SOFT WATER FOR RED EARTH
AN 80 ML/D SOFTENING PLANT FOR DUBBO

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ABSTRACT

Dubbo City Council's John Gilbert WTP recently underwent an upgrade from 30 ML/d to 80 ML/d. Treatment at the new plant comprises of aeration; PAC dosing; coagulation; softening; clarification; recarbonation; filtration; disinfection; and fluoridation. The project involved significant construction works, while parts of the existing plant were retained and others refurbished for alternate use. The need for continued water supply to the city of Dubbo posed technical and logistical challenges, with HAZOP studies, design and site meetings used to aid in problem solving. John Gilbert WTP is now the largest water softening plant in NSW.

KEY WORDS

Water, treatment, plant, upgrade, construction, augmentation, dosing, commissioning.

1 INTRODUCTION

Dubbo City is a growing regional hub with a population of nearly 40,000 people, a figure expected to increase by 18,000 over the next 30 years. When planning to treat the additional quantity of water required to meet this demand, Dubbo City Council (Council) took the opportunity to also consider water quality improvements to its supply. A number of community consultation initiatives were undertaken to determine the water quality improvements the community of Dubbo desired.

Dubbo's water supply is the Macquarie River and seven deep bores. It is treated at John Gilbert Water Treatment Plant (WTP), which opened in 1981. The original design capacity of the WTP was 30 ML/d. The treatment process included aeration; powdered activated carbon dosing (PAC); coagulation with ferric chloride and polymer; softening and clarification with lime and soda ash; recarbonation using carbon dioxide; filtration using single media gravity filters; disinfection with chlorine gas; and fluoridation.

Due to increased water demand, the treatment plant had been operating at its maximum hydraulic load of 42 ML/d. With the addition of 15 ML/d of aerated bore water the total supply capacity was just matching peak day demands of 57 ML/d.

For this reason, John Gilbert WTP recently underwent an upgrade to 80 ML/d, a throughput chosen to meet the projected peak demand for 2021. The new upgraded WTP is the largest water softening plant in NSW. In addition to increased production rate, the augmentation reduces hardness to 60-80 mg/L, improves taste and algal toxin removal and reduces odour.

2 DISCUSSION

2.1 Upgrade Options Considered

A preliminary options report for the WTP upgrade was prepared. The options included four source water and treatment options and three different service level options.

The four water source and treatment options investigated were:

A River water to be used for bulk supply, with addition of bore water for recarbonation and to meet supply requirements during peak demand periods. River water would be softened. The portion of bore water not used for recarbonation would receive aeration to remove carbon dioxide only. Water hardness would be about the same.

B River water would be used to supply all the raw water. CO_2 would be required for recarbonation. The hardness of water produced would be lower than that of Option A.

C Similar to Option A, except that bore water not used for recarbonation would be softened along with river water. Hardness of the water produced would be lower than in Option A.

D River water would be used for raw water supply and bore water would be used solely for recarbonation. The hardness of the water produced would be lower than that of Option A.

Option B was discarded early on, as Council wanted to maintain the flexibility and security of the availability of two water sources. For the remaining three water source and treatment options, three water quality service level options were investigated. These were:

0 Existing level of service.

1 Improved hardness reduction to 60-80 mg/L. This would be achieved by softening all bore water that is not used for recarbonation.

2 Improved taste and odour reduction and algal toxins removal by providing a PAC contact tank. This would improve PAC efficiency compared to the current process operation.

3 Provision of ozone/BAC. This offers a high level of service in regard to taste, odour and algal toxins removal, THMs reduction, as well as a range of other benefits, including reduced chlorine usage.

2.2 Community Consultation

A community consultation program was undertaken to inform residents of Dubbo about the plant upgrade and to also obtain and consider their views and opinions. The program included the creation of a Community Special Interest Group (CSIG), whose role was to keep the community informed and to advise Council of the suggestions and opinions received from residents. The CSIG comprised of a representative from the Department of Health, a Department of Land and Water Conservation representative and seven Dubbo residents.

The community was kept informed via newsletters from the Mayor. Comments were obtained from residents via “Have Your Say” comment forms and a telephone survey. Feedback indicated that people wanted cleaner water using fewer chemicals. During the telephone survey, comments indicated that residents felt they did not have the technical expertise to provide treatment recommendations. Others stated they wanted cheaper water rates.

2.3 The Option Selected

Following community consultation, Council decided to proceed with Water Source Option C and Service Level Option 2 (incorporating Service Level 1), with provision to allow Service Level 3 to be constructed in the future if necessary. Due to the arrangement of the existing plant, the new plant is also capable of removing some THM precursors.

Though the community would have preferred chlorination be removed from the treatment process, other options such as Ozone/BAC and UV disinfection would still require the addition of chlorine to ensure bacteria did not grow in the distribution.

2.4 Upgrade Works

Works performed during the augmentation included:

- Refurbishment of the disused intake and pump station to draw an additional 460 L/s of raw water from the river;
- New raw water rising main;
- New 4.2 ML PAC contact tank;
- New 50 ML/d clarifier;
- New recarbonation tank;
- Six new gravity filters;
- Conversion of four existing filters into a filter-to-waste tank;
- Conversion of the existing recarbonation talk to a service water tank;
- New 2 ML chlorine/contact tank;
- New clearwater pump station;
- Upgrading of chemical dosing systems;
- Two new drying beds; and
- Access to new site facilities, including constructing two internal roads.

The existing clarifier has been maintained and is used in parallel to the new clarifier, as is the existing chlorine contact tank and clearwater tank. The existing Lime, Soda Ash and Polymer dosing systems have also been retained and dose water flowing through the existing clarifier.

2.5 The Treatment Process

The major treatment process used at the new plant include: aeration for bore water; PAC dosing; coagulation with ferric chloride ($FeCl_3$) and polymer (LT_{25}); softening and clarification with lime ($Ca(OH)_2$) and soda ash (Na_2CO_3); recarbonation using carbon dioxide (CO_2); filtration using sand/coal gravity filters; disinfection using chlorine gas (Cl_2); and fluoridation using hydrofluosilicic acid (H_2SiF_6). The process flow diagram for the new plant is shown in Figure 1.

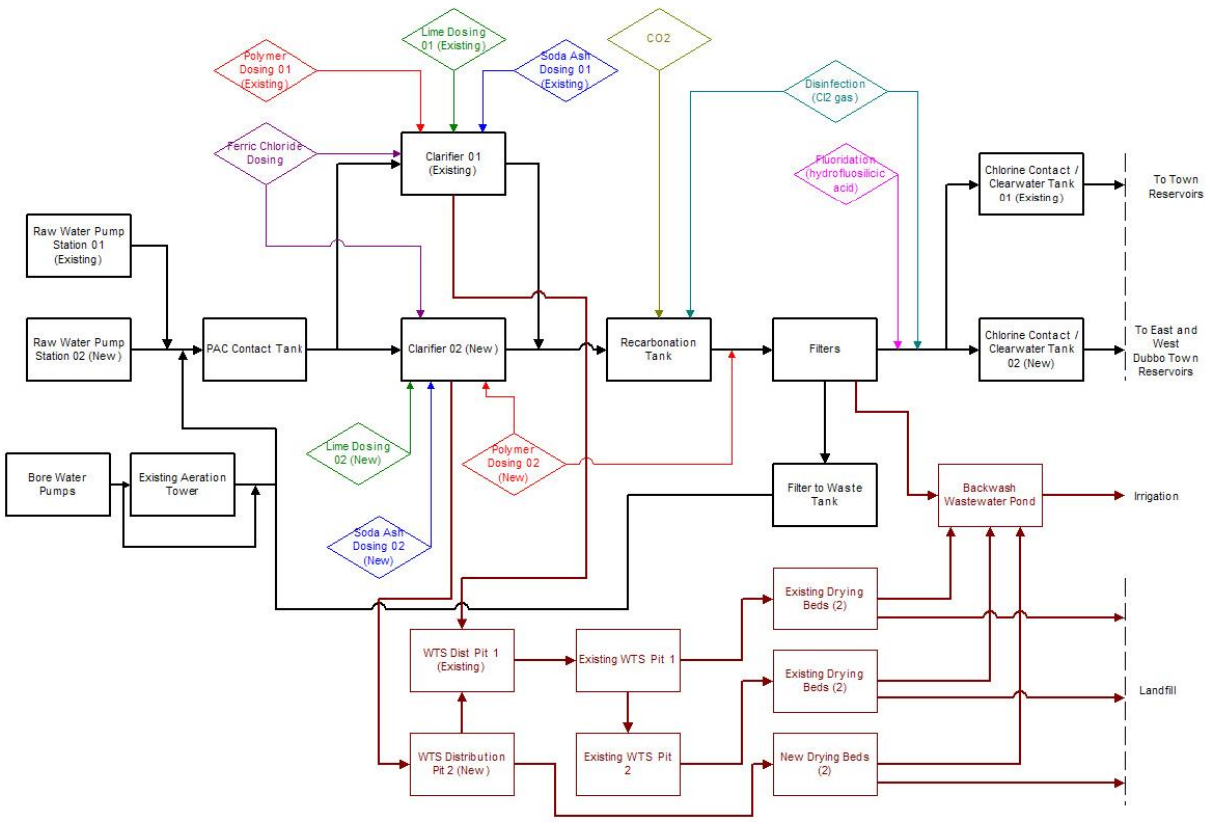

Figure 1: ***Process flow diagram for the upgraded John Gilbert WTP***

If bore water is being used, it is first aerated to remove dissolved volatile compounds found in groundwater. The bore water is then mixed with raw river water in the PAC contact tank, where adsorption by means of PAC dosing is performed to remove algal toxins and subsequent taste and odour causing substances.

Following adsorption, the water flows into the two large clarifiers for coagulation, flocculation, clarification and lime/soda ash softening. Ferric chloride and polymer are dosed as the coagulant and coagulant aid respectively at the inlet of the flocculation chambers. Colloidal particles coagulate and then flocculate upon agitation.

Clarification occurs in the large outer ring of the circular sludge blanket type clarifiers. Lime and soda ash are also dosed into the clarifiers for the purpose of softening the water.

From the clarifiers, water gravitates to the recarbonation tank, where carbon dioxide is added for pH stabilisation. When required, polymer may again be added to aid in filtration prior to the water entering the dual media filters. Dosing chlorine gas into the filter outlet channel disinfects filtered water. Fluoride for dental health is also dosed into the filtered water channel. Waste by-products of the treatment process are dried out in the drying ponds before use as soil conditioner on agricultural land within the district.

2.6 Construction, Demonstration and Commissioning

Council contracted the NSW Department of Commerce (Commerce) to provide construction project management and technical advice for the duration of the contract. The contract was a design and construct contract under GC21 (Edition 1). The winning tender was selected on price and non-price criteria. The winning tenderer was United Group Infrastructure (UGI).

During the design period, design review meetings were held once a fortnight between UGI, Council and Commerce. The purpose of these meetings was to foster brainstorming and problem solving. The meetings were also a good way of ensuring contract obligations were being met and that discussions were recorded in an auditable manner.

Three Hazard and Operability Studies (HAZOP) were performed during the design phase to prevent deviations from design intent and to eliminate potential design and operating hazards.

Once construction commenced, site meetings between the contractor, WTP operators and the Commerce project manager were held weekly. Construction issues affecting the existing plant and continued supply were discussed in these site meetings. These meetings continued throughout demonstration and commissioning of the plant.

The design and construction of NSW's largest softening plant, while maintaining supply through the existing plant, posed a number of technical and logistical challenges.

2.7 Project Challenges and Learnings

Identification of Project Constraints

The major constraint on the project was the need to continue supplying water to the City of Dubbo during construction, demonstration and commissioning. This meant that timetabling of numerous project components was paramount. UGI, Commerce and Council worked closely to ensure integration of the two plants and that all testing could be performed with as little disruption to the water supply as possible. Brainstorming sessions were held to facilitate this.

Work Requiring Plant Shutdown

During tender review meetings with UGI, a number of events were anticipated to require plant shutdown, while other events were foreseen to temporarily limit operation of the plant.

Those works identified as requiring shutdown included tying in the new PAC system to the existing clarifier; connection of the new filters to the existing clearwater tank; tying in the new chlorine dosing system and changeover to the new chlorine dosing points; backwash wastewater tie-ins; connection of the clarified water channel to the existing channel; and connection of the new PLCs and control system to the existing plant control system.

Process Changeovers

As part of the project upgrade, the existing recarbonation tank was converted into a service water tank. This meant that the new service water tank could not be demonstrated until the existing recarbonation tank had been decommissioned. However, the existing recarbonation tank could not be decommissioned until the new recarbonation tank had been demonstrated.

The existing filters were converted into the new filter-to-waste tank. Consequently, the new filter-to-waste pumps could not be tested prior to demonstration due to the need to first decommission the existing filters. However, decommissioning of the existing filters could not occur until after the new filters had been completely tested.

Changeover from the old to the new PAC system was also complicated. This was because once the system had been changed there was no way to revert back to the existing PAC system. This was a risk, as if the new system had teething problems and an algal bloom were to arise, dosing would need to occur manually.

Switching over to the new aerated bore water pumps would mean no aerated bore water could be delivered to the existing plant. The proposed solution should bore water be required was to pump it directly to the recarbonation tank, meaning CO_2 dosing would need to be turned off.

Water Quality

During filter control sequence testing, manual post dosing was required. This was done due to difficulty in disposing of chlorinated water used during testing. Another option considered, but not chosen due to environmental concerns, was neutralising chlorinated water with bisulphate then pumping it into the river. Also discarded was the option to pump the water to the backwash ponds. In this case the volume of water requiring disposal was too large.

Disinfection of the filters was another potential challenge, however, it was determined that the chlorinated water could be disposed of in the drying beds.

Another water disposal predicament arose when the new clarifier was brought online. After the initial dosing, the pH was very high. To overcome the high pH, the water from the new clarifier was mixed with that from the existing clarifier and aerated using bore water. The water was then put through the new filters. The final result of this was potable quality water.

Due to the disruption caused by demonstration and testing, water quality was sometimes slightly out of specification. These situations occasionally required plant shutdown until the quality of the water was brought back within specification. There was consternation that reservoirs would not contain sufficient water in the event of a lengthy shutdown, however, this concern was not realised.

Other Project Complexities
Refurbishment of the old pump station was complicated. The original suction pipe tunnel was large enough to fit the new suction pipe, so after an inspection by divers the decision was made to reuse it. To enable installation of the new intake screen and refurbishment of the tunnel, sheet piling was set up in the river to provide a dry work area. This sheet piling was installed from a piling rig mounted on barges, as access from embankments was not possible. Dolphins and support piles for the suction pipework were also installed from the barges.

There was a delay in the design and installation of the surge vessels on the new clearwater pumps. This meant that the plant could not be operated at full flow, except for short periods of time for the purpose of testing plant hydraulics only.

The original design of the recarbonation system proved to be inadequate, leading to delays in testing and demonstration of the new recarbonation system.

The quicklime system also produced some unforseen difficulties with respect to unreliable feed rates, flooding and hang-ups. This required all staff involved to utilise their knowledge of quicklime systems to correct the problem.

The large size of the new clarifier introduced design complexities with respect to strength of the rake and prevention of bowing.

Due to many of these complexities, the project program was extended. Due to other commitments, some contractor staff were removed from the project, with new staff taking over their roles. This was a hindrance as project knowledge was lost in the process.

3 CONCLUSIONS

Upgrading the 30 ML/d John Gilbert WTP to an 80 ML/d WTP produced many foreseen and unforseen challenges and learnings. However, close working relationships between Council, Commerce and the contractor, United Group Infrastructure, ensured that the plant upgrade had minimal impact upon the community of Dubbo.

John Gilbert WTP is now the largest lime/soda ash softening plant in Australia and will be capable of meeting water quality and quantity demands as Dubbo’s population increases over the next 15 years.

4 ACKNOWLEDGEMENTS

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