WATER ENVIRONMENT ASSOCIATION OF ONTARIO
2004 TECHNICAL SYMPOSIUM
April 19, 2004

PHOSPHOROUS REMOVAL – PUSHING THE ENVELOPE

MICHAEL GUNDRY, P.ENG.
TOTTEN SIMS HUBICKI ASSOCIATES

ABSTRACT

The Town of Deseronto Water Pollution Control Plant (WPCP) discharges treated effluent to the Bay of Quinte. In 2001, the Town commissioned a ballasted sand enhanced sedimentation process (Actiflo) to provide tertiary phosphorus removal in order to meet the objectives of the Bay of Quinte RAP. The tertiary phosphorus removal system produces effluent phosphorus concentrations of 0.07 mg/L with the plant operating at 73% of its rated capacity. The effluent phosphorus concentrations of 0.07 mg/L are less than 1/3 of the compliance limit for phosphorus of 0.30 mg/L.

The full-scale tertiary treatment system at Deseronto was designed based upon a rise rate of 55 m/hr at peak flows of 5,478 m^3/day. In the pilot plant study, various rise rates from 60 m/hr to 120 m/hr were tested, simulating full-scale plant peak flows of 12,052 m^3/day. At a rise rate of 120 m/hr, which is 220% greater than the existing Deseronto WPCP tertiary phosphorus treatment system design rise rate; effluent phosphorus concentrations from the pilot plant were in the only 0.15 mg/L. Effluent total suspended solids concentrations during the pilot test ranged from 4 to 12 mg/L

During the pilot plant test, dual point alum addition was also investigated. It was found that the optimum alum addition to the influent of the Actiflo system was 64 mg/L. During the pilot tests, polymer additions of 1.0 mg/L were used.

Key Words

Tertiary Wastewater Treatment, Phosphorus Removal, Enhanced Tertiary Sedimentation, Actiflo, Polymer

1. INTRODUCTION

Phosphorous is a nutrient and as such the Ministry of the Environment has limited phosphorous concentrations in the effluent of municipal wastewater treatment plants. The maximum allowable phosphorous discharge is dependent upon the characteristics of the receiving water body and its ability to assimilate phosphorous and prevent algae blooms and/or unwanted aquatic vegetation growth.

A Remedial Action Plan (RAP) has been prepared for the Bay Quinte. As part of the RAP, effluent phosphorous concentrations for municipal wastewater treatment plants discharging directly to the Bay have been limited to annual phosphorous loading based upon 0.3 mg/L times the rated capacity of the wastewater treatment plant at the time the RAP was adopted. Thus, in order to increase a wastewater treatment plant capacity, there must be a corresponding decrease in the effluent phosphorus concentrations.

The Deseronto Water Pollution Control Plant discharges treated effluent to the Bay of Quinte and subject to the effluent phosphorous concentrations identified in the RAP. In order to meet the objectives of the Remedial Action Plan, the Town of Deseronto upgraded its existing secondary wastewater treatment plant by the addition of enhanced tertiary sedimentation for effluent phosphorous control. The tertiary treatment system performs extremely well, providing effluent phosphorous concentrations of less a third of the effluent limit.

The neighbouring Mohawks of the Bay of Quinte Reserve wished to extend municipal wastewater servicing to unserviced areas in their territory to remediate failing private systems as well as expand a local school and add additional serviced population within the territory. In order to evaluate the capability of Deseronto Water Pollution Control Plant to accept these additional sewage flows beyond the plant rated capacity, while meeting the effluent phosphorous concentration loading limits specified by the RAP, a pilot study was undertaken to evaluate the optimized performance of the enhanced tertiary sedimentation process at the Deseronto WPCP for phosphorous removal.

This paper describes the pilot plant study that was undertaken and the results achieved.

2. DESERONTO WATER POLLUTION CONTROL PLANT

Plant Description

The Deseronto Water Pollution Control Plant consists of two package type extended aeration sewage treatment plants with an overall rated capacity of 1,539 m;/day operating in the extended aeration mode and 1,600 m;/day operating in the contact stabilization mode. The major processes at the plant include:

- inlet sewage grinding;
- two screw centrifugal type dry pit raw sewage pumps;
- two longitudinal channel type grit collectors;
- extended aeration basins with fine bubble aeration;
- two circular clarifiers;
- tertiary treatment using ballasted stand flocculation process;

- UV disinfection;
- outfall to the Bay of Quinte;
- aerobic digester;
- winter sludge storage tank.

A process schematic and a site plan for the Deseronto Water Pollution Control Plant are shown in Figures 1 and 2.

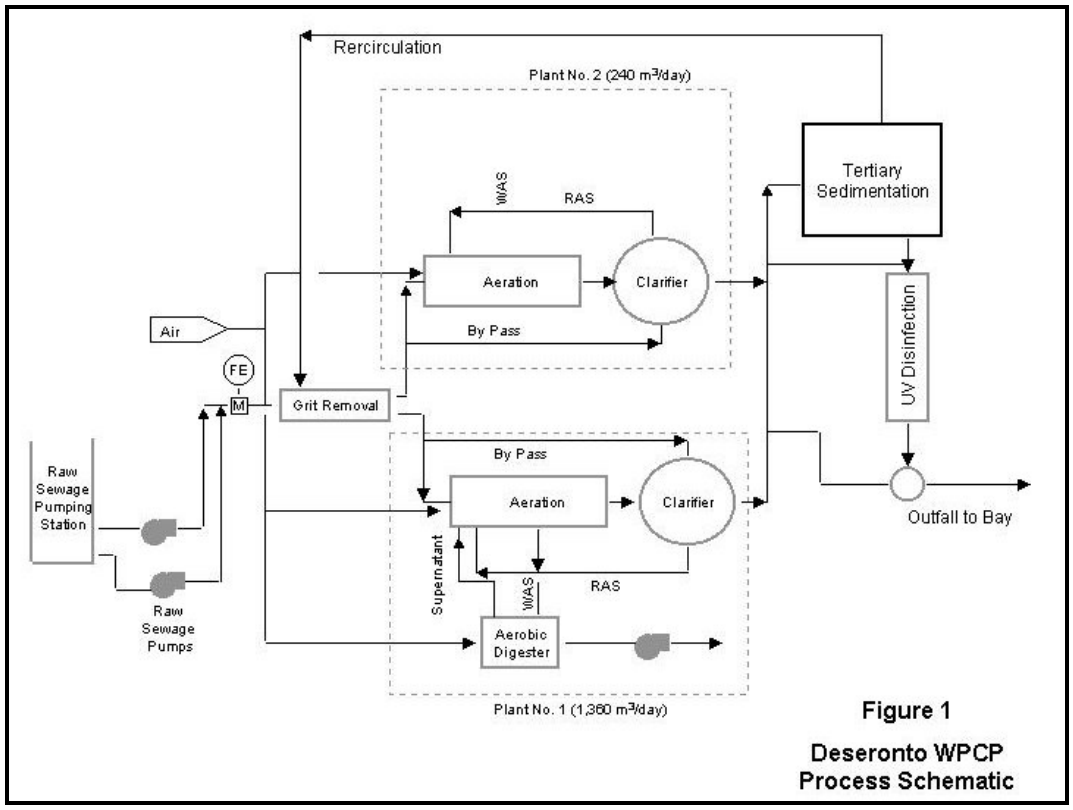


Figure 1

Deseronto WPCP Process Schematic

Wastewater Characteristics

The average wastewater characteristics for the Deseronto Water Pollution Control Plant for 2001 are summarized in the following Table 1. The effluent compliance and objective limits are summarized in the following Table 2.

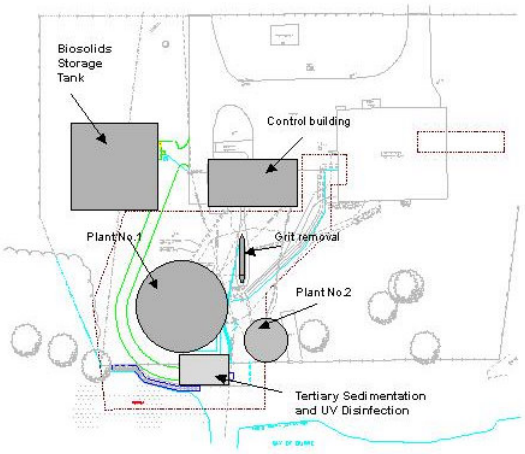


FIGURE 2
DESERONTO WPCP
SITE PLAN

TABLE 1
SUMMARY OF INFLUENT AND EFFLUENT WASTE CHARACTERISTICS (2001)[1]

Month	Average Day Flows (m;/day)	BOD (mg/L)		Suspended Solids (mg/L)		Phosphorus (mg/L)		Ammonia NH_3+NH_4 (mg/L)
		Raw	Effluent	Raw	Effluent	Raw	Effluent	Effluent
January	1,001	118.0	8.5	115.0	6.9	2.50	0.37	0.10
February	1,697	101.0	2.7	106.1	5.4	1.97	0.22	0.10
March	1,672	51.3	6.5	172.4	4.6	3.30	0.14	4.40
April	1,247	320.5	2.0	266.4	4.3	6.00	0.09	2.80
May	979	141.5	2.5	130.3	5.6	3.55	0.10	2.45
June	1,033	121.5	4.5	231.1	4.1	2.77	0.05	12.65
July	968	104.5	4.5	134.0	8.9	3.02	0.05	12.05
August	963	149.0	2.0	179.2	12.3	3.03	0.07	2.30
September	934	128.0	2.0	192.1	4.5	3.16	0.05	5.85
October	907	126.0	1.0	240.0	6.5	2.62	0.35	3.20
November	1,011	118.0	4.0	173.4	32.8	2.57	0.18	0.10
December	1,408	124.0	4.0	105.8	24.0	2.31	0.17	
Average	1,167	133.8	3.5	170.7	10.0	3.12	0.15	4.18

[1] Ontario Clean Water Agency – Performance Assessment Report, 2001.

TABLE 2
SUMMARY OF EFFLUENT COMPLIANCE LIMITS

Parameter	Concentration (mg/L)	Loading (kg/d)
BOD	25	40
Suspended Solids	25	40
Total Phosphorous	0.3	0.48

The Deseronto Water Pollution Control Plant is currently operating at 73% of its rated capacity and producing an effluent quality exceeding the requirements of the Certificate of Approval. The phosphorous removal facility operated intermittently during 2001 due to start-up issues. When the phosphorous removal facility was operating, effluent phosphorous was typically 0.07 mg/L or less or less than 1/3 of the compliance limit.

3. PILOT PLANT STUDY

The tertiary sedimentation process at the Deseronto Water Pollution Control Plant consistently produces an effluent phosphorous concentration much below the compliance limits. In order to ascertain the reserve phosphorous removal capability of the enhanced sedimentation process, an on-site Pilot Plant Study was undertaken. The objective of this study was to determine the effect of various loading rates on the effluent phosphorous concentrations

From February 24, 2003 to February 28, 2003, a Pilot Plant Study was conducted at the Deseronto Water Pollution Control Plant. The pilot plant consisted of a trailer mounted Actiflo Ballasted Sand Flocculation Pilot Plant, installed at the water pollution control plant using secondary effluent from the secondary clarifier as influent. The pilot plant was operated at various flow rates with varying coagulant and polymer dosages and the influent and effluent total suspended solids and total phosphorous were measured. A schematic representation of the Actiflo Pilot Plant is shown in Figure 3.

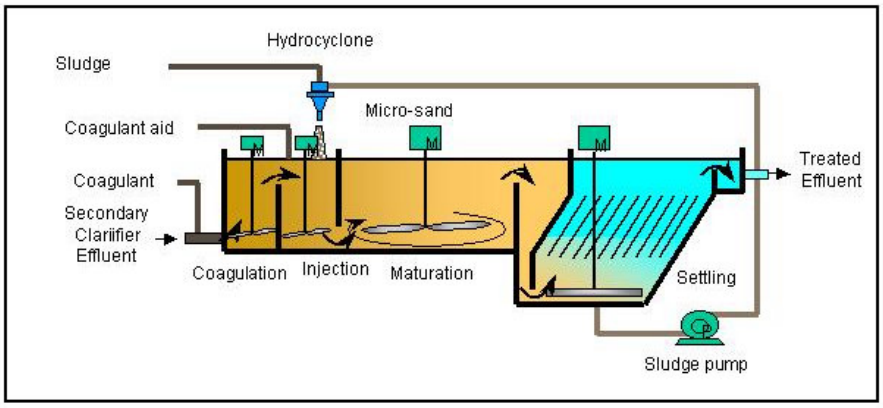


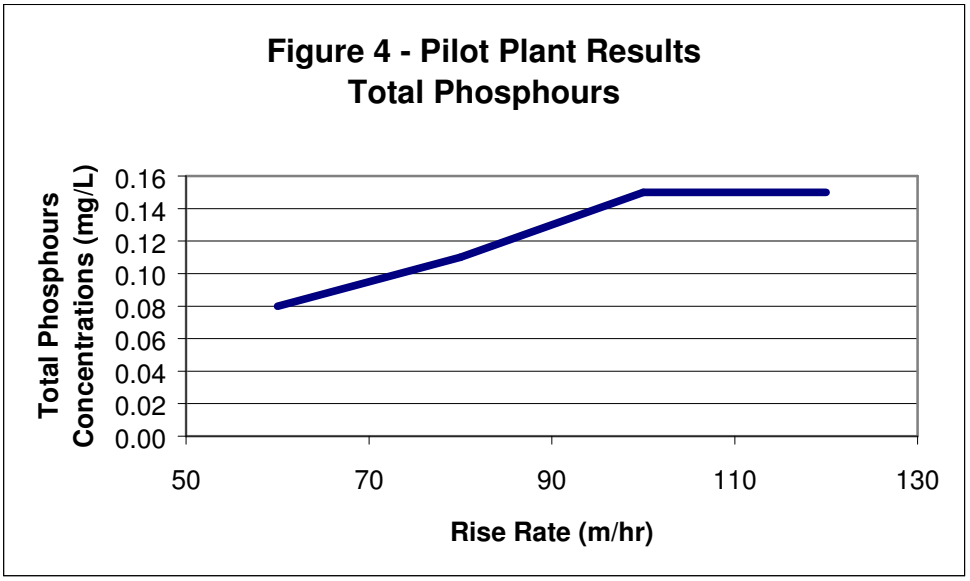
Figure 3 – Actiflo Pilot Plant

The pilot plant results are summarized in the following Table 3, and Figures 4, 5 and 6 for total phosphorus, turbidity and Total Suspended Solids (TSS) respectively. The results are presented in terms of loading rates ($m^3$of flow/m^2 of area/hour) to facilitate scaling up of the results from the pilot plant unit to the full-scale plant. Based upon a design average day flow rate of 1,600 m;/day and a peak flow rate of 5,478 m;/day, the existing Deseronto Water Pollution Control Plant enhanced sedimentation process has a design overflow rate at peak flows of 55 m/hr.

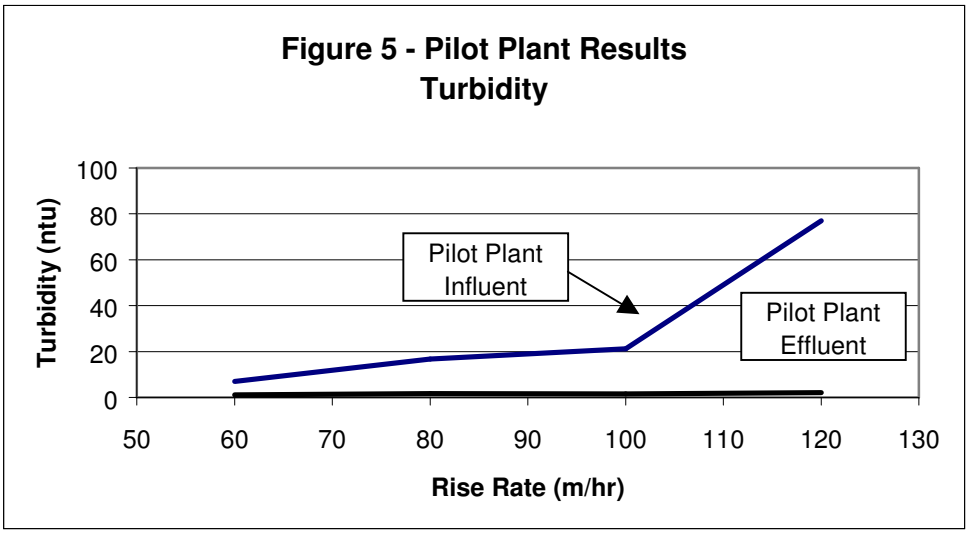
During the pilot test, an alum was added to the pilot plant unit at dosages between 61 mg/L and 64 mg/L. Magnifloc 1011 was used as a polymer and tested with dosages varying between 0.7 mg/L to 1.1 mg/L.

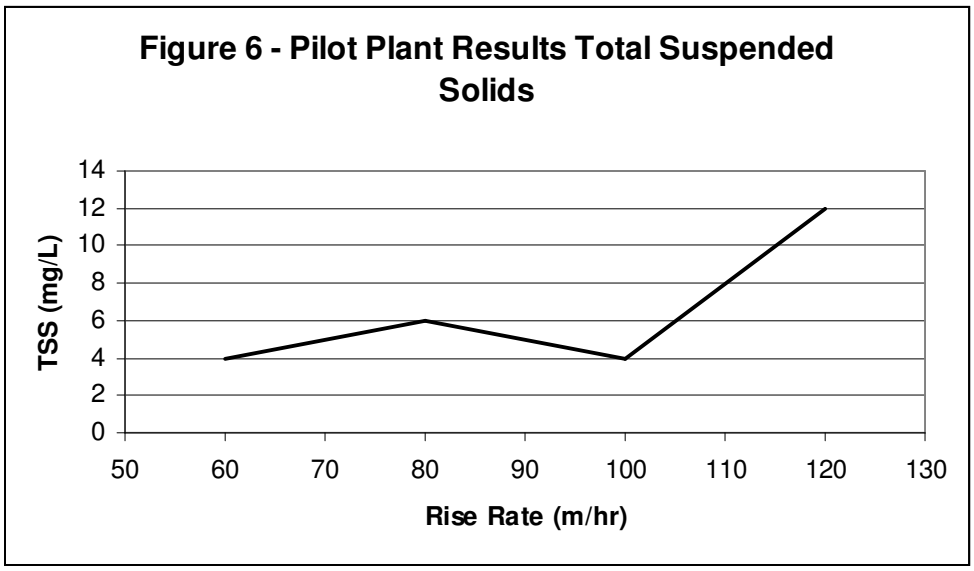
Table 3
Pilot Plant Results

Rise Rate (m/hr)	Total Phosphorus (mg/L)		Turbidity (ntu)	
	Influent	Effluent	Influent	Effluent
60	0.52	0.08	7.0	1.1
80	0.81	0.11	16.7	1.7
100	1.20	0.15	21.2	1.6
120	0.78	0.15	77	2.1



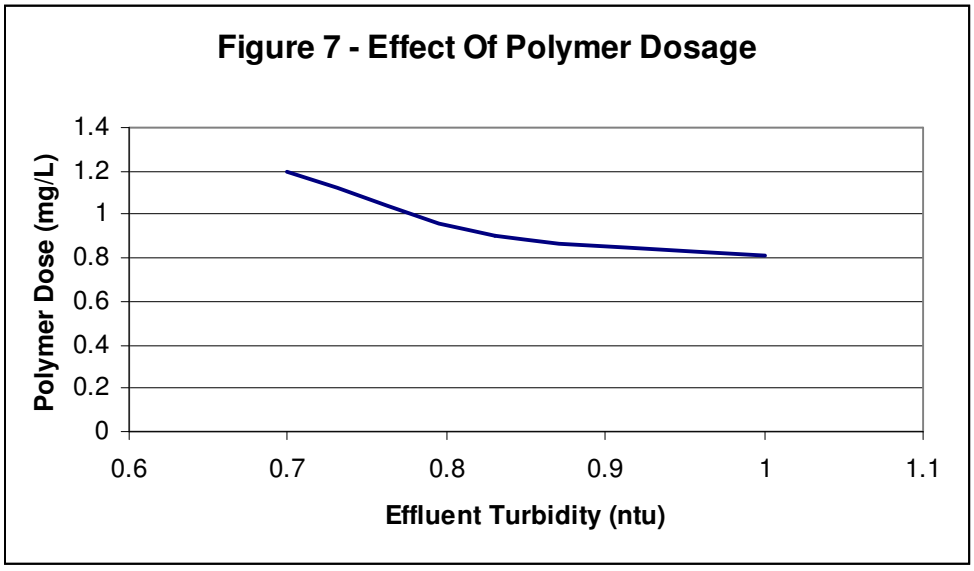
The pilot plant showed excellent phosphorous removal results for all the flows tested. At a rise rate of 120 m/hr which is 2.2 times the design rise rate for the existing tertiary sedimentation system, the effluent phosphorous concentrations from the pilot plant were 0.15 mg/L, half the compliance limit of 0.3 mg/L.





During the pilot plant study various polymer dosages were tested to determine the optimum polymer dosage. Using Magnifloc 1011, it was found that increasing the polymer dose from 0.7 mg/L to 1.0 mg/L provided improved treated water turbidity with increasing polymer dose.

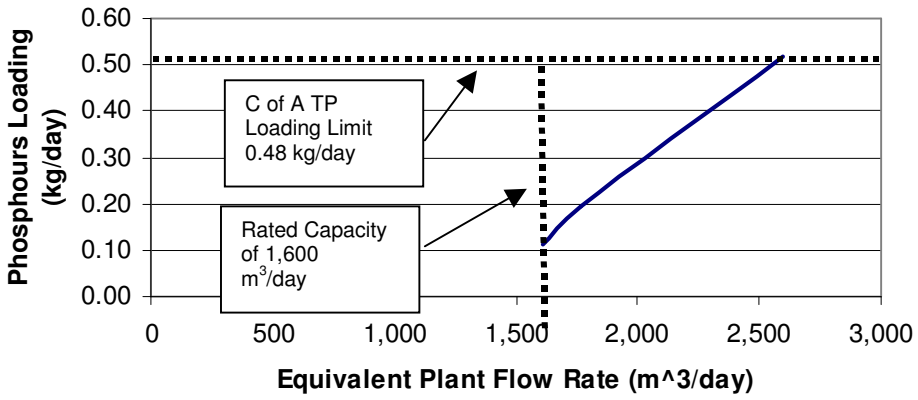
The Certificate of Approval for the Deseronto Water Pollution Control Plant limits phosphorous at 0.48 kg/day. This is equivalent to an effluent phosphorous concentration of 0.3 mg/L for the existing water pollution control plant rated capacity of 1,600 m;/day.



The Pilot Plant Study showed that at elevated loading rates the tertiary sedimentation process produced excellent phosphorous removals in the order of 0.15 mg/L. Increasing the rise rate to over twice the design rise rate still maintained effluent phosphorus concentrations less than the plant compliance limits.

The phosphorus effluent loading criteria for the Deseronto Water Pollution Control Plant is based upon a mass-loading rate. At an equivalent plant capacity of 2,400 m^3;/day, based upon an extrapolation of the Pilot Plant results, the phosphorous loading is 0.48 kg/day as shown in Figure 8. From Figure 8, it can be seen that there is significant capacity available in the enhanced sedimentation process for tertiary phosphorus removal based upon maintaining the design loadings.

Figure 8 - Effluent Phosphours Loadings



Conclusions

The tertiary treatment system at the Deseronto Water Pollution Control Plant operates extremely well. Based upon the results of the Pilot Test, the design rise rate could be doubled to 120 m/hr while providing effluent phosphorus concentrations of 0.15 mg/L.

Based upon an overall plant loading criteria of 0.48 kg/day, the plant rated capacity could be increased to 2,400 m^3/day, which is 150% of the design rated capacity and still meet the effluent loading rates.