Environmental Health Unit
Department of Human Services
GPO Box 4057
Melbourne
VIC 3001

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Attention: Ms Suzie Sarkis

Dear Suzie

Bendigo Water Reclamation Plant - Microbiological Reductions Across the Existing Treatment Plant

1 Introduction

The Victorian Department of Human Services (DHS) and Environment Protection Authority (EPA) require a median of 6 log ***Cryptosporidium*** and ***Giardia*** and 7 log virus removal across the sum of all treatment processes to meet wastewater recycling Class A requirements. This report documents the testing of the microbiological removal of the existing Bendigo Water Reclamation Plant (WRP) for the period from July 2006 to March 2007.

The aqueous process stream of the existing treatment plant comprises the following processes in sequence:

§ Fine screening and grit removal ;
§ biological nutrient removal (Modified University of Capetown Process);
§ secondary clarification;
§ lagoon detention (approximate retention time is 11 days);
§ dual media deep bed filters; and
§ UV disinfection.

2 Sample Program

It was proposed to utilise the indigenous wastewater pathogens to determine the removal performance of the treatment plant. Use of indigenous microorganisms provides a steady input concentration to the treatment plant. This ensures that there are no significant lag and attenuation effects, which would occur with dosing microorganisms at the inlet works.

Beca Pty Ltd
Level 4, 5 Queens Road, Melbourne, VIC 3004
PO Box 7079, St Kilda Road, VIC 8004, Australia
Telephone +61-3-9272 1400
Fax +61-3-9272 1440
www.beca.com
ABN 85 004 974 341

It also avoids the need to culture large numbers of microorganisms, to dose the substantial influent flow.

The microorganism sampling program comprised sampling and analysis for:

- ***E. coli*** (1 per 100mL) as representative of bacterial removal;
- fRNA (1 pfu per 100mL) bacteriophage as representative of viral removal;
- ***Cryptosporidium*** (1 oocyst per 50L); and
- ***Giardia*** (1 cyst per 50L)**.**

Sufficient sample was taken to meet the required limits of detection (as stated above). ***Cryptosporidium*** and ***Giardia*** samples were taken over winter to spring, when the number of these microorganisms in the influent are normally elevated.

3 Sampling

Samples were collected by Campaspe Asset Management Services (CAMS), the treatment plant operator. Samples were collected between 8:00 am to 10:00 am on selected weekdays. There were two exceptions. Tertiary filter effluent was always taken at approximately 10:30 am. This time occurred at the recommencement of normal operation, following one filter's backwash. ***Cryptosporidium*** and ***Giardia*** samples were sampled when the laboratory came to transport the samples offsite, between 10:00 am and 12:00 am. The samples were transferred to Ecowise laboratory at Bendigo, with 24-hour turnaround delivery to Ecowise Melbourne laboratories, for analysis.

Sample locations were as follows:

- Influent wastewater — downstream of fine screens;
- Secondary effluent — in combined effluent channel at secondary clarifier outlet;
- Lagoon outlet — tertiary filters inlet; and
- Tertiary filter outlet — downstream of the tertiary filters , upstream of UV unit.

4 Sample Results

4.1 Microorganism Reductions

The microorganism log reductions are summarised in Appendix A. Where samples were less than the limit of detection, the limit of detection was used as the result.

Individually measured recoveries have been used for ***Cryptosporidium*** and ***Giardia*** counts. Average recoveries varied between 20% and 50%. As the recoveries significantly affect the sample counts, they were used in log removal calculation.. The following observations are evident from the data analysis:

- There was 2.9 to 3.44 median log removal of bacteria and viruses across the BNR treatment plant.
- There was 0.9 to 2.6 median log removal of bacteria and viruses across the lagoons. ***Cryptosporidium*** and ***Giardia*** removal across the lagoons was unreliable. On the basis of discussions with DHS, removals across the lagoons are not being claimed as DHS has indicated that more investigations (including enterovirus counts and tracer testing) would be required.
- 1 log median ***E. coli*** and no virus removal was observed across the tertiary filters. There was some removal of ***Cryptosporidium*** and ***Giardia*** in the tertiary filters (1.4 and 1.2 log median reduction respectively), however accurately quantifying this removal performance was limited by available concentrations and detection limits.
- The median log reduction of bacteria and viruses exceeded 5.9 across the BNR plant to the outlet of the tertiary filters. The median log reduction of ***Cryptosporidium*** and ***Giardia*** was . 3.7 and 4.6 respectively.

A more conservative measure of microorganism removal is the 5th percentile observed log reduction. The median removal value is used as the normal performance measure. The existing plant treatment process 5th or 95th percentile operational parameters form the basis of setting critical limits, and the treatment process remains "in control". In this case the total pathogen log removal requirements is one log less and the process still meets Class A limits.

The mean and 5th percentile log reductions across both the existing Bendigo WRP treatment plant (excluding log removal by the lagoons) and the proposed Class A plant, are summarised in Table 1 below. Table 1 also details the target log reductions required by EPA / DHS for Class A reclaimed water. It can be seen that the median log removal exceeds the Class A target log removal by the order of 1.4 or greater.

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[1]Beca Pty Ltd, "Technical Memorandum No. 2, Epsom Spring Gully Recycled Water Project – Bendigo WRP Performance Assessment and Class A Upgrade", 10 July 2006, p 20.

Table 1

Log Removal of Pathogens

Pathogen		Bendigo Water Reclamation Plant & Class A Plant					
	Class A Target Log Rem.[a]	Activated sludge (BNR)[d]	Dual media filtration[d]	UV disinfection (Trojan)[f]	Chlorin-ation	UV disinfection (Wedeco)	TOTALS
Enteric viruses							
Median	7	3.4	0.0	0.3	4	0.7	8.4
Critical limit	6[b]	2.2	-0.2	(0.3)	(4)	(0.7)	7.0
Cryptosporidium							
Median	6	1.7	1.4	3	0	3	9.1
Critical limit	5[b]	0.8	0.6	(3)		(3)	7.3
Giardia cysts							
Median	6	2.5	1.2	3	0	3	9.7
Critical limit	5[b]	1.8	0.7	(3)		(3)	8.5
Helminth ova							
Critical limit	See note c						
Bacteria							
Median	< 10 E.coli / 100 mL	2.9	1.0	-	-	-	<<10 / 100mL

Notes:

a. Microbial criteria for Class A recycled water as defined in Table 5.1 of the Guidelines for Environmental Management: Dual Pipe Water Recycling Schemes – health and environmental risk management (EPA Victoria Publication 1015, October 2005).

b. This value is the critical limit for log removal (i.e. the point below which recycled water produced is not considered acceptable for use as a Class A product).

c. EPA Guidelines for Environmental Management: Use of Reclaimed Water specifies treatment measures to reduce helminth numbers and further guidance is provided by the Deputy Chief Veterinary Officer (to Jeff Cummins EPA, 1 May 2007). Required performance is 4 log removal of taeneid eggs. DCVO requested 6 monthly sampling for taeneid ova in the Class A water and stated the required detection limit is 20 ova / L.

d. At worst case, indicated by 5th percentile performance.

e. The log removal values for enteric viruses are based on fRNA bacteriophages.

f. Only approved by DHS up to 14.5 ML / day.

Table 2 compares the indicative log reductions expected from different treatment processes taken from the new National Guidelines, and compares these with the observed values at the Bendigo WRP . Note that the sum of the observed 5th percentile log removal by individual unit process for each pathogen is not equal to the value across the complete treatment process as the log removal by the lagoon treatment was not taken into account.

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Table 2

Comparison of Indicative Log_{10} Removals[2]

Pathogen	Indicative Reductions[2]			Bendigo WRP Observed		
	Secondary Treatment	Lagoon Storage	Dual Media Filtration (including coagulant)	BNR Plant Median (5th percentile)	Lagoon Median (5th percentile)	Dual Media Filters Median (5th percentile)
E. coli	1.0 – 3.0	1.0 – 5.0	0 – 1.0	2.9 (1.2)	2.3 (0.8)	1.0 (-0.6)
Bacteria*	1.0 – 3.0	1.0 – 5.0	0 – 1.0			
Phage	0.5 – 2.5	1.0 – 4.0	1.0 – 4.0	3.4 (2.2)	2.6 (2.0)	0.0 (-0.2)
Viruses**	0.5 – 2.0	1.0 – 4.0	0.5 – 3.0			
Cryptosporidium	0.5 – 1.0	1.0 – 3.5	1.5 – 2.5	1.7 (0.8)	0.9 (-0.7)	1.4 (0.6)
Giardia	0.5 – 1.5	3.0 – 4.0	1.0 – 3.0	2.5 (1.7)	1.4 (-0. 2)	1.2 (0.7)
Helminths	0 – 2.0	1.5 – 3.0	2.0 – 3.0			

* including ***Campylobacter***

** including adenoviruses, rotaviruses and enteroviruses

The relatively high sludge age, large tankage and good control of aeration contribute to higher than expected log removals across the BNR plant. ***Giardia*** removals across the lagoons were low, perhaps due to the low detention time experienced for half of the trials (two lagoons out of service). Log removals of phage, ***Cryptosporidium*** and ***Giardia*** across the tertiary filters were also low due to the conservative sampling regime (samples were taken after completion of a backwash on one filter), and the very low counts (often at the limit of detection) of the autochthonous phage and protozoa following tertiary treatment.

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[2] National Resource Management Ministerial Council, et. al., "National Guidelines for Water Recycling: Managing Health and Environmental Risks", November 2006, Table 3.4, p 95.

4.3 Operational Parameters

Table 3 below summarises the operational parameters collected during the microbiological sampling period, from July 2006 to March 2007. The 5th and 95th percentiles represent the normal operational range during the monitoring period.

Table 3

Operational Parameters During Sampling Period

Site and Parameter	5th Percentile	Median	95th Percentile	Standard Deviation	Number of Test Results
Influent					
Raw sewage flow [ML/day]	12.4	13.64	16.2	1.8	168
pH [units]	7.0	7.5	8.6	0.52	163
Temperature [°C]	18	21.0	25	2.8	168
BNR Process					
SRT [days]	23	27	60	16	170
ML pH [units]	7.2	7.6	8.0	0.30	163
Temperature [°C]	17	22	26	3.6	168
Secondary Clarifier					
Sludge Blanket Levels [m]	0.08	0.98	3.98	1.23	586
pH [units]	7.1	7.5	8.1	0.35	162
Turbidity [NTU]	1.2	3.0	9.6	4.0	152
Suspended solids [mg/L]	2.0	6.0	27	12	159
DSVI [mL/L] 4x dilution	150	185	280	50	34
Scum cover [% area]	0	5	10		
Primary alum dose [L/hr]	0	0	90	34	169
Lagoon Outlet to Tertiary Filters					
Secondary alum dose [L/hr]	16.8	37.5	51	13	168
Tertiary Filter Outlet					
pH [units]	6.8	7.3	8.0	0.37	162
Temperature [°C]	13	20	26	4	167
UV transmittance [%]	55	63	68	4.4	19
Turbidity [NTU]	0.35	0.48	1.1	0.48	165
Apparent Colour [C units]	25	30	40	4.	20

Abbreviations: SRT – solids retention time
ML – mixed liquor
MLSS – mixed liquor suspended solids
DSVI – diluted sludge volume index

5 Results Discussion

5.1 Log Removals - Literature Values

The Bendigo WRP results can be compared with typical literature values. Table 4 presents summarised results extracted from the literature, and compares these against Bendigo observed values. Generally the median observed Bendigo WRP figure fell in the indicative range. The removal performance of the BNR process exceeded the indicative range. It is hypothesised that this is due to the larger tankage, MLSS and thus solids mass than conventional secondary treatment, which allows more time for grazing on microorganisms and the better controlled aeration input would cause greater excretion of exocellular polymer by the grazers, to better absorb microorganisms into the sludge floc.

The following average log reductions were observed across the secondary treatment plant at the Occoquan Water Reclamation Plant in the USA [3]:

Table 4

Comparison of Occoquan and Bendigo Secondary Treatment Removals

Microorganism		Occoquan WRP	Bendigo WRP Median (5th %ile)
Bacteria	Total coliforms	2.2	
	Faecal coliforms	2.1	2.9 (1.2) [4]
	Enterococci	2.4	
Viruses	Coliphage	2.3 to 2.6	3.4 (2.2)
	Enteroviruses	1.7	
Protozoa	***Cryptosporidium***	0.7	1.7 (0.8)
	Giardia	1.5	2.5 (1.8)

The Bendigo observed median removal data exceeds the Occoquan WRP removals.

The following data is reported for St Petersberg Water Reclamation Facility, Florida[5] and is compared with the Bendigo WRP results.

[3] Rose, J.B., et al., "Reduction of Enteric Microorganisms at the Upper Occoquan Sewage Authority Water Reclamation Plant", Wat Environ Res, 73, 6, pp. 711 – 719.

[4] Numbers for ***E. coli*** and not Faecal coliforms, however the numbers would be very much similar for these two parameters in secondary effluent

Table 5
Comparison of St Petersberg and Bendigo Treatment Removals

Microorganism		St Petersberg WRF[5]		Bendigo WRP	
		Secondary T'ment	Filtration	BNR T'ment Median, (5th %ile)	Deep Bed Filtration Median, (5th %ile)
Bacteria	Total coliforms	1.75	0.5		
	Faecal coliforms	2.1	0.05	2.9 (1.2)[6]	1.0 (-0.6)
Viruses	Coliphage	0.75	3.8	3.4 (2.2)	0.0 (-0.18)
	Enteroviruses	1.7	0.8		
Protozoa	***Cryptosporidium***	1.2	2.0	1.7 0.8)	1.4 (0.6)
	Giardia	1.1	1.7	2.5 (1.7)	1.2 (0.7)

The Bendigo WRP BNR plant median removals again exceed the St Petersberg WRF removals. However the virus and protozoa removal performance of the deep bed dual-media filters at Bendigo are inferior. This may be due to greater alum and polyelectrolyte doses at St Petersberg WRF.

5.2 Removal of Helminths

The sampling program did not assess the helminth removal capability of the existing treatment plant. Normally these organisms are removed by settlement processes or by filtration. Helminths can cause infection when effluent is used for stock watering and is regulated in the Livestock Disease Control Act 1994[7]. The regulation exempts Division 2 of Part 4 of the Act, if:

"A method of purification that results in water which -

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[5] National Research Council, "Issues in Potable Reuse", National Academy Press, 1998, p 100.
[6] Numbers for ***E. coli*** and not Feacal coliforms, however the numbers would be very much similar for these two parameters in secondary effluent.
[7] Victorian Government, "Victoria Government Gazette", No. G 47, 23 November 2000, pp. 2761 to 2762

(a) has received effective primary and microbiological or chemical treatment and which is characterised by having-

(i) a Biochemical Oxygen Demand (5 days at 20 °Celsius) not exceeding a median value of 50 milligrams per litre; and

(ii) a suspended solids content of not exceeding a median value of 50 milligrams per litre; and

(b) has undergone a retention period of 30 days, or has passed through a sand filter having a depth of sand not less than 600 mm – the sand of such filter having an effective size not greater than 0.5 mm and a uniformity co-efficient not greater than 4

- as the standard to which sewage must be purified if Division 2 of Part 4 of the Act is not to apply."

Based on plant data held by CAMS (Coliban Water's operator) the filter media in the existing deep bed dual media filters is as follows (top to bottom):

§	Filter Coal	1.4 mm ± 0.1 mm, UC 1.3	1.6 m deep
§	Filter Sand	ES 0.65-0.75mm, UC 1.4	0.4 m deep
§	Filter Sand	1.0 – 3.0 mm Nom ±8%	0.1 m deep
§	Filter Gravel	3.0 – 6.0 mm Nom ±8%	0.1 m deep
§	Filter Gravel	6.0 – 12.0 mm Nom ±8%	0.1 m deep
§	Filter Gravel	12.0 –20.0 mm Nom ±8%	0.1 m deep

It should be noted that helminths also include human pathogens, such as threadworm and hookworm.

Whilst the media is not specifically designed to meet the Agriculture Victoria requirements, there are three processes in the existing treatment plant; namely: secondary sedimentation, lagoon detention and deep bed dual media filtration, which remove helminth cysts and ova. This is demonstrated by an overall 4.6 log median removal of Giardia and 3.7 log median removal of Cryptosporidium. These log removals were limited by the limits of detection at the tertiary filter outlet and may actually have been higher. Given that three processes are acting and there is significant protozoan removal, then it can be concluded that significant helminth removal is also occurring. The dual media filters, although not specifically complying with the media requirements, have a deep bed of dual media, which would be expected to provide similar removal performance to the specified process. On these bases we believe it is reasonable to claim sufficient helminth removal through the existing treatment plant.

A review of the literature on helminth removal through different treatment processes has found as follows:

BNR/Clarifiers

The work of Rowan as reported in Feachem et al.[8] found that activated sludge treatment in Puerto Rico (including primary and secondary sedimentation) reduced the concentration of ***Ascaris*** ova by 97% to 100%, and ***Schistosoma mansoni*** ova by 99.7%. Feachem et al. noted that "Quite high removal rates have been observed, probably due to physical removal during settlement rather than any adverse effect of aeration."

The settling rate for helminths is reported as 0.61 to 0.91 m/hr in Feachem et al. With all clarifiers in service, and a peak dry weather flow (PDWF) of 24.7 ML/day, the upflow velocity in the three clarifiers is 0.21 m/hr. This should give a high removal (in excess of 2-log). At the maximum possible inflow rate of 77.8 ML/day and all clarifiers in service the upflow rate is 0.65 m/hr, suggesting that removal would start to be compromised during peak wet weather events. Because there has been no pathogen removal monitoring post-secondary during a peak inflow event, its performance during such events has not been tested. This suggests that, in the interim, limits should be placed on the inflow to the plant until testing targeting such events has proven adequate removal of the two protozoans under higher upflow rates.

Lagoons

Although there are three lagoons, from time to time one, or occasionally two, lagoons have to be taken out of service for maintenance. If we assumed that only the smallest lagoon (Lagoon 2) was in service, a predictive equation based on egg removal data from ponds in Brazil, India and Kenya[9] that relates percentage removed to detention time gives a mean removal of 1.4 log. Typically, when all the lagoons are in service, removal would be well in excess of this figure.

Dual Media Filters with Coagulation

As reported in Table 2, indicative helminth removals of 2.0 to 3.0 log can be expected. Feachem et al. reported that "sand filtration is one of the most effective means of removing helminth ova. Removal rates approaching 100% have been found for ova of ***Ascaris*** and hookworm … Schistosoma japonium … and Taenia saginata …".

Concluding Remarks

On the basis of the removals observed for ***Giardia*** and ***Cryptosporidium***, and the literature on helminth removal rates, it is reasonable to claim sufficient helminth removal through the existing treatment plant under normal operating conditions. However, consideration

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[8] Feachem R, McGarry M, and Mara D, 1978. ***Water, Wastes and Health in Hot Climates***. John Wiley & Sons.

[9] Mara D and Pearson H (1998). ***Design Manual for Waste Stabilization Ponds in Mediterranean Countries***, Lagoon Technology International, Leeds, England. p. 51

should be given to monitoring protozoan removal through the clarifiers during peak wet weather events to prove adequate removal.

Following advice from the Deputy Chief Veterinary Officer (DCVO)[10], interim approval of adequate helminth removal has been given subject to a monitoring program being carried out for six months to demonstrate no taeneid ova in the final effluent at the 20L level of detection. Provided this condition is met, the CVO will not require further monitoring of the Bendigo WRP treatment process to prove satisfactory (four log) helminth removal.

5.3 Operational Data

The operational data collected to date covers a nine-month period. As such it is difficult to cover all operational extremes. There are minor differences between the observed results from the nine months of monitoring presented in Table 3 and previous design data. The variation in primary process driver parameters on the output variables of the treatment plant are discussed below. These operational ranges form 5th percentile critical limits for operational parameters. Occasional, small excursions outside these limits will not significantly impact on log removals.

5.3.1 Influent flow

Due to drought conditions significant wet weather events were not recorded at the plant during the monitoring period. There are 3 duty pumps and 1 standby influent pump, each with a capacity of 315 L/s, meaning that up to 945 L/sec (81.6 ML/day) can be pumped into the treatment process with the 3 duty pumps operating. Wastewater flows arriving at the plant in excess of a set figure of up to 945 L/s will be automatically bypassed at the plant inlet. The set figure depends on the number of sedimentation tanks that are in service - the fewer sedimentation tanks in service means the lower the flow rate at which bypass occurs. The bypass will flow to Lagoon 4 (the storm flow bypass is currently being constructed). From Lagoon 4 it will be disposed of by evaporation and the on-site (closed loop) land irrigation system.

There were two moderate-sized wet weather flow events recorded at the plant during the monitoring period: 16/7/2006 at 35 ML/d and 6/9/2006 at 28.2 ML/d. The former occurred just before the pathogen monitoring period commenced and the only effect noticed was an increase in secondary effluent suspended solids to 77 mg/L on 18/7/2006. The first microbiological sampling occurred on 27/7/2006.

The second wet weather event caused secondary effluent SS to reach 24 mg/L. Any such effect would be absorbed by the effluent buffer lagoons (Lagoons 1 to 3). Although the microbiological sampling occurred ten days after the wet weather event, there were no

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[10] Letter from DPI (Andrew Cameron) to EPA (Jeff Cummins) dated 20 April 2007 (ref WA/04/0004)

long-lasting effects observed on the treatment plant, such as effects on microbiological removal.

5.3.2 Sludge Mean Cell Residence Time

The Mean Cell Residence Time for sludge varied from 23.0 to 59.6 days (5^{th}, 95^{th} percentile) during the monitoring period; with MLSS from 5190 to 7655 mg/L (5^{th} and 95^{th} percentile). Solids wasting is presently constrained by insufficient sludge disposal capacity, which is being rectified. It is expected that lower sludge mean cell retention times will be observed in the future, at about 25 days. Lower sludge ages would be expected to cause a higher portion of secondary suspended solids to contain microorganisms. This would result in higher microorganisms in the clarifier effluent. Thus the 23 day minimum sludge age represents a critical limit, but as this may constrain the operation of the plant too much, we propose that a value of 20 days be adopted, subject to determination of the effect of this on pathogen removal.

5.3.3 Wastewater Temperature

The wastewater temperatures (influent and BNR) varied between 17.0 and 26.0ºC (5^{th} and 95^{th} percentile). From routine temperature monitoring of the BNR, the typical winter temperature is around 15ºC, and may drop lower than this for short periods (or low readings could be the result of long sample lines or some other measurement artefacts). Low temperatures could impact on pathogen removal, and needs further monitoring to confirm the significance or otherwise of this.

5.3.4 Sludge Blanket Level

Sludge depths in the secondary clarifier (5.1 m deep at measurement point) varied between 0.1 and 4.0 m (5^{th} and 95^{th} percentile). This covers a broad range of operation.

5.3.5 Sludge Settling

The property DSVI varies inversely with sludge settleability or settling velocity. This increases solids removal with higher settling velocities. The range of DSVIs observed over the past year and the past 6 months is typical and conservative (i.e. includes a selection of high DSVI values).

5.3.6 Secondary Effluent Turbidity

Solids in the secondary effluent are expected to carry microorganisms to the lagoons. The secondary effluent turbidity varied between 1.2 and 9.6 NTU (5^{th}, 95^{th} percentile), and the suspended solids ranged between 2 and 27mg/L during the monitoring period. Before setting these as critical limits, more data is needed to establish the impact of wet weather flows on secondary effluent solids and how this in turn impacts on pathogen removal.

5.3.7 Tertiary Effluent Turbidity

The field turbidity at the UV disinfection unit (by CAMS) is similar to the range of previous 16 months of data to May 2006. Thus the observed turbidity data variation would mimic long-term variation.

5.3.8 UV Transmittance

This parameter usually does not have a seasonal variation, tending to vary more frequently. The transmittance data is similar to the range of the previous 16 months of data, to May 2006. Thus the observed UV transmittance data variation appears to be consistent with the long-term variation. The 5^{th} percentile value could form a critical limit, however the design limit of 56% was set before the sampling program was substantially completed. We believe that the ammonia problem, which occurred during the sampling period, was the cause of the low UV transmittance. This was an unusual event.

5.3.9 Primary and Secondary Alum Doses

Alum doses to the sedimentation tank outlet (primary alum dose) and tertiary filters inlet (secondary alum dose) would improve microbiological removal. For at least half the time the primary dose was zero. Thus the worst case was included in the monitoring period. Although secondary dosing is for phosphorus removal, it also results in microorganism removal. This 5^{th} to 95^{th} percentile dose was between 16.8 and 51.0 L/hr. Higher doses have been necessary. The lower setting represents a critical limit.

6 Conclusions

We consider that the monitoring that has been carried out over the period July 2006 to March 2007 fairly reflects the microbiological removal capability of the BNR plant and conservatively reflects the removal performance of the tertiary filters. The measured median removals will be used for the purposes of determining the log removals required by the remaining processes, while the 5th percentile microbiological removal values would apply to process parameters performing at their 5th/95th percentile value (critical limit).

The following minimum log removals are therefore recommended for the Class A plant and Recycled Water Factory, in accordance with Vic EPA Dual Pipe Recycling criteria [11]:

Table 6

Required Minimum Log_{10} Removals Class A and RWF

Pathogen	Target Overall Log_{10} Reduction	Existing Treatment Reductions	Required Log_{10} Reduction
Viruses	7.0	3.4	3.6
Cryptosporidium	6.0	3.1	2.9
Giardia	6.0	3.7	2.3

As the required log removals are less than those allowed for in the process design of the Epsom Spring Gully Water Recycling Project Class A train and the UF/RO facility, no difficulties are foreseen in meeting DHS/EPA requirements. While there appears to be scope to reduce or delete the proposed secondary UV capacity, we consider this should be retained to provide maximum operational flexibility if there is a need to vary critical control points (CCPs) in the future.

With respect to flows through the BNR process, the microbiological removal process will be tested in steps of a maximum of 15% above the critical limit during wet weather flows in order to progressively raise the flow critical limit to the plant's design capacity. This process has been integrated into the The primary UV disinfection unit is only validated to 14.5ML/day. It will be necessary in the long term to operate this at higher flow rates. Options include validating the points of the UV unit at higher flows, or gaining credit for virus protozoa and helminth removal by testing the removal performance of the tertiary filters with microspheres. This will be the subject of a separate submission to DHS.

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[11] Victorian EPA, "Guidelines for Environmental Management Dual Pipe Water Recycling Schemes – Health and Environmental Risk Management", Publication 1015, October 2005, p 16.

Should you require any further information, please contact me.

Yours faithfully
Beca Pty Ltd

Andrew Watson
Technical Manager, Water
Direct Dial: +61 (3) 9272 1564
Email: andrew.watson@beca.com