OPERATING EXPERIENCES AT HAMILTON'S UF WATER RECLAMATION PLANT

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"…water should be judged by its quality and not its history."
Prime Minister John Howard, *CEDA* Luncheon Address, Sydney, 17th July 2006

1.0 INTRODUCTION

A Mineral Separation Plant (MSP), constructed for *Iluka Resources* at Hamilton, Victoria, is nearing completion. Key to the project's implementation was obtaining a secure supply of process water of adequate quality. The water demand by the MSP is forecast to be 250 ML/y and if connected to Hamilton's potable water supply, would account for more than 20% of existing demand. After examining a number of options, Glenelg Water (now part of Wannon Water) concluded that the supply of renovated secondary wastewater from the Hamilton Wastewater Treatment Plant (WWTP) would:

- provide a secure water supply for the MSP
- meet *Iluka Resources* process water quality requirements
- assist with disposal of treated wastewater, and importantly
- help conserve valuable potable water supplies in the district for future use

This paper briefly reviews the design and operation of an ultrafiltration membrane-based Water Reclamation Plant (WRP) constructed at the Authority's Monivae Storage Dam, which receives secondary effluent, and is located adjacent to the MSP.

The WRP was originally designed to produce reclaimed water meeting Victorian DHS/EPA Class A quality requirements. However, during the implementation phase, there were significant changes made to the validation requirements of Class A WRP's by DHS. In response to these changes and accepting that *Iluka Resources* did not require a validated Class A plant, it was decided not to proceed with formal Class A validation. However, as indicated later, reclaimed water from the WRP did comply with the former Class A quality criteria.

Glenelg Water's Monivae Storage Dam is located approximately 5 km from Hamilton and receives 1,100 ML/annum of treated secondary wastewater, which has first had extensive "polishing" through a series of maturation lagoons situated at the Hamilton WWTP. The Monivae Storage Dam serves as a winter storage, with effluent from the Dam used to irrigate pastures and tree lots when weather conditions permit.

2.0 *Capacity and Water Quality Requirements*

The proposed WRP was designed with a capacity of 0.82 ML/d net output, treating secondary effluent feedwater with quality characteristics given in Table 1. This represents about 27% of the total wastewater produced by the Hamilton WWTP. Required reclaimed water quality targets from the UF WRP are also shown in Table 1.

A limited number of virus assays for Adenovirus, Rotavirus, Enterovirus and Reovirus were also completed on feedwater samples taken from the dam. These analyses returned "None Detected" or "< 1/litre".

3.0 *Treatability Investigations and Benchmark Design*

Laboratory jar-testing work and a detailed review of likely candidate processes resulted in the development of a benchmark WRP design which featured coagulant addition with in-filter/dissolved air flotation and chlorine dioxide for disinfection. Tenders were invited which allowed alternative processes to be offered, and following a detailed tender assessment process, an offer for an ultrafiltration-based WRP was accepted.

Table 1: ***Mean feedwater and reclaimed water quality characteristics***

Parameter[1]	Mean Feedwater Quality	Mean Reclaimed Water Target Quality
BOD_5 (TOTAL)	21	10
Suspended Solids	5	5
Turbidity, NTU	7.4	2
pH, Units	8.1	6-9
Coliforms, MPN/100mL[2]	1310	N/A[4]
E. coli, MPN/100mL[2]	67	10
fRNA coliphage, PFU/100mL	12	N/A[4]
Helminth, No./L	N/D[3]	1
Protozoa, No./50L	N/D[3]	1
Total Viruses, No./50L	N/D[3]	1
Residual chlorine (or equivalent disinfectant)	N/D[3]	1.0

1. ALL ANALYSES mg/L, UNLESS OTHERWISE NOTED.
2. COLIFORMS & *E. coli* DETERMINED USING COLILERT METHOD
3. N/D: NOT DETERMINED
4. N/A: NOT APPLICABLE

4.0 *Ultrafiltration WRP Description*

An ultrafiltration (UF) plant based on *Norit* hollow-fibre membrane technology was subsequently designed and constructed by *Wakool Water* on a turnkey basis, in association with *Ionics* (now part of *GE Water*).

The *Norit* UF process operates in dead-end mode. This means there is no recirculation of feedwater across the membrane surface. Consequently, the membranes must be periodically backwashed using reclaimed water (permeate) to remove accumulated solids and restore flux or throughput. Backwashing of the membranes is an automatic process which occurs every 20 to 120 minutes. The *Norit* hollow-fibre UF membrane operates from inside-out, with feedwater introduced to the inside of the fibre and permeate collected on the outside.

Ferric chloride coagulant is dosed to feedwater at the inlet of the WRP to assist with the removal of suspended and colloidal matter by the UF membrane and to increase the operating period between backwashes. However, over time membrane flux is not completely restored after a backwash and a so-called Chemically Enhanced Backwash (CEBW) is then carried out to more thoroughly clean the membranes. Hydrochloric acid or caustic soda/sodium hypochlorite is dosed into the backwash water and the membranes are then allowed to soak prior to flushing and return to service. The washwater that is produced from CEBW's is pre-treated prior to sewer discharge.

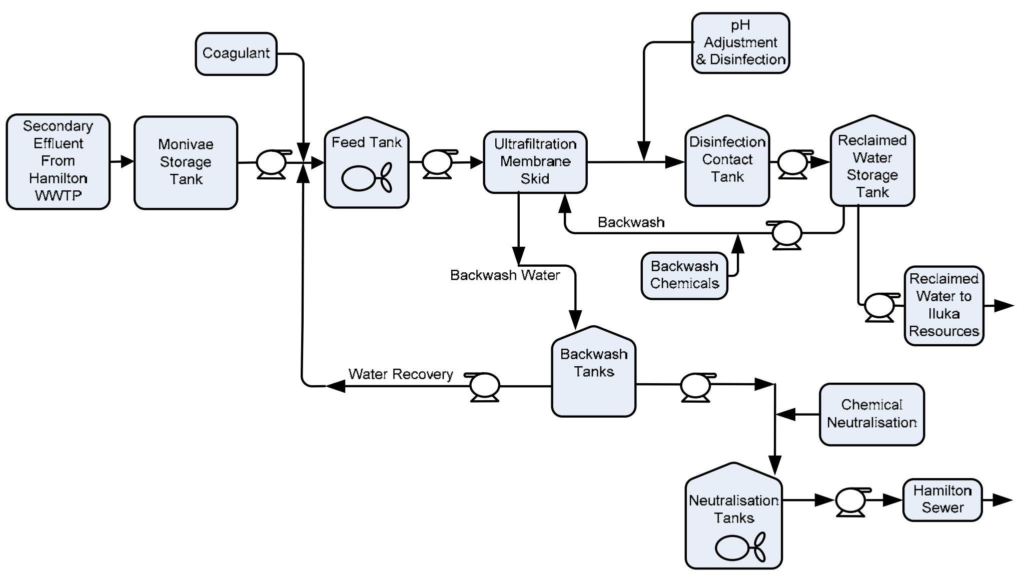
The plant was designed for an overall recovery in excess of 90%.

Treated wastewater from Hamilton is pumped from the Monivae Storage Dam and following dosing with ferric chloride coagulant (26 % w/w) is directed to a retention tank provided with a submersible mixer. This encourages the formation of micro-flocs, which are subsequently removed in the UF process. From here, the chemically dosed feedwater is then pumped through a bank of self-cleaning disc filters and then enters the *Norit* UF skid. The hollow-fibre membranes employed are 1.1 mm outside diameter with an internal diameter of 0.8 mm and have a 0.03 micron pore size. They are thus capable of retaining particles down to a very small size, including colloidal matter and most microscopic animals and pathogens. Typically 4- to 6-log removal of bacteria, viruses and parasites, including *Cryptosporidium* and *Giardia* can be achieved by the UF process.

Feedwater permeates through the UF membranes under pressure and is then dosed with hypochlorite for final disinfection. Alkali can also be added to make sure that the reclaimed water is not corrosive. The reclaimed water is stored prior to transfer and storage at the Iluka Resources MSP site.

Most of the backwash water is recovered and returned to the inlet of the WRP at the Feed Tank, with the remainder and other residuals produced by the WRP pH-adjusted and dechlorinated in a Neutralisation Tank prior to discharge to the Hamilton sewerage system.

A process flow schematic of the WRP is shown as Figure 1, whilst Table 2 gives details of the UF process proper.



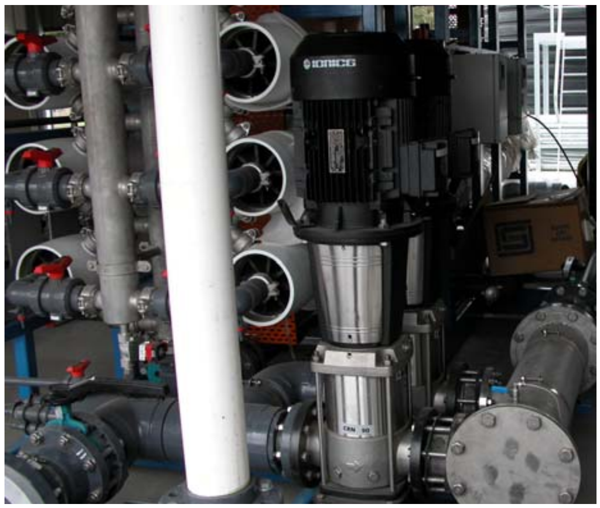
<u>Figure 1:</u> ***WRP Process Schematic***

The $2M contract included the provision of all local infrastructure as well as a reclaimed water delivery pump station, storage tank and pipeline to the *Iluka Resources* MSP site, and a sludge disposal pipeline to take residuals from the WRP back to the Hamilton WWTP via a nearby sewer connection.

Figure 2 is a view of the WRP UF skid, which shows the six *Norit* UF membrane modules.

5.0 *Commissioning and Start-up Experiences*

Commissioning of the UF WRP proceeded smoothly apart from the expected "glitches" with programming of the process control and automation system. For this project *Wakool Water* offered an alternative to the normal PLC-based SCADA system. The *Direct Digital Control* system provided used 24 separate proprietary control devices supplied by *Distech/Lon Works*. This system has proved to have severe limitations compared to the more usual PLC/PC-based operator interface available from *Allen Bradley*/*CI Technologies* (*Citect*), amongst others. The system has proven to be slow in responding to process control commands and occasionally needs to be re-booted after the interface screen "freezes". These "crashes" and the need to re-boot the control system have obviously placed additional demands on WRP Operators.



<u>Figure 2:</u> ***UF skid, with membrane modules shown***

<u>Table 2:</u> ***UF process details***

Parameter	Value or Description
UF Membrane	*Norit Xiga X-Flow S-225 UFC*
Number of Membrane Modules[1]	6
Total Number of Membrane Tubes X Length	18 (3 per module) X 1.5 m
Total Membrane Area	630 m^2 (35 m^2 per tube)
Design Reclaimed Water Flux	59 $L/m^2.h$
Maximum Design Transmembrane Pressure Drop	0.56 bar

1. UF SKID CAN ACCOMMODATE 2 No. ADDITIONAL MODULES TO GIVE TOTAL MEMBRANE AREA OF 838 m^2

Initially aluminium chlorohydrate (ACH) was proposed as the coagulant. However, due to the high pH of the feedwater (see Table 1), effective floc formation was not possible. Ferric chloride was subsequently trialled with success and has now been adopted in the plant.

Float level switches installed to the Reclaimed Water Storage Tank, which start and stop the WRP, required adjustment to ensure sufficiently long run times were possible. There were also problems with the feedwater flowmeter which required rectification.

6.0 *Performance Testing*

An important part of completing contractual obligations was to satisfy the requirements of Performance Testing (PT). This comprised operating the WRP at its design capacity and monitoring performance over five continuous days for at least fifteen hours per day.

Apart from confirming guaranteed reclaimed water production and quality requirements, the WRP had to meet specific criteria in regard to chemical and power utilisation, and sludge production over this period. To pass PT, actual chemical and power consumption had to be within 10% of the guaranteed values.

The results of analyses from samples of reclaimed water taken during the PT showed that the turbidity was routinely less than 0.1 NTU. No *E. coli* were detected in samples of reclaimed water, with Helminths (parasites) reported to be less than 1 per L and protozoa and viruses both less 1 per 50 L of reclaimed water, i.e. none were detected in each case. The output of the WRP was typically 0.86 ML over 22 h with a recovery of 92%, both parameters exceeding the guaranteed requirements. Both chemical and power consumption as measured during the PT period were also less than guaranteed.

A critical aspect of any membrane process is ensuring that the membranes are intact and continue to provide a barrier between the feedwater and the product water. Broken fibres can lead to the passage of particulates, including viruses and parasites into the product water, so it is important to identify, isolate and repair these fibres on site as quickly as possible.

A membrane integrity test (MIT) is therefore periodically carried out to confirm the UF membranes are undamaged. For the *Norit* UF hollow-fibre membranes, a so-called diffusive air-flow test method is used. The MIT procedure involves pressurising the membrane module with air to approximately 100 kPa from the feed side. The volume of any water displaced from air leaking from compromised membrane fibres is then monitored. From these results, the number of broken fibres and the possible reduction in removal of viruses or parasites can then be determined using a proprietary software program supplied by *Norit/Ionics.*

If a broken fibre is found, the fibre can be permanently sealed and isolated from the rest of the system by placing a pin inside each end. The location of broken fibres can also be confirmed by ultrasonic inspection. MIT was routinely carried out during PT and no membrane fibre breakages were observed.

The full regime of tests conducted under the initial PT will again be preformed twice more during the Defects Liability Period of the Contract.

7.0 *Validity Testing*

Because the WRP was originally designed to produce Class A reclaimed water, endorsement from the Victorian Department of Human Services would have been required. As part of that procedure, a continuous Validity Testing Period of typically four to eight weeks is required to demonstrate consistent performance, especially with regard to virus and parasite removal.

Although formal validation of the WRP as a Class A plant by DHS was not sought, a shortened testing regimen was retained in the Contract to confirm long-term performance and subsequently a further testing period of four weeks duration was carried out.
This testing regime further demonstrated the robustness of the UF process and of the WRP overall. The plant successfully passed all guaranteed water quality performance

parameters.

8.0 *Other Operational Issues*

There have been problems with several ultrasonic level transmitters installed to storage tanks. False readings caused by condensation or other build-up on the face of the sensor have lead to some control problems. These have been overcome by periodically washing down the sensor, or just simply just hitting the lid of the offending tank: Gently of course!

The chemical dosing pumps provided have also proved to be a source of nuisance: wrong pumps in the wrong application or not correctly installed. The lack of calibration cylinders to many of the pumps has also been an issue, in spite of the pumps being provided with an on-board means of checking and setting flow. These matters are slowly being sorted out and several pumps have since been interchanged. The use and storage of hydrochloric acid (HCl) on site, which is required for one of the CEBW's, has also caused inconvenience and created occupational health and safety concerns. Although not evident from Figure 2, inadequate ventilation of the storage tank has caused corrosive fumes to enter the storage area. This in turn has lead to localised corrosion of metal components, including galvanised steel pipework and machinery support brackets, as well as the *Colourbond* cladding of the off-loading bay. Again, these issues are also being attended to. Unfortunately there is no alternative to the use of HCl in one of the CEBW's.

Figure 2: ***WRP Chemical Storage Area***

9.0 *Conclusions*

The Hamilton UF Water Reclamation Plant has been a successful project, achieving the principal objective of producing water for reuse that is of exceptional quality.

As with any new and innovative process, it has come with some "hiccups" which will be gradually rectified as operating experience with the plant develops. These are challenges that most Operators thrive on - satisfaction comes from knowing that the plant can be made to work and the process functions correctly, one way or another! This project is also an excellent example of where water quality and not history was the main guiding criteria in the planning of a water reuse scheme.

10.0 *Acknowledgements*

The authors acknowledge the dedication and hard-work of the Wannon Water Ops Staff involved with this project, especially Ray Ryland & Rob Grimmer. To all, many thanks!