OPPORTUNITIES AND BENEFITS OF UNDERTAKING A WATER AGE TRACER STUDY

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ABSTRACT

Once water leaves a treatment plant and enters a distribution system, the pathway which the water takes and the time it remains in the system can be hard to determine. Water age is a major factor in water quality deterioration within the water distribution system. If water age can be determined, it has the potential to assist operators with the day to day operational decisions they are required to make.

During routine maintenance at Northern Water Treatment Plant (NWTP), the fluoride system was taken offline. Townsville Water decided to use this opportunity to undertake a water age study using fluoride as its chemical tracer; fluoride is suitable as it is chemically stable and its short term absence from treated water is safe as fluoride is not required to disinfect.

The study determined that the majority of the reticulated water supply in the region was aged between 4 and 8.5 days.

The project has had two main benefits for distribution system operation. Firstly, flushing programs have been streamlined to target problem areas; this has resulted in less wastage of water and has allowed staff to approach this task more systematically and purposefully compared to past approaches. Secondly, data collected has been used to model chlorine decay in the region; this information was used to assist with setting limits in Townsville Water's Drinking Water Quality Management Plan (DWQMP).

1.0 INTRODUCTION

Water age contributes significantly to water quality deterioration in a distribution system. It can cause water quality issues such as taste and odour complaints, disinfection by-product formation, disinfection decay and microbial regrowth. It is of particular relevance to Townsville due to its high ambient temperatures (mid to high 30s in summer) and long supply lines (due to its spread of population and limited density at endpoints) resulting in long residence periods.

In March 2013, the Northern Water Treatment Plant (NWTP) turned off its fluoride dosing system for routine maintenance. Townsville Water took the opportunity to undertake a water age study using fluoride as a chemical tracer. As fluoride is a stable chemical, the reduction of fluoride in the water samples over time can be attributed to the movement of unfluoridated water through the system and not to chemical degradation of the element itself. It is safe to eliminate fluoride dosing from the treatment process as it is not crictical to disinfection. Additionally, Townsville's customer perception of water quality would not be compromised, which may be the case if a dye is added to a water supply as a tracer (i.e. the tracer is not detectable to customer's using this method).

The purpose of this tracer study was to determine the time that water took to travel from the NWTP through both the bulk and reticultion networks and on to the customers at the outer points of the system.

It was thought that this information could be used to streamline flushing programs and ensure that Townsville Water was targeting genuine dead ends through its existing flushing program. It was also thought that this information could be used to model chlorine decay and thus used to set target and critical limits within the Townsville Water DWQMP.

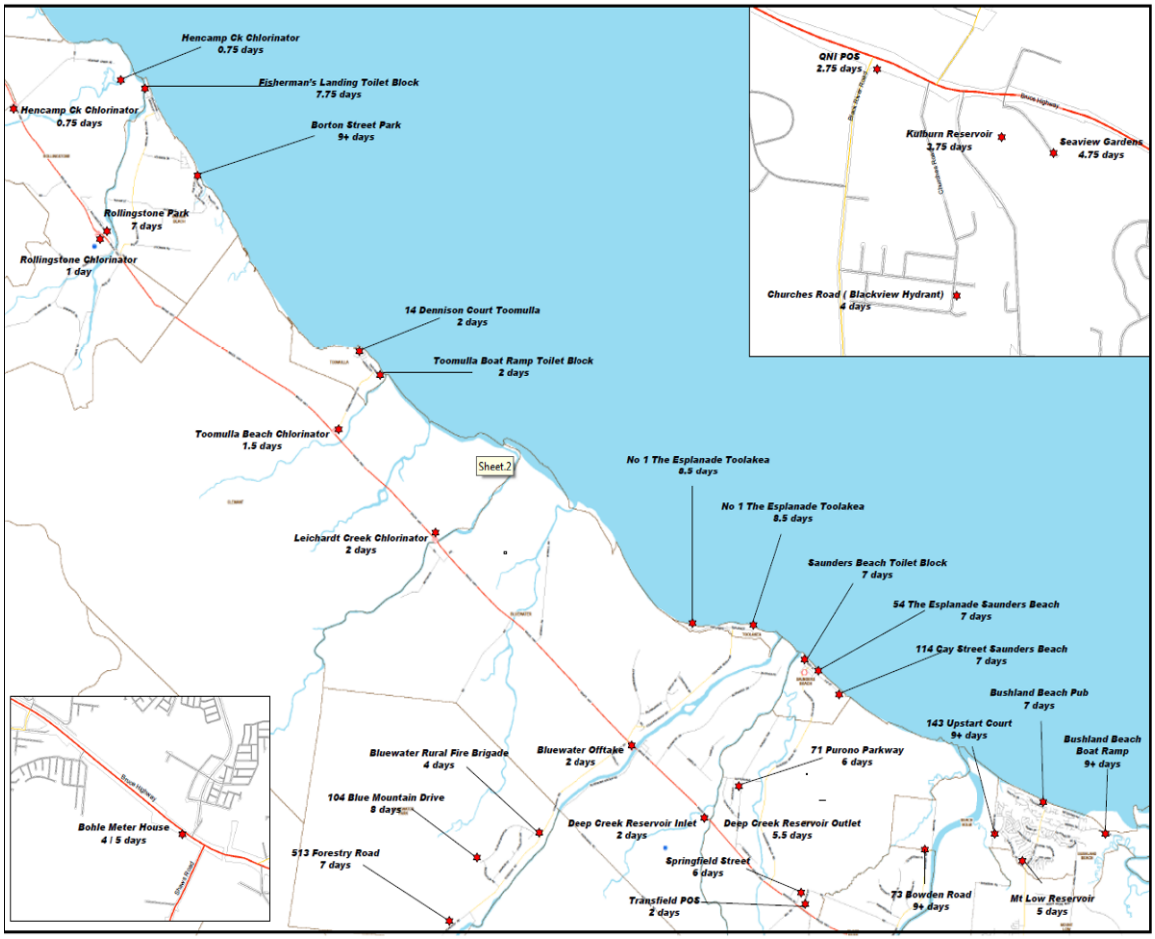

Figure 1: ***Schematic showing sample points and corresponding water age. (NWTP to Kulburn Reservoir =46.4km)***

2.0 DISCUSSION

The reduction of fluoride in the water samples over time can be attributed to the movement of unfluoridated water through the system. Therefore the number of days taken for fluoride concentrations to reach natural levels (< 0.2 mg/L) was deemed to be the number of days taken for the water to travel from NWTP to the sample point.

2.1 Method

Sample points were chosen by distance from NWTP, estimated typical water demand and ease of access. Twenty six sample points were considered. Nine of these were bulk network points of sale (transmission points between bulk and reticulation) and seventeen were from within the reticulation system. The experience of staff was used to identify reticulation sample points that were representative of outer regions of the network.

The sample distribution was split into three sections; southern, central and northern. This allowed three crews to sample concurrently. Sampling occurred three times daily due to resource and time constraints. The following times and the reasons why they were chosen are outlined below:

Table 1: ***Sample times and the reasons why they were chosen***

Time	Reason time was chosen
9.30	This time marks the end of morning usage. High morning usage in Townsville occurs between 5.30 and 9.00 as people prepare for work/ school.
14.00	This time is the midpoint of daytime usage
19.30	This time marks the end of early evening usage. High water usage occurs in Townsville between the hours of 16.00 and 19.30 as people finish work/ school.

NWTP fluoride dosing was turned off at 9.00am on Monday 4 March, 2013. The first samples were taken from 9.30 am at all sample points. This gave the baseline fluoride concentration of the network.

Staff flushed the sample points for 5 minutes prior to taking a sample in pre-labelled bottles. Samples were stored in fridges until they could be analysed by Townsville Laboratory Services, a National Association of Testing Authorities (NATA) accredited laboratory. Analysis was conducted using Ion Chromatography with a limit of reporting (LOR) of 0.005 mg/L and an uncertainty of +/- 0.02.

Samples were taken from the source water and a base measure of natural fluoride was obtained of 0.2 mg/L. Added fluoride was considered to be absent once fluoride levelled off below this cut off point. The number of days taken to reach the natural fluoride level was deemed to be the number of days taken by the water to travel from the treatment plant to the sample point.

2.2 Key Results

Exact water age is an estimate, as the accuracy of fluoride decay may be off by as much as the time passed since the previous sampling time. This ranged from four hours during the day to fourteen hours over night. Therefore data is not acceptable for any precise mathematical treatment but gives a general overview of how long it takes for water to reach the outlying points in the distribution system.

- Water takes from 1.75 to 8.5 days to reach the most outlying points in the reticulation system. It must be noted that this study was undertaken in the dry season, with high water usage menaing water may be older at times of low water usage.
- Water age was greater than expected at some of our outlying sample points.
- A geograpically linear progression is shown on the bulk water sample points with those points furthest from the treatment plant taking the longest time to lose fluoride. However reticulation sample points showed only a relatively geographical linear progression from the plant, due to low water usage at some points (some of our outling points feed only a few houses).

Greatest water age occurs where there are long supply lines and low water usage resulting in long detention times. These findings have implications operationally for our flushing program.

2.3 Results for Bulk Water Sample Points

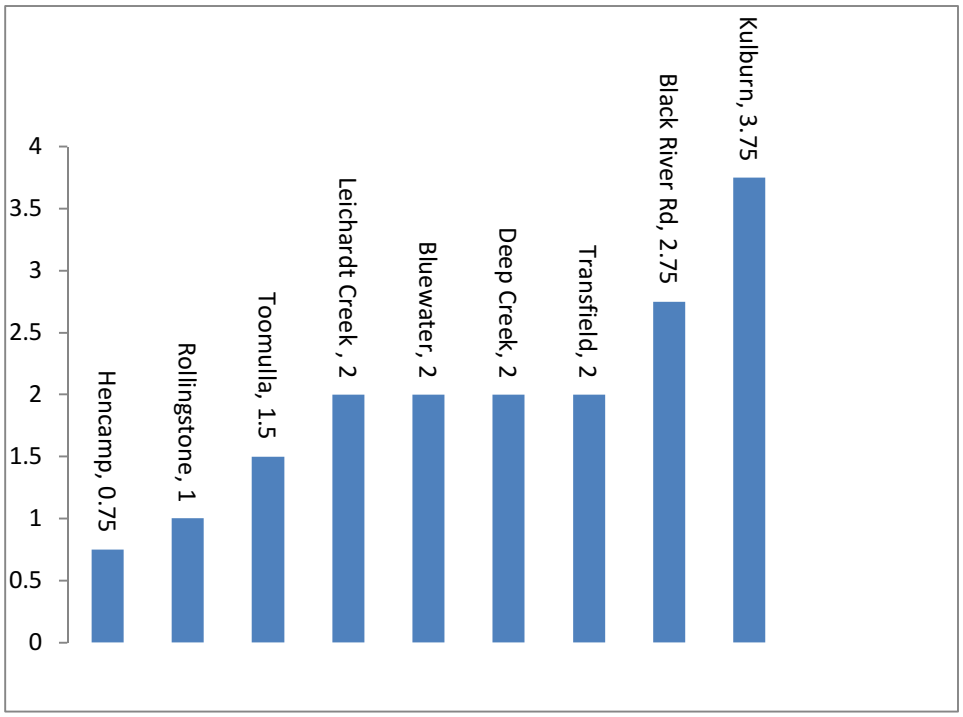

Figure 2: ***Days taken for water to travel from NWTP to the bulk sample points.***

A geograpically linear progeression is shown on the bulk water sample points with those points furthest from the treatment plant taking the longest time to lose fluoride. The water age for the bulk system ranged from 0.75 days to 3.75 days.

Hencamp Creek Chlorinator is the first point of sale (POS) 1.7km from the treatment plant. It took three quarters of a day for the fluoride to disappear from here. Water age was also low at the next three points of sale Rollingstone, Toomulla and Leichardt Creek.

Kulburn Reservoir which is essentially the final transmission point considered, at 46.4km from NWTP, showed the longest bulk detention period of 3.75 days

2.4 Results for Reticulation Sample Points

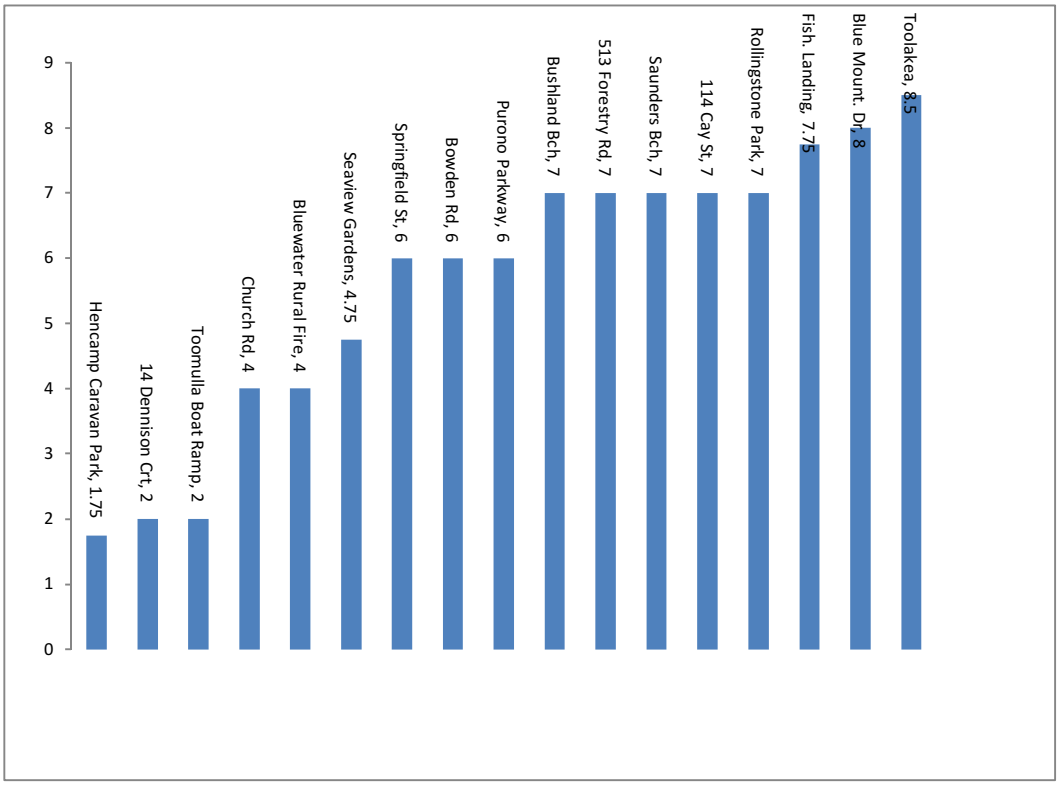

Figure 3: ***Days taken for water to travel from NWTP to the reticulation sample points.***

As expected, water age was greatest at all reticulation sample points. They show a relatively geographical linear spread with distance from the plant. Demand within the network affected the results and as such areas of low turnover returned higher water age values independent of their geographical location. An example of this was Fisherman's Landing which had a water age of 7.75 days, yet it's bulk feed point at Rollingstone had a water age of only 1 day. Comparablly the Toomulla Boat Ramp sample point value of 2 days was only a half a day longer than its bulk delivery point.

Water age was significantly older than expected at many points taking 5-8 days to reach some outlying sample points. Both these findings have implications for the Townsville Water flushing program.

2.5 Operational Benefits of the Study

The data and knowledge gained from this study have been generated into tangible benefits for Townsville Water and its operations.

Water age in the system is greater than expected. Previously Townsville Water's flushing program focused on those areas furthest from the treatment plant. However it is now known that water usage also has a very real effect in Townsville's reticulation system and the areas where this low water usage occurs are now known.

Using this knowledge Townsville Water has streamlined its flushing program to target problem areas. This in turn has improved water quality to these customers.

Townsville Water have used the data to model chlorine decay. This has been used to confirm chlorine set point levels at NWTP i.e. working backwards knowing the chlorine levels at the endpoints in the system, and knowing roughly how many days it takes for the water to reach these points, can be used to determine the chlorine set point levels for the plant. The chlorine decay model has also been used in a similar way to set Critical Control Points, target and critical limits for chlorine levels in the Townsville Water DWQMP.

2.6 Implications for Other Water Suppliers

Any water supplier who fluoridates their water can use this simple approach to determine the age of water throughout their distribution system. It can be carried out when routine maintenance of fluoride dosing systems is occuring, minimising disruption to the treatment plant (and customers) and it can be carried out without compromising public perception of the quality of the water. Water providers can use the knowledge gained to implement/streamline flushing programs and to set chlorine target and critical limits.

3.0 CONCLUSION

Undertaking a water age study using fluoride as a tracer has delivered valuable knowledge and tangible benefits to Townsville Water. The flushing program has been streamlined which has improved both water quality to our customers and saved money through less "water wastage" and better use of operator time. Public perception of Townsville Water has improved as we are no longer viewed as "wasting water", which was especially relevant this year as it was an extremely dry year in Townsville. Townsville Water have used the data to model chlorine decay which has enabled meaningful target and critical limits for chlorine levels in the Northern Beaches area of Townsville to be set. In addition it can be used to determine the chlorine set point required at the NWTP for the network.

The study was undertaken with no disruption to the service supplied to Townsville Waters customers and without compromising public perception of water quality.

The study can be easily undertaken by other water suppliers who supply fluoridated water to their customers.

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