# HISTORICAL ANALYSIS OF FILTER PERFORMANCE AT ACTEWAGL'S WTP - WHERE DO WE STAND WITH THE NEW 2011 AUSTRALIAN DRINKING WATER GUIDELINES FILTER TURBIDITY TARGETS?

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# HISTORICAL ANALYSIS OF FILTER PERFORMANCE AT ACTEWAGL'S WTP - WHERE DO WE STAND WITH THE NEW 2011 AUSTRALIAN DRINKING WATER GUIDELINES FILTER TURBIDITY TARGETS?

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## ABSTRACT

This paper analyses several years of operating filter turbidity data to assess the performance improvements made through the implementation of various filter optimisation modifications. The data analysis was undertaken using the Water Services Association of Australia (WSAA) Filter Performance Analysis Tool v1.7. The results of the historical data analysis verified that continuous improvement in setting best practice filter performance targets and implementing improvements to process controls have significantly improved the operation of ActewAGL's filters, contributing to the production of safe drinking water.

**KEY WORDS -** Filtration, filter, turbidity, performance analysis

## 1.0 INTRODUCTION

ActewAGL operates Stromlo and Googong Water Treatment Plants on behalf of Actew Corporation, providing drinking water to Canberra and Queanbeyan. Since the upgrade of both plants in 2004, various operational improvements have been implemented in the pursuit of best practice for filter performance. ActewAGL achieved HACCP certification for the Canberra water supply system in 2006 and accreditation is maintained through the management of water quality risks as per the Water Quality Management Plan. The Filtration step is a Critical Control Point barrier for the management of pathogens at both Stromlo WTP (SWTP) and Googong WTP (GWTP).

### 1.1 Filtered Water Turbidity Standards

There are a range of international guidelines and targets for filter performance however, until recently, there was no Australian "standard" for filtered water turbidity. The 2011 Australian Drinking Water Guidelines (ADWG) identifies the health based guideline: "*Where filtration alone is used as the water treatment process to address identified risks from Cryptosporidium and Giardia, it is essential that filtration is optimised and consequently the target for the turbidity of water leaving individual filters should be less than 0.2 NTU, and should not exceed 0.5 NTU at any time.*" This guideline statement is still open to some interpretation by water utilities and health regulators; however it does provide a driver for analysis of filtration barrier performance.

Since 2005, ActewAGL monthly performance reporting has included a compliance target for combined filtered water turbidity 80$^{th}$ percentile less than 0.1 NTU, analysed daily based on a 15 minute sample period. This was similar to the Australian Water Treatment Alliance target value of less than 0.1 NTU. ActewAGL has also utilised the US EPA Long Term 2 Enhanced Surface Water Treatment Rule (LT2) to analyse monthly individual filter performance for log removal credits for cryptosporidium.

It should be noted that the new ADWG specifically states performance criteria for individual filters, which is significantly different to ActewAGL's historical reporting targets, which were focussed on the combined filtered water sample.

## 1.2 Stromlo WTP Filtration Barrier

SWTP was upgraded to include filtration in 2004. It has a nominal production capacity of 250 ML/day through ten multimedia filters consisting of filter coal and sand media, with dual layers of garnet for support media. Normal operation is direct filtration mode when treating Bendora Dam water. In-filter Dissolved Air Flotation (DAF) is also used when raw water is sourced from Cotter Dam or the Murrumbidgee River.

Prior to filtration, pre-treatment chemical dosing includes pre-lime for alkalinity, carbon dioxide for pH control, aluminium sulphate and poly-aluminium chloride for coagulation, and polymer as filter aid. Each individual filter is monitored continuously using a Hach 1720E turbidimeter. The combined filtered water turbidity is monitored continuously using a Hach FilterTrak 660 sc Laser Nephelometer. Instruments are calibrated monthly as per the HACCP prerequisite program for Calibration and Maintenance.

The turbidity-based HACCP controls in place for the SWTP Filtration Barrier are implemented as SCADA interlocks based on continuous monitoring of online instrumentation. These include:

| | | |
|---|---|---|
| ACTION | Individual filter turbidity >0.1 NTU | Filter Backwash |
| CRITICAL | Individual filter turbidity >0.20 NTU | Filter Offline |

## 1.3 Googong WTP Filtration Barrier

GWTP has two parallel filtration processes. Stage 1 was commissioned in 1979, consisting of clarification and direct filtration through four dual-cell filters providing nominal capacity 180 ML/day. The Stage 2 upgrade in 2004 included six DAFF multimedia filters providing an additional capacity of 90 ML/day (270 ML/day total). All ten filters consist of filter coal and sand media, with either gravel or garnet for support media.

Pre-treatment chemical dosing includes powdered activated carbon for taste and odour removal, pre-lime for alkalinity, aluminium sulphate for coagulation and polymer as flocculation aid. Each individual filter and the combined filtered water turbidity are monitored continuously using Hach 1720E turbidimeters, which are calibrated monthly as per the HACCP prerequisite program.

The turbidity-based HACCP controls in place for the GWTP Filtration Barrier are implemented as SCADA interlocks based on continuous monitoring of online instrumentation. These include:

| | | |
|---|---|---|
| ACTION | Direct filter turbidity >0.2 NTU | Filter Backwash |
| CRITICAL | Direct filter turbidity >0.25 NTU | Filter Offline |
| ACTION | DAF filter turbidity >0.2 NTU | Filter Backwash |
| ACTION | DAF filter ripening turbidity >0.2 NTU | Filter-to-Waste until <0.1 NTU |
| CRITICAL | DAF filter turbidity >0.30 NTU | Filter Offline |

An inherent problem when monitoring GWTP filter performance, is that filter backwash

water is sourced from pH corrected water using lime slurry dosing. The turbidity of backwash water is typically in the range 0.4 to 0.8 NTU, which results in the filter plenum being filled with "off spec" water after a backwash. When the filter comes back online, this takes approximately 45 minutes to turnover for Stage 1 filters and completely obscures the filter ripening period. For Stage 2 the consequence is a long period of filter-to-waste, impacting on production capacity.

## 2.0 DISCUSSION

Implementation of HACCP to manage drinking water quality risks at ActewAGL's water treatment plants has lead to many modifications and improvements to filter monitoring and controls at both SWTP and GWTP. Some of the changes have included online monitoring data validation logic, improvements to data collection techniques, modification of SCADA controls for stable filter operation, filter inspections, regular backwash assessments to optimise backwash efficiency, and implementation of best practice targets for action and critical limits for filtered water turbidity. The effectiveness of these improvements was assessed by performance analysis of individual filters using the WSAA Filter Performance Analysis Tool.

### 2.1 Stromlo WTP Filtration Barrier Performance

SWTP individual filter turbidities were analysed for the period 2007-2012. Data prior to 2007 was excluded, as the SCADA data collection was inconsistent with current practice and the required input format for the WSAA Tool. Figure 1 shows the comparisons plot from the WSAA tool comparing 2007/08 with 2011/12.

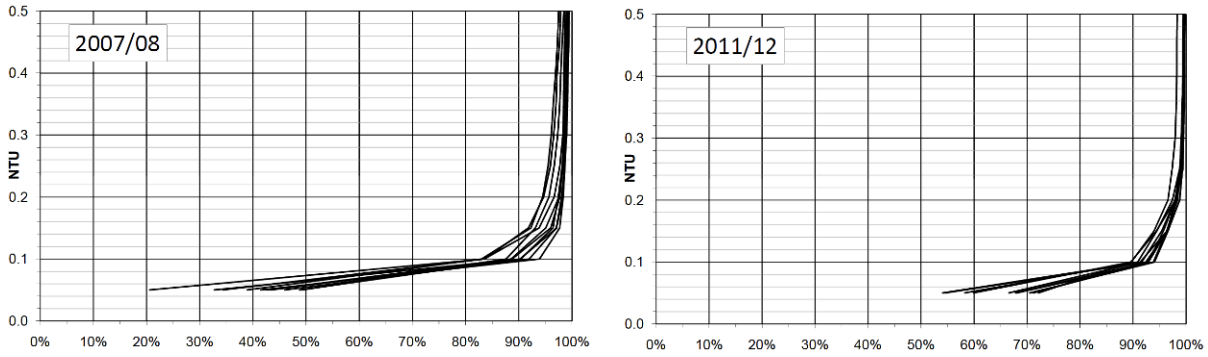


**Figure 1:** ***SWTP historical filter performance summary 2007/08 and 2011/12***

The plots show an improvement in baseline performance of all individual filters, indicated by the greater proportion of results <0.05 NTU and <0.10 NTU. The consistency between individual filters also improved in that the ranges for each percentile bracket are closer together. There are however some results >0.50 NTU that need to be investigated further to determine root cause and identify possible improvements to control measures.

Figure 2 shows the box plot output from the WSAA Tool for the current 2011/12 year. The plot indicates the ranges of results for each filter: the Box is 25 and 75 percentiles; Bars are 5 and 95 percentiles.

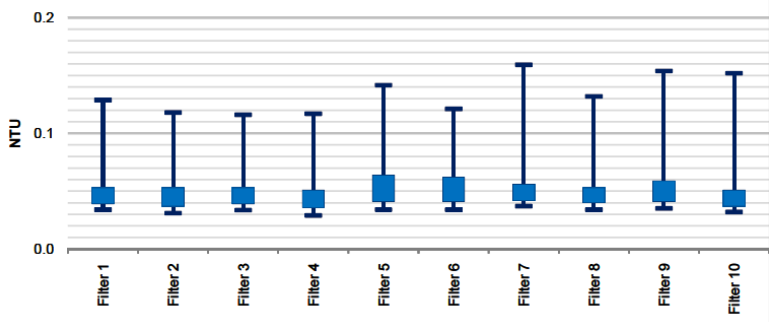


**Figure 2:** ***Stromlo WTP current performance summary (2011/12)***

In general, performance was very good compared to ADWG targets. The overall results were excellent but the plot shows that Filters 5, 7, 9 and 10 were the worst performing. These filters were all rebuilt in late 2011, had several high results during commissioning of the new media. The filters were out of service for several months which meant a smaller sample population for data analysis, so the results proportionally look worse than the other filters.

The results tables from the WSAA Tool provide detailed statistics of the analysis and indicate that the worst performing individual filter has 97th percentile <0.2 NTU (ADWG target) and 98th percentile <0.5 NTU (ADWG shall not exceed limit).

In summary, the results demonstrate that the implementation of HACCP filter turbidity action and critical limits and improved SCADA controls has ensured that SWTP filters can meet the filter turbidity targets of the ADWG in most instances.

## 2.2 Googong WTP Filtration Barrier Performance

GWTP individual filter turbidities were analysed for the period 2007-2012. Data prior to 2007 was excluded, as the SCADA data collection was inconsistent with current practice and the required input format for the WSAA Tool. Figure 3 shows the comparisons plot from the WSAA tool comparing 2007/08 with 2011/12.

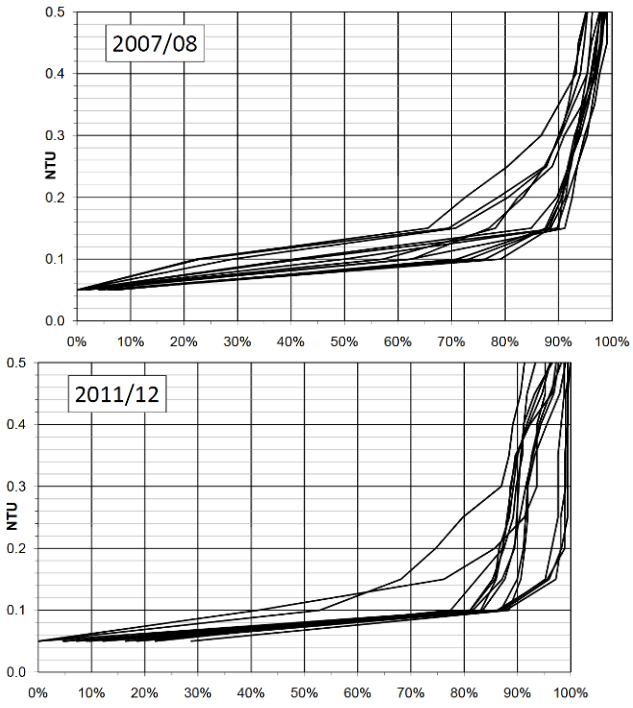

**Figure 3:** *GWTP historical filter performance summary 2007/08 and 2011/12*

The results are much poorer than SWTP with many results >0.2 NTU and >0.5 NTU highlighting significant turbidity breakthrough events. The plots do however show an improvement in baseline performance, indicated by the trend towards a much greater proportion of results <0.05 NTU and <0.10 NTU. This is positive considering the challenging conditions of recent operations following the major inflow events of December 2010, where the raw water quality exceeded the design limits for the treatment plant.
There were clearly two worst performing filters, which were DAF Filters 1 and 5, also highlighted in the box plot shown in Figure 4. These two filters struggled in the recent run and were not operated often; therefore the sample population for these was one third of the other filters. There were also two "groupings" of filters, the poorer performing group being the Direct filters which were affected by lime turbidity during ripening. The better performing group were the DAF filters, which is due in part to filter-to-waste capability.

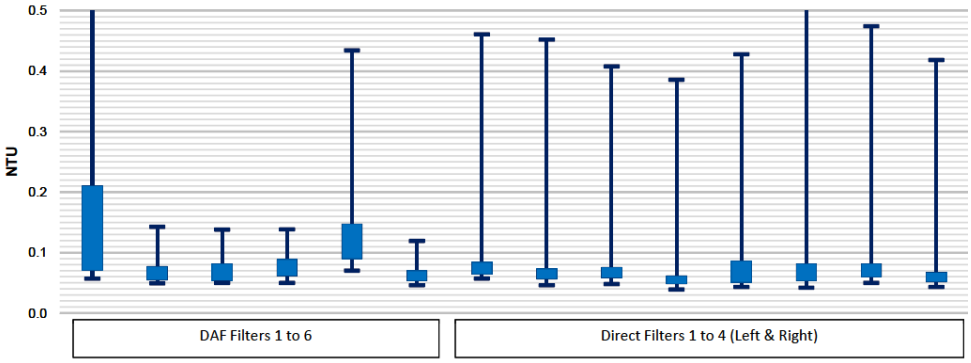


**Figure 4:** *GWTP current performance summary (2011/12)*

The Googong data analysis shows that although implementation of improved controls resulted in improved baseline performance, there were many significant filter turbidity breakthrough events during recent operation. The challenge of poor raw water quality highlighted the fact that the HACCP Action Limits and Critical Limits were not fully implemented for the GWTP filters. ActewAGL has since committed significant resources to implementing improved control measures in preparation for the next planned operating period.

## 2.3 Assessment of the WSAA Filter Performance Analysis Tool

The WSAA Tool was simple and intuitive to use; importing and processing of data was relatively fast (i.e. one month of Stromlo WTP (10 filters) at 1 minute sample frequency took less than 5 minutes) and the results were presented in plots and tables that were easily exported for effective presentation. A thorough set of instructions were provided and the tables were explained well so that they were quickly understood and interpreted by the user.

The most time consuming part of the analysis was found to be data collection and validation. To aid this, ActewAGL created "validated trends" that exclude unrepresentative operating data from a filter that is offline, in backwash sequence, or during calibration of the turbidity instrument. Validated trends are therefore an accurate representation of the full filter run period including filter ripening, filtering, turbidity breakthrough and draining for backwash. A filter turbidity trend is "validated" IF: (1) the individual filter is online (level control / rate valve not fully closed); AND (2) there is sample flow to the analyser (flow switch active or solenoid valve is open); AND (3) the

turbidimeter instrument is not in calibration mode.

In a further attempt to minimise data handling in terms of exporting and formatting, ActewAGL created a PLC calculation that records the maximum validated filter turbidity value for each 2-hourly period for each individual filter, time- and date-stamped (required inputs into the WSAA Tool). The maximum results are reported to a database, and imported into the WSAA Tool. The use of this report saved a lot of time and effort in data management.
The major difference between the WSAA Tool and other analysis such as the US EPA LT2 Rule is that the WSAA Tool actively looks for worst case data point in every 2 hour period, where the LT2 Rule uses an instantaneous 15 minute sample interval (WSAA 12 samples/day compared to LT2 96 samples/day). The results are therefore statistically very different, which users must take into account when comparing the WSAA Tool results with other analysis methods. For example, in December 2011 for SWTP the WSAA Tool results in a Combined Filtered Water Turbidity 95$^{th}$ percentile value of 0.060 NTU, compared to LT2 result of 0.048 NTU.

## 3.0 CONCLUSIONS

The WSAA Filter Performance Analysis Tool was simple and intuitive to use; providing results in a format that could easily be exported for effective presentation to stakeholders. The WSAA Tool provides water utilities with a standard spreadsheet, which is appropriate to undertake self assessment in preparation for the adoption of the ADWG 2011 filter turbidity targets, without needing to invest time and resources to build unique or customised and complex spreadsheets. The use of an "industry standard tool" would also benefit water utilities seeking external review or for industry benchmarking.

Overall the historical data analysis verified that continuous improvements in setting best practice filter performance targets and implementing process controls have significantly improved the operation of ActewAGL's filters.

The results of the analysis show that Stromlo WTP can meet the ADWG 2011 filter turbidity guidelines, although further investigation into occasional exceedences of >0.5 NTU is required to achieve the "shall not exceed" limit. The Googong WTP filters however do not comply with the ADWG targets on many occasions. SCADA controls require further work in the implementation of the HACCP Action and Critical Limits to improve the consistency of filter performance. Capital works investments such as filter-to-waste and post-lime dosing modifications may be required to meet the new filter turbidity targets.

The WSAA tool is invaluable for process engineers and treatment plant operators to review filter performance data on a worst case basis. In order to produce safe drinking water 100% of the time, extreme events and "outliers" should be the priority of the responsible person to troubleshoot operational issues, investigate incidents, and respond with the implementation of improved control measures to prevent future recurrences.

## 4.0 ACKNOWLEDGEMENTS

ActewAGL Water Industry Operators who are responsible for the production of safe drinking water on a day to day basis at the Stromlo and Googong Water Treatment Plants.

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data collection, data validation and interpretation (Teresa Morey, Anthony Mayer, and Shaun Fanning).

## 5.0 REFERENCES

National Water Quality Management Strategy, *Australian Drinking Water Guidelines 6* (2011), National Health and Medical Research Council