"GREENING BENDIGO" – CLASS A^{+} WATER PRODUCTION FROM BENDIGO'S RECYCLED WATER FACTORY

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ABSTRACT

As part of their 2050 Water Plan, central Victorian water authority Coliban Water during the autumn of 2006, embarked on an ambitious $55 Ml capital project to further treat class B wastewater from its Bendigo Water Reclamation Plant. Regional stage 4 potable water restrictions combined with falling bulk water storage reserves, combined as the drivers to bring forward this ambitious and timely capital project.

The production of class A$^+$ recycled wastewater from the "Recycled Water Factory"(RWF) has been designed to effectively substitute up to 5000 ML initially and ultimately up to 10,000 ML annually of potable and rural water demands from irrigation, restricted domestic and industrial uses across the immediate Bendigo region.

KEY WORDS
Recycled Water Factory (RWF), Class A$^+$ recycled wastewater, ultra-filtration (UF), reverse osmosis (RO), electrodialysis reversal (EDR), critical control point (CCP)

1.0 BACKGROUND

The Bendigo "Water Factory" has been in operation for over 12 months, producing extremely high grade recycled wastewater, meeting stringent DHS and EPA requirements. Combining chlorination, de-chlorination and UV disinfection, class A+ water is now delivered through the urban areas of central Bendigo.

To meet the class A+ status, reduce salinity and further enhance the irrigation needs of Bendigo's parks, gardens and rural irrigators, a 3ML/day membrane plant has also been constructed as part of the "water factory", utilizing ultra filtration (UF), reverse osmosis (RO) and electrodialysis reversal (EDR).

Class A$^+$ water is delivered through Bendigo via a 14km recycled water pipeline supplying urban customers. Surplus water is then stored in a local 3500 ML capacity reservoir at Spring Gully, to be used by irrigators through the urban and rural channel systems.

The initial nine months of operation included flows from the Bendigo Mine Limited (BML) shaft dewatering program, whereby approximately 3 ML/day of reverse osmosis treated shaft water was piped to the RWF for delivery into Bendigo via the newly constructed pipeline. Treated flows from the mine ceased in May 2008.

1.1 HACCP approach to risk and Critical Control Points (CCP's)

As part of the Bendigo Recycled Water Factory project the Critical Control Points (CCP) and Critical Limits (CL) for the Bendigo Water Reclamation Plant (BWRP) and the RWF were established based on the results of an initial extensive monitoring programme and a Hazard Analysis Critical Control Point (HACCP) process. As a result of this process twenty-four specific CCP's were identified with approximately sixty CL's for both the

class A and UF/RO treatment streams.
This process formed the framework for initial approval, quality benchmarking and operability for the treatment of this type of water and its use between Coliban Water, EPA and DHS. This was the first stage of the process which allowed construction to begin.

2.0 DISCUSSION

2.1 Construction and Commissioning

Construction of the RWF was carried out in two stages, milestone 1 and milestone 2. Milestone 1 was the completion of the class A train which consisted of a gravity fed wet well system, low lift pump station (LLPS), chlorine contact tank (CCT), UV disinfection, final water tank (FWT) (mixing tank with BML water), high lift pump station (HLPS) and 14 km of distribution pipeline. This stage was completed within 8 months on the 8th of October 2007.

Milestone 2 consisted of the construction of a 3 ML/day UF/RO plant, 170 ML brine lagoon, drying beds, temporary brine storage (for commissioning), and a 1.7 km brine pipeline. The UF/RO plant was completed and commissioned on the 4th July 2008 and took 8 months to complete. There is still a 4 week proving run to be completed during August 2008. Earlier proving of the facility was held up due to inclement weather preventing timely completion of the brine lagoons.

2.2 Bendigo Mining Limited (BML) water source

The initial stages of milestone 1 incorporated BML RO treated groundwater into the RWF. This enabled the provision of high quality water to the distribution pipeline whilst the construction of the class A plant was being completed. After construction of the class A plant this low salinity water source was to be used to shandy the class A stream and to provide continual water production until milestone 2 had been completed. Pumping of the BML water commenced in April 2007 after the completion of the urban distribution pipeline in milestone 1. This was done using a temporarily installed pumping station during the interim period until the HLPS was complete and commissioned, as part of the class A plant.

2.3 Plant Process and Overview

The Class A and UF/RO process trains run in parallel from the LLPS and then re-combine for mixing in the FWT prior to being pumped to Spring Gully reservoir and various end users that are directly fed from the pipeline (Figure 1.)

2.4 Class A Process Train

The class A process consists of sodium hypochlorite dosing into the LLPS header pipe prior to the chlorine contact tank. Contact time for the chlorine is 80 mins at 100 L/s. Chlorine dosing is controlled using a trim control on the inlet free residual chlorine value. Outlet chlorine is monitored and then the chlorinated water is passed into the UV disinfection channel.

The Wedeco UV disinfection unit consists of 3 banks of 48 lamps and has been initially validated to treat up to 9.936 ML/day of flow. After the UV channel sodium

metabisulphite is dosed to remove the chlorine before entering the FWT and the HLPS for discharge to the recycled water distribution system.

2.5 Ultra-filtration (UF)

The ultra-filtration unit consists of two skids containing 8 pressure vessels with 4 semi-permeable membranes in each. The two skids combined can treat up to 3.74 ML/day at greater then 90% recovery after backwash (3.37 to 3.45 ML/day filtrate produced). As the membranes are semi-permeable the system is pressure driven to achieve the particle removal. Cleaning of the membrane consists of a sodium hypochlorite assisted backwash on an hourly basis which mechanically lifts the particles from the membranes using high reverse flows and three different types of chemically enhanced backwash processes to remove different types of fouling from the hollow fibres within the membranes.

The membranes achieve log 4 removal by separating macro-molecular to molecular sized particles from the water. The UF membranes will block particle larger then approximately 0.01 to 0.1 micron in size. In order to ensure log removal is maintained alarms are initiated on trans membrane pressure and the number of backwashes (both normal and chemically enhanced) and the entire system does an automatic pressure integrity test of the membranes every 24 hours to ensure no membrane breakthroughs have occurred and the hollow fibres in the membranes are intact. The filtrate from the UF process is then passed to the RO process.

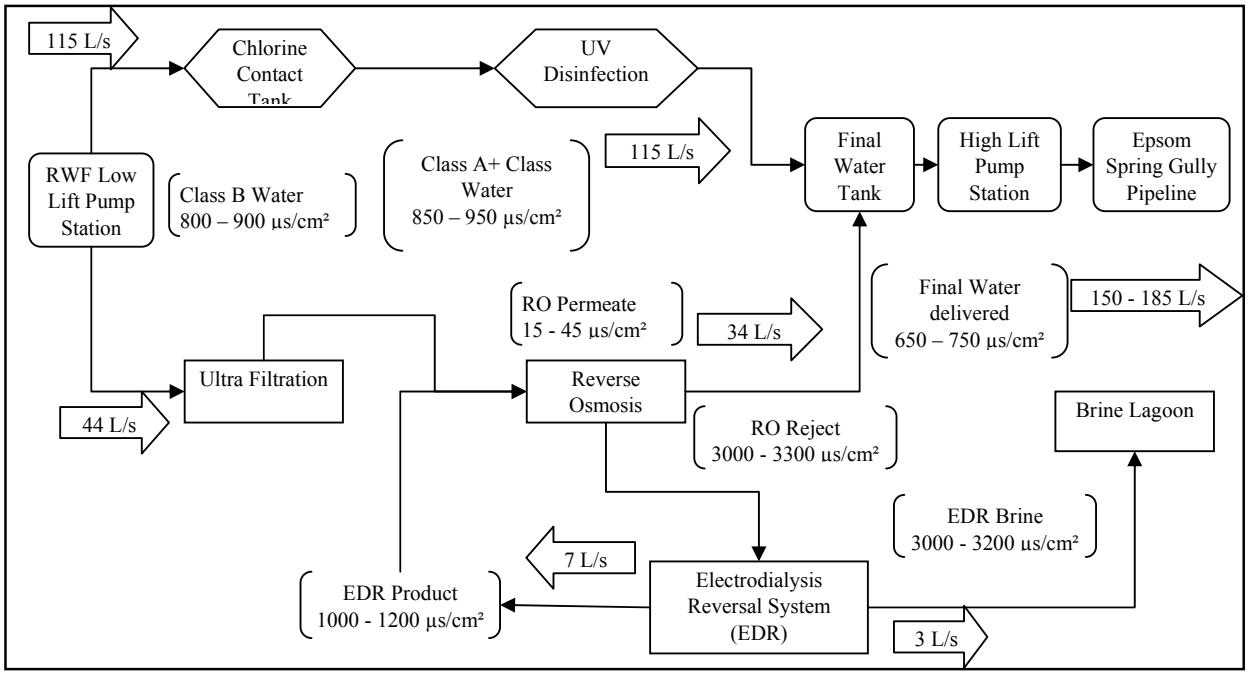

Figure 1: ***Process overview displaying salinity passage and flow balance for the RWF***

2.6 Reverse Osmosis (RO)

Reverse osmosis is the use of reverse osmotic pressure across a membrane to primarily remove ions (salt) from the water source. The RO membranes will block particles larger than approximately 0.001 micron. The RO system has two skids and each skid contains a two stage RO process with the first stage consisting of 10 pressure vessels in parallel and a second stage with 5 pressure vessels. Each pressure vessel houses 6 membranes. Permeate from the first stage flows to the final water tank and the reject from the first stage is then treated by the second stage in each RO skid. This procedure allows

recoveries across the RO system of up to 80% at treated flows of approximately 3.74 ML/day (total permeate flow between 2.8 and 3.1 ML/day).

2.7 Electrodialysis Reversal System (EDR)

The Electrodialysis Reversal System (EDR) uses electrodeionization (EDI) to remove ions from the water. The basic theory behind its operation is the use of electrolysis principles and ion exchange (cation and anion) membranes to remove ionic (salt) particles from the water. The EDR treats the total RO reject flow from the second stages of both RO skids. EDR flows are approximately 0.77 ML/day feed flow with 0.19 ML/day brine flows and 0.58 ML/day product. The EDR product is then fed back through the RO system. This brings the recovery of the system from 80% to approximately 95% of water recovered. The brine from the EDR is removed to the brine lagoon and then to crystallizing drying beds.

2.8 Water production and quality from the RWF

The plant has produced an average flow of 6.46 ML/day and all water quality compliance parameters for the plant have been met. CCP compliance, which governs the operation of the plant, has been met to date with some minor operational/commissioning issues shutting down the RWF.

Initial flows from BML were intermittent. Salinity compliance from the RWF was initially dependent on the shandying effect of the RO treated BML water. With the unreliability of the BML flows the class A plant shutdown on average, twice weekly. Frequent shutting down of the RWF reduced the production of water from the site and created the potential for shortening the operating life of the UV lamps. To rectify this problem critical limits for total dissolved solids (TDS) initially set at 500 mg/L were amended to 550 mg/L. This was done to allow for the class A water quality at TDS 510 mg/L to continue to operate irrespective of BML operations.

Total production from the plant including BML flows since April 07 until June 08 was 1300 ML.

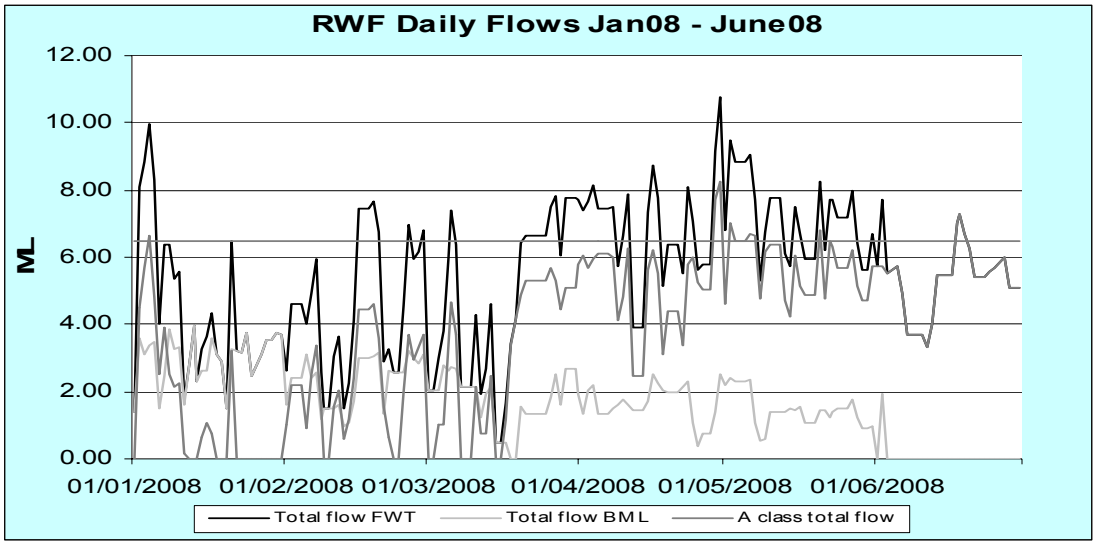

Figure 2: ***RWF Daily flow in ML from January to June 2008***

The overall log removal for the whole Bendigo Water Reclamation Plant process is highlighted in Table 1 and shows the virus log removal for each part of the plant.

Table 1: ***Virus log removal - Bendigo Water Reclamation Plant including the Class A***

Plant	Process	Log Removal
Biological Nutrient Removal	Activated sludge	1.0
Tertiary Treatment Plant	Clarifier, Lagoons and Media Filtration	1.0
Tertiary Treatment Plant	UV Treatment	1.7
Class A	UV Treatment	0.3
Class A	Chlorination	4.0
Total		**8.0**

Typical differences for water quality between the class B feed water and class A water are highlighted in Table 2. The addition of chlorine disinfection improves turbidity and the transmittance of the water with total removal of Ecoli, but the added chemical increases EC due to its salt base (sodium hypochlorite).

Table 2: ***Typical water quality differences between Class A and Class B***

Parameter	Class B	Class A
EC (µs/cm²)	787	842
Turbidity (NTU)	0.8	0.5
Total Phosphorous (mg/L)	0.5	0.4
Suspended Solids (mg/L)	3.1	3.6
Transmittance (%)	67	72
Giardia (cysts/50L)	<1	<1
Cryptosporidium (ocysts/50L)	<1	<1
E Coli (org/100ml)	1	0

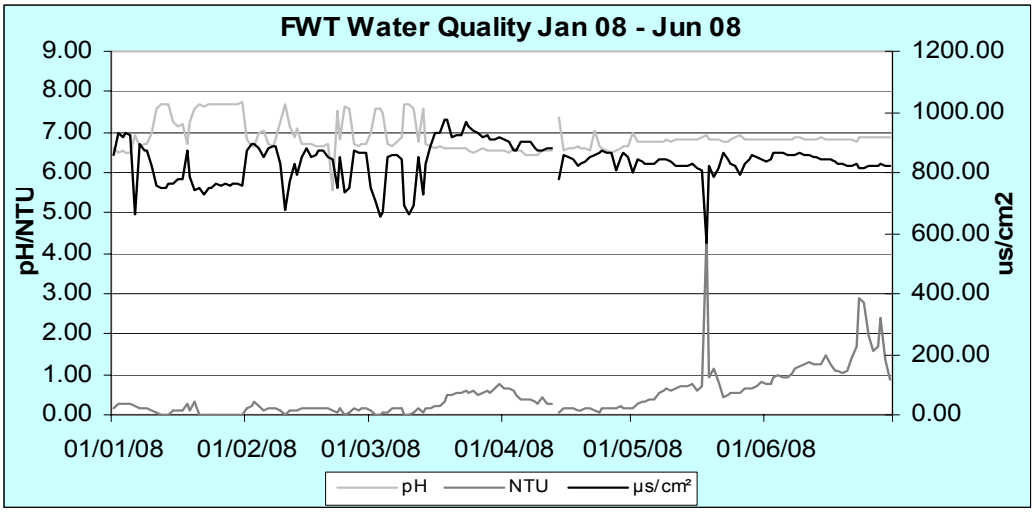

Figure 3: ***RWF product water quality from January 2008 to June 2008***

2.9 "Greening Bendigo"

Since the RWF high lift pump station was commissioned in late 2007, approximately 1300 ML of recycled water has been delivery through the Epsom / Spring Gully pipeline. Of this 1300 ML the following allocation of recycled water was achieved.

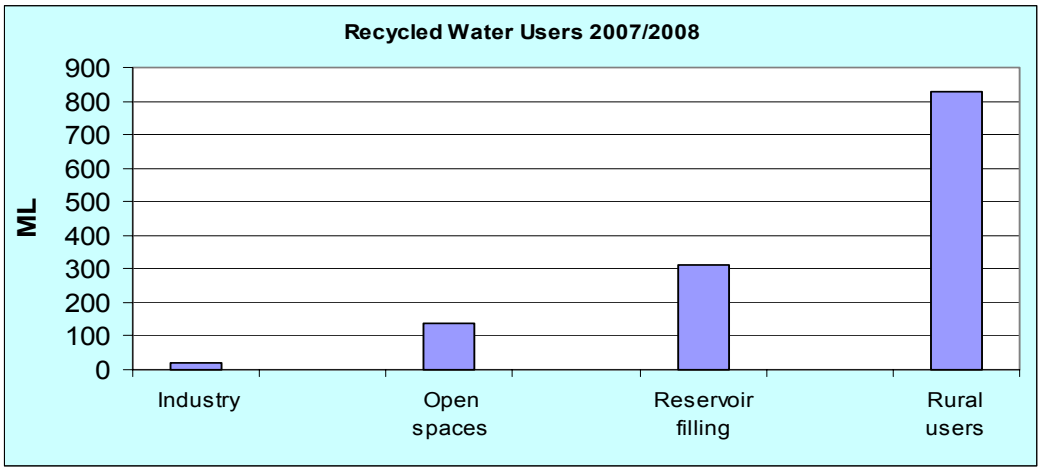

Figure 4: ***Recycled water user from the RWF***

One of the primary industrial users of the recycled water is the Loddon Laundry servicing Bendigo's regional hospitals. Since February 2008 approximately 22 ML of recycled water has been used through the laundry.

During the 2007/2008 rural irrigation season, due to reduced raw water storage levels, normal bulk water channel users were given a seasonal allocation of 30%. Recycled water channel users, of which 210 customers took up the option to use, were allocated 100% due to the availability of the recycled water supply. Further application of the recycled water in rural channels will be pursued during the 08/09 irrigation season with an additional 150 customers coming online.

The Greater City of Bendigo Council benefitted hugely through the unrestricted use of the recycle water, watering sports ovals, regional parks and general public recreational areas. Compliance of use through guideline application controls on the use of the recycled water being embraced by the local council.

3.0 CONCLUSION

Coliban Water's ambitious recycled wastewater project has to date proven extremely successful, supplying Bendigo with a first class water product with obvious benefits from potable and rural water substitution, increases in rural water supply allocations, industrial uses and the greening of parks and gardens. Other less obvious benefits are the social impacts on the residents of Bendigo through restoring Bendigo's historic parks and gardens to their former glory.

Coliban Water will further expand the use of recycled water into the rural system with the addition of another 200 customers for the 08/09 irrigation season. Future expansion of the UF/RO and EDR processes planned for 2012 will further increase the "useability" of the end product within industry and potentially opening the door for indirect potable reuse.