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2006: Phosphorus and Algae Removed from Waihi Facultative Pond Discharge. Outlet concentrations of total P < 0.1mg/1 and SS < 10mg/l achieved. This paper gives details of the plant, its operation and first year of performance

PHOSPHORUS AND ALGAE REMOVED FROM WAIHI FACULTATIVE POND DISCHARGE

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ABSTRACT
A new tertiary treatment plant commissioned in July 2005 is removing phosphorus and algae from the discharge of the facultative ponds that treat the wastewater from the town of Waihi. The phosphorus is chemically precipitated out using alum and then floated off together with algae and other suspended solids. After removal of phosphorus, algae and suspended solids, the treated water passes through an ultra-violet disinfection stage and then via a rock cascade to the Ohinemuri River. The tertiary treatment plant is capable of reducing the TP (total phosphorus) from around 3 mg/l to less than 0.1 mg/l and the suspended solids concentrations from over 150 mg/l to less than 10 mg/l. The plant operating results are significantly better than the resource consent requirements of 1.4 mg/l for TP and 35 mg/l for suspended solids. The plant operates on a timed basis with throughput set to achieve the desired water level reduction in the facultative ponds over the running period of the cycle. There has been a significant drop in the concentration of both the DRP (dissolved reactive phosphorus) and the TP in the Ohinemuri River downstream of the plant since the plant was commissioned.

KEYWORDS
Phosphorus, algae, tertiary treatment, facultative ponds

1. NEW TERTIARY TREATMENT PLANT
The new resource consent for the discharge of the Waihi Sewage Treatment Plant requires the Hauraki District Council to remove phosphorus, suspended solids and E coli (Environment Waikato, 2002) are in Table 1.

***TABLE 1**: Conditions of Resource Consent*

Parameter	Conditions	Median (g/m^3)
Total Phosphorus	1 November to 30 April & when Ohinemuri River < 10.1 cusecs	1.4
Total Phosphorus	1 May to 31 October except when Ohinemuri River < 10.1 cusecs	5.7
BOD	At all times	20
Suspended Solids	At all times	35
Ammonia Nitrogen	At all times	4.0
E coli	Ohinemuri River < 10.1 cusecs	126
E coli	Ohinemuri River > 10.1 cusecs	5000 (max)

Phosphorus removal is required because Environment Waikato had identified (Beca Steven, 1995) that the Waihi discharge contributes more than 65% of the phosphorus measured in the Ohinemuri River. This river is popular for swimming, fishing and other activities as it flows through the Karangahake Gorge. There have been algae blooms in the Ohinemuri River over summer periods, with extreme events literally turning the river shades of green and red.

A new tertiary treatment plant commissioned in July 2005 is removing phosphorus and algae together with other suspended solids from the Waihi discharge. After removal of phosphorus, algae and suspended solids, the treated water passes through an ultra-violet disinfection stage and then via a rock cascade to the Ohinemuri River. The facultative ponds still remain the main treatment engine for $CBOD_5$ (carbonaceous biochemical oxygen demand) reduction achieving an exit $CBOD_5$ of from 25 to 50 g/m^3.

2. PHOSPHORUS & ALGAE REMOVAL

In this chemical treatment process, alum is used to chemically precipitate DRP (dissolved reactive phosphorus). At the same time, the alum coagulates the precipitated phosphorus, algae and suspended solids, and with the addition of a polymer and a surfactant, flocs are established suitable for separation by flotation.

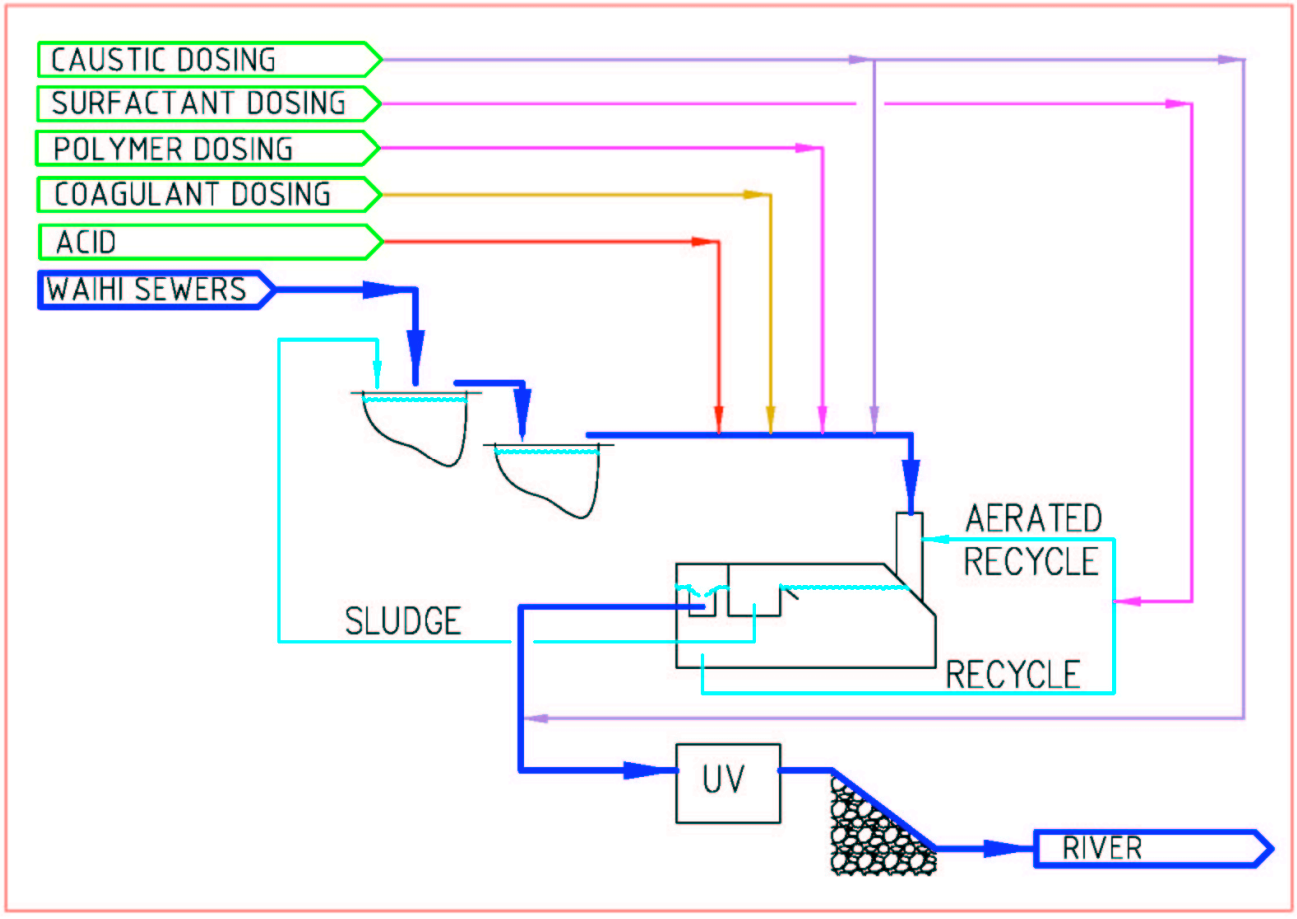
As the precipitation and coagulation are pH dependent, acid addition is used to firstly bring the wastewater to the correct pH. The quantity of acid varies throughout the year and throughout each day as a result of the constantly changing pH in the facultative ponds. A diurnal pH range of 6.5 to 9.5 has been recorded. Alkali is added last to return the pH to near neutral for discharge to the Ohinemuri River.

The flocculated solids are separated from the treated wastewater in a hybrid combination induced and dissolved air flotation tank. Finely dispersed air bubbles are brought into contact with the chemically conditioned slurry where particulate-bubble attachment occurs. The particle-laden bubbles float to the surface of the flotation tank from where they are intermittently scraped off and removed. Until a suitable disposal option is found the solids are returned to the facultative ponds.

The phosphorus and algae removal plant is designed for a typical throughput of 167 cubic metres per hour, and has a maximum throughput of about 200 cubic metres per hour.

Whilst the chemistry of phosphorous removal is well established, this tertiary treatment plant is a first of its kind in New Zealand. The small footprint and high phosphorus and suspended solids removal efficiencies were the key attributes that led to the choice of this plant.

***FIG 1**: Flowchart of plant and chemical additions*



3. PLANT TREATMENT RESULTS

Independent laboratory analyses (R.J. Hill Laboratories, 2005,06) have been used to monitor plant performance. Regular sampling for analysis by this independent laboratory began in April 2006.

***TABLE 2**: Independent Laboratory Analyses of Raw and Treated Water*

Date	TSS (g/m3)		DRP (g/m3)		Total P (g/m3)		CBOD5 (g/m3)		E-coli (/100ml)	
	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated
27-Jul-05		6		< 0.004		0.278		2		< 1
28-Jul-05		10		< 0.004		0.327		4		3
29-Jul-05				< 0.004		0.118		2		< 10
21-Sep-05	112				3.83					
12-Oct-05	126	5	1.4	< 0.004	2.75	0.074				
26-Nov-05	92	9	1.59	< 0.004	2.76	0.108	27	1		
6-Apr-06	178	5			4.24	0.094	22	< 1		< 1
19-Apr-06	251	4			5.66	0.086	33	< 1	12400	41
4-May-06	77	< 3	1.86	< 0.004	3.04	0.054			717	17
18-May-06	58	10	1.73	< 0.004	2.43	0.148	24	1		
1-Jun-06	62	8	1.9	0.005	2.83	0.155	22	1		
29-Jun-06	94	10	1.69	< 0.004	3.1	0.207	37	1		
19-Jul-06	112	< 3	2.09	0.005	3.65	0.137	53	1		

The E-coli results are from samples taken after the UV plant, but the UV plant may or may not have been operating. Results have found that the phosphorus and algae removal plant is reducing the E-coli to less than the resource consent conditions without the UV plant operating.

All the results in Table 2 for the treated wastewater are significantly better than the resource consent requirements of 1.4 mg/l for total phosphorus and 35 mg/l for suspended solids respectively.

4. PLANT OPERATION

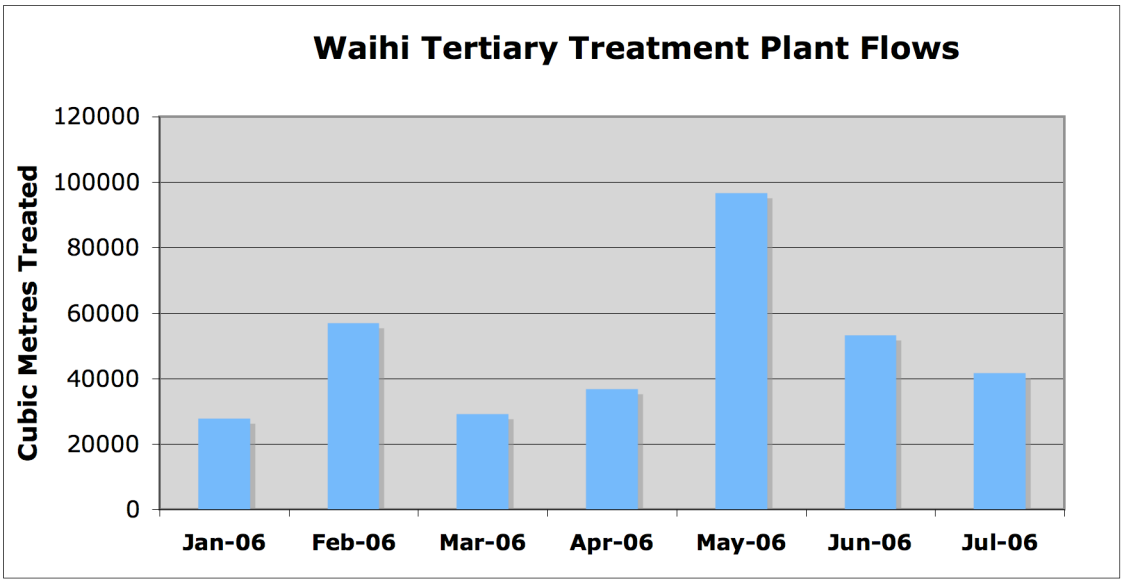
The plant operates on a timed basis usually running for 5 days per week to suit incoming flows and operator schedules. This allows the operator to have the plant off during weekends and parts of holiday periods minimising operator labour cost. The plant throughputs for the first seven months of 2006 are given in Fig 2. Frequent wet weather events during the months of April and May 2006 required the plant to be run at higher throughputs for longer periods. The average inflow to the plant is 1,000 cubic metres per day, increasing to 3,000 cubic metres per day in wet weather. A total of 342,545 cubic metres of wastewater were treated in the first seven months of 2006.

The plant is fully automated with operator supervision at start-up and shutdown. Thus the operator is able to attend to the running of other plants in the area as well. The plant operator's attendance is for between 1 and 3 hours per day, depending on the maintenance regime to be followed.

During the stand-down period of the plant's operating cycle, the water levels in the facultative ponds are allowed to rise to provide temporary storage. Plant throughput is set to achieve the desired water level reduction in the facultative ponds over the running period of the cycle. This flexible plant operation also allows for extended shutdown periods for maintenance on the plant and the facultative pond structures.

Current chemical costs in the first half of 2006 were $120 to $140 per thousand cubic metres of wastewater treated. This includes the additional acid and alkali required for pH adjustment due to the low alkalinity of the wastewater. Electrical consumption for the plant excluding the UV plant is approximately 190 kW/hrs per thousand cubic metres of wastewater treated, with the majority of this being UV plant consumption. In addition there is the 40 kW supply pump to pump the wastewater from the facultative ponds to the elevated site of the tertiary treatment plant.

FIG 2: Monthly Plant Throughputs - January to July 2006



5. PLANT RELIABILITY

Power fluctuations have caused the most disruption to the operation of the plant. The plant is located at the end of a power distribution network so is always the first to be affected by supply irregularities. A series of power cuts posed a number of challenges not long after the plant was commissioned. A number of changes had to be made to the plant defaults and logic to take account of unplanned power failure events, in order to make restarts straightforward.

In January 2006 a swan flew into the supply power line to the plant, and the resulting power surge knocked out the UPS and caused other electrical damage in the plant. This resulted in a number of plant shutdowns for no apparent reason. It was only after the instrumentation voltage levels were found to be fluctuating that progress was made in rectifying these issues.

Delays in establishing a reliable and fast remote access to the plant PLC caused difficulties and slow resolution of plant shutdowns. The planned radio link was never able to achieve the required speed and reliability. A wireless broadband internet connection was finally installed and this has greatly improved the speed of troubleshooting at the plant.

6. PHOSPHORUS CONCENTRATIONS IN OHINEMURI RIVER

There has been a significant drop in the concentration of both the DRP and the TP in the Ohinemuri River downstream of the plant since the plant was commissioned (Fig 3). The student-T analysis of these results is less than 0.1% and 0.8% respectively for the DRP and TP respectively indicating that the figures for the DRP and TP before and after the treatment plant was operational are different data sets.

There has also been a drop in the mass flow of both the DRP and the TP (Fig 4). The student-T analysis of these results is 1.6% and 32.3% respectively indicating that the DRP result is statistically significant whereas the TP is not. As more monthly results come to hand, the latter is decreasing and becoming more statistically significant.

These results are evidence that the plant is achieving the desired results of reducing the phosphorus contributed to the Ohinemuri River by the Waihi wastewater treatment plant discharge.

***FIG 3**: DRP and TP Concentrations in Ohinemuri River Before and after Treatment Plant Operational*

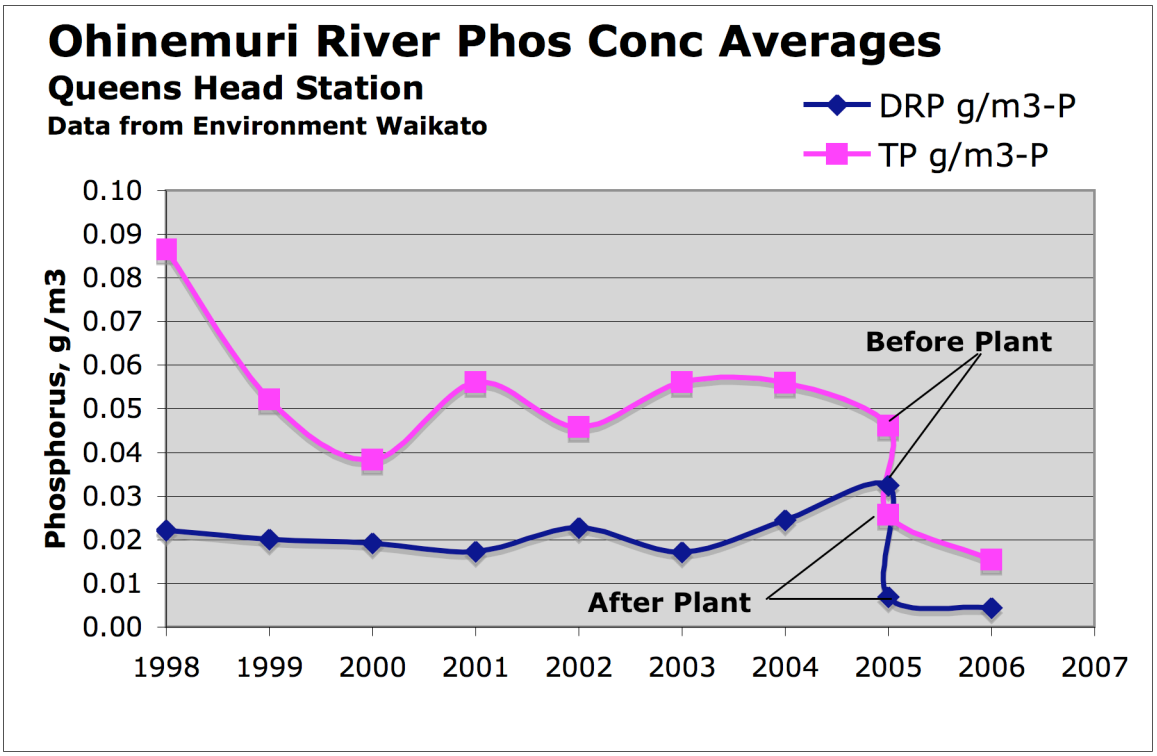
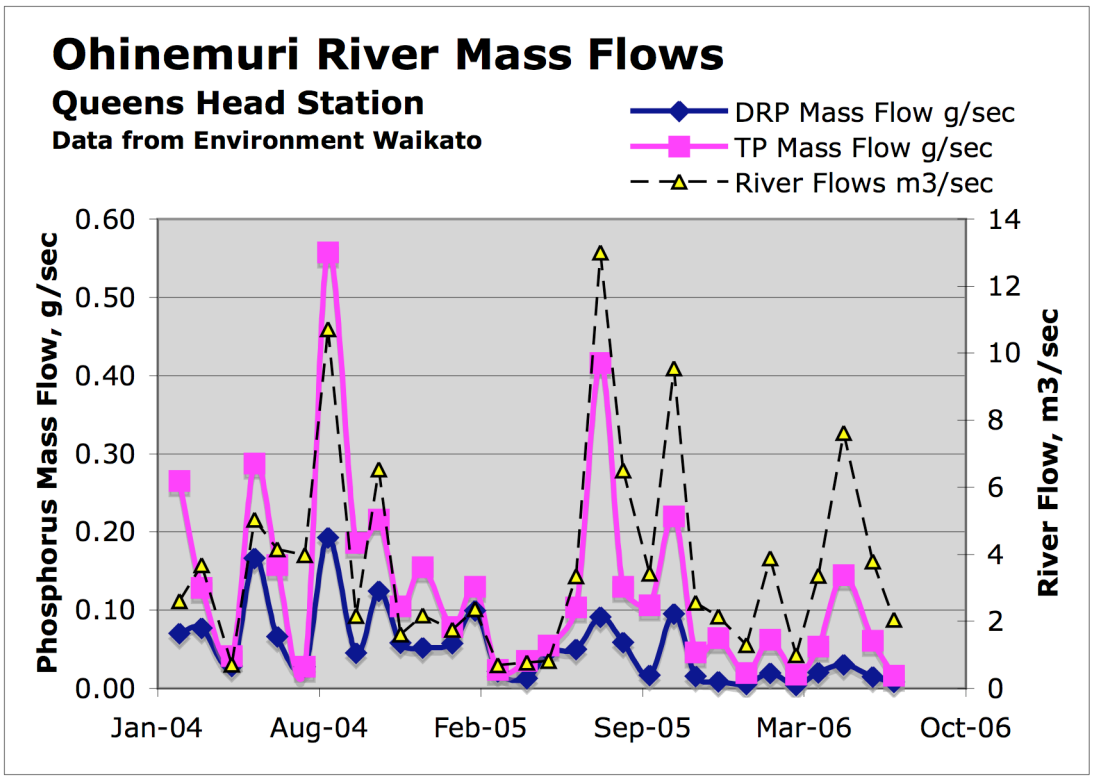


***FIG 4**: Ohinemuri River Mass Flows Before and after Treatment Plant Operational*



7. DISCUSSION

When the phosphorus and algae removal plant was originally conceived, it was anticipated that the plant would only operate from the beginning of November through to the end of April each summer. It was anticipated that the river flows would be in excess of 10.1 cubic metres per second for most of the winter months, and that the level of suspended solids in the discharge would be low enough to meet the resource consent conditions during this period. Neither of these eventuated. The Ohinemuri River flows are less than 10.1 cubic metres per second in winter months for nearly 30% of the time. The suspended solids content of the discharge from the facultative ponds is always in excess of 35 mg/l. Therefore the discharge from the facultative ponds is required to be run through the tertiary treatment plant at all times.

The plant is not able to remove suspended solids only without additions of alum, polymer and surfactant. This has meant that the plant is treating the water to a higher degree than is required by the resource consent, but on the other hand demonstrates that this level of treatment is able to be achieved with the use of this technology.

The plant is designed primarily to remove DRP and suspended solids. However, it is also removing over 90% of other forms of phosphorus, over 95% of $CBOD_5$, 60% to 90% of total nitrogen, and over 90% of the E-coli. Whilst these levels of removals are not required by the resource consent conditions, they can only be positive for the Ohinemuri River that has been described as a poor quality aquatic habitat (Beca Steven, 1995).

The phosphorus and algae removal plant has greatly reduced the load on the UV disinfection plant. E-coli measured in the inlet to the phosphorus and algae removal plant have been in the range of 500 to 3000 MPN/100ml, and in the outlet of the phosphorus and algae removal plant in the range of 7 to 20 MPN/100 ml. The treated water has a UV transmittance of 70% to 80%, and this has resulted in a substantially reduced load and power consumption in the UV disinfection plant.

8. CONCLUSION

The tertiary treatment plant is removing phosphorus and algae from the discharge of the Waihi Sewage Treatment facultative ponds. The treated discharge is meeting the conditions of the resource consent for phosphorus, suspended solids and E-coli. The contribution of phosphorus to the Ohinemuri River by the Waihi wastewater treatment plant has significantly reduced.

ACKNOWLEDGEMENTS

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