SOLVING THE SHEMOZZLE OF THE MEDIA TRANSUDING NOZZLE

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ABSTRACT

A history of under-resourced, poorly trained staff, a remote location and disjointed record keeping and plant failure, all contribute to poor water quality. A solution is revealed by simple observations of a recently educated new operator.

1.0 INTRODUCTION

Croydon is a remote former mining town in the savannah region east of the base of the Gulf of Carpentaia. Croydon has a history of water quality issues with water clarity and heavy metal concentrations being of concern. Limited staff training and poor resources have further exacerbated problems – not least of which was the transuding nozzle.

The township is located 600km by road to the west of Cairns along the Savannah Way. Its nearest neighbouring towns are Georgetown 150 km to the east and Normanton 150 km to the West. It has a permanent population of less than 200 people with tourist numbers almost doubling the population in winter months. Historically it was one of Queensland's largest towns in the 1890s mining boom with more than 6000 inhabitants and a virtual ghost town in the 1940s. A cadastral layout for around 1000 allotments exists but less than 100 are occupied.

Lake Belmore was constructed in 1995 as Croydon's primary water supply. Situated less than 4 km from town the lake was designed to supply the township with a reliable quantity and quality of water. The lake is the largest body of fresh water in the region with a capacity of over 5GL and has become a very important recreational venue for locals and tourists alike. Stocked with Barramundi and with Black Bream occurring naturally, it boasts a range of recreational facilities making it a destination for locals and tourists alike.

The water supply reticulation system was first constructed in the late 1960s with an elevated storage tank of 227 kL with less than 9 m head and asbestos cement 6,4 and 3 inch pipelines. This pipeline has been added to in an adhoc fashion with a mix of various sized poly and PVC pipe.

1.1 Securing the FUTURE?

In my efforts to understand the system and identify how it came to be as it was, I uncovered some interesting facts related to planning and development of what exists today dating back some 20 years.

Back in 1999 the system failed to comply with guidelines and reports identified that "dirty water was a problem Council would like to rectify". Subsequent development reports and growth estimates led to the system we have today being significantly oversized for its actual requirements. Census figures and growth forecasts a population of around 650 now, which is actually now less than 150 people, storage tanks and pipelines are large, in fact the clear water storage can hold up to 20 days supply in the wet season when demand is low. The WTP design is also similarly oversized, meaning it only runs for short periods leading to stagnation in the clear water storage.

There is subsequent degradation of chlorine residual which is further compounded by the size of the reticulation pipework, which with a 250mm main from the tank to town, holds almost a days worth of water in the pipe alone. The degredation of chlorine residual has historically been compounded by poor water quality caused by various process and operational failures both infrastructure and human resources based.

2.0 BATTLING TO FIND STRUGGLING PLANT OPERATORS

Croydon's remote location and percieved harsh climate makes it difficult to attract staff. On my first journey here driving several hours; getting further away from the beautiful coastal rainforest and reefs of Cairns, well beyond the picturesue Tablelands to an arid region with endless stretches of deteriorating narrow single lane and sometimes gravel roads – I certainly had thoughts of What am I doing? Do you really want to uproot your family and come all the way out here?

Prior to 2004 when the current WTP was commisioned, it was clear that water quailty was not up to scratch with records showing that the reticulation contained carry over coagulant and inadequete disinfection from a small clarifier not keeping up to demand.

It was alarming to find that after the plant was installed that these results continued - in the period between 2004 - 2010 – there were serveral cases of *E. coli* some at 80 CFU and some alarming levels of Aluminium recored in the water supply. Other anecdotal evidence suggests that operators had mixed up chemicals and chemical rates.

When automated sytems were working (and often were not) that metering pumps failed to stop. I have indeed found chemical metering pumps to continue when a flow switch has been stuck and not sent the no-flow signal to shut them down. The operation of the plant requires vigilance and persistance at times.

I have been fortunate to receive more understanding than some past operators who were not trusted or privy to certain information. Also I came to the role as the shire IT officer, so my improved understanding of automated systems and knowledge of computer technology over past staff has been a big help in improving control logic and the functionality of the system and its capacity to provide early warnings and alarms which was only implemented recently.

3.0 MY INVOLVEMENT IN TURNING IT AROUND

In April 2012, I was first employed by Croydon Shire Council as Information Technology Officer. Being a small council with limited staff, the scope of duties was quite broad and included communication links and telemetry and 'other such duties as may be directed'.

When I was first introduced to the telemetry radio system it only had serial communications between PLC's and did not allow remote access to the individual PLC's from the SCADA computer. We then upgraded the existing telemetry control system to a Citec SCADA system with SMS alarm dial out facility and remote access to the SCADA via the internet.

I soon found myself second on the list of pagers to receive alarms. Before 2013 was over the then water officer was injured and off work and I found myself attending to most alarms. Along with our Town Maintenance Manager had to both operate and repair various aspects of the plant.

- January 2014: I was one of three people sharing the responsibility of water sampling, testing and recording. Jeff Norman, our local plumber being the only one with any real prior knowledge and experience in the water industry.
- Feb 2014: I was regularly doing testing and was made aware that the reservoir and reticulation system had poor chlorine residuals despite the fact that it was being heavily dosed. Fortunately, our bacterial sampling was coming back from a third party testing okay and continued to supply the town without any issue.
- April 2014: After a couple of plant failures had lowered the reservoir I started to see a relationship between the reservoirs levels and chlorine residuals. I found that by having a lower set point and more frequent top ups a better chlorine residual could be achieved.
- June 2014: I started a Certificate III in Water Operations and really became Water Officer – with no prior experience or training. I guess this was the 'undertake projects, research and other such duties as directed' part of my IT contract.

During the previous six months I had been keeping the plant running one of the tasks was to add a chemical called 'floc'. I didn't really know how it was supposed to work but that it was called Klaraid and presumably made the water clearer. It didn't appear to be working too well and I wasn't sure of the dose, I just kept mixing it at the rate I had been told worked.

I soon learned that 'flocculation' was a process occurring in the plant, and that our plant was a 'direct filtration plant'. Previously I had been told by various people around Croydon that the plant was designed to be a sewer plant and 'flocculation' sounded like a swear word to me.

Around July and August 2014 taking on board what I had been learning from my Certificate course, I decided I needed to really take ownership of my water treatment plant. The plant really needed a good clean up and I needed to update and acquire some more testing equipment and really delve into my plant records to try to gain a better understanding of its workings and history to foresee problems that would likely reappear.

One of the most obviously important documents I had been seeking from the time I first entered the plant was an operators manual. The problem was that the treatment process did not entirely follow what the manual said –

Table 1: ***Brief Summary of Water Treatment Process Description from Manual***

1. Sodium Hypochlorite is dosed in the inlet line to the pump station to oxidise metals, in particular Iron, to an insoluble form	Was occurring
2. Liquid Ultrion 8588 coagulant is dosed after the Hypo and before the pumps, which are utilised as a "flash" mixing device, to begin the flocculation process.	Was not occurring
3. The rising main from the dam to the Water Treatment Plant provides detention time for floc formation so that by the time the water reaches the plant it is of a suitable size for filtration.	Was not occurring, but would a floc survive the sheer of the inlet works and control valve anyway?
4. At the WTP, liquid Alum is dosed to complete the flocculation prior to the slow to medium sand filters.	Was not occurring
5. When required, Sodium Hydroxide solution can be injected to adjust the pH to the required range of 7 to 8.	Raw Water pH high 7's, not needed?
6. A final injection of Sodium Hypochlorite is dosed immediately before the storage reservoir to provide disinfection and a chlorine residual in the reticulation system.	Was occurring

I also discovered a long disused portable flocculator and understood the need for jar testing and turbidity testing. The portable flocculator had been misused; when I found it the associated jars had what seemed to be about 2cm deep of neat Klaraid (this must be the most viscous substance known to man?) in a couple of them and all 4 jars were very discoloured plastic.

I purchased new jars and other volumetric flasks but although I knew approximately the kind of volumes (mg/L or ppm), I still didn't quite know where to start.

The other advancement I had made was flushing water mains. I embarked on a flushing program where I worked away from the plant toward the extremes, drawing water through hydrants and increasing velocity using pumps into water trucks. I tested chlorine residuals after raising dosages at the plant to around 5mg/L and found I could get chlorine residuals to the extremities of the reticulation and Lab results showed lowering Heterotrophic Plate Counts. These results were short lived - the high turbidity in the treated water and pipelines and hence chlorine demand in the reticulation system was obvious.

I needed some help! Consultants Aeramix were engaged by Croydon Shire Council in December 2014 to review the water supply system for the township of Croydon QLD.

Aeramix's Mark Samblebe and Joel Fitzgerald spent a busy week in Croydon which included undertaking a limnological study of Lake Belmore; jar testing to optimise current system performance and testing of alternative chemical combinations that might provide benefit to the process; physically inspecting current infrastructure, PLC program and operating philosophy.

They found the WTP to be primarily sound in its physical configuration however other factors were found to contribute to reduced efficiency and process performance.

- The plant was running 25% above its maximum design flow meaning that flocculation and coagulation and effective filtration times were reduced. Also elevated backwash rise rates potentially leading to media loss.
- There was also an issue with build up of trapped air in the pressure filters reducing available flocculation space and time.
- They considered that the floc would be forming after filtration or within the filter bed but be unable to coagulate to a size that the filter could remove.
- Filter media inspection was undertaken in cell 6 and confirmed significant mud balling ranging in size from 2-5mm up to 15-20mm. It was believed that an uneven and large particle size distribution may be reducing filter performance or causing some short circuiting allowing solids to pass through.

In conjunction with assessing the physical capacity components multiple laboratory scale tests (Jar Tests) were undertaken. Optimal doses were also implemented in the WTP for performance comparison. This was a great learning experience for me and quickly helped develop knowledge and understanding of process requirements as well as how the plant flows worked.

The current chemical configurations (Klaraid 1195P) with prior chlorine oxidation was first tested at laboratory scale. Results showed Klaraid could form acceptable floc sizes and produce a high quality water of an average of 0.25ntu. Optimal dose rate was in the order of 6-12 parts per million (ppm), which was higher than the 4ppm being dosed at the plant at the time. However results could not be replicated in the plant.

In fact treated water quality deteriorated which prompted detailed investigation into the plants physical capacity as detailed above. Tests on un-oxidised raw water did not achieve filtered water turbidities of less than 1.31ntu and even higher doses rate ranging from 8 to 16 ppm were required. From these findings it was deemed essential to retain pre chlorine dosing to enable oxidation of soluble iron and manganese in the raw water supply and stimulate more efficient floc formation.

Jar tests of 15 minutes had been the starting point, however when jar tests were repeated at shorter flocculation times more representative of plant detention times, similar performance was then observed in Jar tests as was in the WTP itself. The Klaraid needed 8 minutes minimum to form a micro-pin floc, which was still too small for the filters to trap, and as such floc formation was now occurring within the bed and post filtration which led to worse treated water than previously encountered despite initial test indicating improved performance at higher dosages.

A revised chemical configuration was required in order to promote floc formation at a more rapid pace, and Alum (Aluminium Sulphate), and ACH (Aluminium Chlorohydrate) were then tested both alone and in conjunction with the Klaraid coagulant.

The recommended configuration was to dose ACH prior to the Klaraid which worked well at the elevated pH levels in raw water averaging 7.7-7.95 producing a compliant end product. A dosing tapping point was observed prior a 90 degree bend and the inlet flow control valve. This should provide adequate mixing prior to addition of Klaraid at its existing dose point. Alum was tested and showed no benefit in the results achieved, this would also require pH correction.

The Consultants also detected issues in the control philosophy. The chemical dosing systems stop working throughout the backwash sequence, this is a critical error in the control philosophy for the following reasons;

1. Each filter is backwashed using water being generated by the remaining filters which stay on line via a change in valve position.
2. During this time filters providing the backwash water are not being dosed despite being in normal operating mode which requires coagulation in order to ensure the filters are actually filtering.
3. By the end of a backwash sequence, all six filters are full of raw, un-dosed water, meaning that when the plant returns to normal operation the entire plant has to be flushed out once chemical dosing recommences, forcing untreated water (except disinfection) into the storage tank until such time that the chemical dosing system has worked its way through the process and returned the filters to an operable state.

The Consultants reported their conclusion, that the Croydon WTP facility has the capacity and capability to deliver a compliant water supply to the township however shortfalls interlinked between physical capacity, chemical configuration and the process control logic that drives the plant existed.

Multiple changes could be made at a reasonable cost to improve the way the process operates and enable the operator more control over the system and process as a whole in order to optimise and maintain the system. Further to the direct assessment of the plant and process, observations were made regarding the laboratory equipment and analytical equipment available to the operator that should be upgraded to meet the operator’s needs in determination of water quality parameters.

The limnology study conducted on Lake Belmore revealed that through multiple sample sites and depths the lake exhibited quite uniform parameters throughout. The investigation revealed that Iron, Manganese and turbidity levels were on average above the Australian Drinking Water Guidelines (ADWG), with Manganese being more an aesthetic than health concern at levels present.

Shortly after the Consultant's visit, I purchased a more accurate turbidity meter and added ACH dosing while also slowing plant flows as discussed with the consultants while they were onsite. I had Welcon reprogram PLC operation to ensure chemical dosing occurred during backwash.

It was shortly after this that I found a major problem at the plant. Despite jar tests showing that the new chemical blend was achieving desired results in good time, I lowered the treated reservoir level to near empty and ran fresh water from the plant. I then inspected the water in the treated tank and could see floc floating in the water.

There is a section of clear pipework that backwash flows through and I observed a backwash cycle more closely than I ever had before. When the first cell backwashed the water was dirtier than I had ever noticed it to be before – the flocculation process was working to remove suspended particles better than I had seen before. However it cleared toward the end of this cell and remained relatively clear through the second cells cycle. It became dirty again on the remaining 4 cells, similar to what I had observed in the first cell's cycle.

I now had the answer to my turbidity and chlorine demand problem and the explanation as to why the jar tests were not being well replicated in the plant tests. The second cell was short circuiting and I was prepared to bet that it had suffered from media loss through some sort of failure or excessive backwash rise rates.

The next day I took the lid off cell 2 and reached in with a length of tube to measure the filter sand depth – there was none! After shutting the plant down and draining it - there it was – the media transuding nozzle that had the plant crippled for years! One missing nozzle had led to a complete failure of the process.

The Consultants then coordinated the supply of excess filter media from a project they had completed in Georgetown to the east and Mark returned to assist with an emergency filter nozzle and media replacement. With the improved process chemistry, and a filter with actual media in it, the plant now produces high quality water in the realms of 0.05 to 0.15ntu, chlorine residuals remain for longer and the chlorine dose required has dropped significantly.

4.0 ACKNOWLEDGEMENTS

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