EVOLUTION OF CHEMICAL DOSING CONTROL AT DUNGOG WTP

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ABSTRACT

Dungog WTP is located in the lower Hunter Valley in NSW and was commissioned in 1989. It is a direct filtration plant with 10 dual media filters and a maximum capacity of 90 ML/d. Dungog WTP supplies parts of Newcastle, Dungog, Maitland and the Lower Hunter region of NSW. The plant is supplied from the 20,300 ML capacity Chichester Dam. Chichester Dam is encompassed by a large and fruitful catchment area that results in high turnover of dam water during heavy rainfall events and rapid change of raw water quality entering the Dungog WTP. Raw water turbidity can vary between 1 NTU to as high as 120 NTU. As Dungog WTP is a direct filtration process, these rapid turbidity changes put a lot of strain on the filters and therefore create a need for adaptable coagulation and flocculation dosing systems. The direct filtration process commissioned for Dungog WTP incorporated automatic adjustment of coagulant and coagulant aid polymer dosing based on raw water turbidity. There is also the capability to dose hydrated lime to adjust coagulation pH during periods of elevated turbidity. Over the ensuing years and after multiple challenging high turbidity events, a range of strategies have been employed to optimise and fine-tune monitoring and control of chemical dosing systems with the aims of better managing raw water quality risk, improving treated water quality performance, minimising capital and operating costs and ensuring the safety of treated water to a high volume of public consumers.

1.0 INTRODUCTION

Dungog WTP was one of the first plants in Australia to use a direct filtration process. Raw water is sourced from Chichester Dam, a 22 GL run-of-river storage, with raw water turbidity typically below 10 NTU but at times rising to as high as 100 NTU. The plant operates at a reasonably constant flow rate, with flow being altered by manually operating valves on the Chichester Trunk Gravity Main (CTGM) – which supplies treated water from the plant into the reticulation system. The plant flow is normally down-rated during periods of elevated raw water turbidity to allow the filters to cope with increased solid loading rates. The plant's design, coupled with the many challenges of an ever changing raw water quality, required a reliable coagulation and flocculation dosing system.

After numerous jar testing and many pilot plant studies, which included the use of a coarse locally sourced granular coal product for the dual media filters, the Dungog WTP's Chemical Auto Dose table was born *(see Figure 1).* The Auto Dose Table included the capability to automatically adjust the coagulant (alum) and filter aid polymer (non-ionic polyacrylamide) dose rates over a raw water turbidity range of 0-100 NTU. The source water is consistently of low hardness and contains relatively stable organic carbon concentrations. Iron and manganese concentrations generally change in line with turbidity, and testing showed that raw water turbidity was a reliable predictor of coagulant dose. The required filter aid polymer dose could also be reliably predicted as a function of the raw water turbidity. High alum dose rates depress pH to the point where effective coagulation cannot be achieved. Therefore, the table also included a pre-lime dosing trigger point to ensure coagulation could occur at a suitable pH. A general rule of thumb for the chemical dosing of alum (coagulant) and nonionic polymer (filter aid) was also added to the Table as a guide for determining auto chemical dosage.

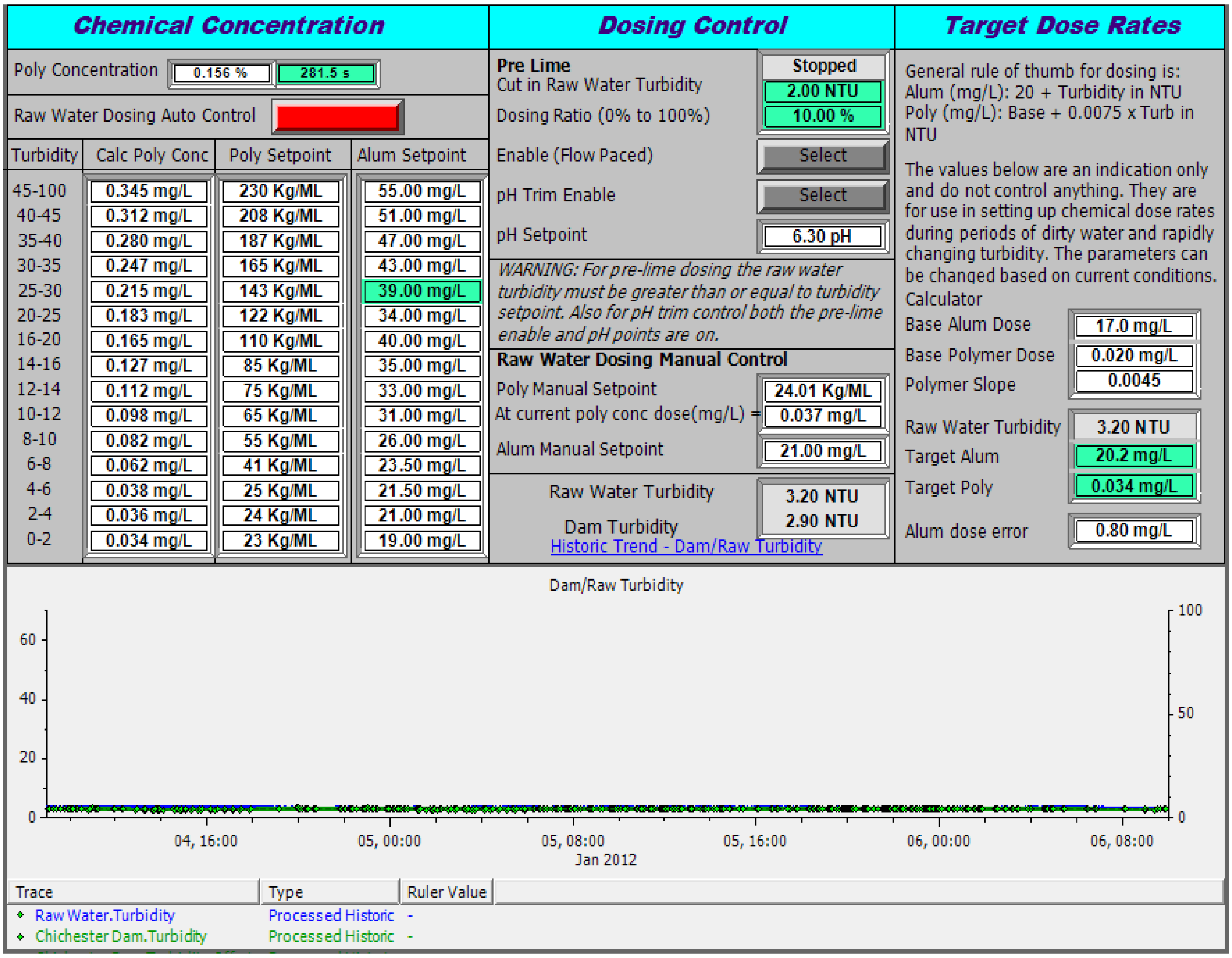

Figure 1: *A SCADA snapshot of Dungog WTP's Chemical Auto Dose Table*

Over the coming years, Dungog WTP experienced numerous turbidity 'events'. Dungog WTP is normally attended by operators from 7:00am until 3:00pm and relies on automatic systems for monitoring and control. Turbidity events involved a rapid increase in raw water turbidity that would arrive at the plant between 36 and 72 hours after heavy rainfall. Therefore, automatic adjustment of alum and polymer dose rates was critical to achieve reliable and effective treatment. The auto dosing control was generally very effective and proved to be an innovative concept. However, operation of Dungog WTP was met with a few challenges during turbidity events. The challenges involved a pre-lime (lime dosing pre-filtration) system frequently failing mechanically when initiated to run, chemical dose set points that frequently needed fine-tuning to cater for changing raw water characteristics, and a heavy reliance of online turbidity meters.

In addition, each raw water turbidity event presented its own unique water characteristics and dose rates appropriate for rapidly changing turbidity were not always suitable as other parameters (e.g. lime, alkalinity) changed. A more reliable chemical dosing control system was needed to optimise dose rates and control risk, while minimising capital and operating costs. An upgrade of the auto dosing table, a polyDADMAC dosing system, and online streaming current monitoring were proposed to achieve such a reliable dosing system.

2.0 DISCUSSION

2.1 Diligent Management of Chemical Dosing

Before changes to chemical dosing control were implemented, management and ownership of the existing dosing system increased. Each turbidity event was a learning opportunity, and knowledge and experience grew throughout the whole water treatment team over time. During and after each turbidity event, chemical dosing targets were fine-tuned to ensure chemicals were being optimised. Some years into Dungog WTP's operation, filtered water turbidity targets decreased to 0.2 NTU, a change from a target of 0.5 NTU when Dungog WTP was first commissioned. Online turbidity meters were maintained more diligently due to their importance, and pre-lime dosing equipment was operated continuously to overcome mechanical reliability issues. Force-cooled motors were also installed on the dry-lime volumetric feeders to improve turndown capability and thus enable more precise control over a wider range of operating conditions, particularly at low dose rates.

All of the ten (10) dual media filters at Dungog WTP are equipped with differential pressure (DP) monitoring, which is used as a trigger to initiate backwashing. One filter is also equipped with intermediate DP monitoring points, which allows assessment of how flocculant solids are penetrating the filter. This feature is very useful for optimising the filter aid polymer dose rate. That is, if an excessive differential pressure observed in the top section of the filter it is likely that the polymer dose is too high. Conversely, a significant pressure differential observed at the bottom layer could be an indicator of imminent turbidity breakthrough and a higher polymer dose may be needed. Customised SCADA monitoring tools have been developed to maximise the value obtained from this DP monitoring data. An example is shown in the diagram below.

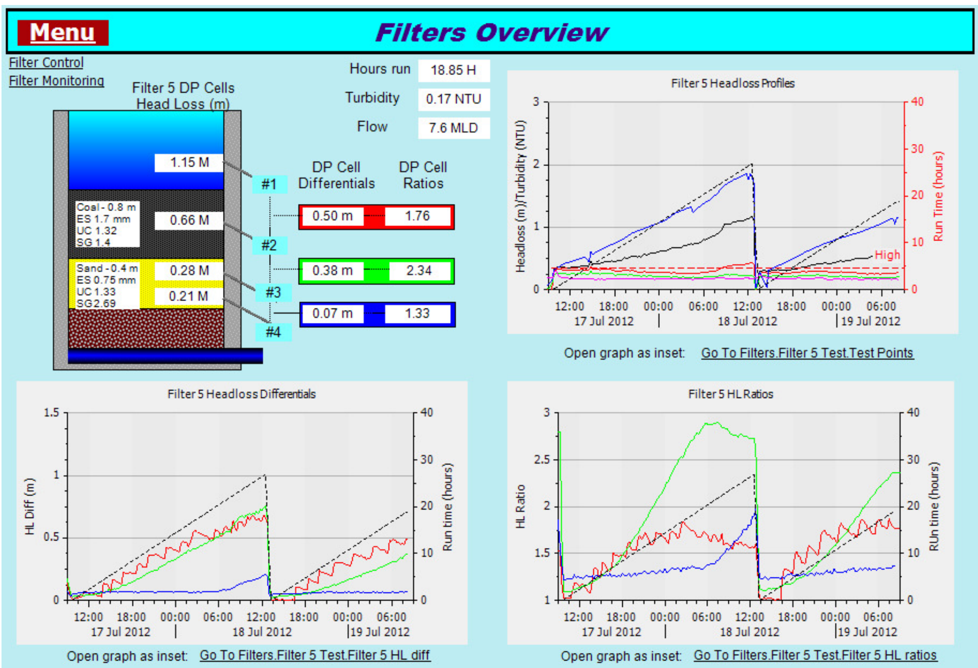

Figure 2: ***Filter differential pressure monitoring SCADA overview***

2.2 Cationic Polymer Dosing

A polyDADMAC dosing system is currently being commissioned at the Dungog WTP as a coagulant aid to be used in conjunction with the existing alum dosing system.

A key driver for the polyDADAMAC dosing system is to allow coagulation to occur within the optimum pH range of 5.8 - 6.5 during periods of elevated raw water turbidity without the need for pre-lime dosing. This will ensure that mechanical issues encountered during pre-lime start-up, which often result in calling personnel out to site after working hours, will be eliminated. An extensive program of bench and pilot scale tests confirmed that 1 mg/L of polyDADMAC would effectively replace between 5 and 15 mg/L of alum, depending on the prevailing raw water quality. Therefore, during periods of high raw water turbidity that had previously required high alum dose rates and pre-lime dosing, a proportion of the alum can now be replaced with polyDADMAC so that the required coagulation pH can be achieved without pre-lime dosing. During periods of lower raw water turbidity the decision about appropriate combinations of polyDADMAC and alum will be made based on balancing operating costs and operational reliability.

2.3 Auto Dose Table Upgrade

The need for a more effective Auto Dosing Table to improve dosing precision and to reduce the amount of personnel hours spent on adjusting chemical dose rates was identified. Control logic and SCADA modifications to the Auto Dosing Table are currently being implemented to change the alum and polymer dosing from a discrete dose setting for each raw water turbidity range (e.g. 2 NTU – 4 NTU) to a dosing regime based on a linear algorithm, with a fixed base value and a slope to automatically adjust the dose set point as a function of the raw water turbidity. The modification will require operator adjustable parameters for the slope and base of the linear equations as well as minimum and maximum dose rates which will override the values calculated by the linear equations. Constraining the minimum and maximum dose rates will provide protection against a malfunctioning raw water turbidimeter causing incorrect dose rates. A standby raw water turbidimeter will also be installed and a discrepancy alarm will be activated if there is a discrepancy between the two turbidimeters. *Figure 3* shows a draft design on how the new Auto Dose Table will appear on SCADA.

It is expected that the upgraded auto dose methodology will achieve chemical cost savings by eliminating some of the conservatism required with the existing methodology. That is, the alum and polymer dose rate settings currently need to be set to suit turbidity at the top of each dosing range. It is also expected to eliminate the current delays in manual optimisation of alum and polymer dose rates when raw water turbidity is dropping. Minor savings in hydrated lime costs are also expected with reduced alum dose rates (1 mg/L lime for 5 mg/L alum).

The improved Auto Dose Table is also expected to better manage water quality risk by removing current step changes in alum and polymer dose rates that occur when turbidity deviates between turbidity ranges (e.g. 4-6 NTU range to 2-4 NTU range) which disturbs coagulation chemistry. Risk will also be managed by eliminating current delays in manual adjustment of alum and polymer dose rates when raw water turbidity is dropping.

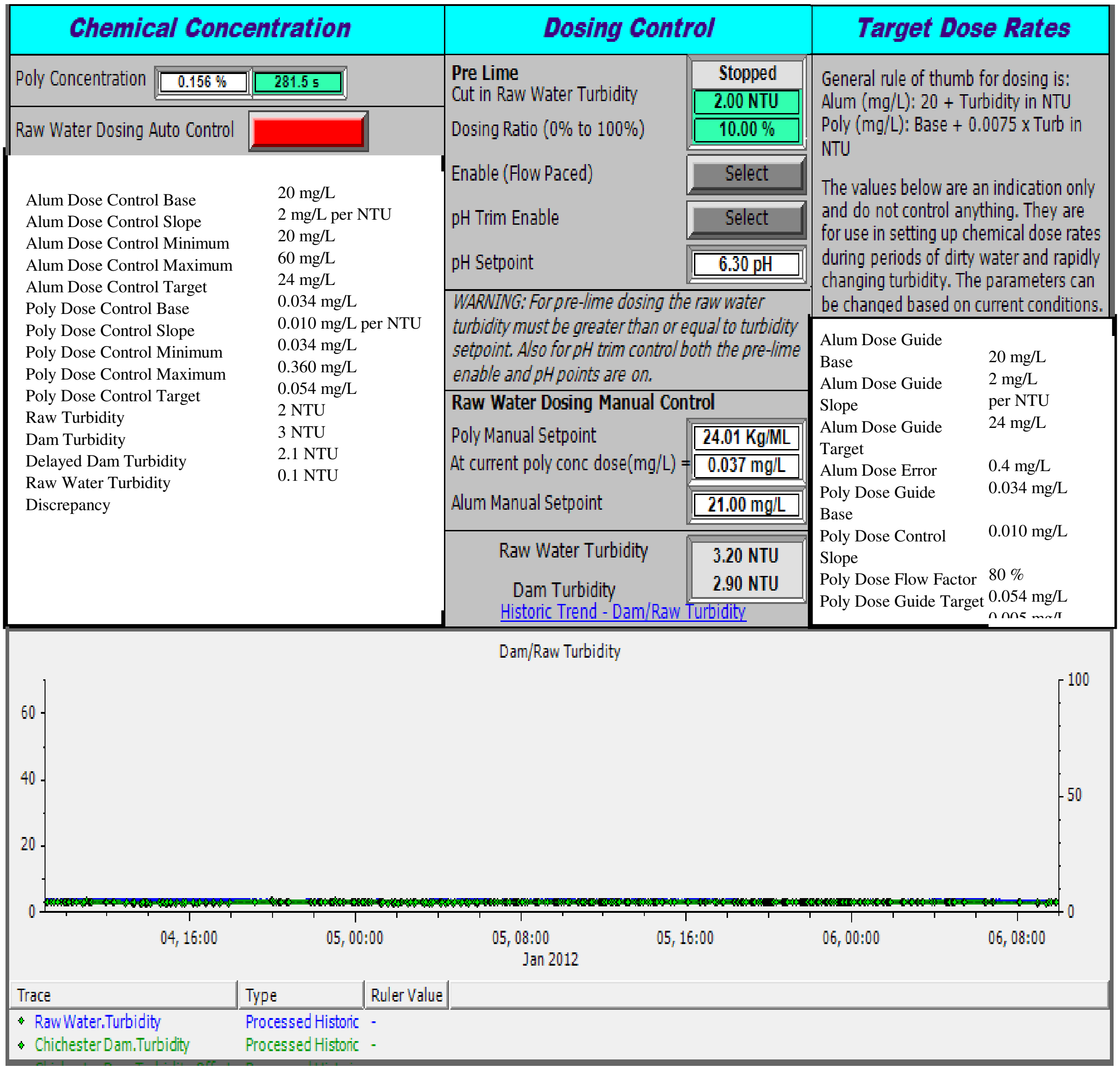

Figure 3: ***A draft design on how the new Auto Dose Table will appear on SCADA.***

The concept of automatic dosing adjustment is also proposed for another Water Treatment Plant within Hunter Water. Gresford WTP is a membrane microfiltration plant that sources raw water from the Allyn and Paterson Rivers. Sodium hypochlorite is used for disinfection at this plant. Raw water turbidity can vary from 1 NTU – 500 NTU and rapid changes in turbidity affect the chlorine demand of the filtered water. It is proposed that the introduction of an Auto Dose table at Gresford WTP, similar to the one used at Dungog WTP, will enable more effective control of chlorine dosing.

2.4 Streaming Current Monitoring

Installation of online monitoring of streaming current, after alum addition, has enabled an accurate assessment of optimum coagulant dose which will assist in the operation of the upgraded Auto Dosing Table. Although the Streaming Current Monitor has yet to be fully commissioned, data has been recorded daily to assist in chemical optimisation with some success, particularly when Dungog WTP has been operating at maximum flow (90ML/D). Ultimately, it is intended that the Streaming Current Monitor output will be incorporated in the logic for automatic control of alum dose rates. This development has the potential to greatly reduce water quality risks because the control would be based on a continuously monitored parameter that provides a direct indication of coagulation effectiveness.

The current logic relies on a less direct correlation between raw water turbidity and optimum alum dose, and relies on filtered water turbidity monitoring to verify that coagulation has been effective. By the time filtered water turbidity is out of specification it is too late to make a dosing adjustment to correct the problem. Therefore, the existing methodology still needs to retain a degree of conservatism when selecting target dose rates. *Figure 3* illustrates how the Streaming Current Monitor functions.

3.0 CONCLUSION

Chemical Auto dosing at Dungog WTP has many factors that have contributed to how it has evolved and will continue to evolve. But the biggest reason why Dungog WTP's chemical dosing is a safe, efficient, risk managing, and cost saving operation has been generated by the attitude of Hunter Water personnel operating and modifying the system over many years. Right from the start, when the first pilot plant studies were conducted, all the way to today's operation and commissioning of improved development, Hunter Water has always approached Chemical dosing at Dungog WTP with the respect, care, and diligence that is required to ensure its effective operation.

Although not yet completed, the upgrade of Auto Dosing (due to be commissioned within the next 6 months) is also recognised as an integral step forward to the evolution of Dungog WTP's chemical dosing. The commissioning of this upgrade is of high importance and Hunter Water is eagerly anticipating its cost savings and water quality risk management outcomes.

PolyDADMAC dosing and streaming current monitoring, which both will be associated with the Auto Dose Upgrade, will also be important steps forward to chemical dosing evolution. DAF pre-treatment has also been proposed for Dungog WTP, although due to the size of the project it may be some years away from development.

4.0 ACKNOWLEDGEMENTS

Special thanks to Keith Craig from Veolia Water and Cathy Cole who both conducted many pilot plant tests during the commission of Dungog WTP in 1988. Their expertise has provided much of the platform for today's high quality dosing systems.

Dungog Water Treatment Operator – Neil Cummings has contributed to the operation of chemical dosing, and witnessed it grow from the Plant's commission.

Operations Manager – Darren Bailey also has been present from Dungog WTP's early days and is ever-present in directing improved operation of chemical dosing.

Brock McPhee – Project Manager of Auto Dose Upgrade. Russell Lyne – Project Manager of cationic polymer dosing facility.

Luke Bianchi – Project Manager of implementing streaming current monitoring.