in a trial of implementing the manual. Tweed Shire Council (TSC) was involved in this trial and completed the requirements of the manual in late 2014. This paper reports the outcomes of this trial and the challenges and benefits of implementing HBTs.

2.0 DISCUSSION

The HBT Manual details a process for developing water supply system specific HBTs. The manual follows the WHO (2011) definition of acceptable pathogen risk, which is a target of one µDALY (Disability-adjusted life years). The assessment process is consistent with the ADWG Framework and was developed to quantitify the risk caused by pathogenic microorganisms in the source water using internationally accepted standards (Figure 1). The process commences with a mandatory Tier 1 assessment of the source water using a Sanitary Survey. The outputs of the Sanitary Survey are used to produce a Vulnerability Assessment.

This step involves placing the source into one of four categories: protected, moderatly protected, poorly protected or unprotected catchment. Raw water *E. coli* data are then used in a Microbial Indicator Assessment to confirm the Vulnearbility Assessment (Table 1). The pathogenic reduction requirements for bacteria, viruses and protozoa have been determined for each source water category and this determines the treatment level required as log reduction values (LRVs, Table 2).

The Tier 1 system is described as a binning system and groups the system risk and assigns a conservative LRV. An optional Tier 2 assessment can be used if sufficient pathogen data is available. This requires a Quantative Microbial Risk Assessment (QMRA) and the procedures for this assessment are outlined in the manual. A Tier 2 assessment was not attempted in this trial due to lack of protozoan data.

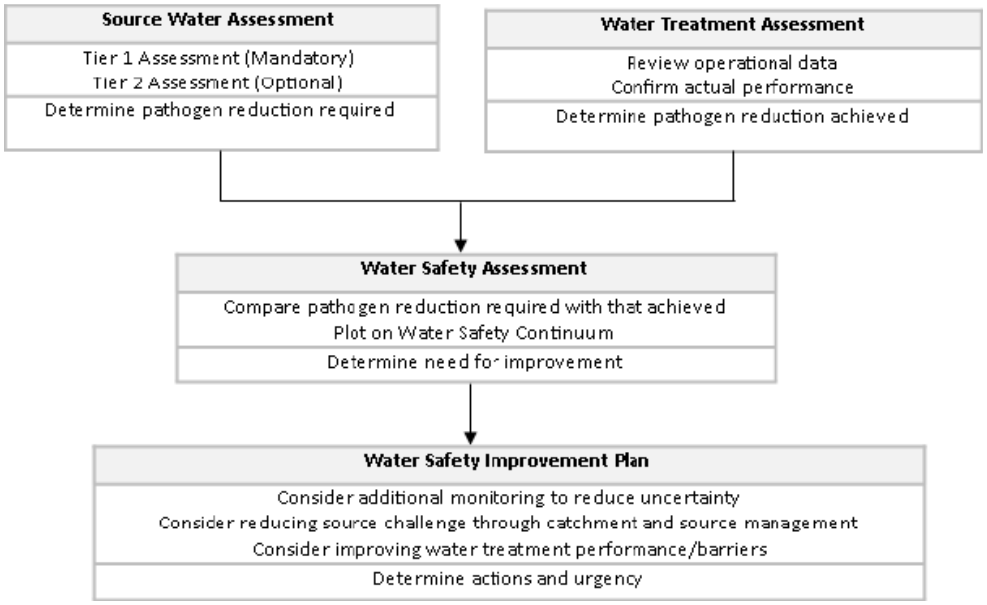

Figure 1: ***Water Safety Assessment Process (WSAA 2014)***

Table 1: ***Comparison of* E. coli *Concentration with Sanitary Inspection Category as an Independent Reality Check (WSAA 2014)***

Source water vulnerability assessment category	**Microbial indicator concentration category Maximum *E. coli* (#) per 100 ml**			
	≤ 20 Typical of category 1 sources	> 20 ≤ 2,000 Typical of category 2 and 3 sources	> 2,000 ≤ 20,000 Typical of category 4 sources	> 20,000 Not suitable as a drinking water source without a high level of treatment
1	Source = Cat 1	Source = Cat 2	Anomalous	Not suitable
2	Source = Cat 2	Source = Cat 2	Anomalous	Not suitable
3	Anomalous	Source = Cat 3	Source = Cat 4	Not suitable
4	Anomalous	Source = Cat 4	Source = Cat 4	Not suitable

Once the LRV targets have been determined a water treatment assessment is required to determine if the processes will achieve the HBTs. To achieve the LRV the water treatment process needs to be first detailed and then the treatment performance compared with the default LRVs for treatment processes provided in the HBT Manual. The HBT Manual provides process critical limits that must be achieved to justify claiming the LRV for each treatment process.

Table 2: ***Recommended Minimum Pathogen Reduction Requirements (WSAA 2014)***

Source water category	Minimum pathogen log reduction required		
	Bacteria	**Viruses**	**Protozoa**
1	4.0	0	0
2	5.0	3.0	2.5
3	5.0	4.0	3.5
4	6.0	6.0	5.5

Finally, a Water Safety Assessment is conducted to compare the LRV requirements with the LRV achieved by the treatment process. If the target LRV is achieved then the HBT of one µDALY is being achieved. The difference between the LRV required and that achieved can be plotted on the Water Safety Continuum. A shortfall of 0.5-1 log is considered to be in the 'safe' part of the continuum, 1.5-2.5 'marginal' and >2.5 'outbreak'.

If the HBT of one µDALY is not acieved then the continuum determines the overall response of the system operator and leads to a Water Safety Improvement Plan that details the actions required to reduce the pathogenic risk to the acceptable HBT.

2.1 Sanitary Survey and Vunerability assessment

TSC operates three water supply systems: Bray Park, Uki and Tyalgum (Figure 2). Uki and Tyalgum are subcatchments of the Bray Park catchment. All systems draw water from the Tweed River catchment which covers an area of 570 km^2 and is entirely located within the boundary of the Tweed Local Government area. The water supply systems are owned and operated by TSC under a Drinking Water Management System (DWMS) that was developed to comply with the ADWG and approved by NSW Health in 2014. While a source water assessment was completed for the DWMS, it did not meet the requirements of a Sanitary Survey which is focused on pathogen sources. So a Sanitary Survey was undertaken to comply with the outline provided in the HBT manual (Appendix A). This required the mapping of landuses in a GIS system from which land use areas could be calculated. Potential pathogen point sources were also identified and mapped.

The main land uses were broad scale grazing (approx. 30%), privately owned bushland (approx. 30%) and National Park (approx. 30%). The main sources of pollution were dairies, piggery, wildlife, broad scale grazing with access to waterways, onsite sewage management systems (approx. 830) and itinerant human activities.

The outcomes of the Sanitary Survey were then used to complete the Vulnearbility Assessment for each water supply system. The Bray Park system was characterised by:

- Permanent urban and rural residents with low to medium intensity and no exclusion zones.
- Itinerant human activities with low water based and land based activities and no exclusion zones from water ways.
- Stock animals primarily broad scale grazing of cattle and horses and intensive stock including three dairies and two piggeries some of which are adjacent to the water offtake. There is some exclusion to waterways but for much of the catchment livestock are not excluded from waterways and overall all intensity is high.
- Wastewater Treatment plants with low intensity due to size and onsite reuse and little discharge to waterways.

- Wildlife with low intensity but Flying Fox colonies are located adjacent to waterways and are medium intensity.
- Horticulture with low intensity

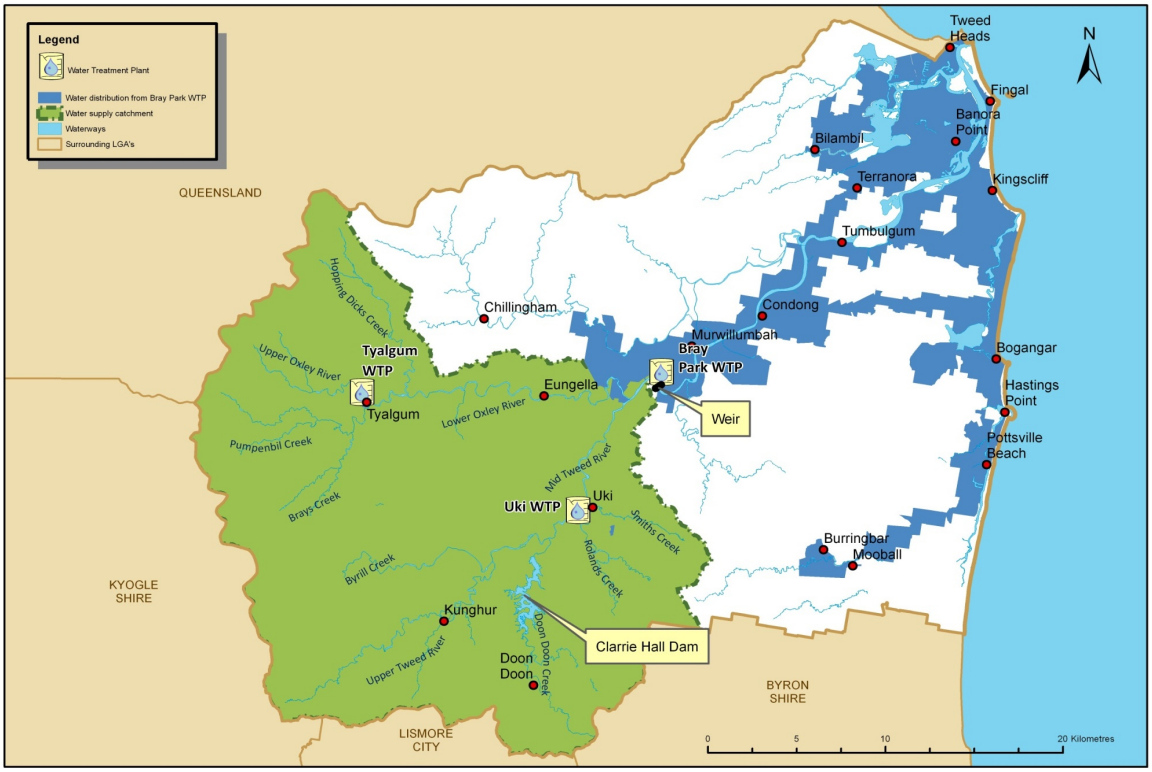

Figure 2: ***Overview of TSC Water Supply Network***

This assessment best fits the criteria for Category 4 - Unprotected Catchment. The HBT manual definition for Category 4 is: sources have high levels of faecal contamination from human and agricultural activities. The inner catchment is not protected and recreation may occur throughout the catchment and on the water body. The Tyalgum system was also categorised as Category 4, however the Uki system was assigned a Category 3, primarily due to the absence of any wastewater treatment plants and any intensive livestock.

The Microbial Indicator Assessment found a maximum of 9,208 *E. coli* per 100mL in the Bray Park system and 49,020 in the Tyalgum system and confirmed the Category 4 Vulnearability Assessment (Table 1). However the Uki system had a maximum of 9,404 *E. coli* per 100mL which does not support the Category vulnearbility assessment. Since according to the HBT Manual the Microbial Assessment should take precedance over the Vulnearabilty Assessment all three systems were assessed as Category 4. Using Table 2, the minimum pathogen reduction requirements for all three water supply systems are: bacteria - LRV 6.0, viruses - LRV 6.0 and protozoa - LRV 5.5.

2.2 Water Treatment and Safety Assessment

Bray Park and Tyalgum WTPs are ultrafiltration membrane plants with chlorine disinfection. Uki WTP is conventional media filtration with Dynasand filters and chlorine disinfection. The LRV credits claimed for each treatment process were based on the default values provided in the HBT Manual unless the manufacturer's specification defined otherwise (Table 3). To claim the default LRV credits the treatment plant performance for the process must meet the critical limits.

This was easily confirmed for the ultrafiltration and chlorination processes, however the conventional treatment required demonstration of individual filter turbidity ≤ 0.15 NTU for 95% pf the month and not > 0.3 NTU for ≥ 15 consecutive minutes. While the plant has an on-line treated turbidity analyser, extracting the data from SCADA and then demonstrating the critical limits was problematic and could not be consistently verified.

Table 3: Comparison of Required and Achieved LRV

	Log Reduction Value		
	Protozoa	**Bacteria**	**Virus**
Category 4 requirement	5.5	6	6
Bray Park WTP			
Ultrafiltration	>4	3	2
Chlorination	0	4	4
Total	>4	7	6
Shortfall	<1.5	0	0
Uki WTP			
Conventional (Dyna sand)	3.0	2	2
Chlorination	0	4	4
Total	3.0	6	6
Shortfall	2.5	0	0
Tyalgum WTP			
Ultrafiltration	>4	4	2
Chlorination	0	4	4
Total	>4	8	6
Shortfall	<1.5	0	0

The Water Safety Assessment then requires a comparison of the LRV credits versus the LRV requirements (Table 3). The HBT of one µDALY for bacteria and virus risk was achieved for all treatment plants, however, there was a shortfall for protozoan reduction for all plants. The membrane manufacturers for Bray Park and Tyalgum WTPs specify >4 LRV for protozoans. Although no more than 4 LRV can be claimed for any one process, the protozoan shortfall is in the border safe/marginal part of the continuum and the safe range (0.5-1 LRV shortfall) was claimed.

This means these WTPs should be in no danger of an imminent public health incident. Due to uncertainty in the assessment it is considered reasonable to undertake targeted information gathering to reduce the uncertainty and review within a year. Uki WTP is considered to be in the marginal (1.5-2.5 LRV shortfall) part of the continuum. While a public health incident is still unlikely, there is no buffer should the source experience an unusually high challenge or the WTP performance deteriorates. This requires close monitoring of the source water and the WTP performance with appropriate contingency plans to protect public health should source or WTP performance deteriorate.

2.3 Improvement Plan

The final stage of the HBT assessment is to develop an improvement plan.

The key items identified were:

- Develop a Catchment Management Strategy to identify pathogen sources
- Consider a Tier 2 assessment of the catchment to verify the Category 4
- Review DWMS Critical Control Points to align with HBT process critical limits.
- Ensure online monitoring is recorded to allow verification of HBT limits
- Conduct a process review of Uki WTP with the aim of improving turbidity
- Consider treatment process improvements, particularly UV

3.0 CONCLUSION

Tweed Shire Council completed a trial implementation of the HBT Manual (2014) and found it to be a very useful tool for the introduction of HBTs and the methodolgy appropriate for pathogen risk assessment. The assessment outcomes were documented in an improvement plan. Some of these improvements were not unexpected and TSC will be implementing these in the short term. The HBT shortfall in protozoan reduction was unexpected, particularly for the recently commissioned Bray Park and Tyalgum Ultrafiltration WTP's.

TSC was of the view that these plants were appropriately designed to meet the pathogenic risks from an unprotected water source. The minimum LRV requirement of 5.5 means that a second treatment process is required. While membrane filtration is a very effective barrier to protozoans one of the HBT Manual requirements is that no greater than 4 LRV can be claimed for a single barrier. The most suitable additional barrier to gain the additional 1.5 LRV would be UV. Given the WTPs are still in the 'safe' part of the continuum TSC will wait to see the final inclusion of HBTs into the ADWG before making changes.

4.0 ACKNOWLEDGEMENTS

To Tweed Shire Council Water Unit for supporting this trial and the GIS staff for many hours of mapping required to inform the Sanitary Survey.

5.0 REFERENCES

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