OPERATORS PERSPECTIVE : OPTIMISATION OF A NEW PACKAGE WATER TREATMENT PLANT

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ABSTRACT

Plant optimisation is a continuous process and is one of the most important parts of running water treatment plants. Installing a 'high tech' and wise complete package treatment plant with touch screens and flow paced pumps will not ensure operating success. The Springhurst treatment plant commissioned in 1999 has been a very difficult plant to operate. Alterations to the inlet pipe work, calibration system and pipe work into the clarifier were undertaken, along with investigations into raw water quality and reservoir management options. Problems such as precipitating iron and floc formation have been improved by process changes. Since alterations, operator time put into the plant has been dramatically reduced and chemical usage significantly lowered. Dose rates previous to the changes were in the order of 80 – 220mg/L Aluminium Sulphate, now reduced to 40 – 65mg/L. Average turbidity of treated water has been reduced from 0.2 – 4 NTU to 0.1 – 0.2 NTU.

KEYWORDS

North East Water, iron removal, Springhurst Water Treatment Plant, optimisation, control program.

1.0 INTRODUCTION

The Springhurst water treatment plant is a conventional type plant that incorporates a compact modular design. Consisting of two flocculation chambers, one up flow contact clarifier and a silicone sponge filter. The water treatment plant has an average annual demand of 28 mega litres. The treatment plant receives water under gravity from the 55-mega-litre capacity Diddah Diddah Basin; this can also be blended with water from the Springhurst bore pump station.

The Springhurst water treatment plant is a 'hi tech' and wise complete package treatment plant with touch screens and flow paced pumps. In general the control system of the water treatment plant is a PLC system with the facility to control and monitor all items of equipment associated with the treatment plant. An operator interface of the plant allows access to monitor and control the operation of the plant. The touch screen permits operator interrogation of plant settings, levels, rates and allows direct operator setting of specific parameters to be adjusted for the optimum operation of the water treatment plant.

With this control program it would be easy to imagine that the water treatment plant would run smoothly and with ease. After all how hard could it be to optimise a plant while standing on the spot changing set points and controls?

The Springhurst Treatment Plant was commissioned in 1999, and has been a very difficult plant to operate and achieve optimum results. This paper discusses the changes that were made to the design of the WTP to achieve good water quality. Also how to possibly avoid these problems when designing and constructing new treatment plants.

1.1 Springhurst Raw Water Supply

The incoming raw water quality changes frequently, with parameters ranging from 5 to 100 NTU for turbidity, and true colour between 10 – 400 PtCo. But the main problem at Springhurst is the high levels of iron. See table 1: Raw Water Quality below for parameter ranges.

Table 1: ***Raw Water Quality***

Water Quality Parameter	Range
PH	6.0 – 7.0
Turbidity	5.0 – 100.0 NTU
True Colour	10 – 400 PtCo
Alkalinity	15 – 30 mg/l
Iron	10 –20mg/l

Ferrous iron (Fe^{2+}) is a soluble cation, when exposed to the air reduces the form and slowly transforms to insoluble, visible oxidised ferric iron (Fe^{3+}). The rate of oxidation depends on pH, alkalinity, organic content, and presence of oxidation agents. If both forms of iron aren't removed in treatment, the brown coloured oxide of iron can create can anaesthetic conditions and may interfere with some water uses.

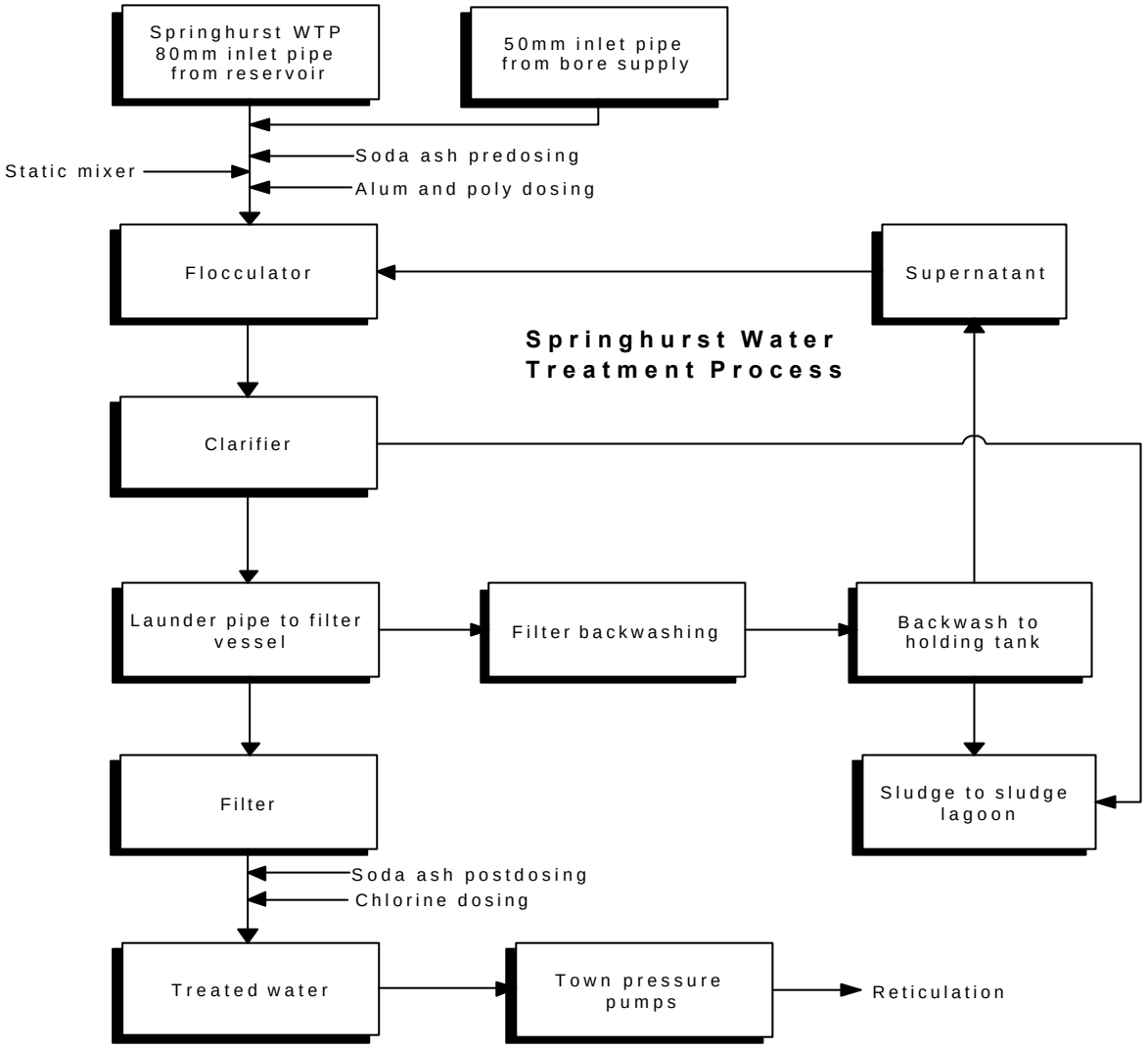
2.0 DISCUSSION

Problems experienced with treating the Springhurst Water Supply have been attributed to several factors. High levels of iron present in the raw water supply, low dissolved oxygen when inflow into the reservoir stops, and also Blue Green Algae (Cylindrospermosis) during the summer months. These problems were proving difficult to solve. Endless jar tests without replicable results in the plant showed that something was missing in the physical system of the treatment process. It was time to look at the basic properties of the treatment process.

Properties of the water treatment process rely on the basic physical systems of the treatment plants. Areas such as chemical dose point spacing, mixing times and pump placement have profound effects on a treatment system. All physical treatment processes usually include chemical assistance, such as the use of coagulant chemicals to aid in solids removal. Using the correct chemicals to achieve optimum results, also relies on the raw water quality. Sufficient knowledge of which parameters in the raw water will cause the most concern for removal or by-products when other treatment chemicals are added

The Springhurst WTP lacked the capacity for the mixing time for the coagulation process, with the chemical injection immediately prior to the flocculation tanks, and no form of rapid mixing. Other problems with the physical set up of the Springhurst WTP, included no chemical dose point spacing, incorrect pipe work for the dose pump calibration drop tubes. Also changing to more efficient chemicals, which act more effectively against the raw water parameters that exist for this particular area.

Figure 1: ***Springhurst Water Treatment Process***



The complete package WTP at Springhurst was originally designed with Aluminium Sulphate (Alum) as the coagulant. Alum was unable to achieve the results needed for optimum water quality, it was unknown why Alum was not working in the WTP. The jar tests which where undertaken proved that something was wrong in the set up of the chemical addition. This would be why the Alum was being unreliable in the coagulation process. To prove this Ferric Sulphate (PFS) was trialled, as it was suggested to be a more reliable and stable coagulant.

The WTP was then being dosed with PFS as the coagulant, and Poly 1120 to aid in flocculation, with Sodium Carbonate (Soda Ash) for post pH correction. This achieved the results in the plant which Alum couldn't, and reliably removed the impurities from the water supply. Until customers complained that a brown stain was coming through into the treated water supply. Investigations were undertaken to find what could be causing this problem.

Treated water was crystal clear when it went into the clear water storage tank, but the reticulation system samples showed that the colour was returning into the water.

Analysis of the water showed high iron residuals, it was not being removed in the WTP, or overdosing with PFS was occurring. The dosage of PFS was lowered, but this caused problems in achieving results in the plant. PFS was eliminated as a possible coagulant for the Springhurst WTP and Alum was trialled with the following changes to the chemical dosing system.

Changes to the set up of chemical dosing included pre pH correction dosing with Soda Ash, to bring the pH up to 8.5 before coagulation this was to aid in iron precipitation. Sample points were also changed to ensure a representative samples could be taken. Pipe work for the addition of coagulant to the raw water was moved to allow the installation of a rapid mixer unit, this allowed chemical mixing times to increase. Improving the coagulation and flocculation process for the WTP.

Table 2 : ***Chemical Dosages Pre and Post Changes***

Treatment	Chemical	Pre-changes	Post Changes
Coagulant	Aluminium Sulphate	80 – 220 mg/l	30 – 70mg/l
Coagulant	Ferric Sulphate	80 – 180 mg/l	Not used
Coagulant Aid	Poly 1120	0.50 – 2.00mg/l	1.00 – 2.00mg/l
PH Correction	Soda Ash	50 – 90mg/l	50 – 80mg/l
Disinfection	Sodium Hydroxide	1.00 – 3.00mg/l	1.00 – 3.00mg/l

The plant optimisation changes that were undertaken greatly reduced the chemical dosages needed to achieve high standard results. This can be seen in Table 2, reducing the coagulant dosage by over 300%. Although the other chemicals haven't changed significantly there has been a noticeable decrease in chemical costs at the Springhurst WTP.

Introducing an aeration step to the start of the treatment process was seen as a simple method for improving the problems in the Springhurst supply. By decreasing the iron reaching the WTP. Oxygen in the air reacts with the soluble ferrous iron (Fe^{2+}) and oxidizes it to a visible and insoluble ferric iron (Fe^{3+}). The insoluble ferric iron is easily removed by either precipitation or filtration.

The aeration process will also increase dissolved oxygen levels and the reduction of taste and odour problems.

These changes were increasing the iron removal as can be seen in the table below:

Table 3: ***Iron Removal Post Changes***

Sample Source	Range
Raw Water	10 – 20mg/l
Post Aeration	3 – 7mg/l
Clarified Water	0.5 – 2.0mg/l
Filtered Water	0.00 – 0.2mg/l

2.1 Theory Behind the Changes

As the coagulation – flocculation process helps in the removal of non- settable particles from water. It is known that water contains three types of non-settleable solids, suspended solids, colloidal solids, and dissolved solids.

The dissolved solids need to be converted to a solid form before they can be removed from the water, by a process known as precipitation.

The coagulation process is reliant on mixing to attract the particles together for the process of particle stabilization. This is where the particles are attracted together to form micro flocs. The flocculation action of gentle stirring brings these micro flocs together to form macro flocs, which are then heavy enough to settle. Proper design for the rapid mixing unit is essential to good water treatment (Deakin University 1996).

The kinetics of iron oxidation by oxygen is rapid at pH values above 6.5, at around 15 minutes. The reaction is as follows:

$$4Fe(HCO_3)_2 + O_2 + H_2O \rightarrow 4Fe(OH)_3 + 8CO_2$$

Insoluble iron precipitate will cause staining in the aeration tank and possibly at the WTP. Insoluble iron that reaches the WTP will be removed by being bound up in the floc and settle out in the clarifier, or will be removed by filtration.

3.0 CONCLUSION

Water treatment can be achieved without computer programs but if you take away all the basic principles of water treatment then what happens?

The experience that the operators had in optimising the Springhurst WTP, shows us that more emphasis needs to be on the physical design of the plant. Technology today is very involved in WTP's, this aids in both the treatment process and the monitoring. But those involved in the design and construction of water and wastewater treatment plants, must not forget the basic properties of the water treatment process.

Dedicated operators know that plant optimisation is a continuing process. But if the design of the plant allowed for correct dose point spacing, mixing times and pump placement, then the operators have a helping hand in achieving plant optimisation. Also the more raw water samples taken the better idea everyone can have on which treatment chemicals would be best suited for the area involved.

Overall the treatment at Springhurst WTP is now outstanding, and this is due to the never ending process of plant optimisation.

4.0 ACKNOWLEDGEMENTS

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