EASTERN IRRIGATION SCHEME, VICTORIA: OPERATION OF AN ULTRA-FILTRATION PLANT FOR A CLASS A RECYCLED WATER SCHEME

Paper Presented by :

David Aitken

Authors:

David Aitken, *Plant Operator,*
Liz Roder, *Operations Engineer,*
Peter Everist, *Operations Manager,*

Earth Tech Engineering

69th Annual Water Industry Engineers and Operators' Conference
Bendigo Exhibition Centre
5 to 7 September, 2006

EASTERN IRRIGATION SCHEME, VICTORIA: OPERATION OF AN ULTRA-FILTRATION PLANT FOR A CLASS A RECYCLED WATER SCHEME

David Aitken, *Plant Operator*, Earth Tech
Liz Roder, *Operations Engineer*, Earth Tech
Peter Everist, *Operations Manager*, Earth Tech

ABSTRACT

The Eastern Irrigation Scheme (EIS) is a joint project between Topaq Pty Ltd and Melbourne Water Corporation (MWC). The EIS operates under the brand Topaq, a wholly owned subsidiary of Earth Tech. Topaq will own and operate the scheme for 25 years. Under the partnership, Earth Tech designed and built an ultra-filtration treatment plant and a 60km pipeline network to supply and distribute Class A recycled water to over 60 customers in and around the Cranbourne area. The Interim Treatment Plant (ITP) is Australia's largest recycled water ultra-filtration treatment plant for the treatment of Class C water. It has a capacity of 30 ML/day of Class A water for irrigation and third pipe use. The annual demand is approximately 5,000ML. Individual customer demands range between 1 and 400 ML per year. The EIS recycles approximately 3.5% of the treated water from Melbourne Waters Eastern Treatment Plant (ETP), contributing significantly to the Victorian Government's target of 20% water recycling by 2010.

KEY WORDS

Membrane, recycling, irrigation, wastewater, ultra-filtration, operation

1.0 INTRODUCTION

Melbourne's south east region is one of Victoria's largest producers of vegetables. The EIS provides growers with access to safe, reliable, high quality water to irrigate their crops and develop their businesses. The Class A recycled water is also used for agriculture, open space irrigation and for recreational facilities such as golf courses, race tracks and sports ovals. Residential developments in the area, such as the Sandhurst Club, use dual pipe systems to distribute Class A recycled water to residences for watering gardens and flushing toilets.

2.0 DISCUSSION

2.1 Contract with Melbourne Water

Under the Private Public partnership a 25 year contract with Melbourne Water is in place to operate the EIS. The contract has several key responsibilities and requirements, including:

- Monitoring the water quality of Class C influent (turbidity in particular)
- Operation of the ITP to produce Class A water
- Supply of Class A water to irrigation customers as required, and managing the reticulation pipeline to preserve the Class A water quality for customer use
- Managing products and by-products of the ITP
- Monitoring environmental impact, and compliance with a Regional Environmental Improvement Plan
- Reporting to Melbourne Water, EPA and DHS

2.2 Treatment Process

The volume treated each day is dependent on the demand from customers. The peak demand period is in January to March, with only small to moderate flows during winter. In summary, after receiving Class C water from the ETP, the following treatment steps are followed:

- Sodium hypochlorite dosing for pre-chloramination
- Fine screening through microstrainers
- Aluminium chlorohydrate (ACH) dosing for coagulation
- Caustic soda (sodium hydroxide, NaOH) dosing for pH correction as required
- Ultra-filtration (UF) through membrane units
- Post-chlorination to achieve a CT_{10} (combined measure of chlorine dose and contact time) of 129 mg.min/L at 20 deg.C
- Storage in the Reclaimed Water Tank until it is pumped on demand to customers for irrigation

2.3 Influent Monitoring and Pre-treatment

The ETP discharges Class C water via the South Eastern Outfall (SEO) at Rossiter Rd. The feed water pipeline from the takeoff is approximately 1.8km to the ITP. The plant is supplied under 4-6 bar pressure. Turbidity is monitored on-line at the ETP outlet, the SEO off-take point, and the inlet to the ITP. Originally only one turbidimeter was used, at the inlet to the ITP, but growing operational experience has led to the installation of the 2 upstream turbidimeters, which provide a forewarning of any lower quality (higher turbidity) water being fed from the ETP. By derivation, Class C water should have turbidity lower than 50 NTU. In the event higher turbidity water does get discharged into the outfall, the ITP can be shut down in advance, allowing preventative measures to be taken. The influent turbidity can affect the control of plant functions significantly.

Prechlorination is performed at the plant inlet, through a flow based dose of sodium hypochlorite. The water is then screened under pressure through a bank of 24 microstrainers, with a filter pore size of 100 microns. The microstrainers are controlled automatically through the CITECT system. They are backwashed every 8 hours, or triggered by head loss. All backwash water is discharged into a concentration tank and metered prior to returning to the Melbourne Water ETP under a Trade Waste Agreement.

The screened water is then dosed with Aluminium Chlorohydrate (ACH) for coagulation and if required, Sodium Hydroxide (caustic soda) for pH correction (pH increases only). The water then passes through a pressure sustaining valve and static mixer before entering the membrane filters.

2.4 Ultra-filtration

The main treatment process used at the ITP is ultra-filtration (UF) through a series of Norit Process Technology membrane units. The UF system is comprised of 8 membrane units, each consisting of 20 horizontal cylinders containing 4 membrane modules each, a total of 640 membranes.

Each membrane contains around 12,000 capillaries, all of which contain thousands of minute pores to provide a physical barrier to particles and pathogens. To put the membrane pore size in perspective, the following comparison can be made:

- Membrane pore size 35 nanometers
- E.coli > 500 nanometers
- Cryptosporidium > 3000 nanometers
- Human hair approx. 50,000 nanometers

The water passes through the membranes into a permeate header which feeds the reclaimed water storage tank. A chlorination level of 5mg/L is maintained in the product water by dosing the water with sodium hypochlorite as it enters the storage tank.

The rate of flow of screened and dosed water into the UF system is controlled automatically by the CITECT system (via a control valve), and is dependent on a number of factors:

- Influent turbidity: As the influent turbidity rises the flow allowed per unit reduces to protect the membranes. Depending on the number of units already on-line, the total plant influent flow may decrease, or the number of units on-line will be increased to compensate for the lower flow per individual unit and maintain the overall flow. Conversely, as the turbidity decreases the flow allowed per units is increased. The turbidity levels corresponding to flow changes and changes in the number of units on-line are defined in the CITECT system.
- Reclaimed water storage level: When the level of water in the reclaimed water storage tank increases above a predefined trigger level, the inflow per membrane unit will be reduced to prevent the plant shutting off, initiating CEBW 3 cleans and promptly wasting the membrane storage chemical, or overflowing the tank. Conversely, as the demand increases and the level in the tank starts to decrease, the flow into the UF system will automatically increase.

2.5 Membrane Cleaning

The backwash regime for the UF system is dependent on the turbidity of the influent entering the plant. At influent turbidities greater than 20 NTU, the units backwash every 20 minutes for 60 seconds. During lower turbidity conditions, backwashes occur every 28 minutes for 60 seconds. As for the microstrainers, all the backwash water is discharged to sewage via the concentrate tank.

In addition to standard backwash regimes, the following Chemically Enhanced Backwashes (CEBW) are also performed on the membrane system, at varying frequencies:

- **CEBW 1:** Sodium hypochlorite and caustic soda are dosed into the membranes. The units are soaked in this chemical mixture for 20 minutes, and then rinsed for 90 seconds before being returned to service. Alternating CEBW 1 and CEBW 2 cleans are performed every 8 hours.
- **CEBW 2:** Hydrochloric acid is dosed into the membranes. The units are soaked in the acid for 20 minutes, and then rinsed for 90 seconds before being returned to service. As mentioned above, alternating CEBW 1 and CEBW 2 cleans are performed every 8 hours.
- **CEBW 3:** The membrane units are injected with sodium hypochlorite for a disinfection hold if they are idle for longer than 1 hour. To protect the integrity of the membrane, they are not in a disinfection hold for longer than 24 hours.
- **CEBW 4:** If a membrane unit is idle for longer than 24 hours, it must be dosed with Sodium Metabisulphite (SMBS) for a preservation hold. Preservation holds are initiated if the unit is in a CEBW 3 disinfection hold for longer than 24 hours.

The integrity of the membranes will not be affected by the SMBS; they can sit in this preservation chemical indefinitely.

An additional cleaning method available for the membranes is the "Clean in Place" (CIP) membrane cleaning procedure, which is manually initiated by the operators only when units are not self-recovering after normal backwashes and CEBW's are performed. The CIP process involves the circulation of hot water and a cleaning agent (surfactant) through the units to remove any particulate build up on the membranes. A small volume of sodium hypochlorite has been found to enhance the performance of the CIP "hot cleans". CIP's have been very successful at the ITP, demonstrating good permeability recovery after cooling and being returned to service.

The need for CIP hot cleans was greater in the early months of operation of the ITP. Improved operator knowledge and management of the UF system has enabled a reduction in the frequency of the CIP's. Avoiding the need for CIP's in winter is especially preferred, due to the high energy costs associated with increasing the temperature during the colder months. CIP's are a last resort, and generally only applied if the raw influent quality (turbidity) is poor enough to warrant the effort and cost. They also provide a good backup for the operator.

All wash waters from membrane backwashes and chemical cleans (including CIP's) are pumped into a neutralisation tank. The pH in the neutralisation tank is continually monitored, and adjusted for pH and ORP before being pumped via the concentrate tank for discharge to waste.

2.6 Monitoring Water Quality and Plant Performance

Strict water quality performance requirements are in place at the EIS. As such, there is an extensive monitoring system in place. Earth Tech uses several tiers of monitoring including water quality, plant performance and asset condition, as described in more detail below.

Water quality and plant performance are monitored throughout the plant from the point of raw water influent through to the discharge of class A water into the distribution network for irrigation. Signals from all on-line monitors / equipment are sent to the CITECT system for constant review. A large number of alarms are programmed into CITECT to ensure that if any aspect of the water quality or the performance of key items of equipment exceeds pre-defined limits, the operators will be informed immediately via alarms listed in CITECT and / or text messages sent to mobile phones. Examples include the operation of critical pumps, turbidity levels throughout the plant, water or chemical levels in storage tanks, and the permeability of the membrane units.

A large number of grab samples are taken for analysis of parameters which cannot be measured on-line. These samples are either analysed by the operators in the on-site laboratory or off-site at a NATA accredited laboratory for parameters such as FRNA's (virus indicators) BOD_5, and E.Coli, which cannot be analysed on-site.

Environmental sampling and analysis, and groundwater sampling are also performed throughout the irrigation system, in compliance with Earth Tech's EPA approved Regional Environmental Improvement Plan.

A computer based maintenance and asset management system was implemented at the EIS during the first year of operation to facilitate the coordination and recording of asset condition, performance monitoring, and implementation of an extensive maintenance schedule. The software chosen, MEX, is used mainly to schedule routine (planned) maintenance, record unplanned / breakdown maintenance if / when it occurs, and provide Earth Tech with an effective asset register.

2.7 Monitoring Membrane Unit Integrity

There are 2 main types of integrity monitoring performed on each unit, which are both very important for ensuring water quality is maintained. They are particle count monitoring and integrity testing, both of which are described in more detail below.

Particle counts provide an indication of the membrane performance and the prevention of particle breakthrough being achieved. At the ITP an on-line particle counter rotates between the 8 membrane units every 7.5 minutes, to monitor the quality of filtered water leaving the UF system. To avoid any sample contamination and misleading results, the first 2.5 minutes of data for each 7.5 sampling period are ignored. Therefore, 5 minutes of particle count data are collected and analysed for each unit once every hour. Particle counts are measured in counts per 100mL, in the 6-9µm size range. The membrane is a physical barrier; subsequently low particle counts in the permeate are expected. An alarm is raised for any particle counts above 15 counts/mL (6-9µm), and sustained spikes in particle counts > 15 counts/mL (6-9µm) initiate a water displacement integrity test (refer notes below).

To assess the integrity of a membrane unit the log removal of particles through the unit is determined by measuring the volume of water displaced under positive pressure, which is done through a Water Displacement Integrity Test. The air that passes across the membrane displaces an equivalent volume of water on the opposite side of the membrane. The volume of displaced water is metered over a known period of time and converted to the equivalent volume of air to determine the air flow. If there are no breaches in the system and the integrity is maintained, there will typically be a small flow of displaced water resulting from the displacement of air with a fast recovery to the design LRV of 5. A large volume (or flow) of displaced water and a recovery to LRV levels below 5 indicate an integrity breach to the membranes. The test can detect integrity breaches in the order of a single broken fibre.

An integrity test is performed automatically on each unit once per week. Additional integrity tests are initiated if high particle counts are recorded, or other plant performance problems create the need. The LRV is monitored on-line continuously. If after an integrity test, at any point during filter operation, the LRV for a unit is below one of the set-points defined in CITECT, there will either be an additional integrity test performed, or the unit will be taken off-line for further investigation and / or repair (eg: pinning). If there are no breaches of integrity indicated by the LRV, the unit will automatically be returned to normal operation.

2.8 Irrigation Water Management

As previously mentioned, the permeate from the UF system is pumped to a reclaimed water storage tank, with sodium hypochlorite addition as it enters the tank. The chlorine dose target is based on achieving a 0.8 log deficit for disinfection.

The outcome of this is the need for a CT_{10} of 129 mg.min/L at 20 deg.C. The actual chlorine dose rate applied into the reclaimed water storage tank is dependent on both the flow rate and the temperature of the water at the time of dosing. A dosing strategy has recently been approved with DHS regarding a flexible dosing methodology, and a move from a permanent chlorine dose target of 5 mg/L. The dosing methodology will now involve a daily review of the flow rate and temperature and the use of a lookup table prior to setting the chlorine dose each morning. This will reduce the total volume of chlorine used, whilst ensuring a CT_{10} value of 129 mg.min/L is maintained.

The reclaimed water storage tank holds 4ML of Class A water. Class A water is used for backwashing as well as for supply to our customers. If the level of water in the tank falls below 50%, we stop pumping to irrigation while the plant keeps running to prevent an insufficient volume of water being available for backwashing. The plant is also ramped down when the tank water level reaches 90%, to avoid overflowing the tank.

The Class A irrigation network is owned and operated by Topaq, and consists of approximately 60km of irrigation pipework supplying over 60 customers in and around the Cranbourne area. The size of the supply pipework ranges between 750mm diameter pipe leaving the ITP, down to 80mm supply mains at the extremities of the system.

The water is supplied with a series of pumps, three high pressure pumps (2 duty, 1 standby) for greater demand periods (up to 400 L/s), and two smaller pumps fur use during low demand (down to 30 L/s). The demand from customers, the level of water in the reclaimed water storage tank, and the pressure achieved at the highest point in the irrigation system determine which pump combination is used to supply the irrigation water. Pressure is monitored at 4 points within the irrigation system, and alarms are triggered if the pressure falls below the level required to maintain supply to all customers.

All customer properties are metered to record the volumes being received at each site. The locations of customer properties and meters have all been entered into a GIS to facilitate finding and maintaining the various components of the system. Additionally, restrictors are used downstream of the meters to ensure that no individual customer accidentally drains the supply main or is able to receive flows greater than their allowance. Each customer has their own site specific storage facility, and an annual Contracted volume of water to be supplied. Earth Tech is responsible for reading the meters and charging the customers for the volumes of Class A water delivered.

3.0 CONCLUSIONS

There has been considerable positive feedback from customers since the project began. More schemes like the EIS should be implemented to obtain all the benefits available to both the environment and the community.

4.0 ACKNOWLEDGEMENTS

To the staff of Melbourne Water in their Head Office and at the Eastern Treatment Plant, in the Operations and the Engineering Groups.