SETTING CHLORINE CONTACT TIME TARGETS BASED ON SYSTEM PERFORMANCE ANALYSIS

Paper Presented by:

Kimberly Lippmeier

Author:

Kimberly Lippmeier, *Water Treatment Engineer,*

ACTEW Water

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Kimberly Lippmeier, *Water Treatment Engineer,* ACTEW Water

ABSTRACT

Stromlo Water Treatment Plant is a 250 ML/day DAFF plant which operates with two disinfection barriers: ultraviolet irradiation and chlorination with chlorine gas. Chlorine contact time is provided by the 34 ML capacity Stromlo Balancing Reservoir, before treated water is supplied to the distribution system.

The source water to Stromlo WTP is very low in alkalinity, and treated water corrosivity is an issue which needs to be managed without compromising disinfection. The distribution system has a history of high pH in some areas which has the potential to compromise disinfection efficiency.

This paper discusses the results of the analysis of 12 months of operating data using the WIOA WTAnalyser Disinfection Tool. The tool was calibrated using existing computational fluid dynamic models of the Stromlo Balancing Reservoir.

The outcomes of the analysis are a clear understanding of the operating range of the disinfection system and chlorine contact times. The impact of final pH and corrosivity management on disinfection effectiveness is assessed. The result is setting of realistic critical limits for this critical control point, and the development of online SCADA calculation for chlorine contact time, including monitoring and alarm functions.

1.0 INTRODUCTION

Stromlo WTP was replaced in 2004 with a 250ML/day DAFF plant to treat water from the bushfire impacted catchment and reservoirs on the Cotter River. Stromlo WTP was then upgraded in 2007 to include UV treatment prior to the commencement of abstraction of higher pathogen risk source water from the Murrumbidgee River. The plant now has two disinfection barriers, UV irradiation and chlorination with chlorine gas.

Following the USEPA Long Term Enhanced Surface Water Treatment Rules (LT2) rules for log reduction of *Cryptosporidium*, Stromlo WTP targets 6 log reduction credits. This is achieved through filtration, DAFF, filtered water turbidity targets and UV disinfection. Due to the ineffectiveness of chlorine on cryptosporidium without high chlorine contact time, chlorine disinfection is not included toward reduction credit. Chlorination is a Critical Control Point under the ACTEW Water Drinking Water Quality Management Plan as a disinfection barrier for microbiological pathogen risk.

The UV treatment system operates at 30mJ/cm2 which assures 2 log removal for the indicator pathogen Cryptosporidium. The UV treatment system is three Calgon 150ML/day UV reactors which operate in duty/assist/standby.

The chlorine residual target for Stromlo WTP is in the range of 1.0 – 1.6mg/L Free Available Chlorine (FAC) varying to maintain chlorine residual in the distribution network and town reservoirs. Chlorine contact time is provided by the 34ML/day Stromlo Balancing Reservoir (SBR) constructed as part of the original Stromlo facility in 1960s.

The SBR is 76m in diameter with no internal baffles. The inlet and outlet can be seen in

the detail of Figure 1. This inlet and outlet configuration is the original design prior to the construction of Stromlo WTP in 2004. From 2004 until 2011 an overhead inlet was utilised, almost opposite the outlets. Following construction of pipework for a maintenance bypass, in 2011 the original inlets were recommissioned to reduce short circuiting.

The main factors that affect chlorine disinfection efficiency are concentration, contact time and pH. ACTEW Water has utilised the WTAnalyser Disinfection Tool produced by the Water Treatment Alliance and the Water Services Association to analyse the efficacy of chlorine disinfection at Stromlo WTP.

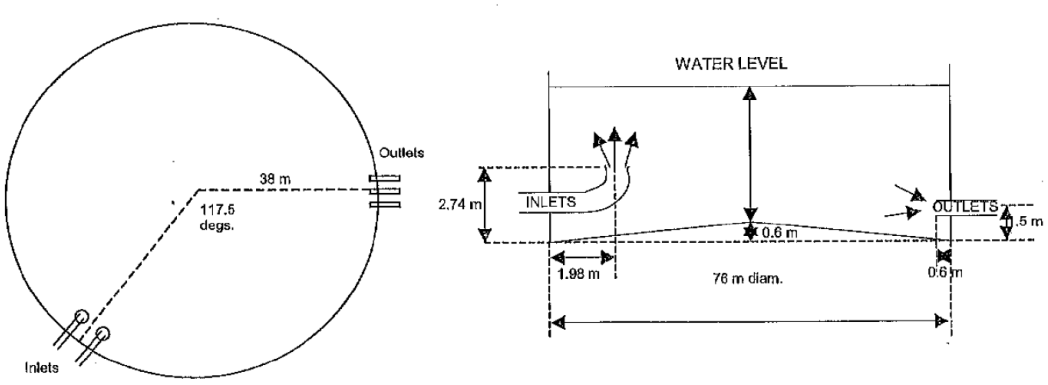

Figure 1: ***Stromlo Balancing Reservoir***

The WTAnalyser Disinfection Tool is an Microsoft Excel based tool that can be used to analyse the performance of a treatment plant for chlorine disinfection by considering effects of Flow, Free Available Chlorine, pH and Turbidity data to calculate and analyse chlorine contact time.

For optimum efficacy of chlorine disinfection best practice (as discussed in the Drinking Water Standard for New Zealand, in lieu of an Australian equivalent) recommends a Chlorine contact time of greater than 30 minutes. As most water treatment plants utilise tanks for chlorine contact time it is expected that contact time will be reduced by short circuiting and other fluid dynamics in the tank. The method for accounting for this reduced contact time in the disinfection tool is by the T_{10} contact time calculation which identifies the minimum detention time of 90% of the water flowing through the tank.

A Computation Fluid Dynamics (CFD) model of the SBR (with the overhead inlet configuration) was conducted by BMT WBM in 2008. This CFD model shows that at the worst case 250ML/day and SBR level of 6.5m the contact time as T_{10} is 10 minutes. The further results from the model are listed in Table 1.

Table 1: ***T_{10} Contact time results from CFD***

ML/day	250	150	60	250	150	60
%Volume	87%	87%	87%	60%	60%	60%
$T_{10\ (minutes)}$	10	40	18.5	9.5	20	80

The pH target at Stromlo WTP is 7.4, recently increased from 7.2 in a trade-off between

disinfection efficiency and corrosivity of water in the concrete lined distribution network. Chlorine disinfection efficacy is impacted at high pH where the disinfection reaction favours the hypochlorite ion (OCl^-) over Hydrochlorous Acid ($HOCl^+$). This impact is considered significant at pH greater than 8.

In the disinfection tool Free Available Chlorine equivalent (FACe) is calculated to account for the lowered disinfection efficiency at pH above 8. The impact of pH on FAC is outlined in Table 2.

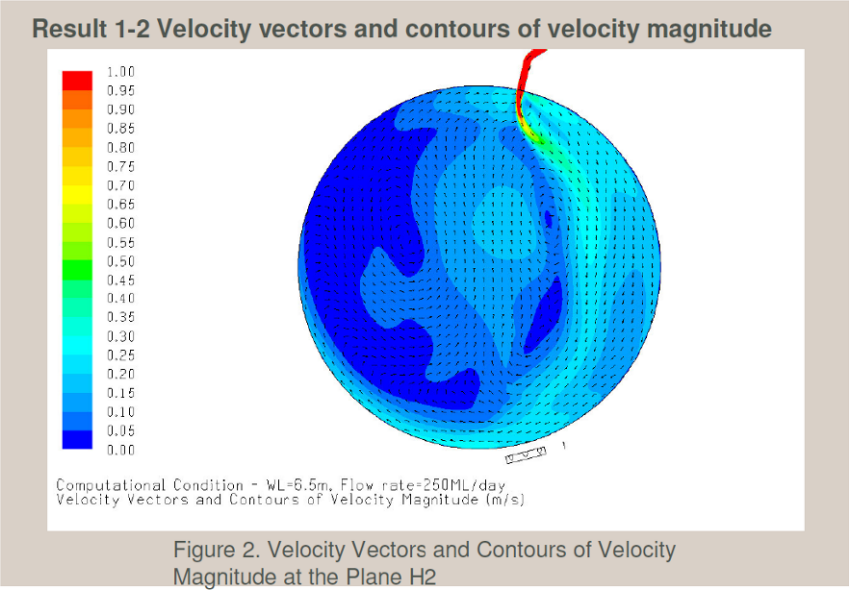

Figure 2. Velocity Vectors and Contours of Velocity Magnitude at the Plane H2

BMT WBM

Figure 2: ***CFD results for Stromlo Balancing Reservoir***

Table 2: ***Free Available Chlorine equivalent (FACe) calculated for Free Available Chlorine (FAC) of 1mg/L***

pH	FACe
8	1
8.1	0.85
8.2	0.72

2.0 DISCUSSION

2.1 WTAnalyser Disinfection Tool Setup

Data for the WTAnalyser Disinfection tool was extracted from SCADA in 5 minutes intervals for the trend of Plant Flow, FAC, pH, turbidity and tank level listed below. The water quality parameter trends are validated data, which eliminate a portion of the erroneous data due to calibration or offline analysers. Further the data was cleaned to remove further erroneous data from analyser spikes and major plant flow changes to provide representative data for the tool. In each case where data was removed, the entire time stamp data entry was removed to avoid the tool treating blank entries as zero. This treatment of the data provided representative outputs. A baffle factor of 0.1 was used as recommended by the CFD model.

2.2 First Round Disinfection Analysis on Chlorine Contact Time

Initially the tool was run on monthly subsets of the period from December 2011 through to November 2012. The results for minimum chlorine contact time in minutes are summarised in Table 3. During this data capture period the average plant flow in ML/day did not move far above half of maximum plant capacity.

Table 3: ***SBR Chlorine Contact Time Analysis Results Summary***

Month	*Average Plant Flow (ML/day)*	***Minimum CCT (Minutes)***	*Average CCT (Minutes)*	*Maximum CCT (Minutes)*
December (2011)	113	**207**	344	605
January (2012)	141	**174**	280	856
February	115	**168**	322	771
March	105	**203**	367	1346
April	110	**200**	341	642
May	109	**196**	345	681
June	104	**210**	376	728
July	98	**235**	394	1001
August	96	**228**	389	1086
September	90	**252**	444	945
October	119	**187**	315	666
November	134	**156**	285	1360

2.2 T_{10} Chlorine Contact Time Analysis

Analysis run on contact time T_{10} is show in Figure 3, throughout the 2011/12 year T_{10} contact time was reasonable stable. There is apparent seasonal variation which shows that the main influence on T_{10} contact time at Stromlo WTP is flow. The optimum T_{10} contact time was experienced in September which is a when Stromlo WTP had the lowest flow periods due to the sister plant Googong WTP being online. Maximum contact times were investigated and confirmed as plant showdowns where flow was low and SBR high.

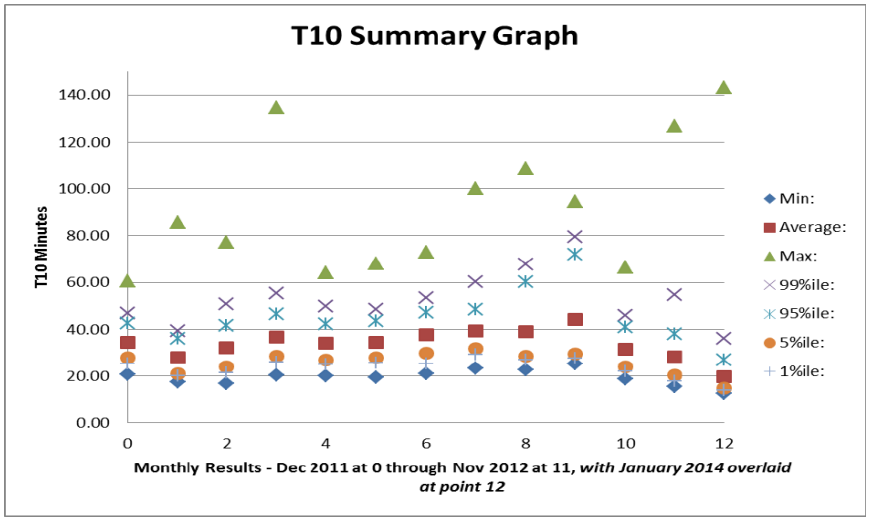

Figure 3: ***Summary of T_{10} Contact Time values for the data period December 2011 – November 2012 and January 2014***

Further detail of the influence of flow on contact time is displayed in the comparison be a

low flow month July 2012 and a high flow month January 2014. In July 2012 the flow was reasonable steady around 100Mlday with daily variation between 75 and 125ML/day. During July 2012 the T_{10} contact time remained stable around 40 minutes, within a nominal range of 30 – 50 minutes. January 2014 trends show the influence of the high flow, in this month the nominal plant production capacity was pushed and the plant operated up to 265ML/day.

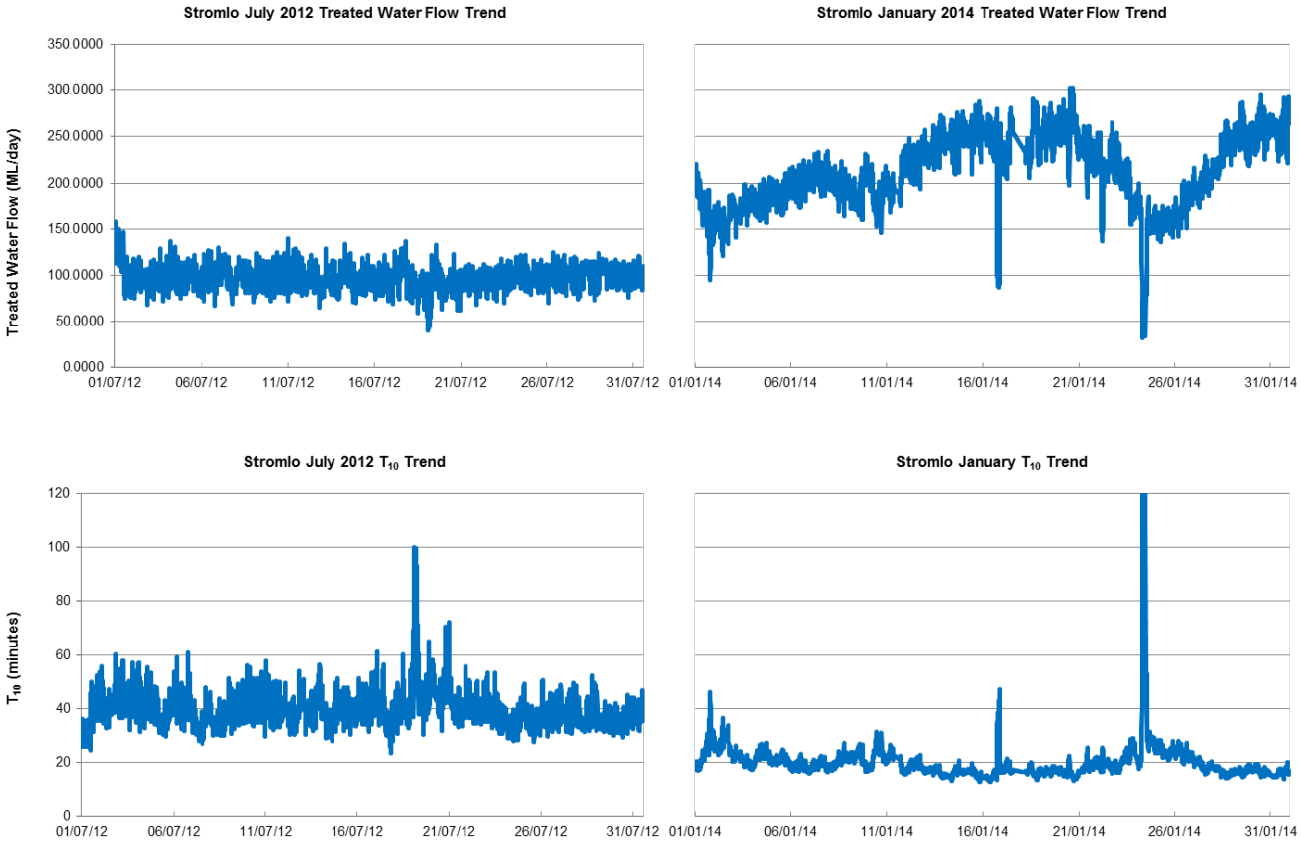

Figure 4: ***Comparison of Flow and T_{10} Trends for July 2012 and January 2014***

2.3 High Flow T10 Contact Time Model Comparison

The high flow period of January 2014 allowed for analysis of the impact of chlorine contact tank level on the contact time at nominal plant capacity, FAC of 1.3mg/L and pH of 7.2.

Figure

Figure 5 shows a selection of data sample points from the WTAnalyser disinfection tool at 250ML/day with a linear trend between chlorine contact tank level and T_{10}. In comparison to the estimated T_{10} from the CFD model, this linear trend reports an obvious difference. The CFD model was run on two SBR levels and does not reflect a major influence of level of T_{10} that is observed in the WTAnalyser results.

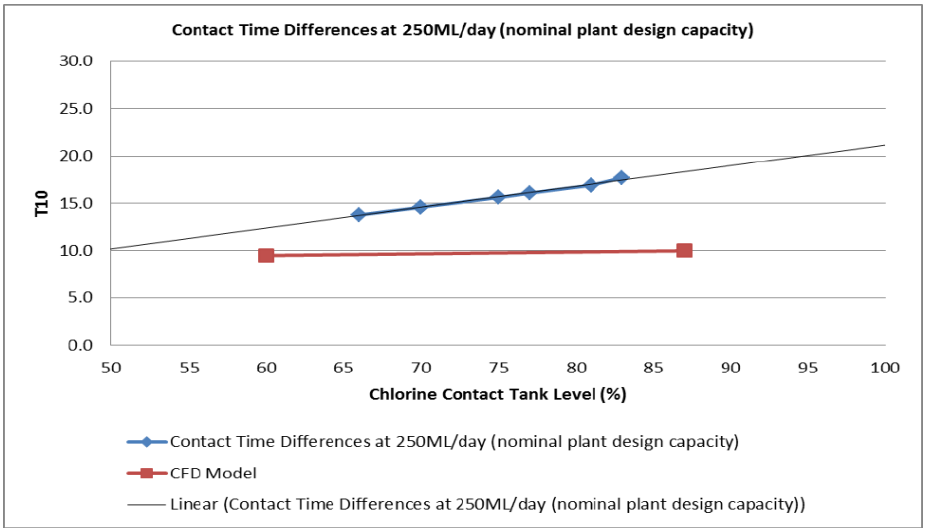

Figure 5: ***Model comparison of contact time at 250ML/day***

3.0 CONCLUSION

At Stromlo WTP the Chlorine contact time reported by the WTAnalyser Disinfection Tool measured as T_{10} contact time varies between 10 and 60 minutes. The T_{10} contact time is heavily influenced by plant flow and to a lesser extent by contact tank level. The T_{10} contact time drops below the best practice target of 30 minutes when plant flows exceed approximately 150ML/day. This highlights the importance of the multiple barrier approach to water quality employed at Stromlo WTP, specifically UV disinfection.

4.0 ACKNOWLEDGEMENTS

Gail Sutton for running the tool on the data for December 2011 through to November 2012 and Cameron Patrick who has is integral over years of studying chlorine contact in the SBR.

5.0 REFERENCES

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