City of Oneida Mobilized Film Technology Pilot Study Report

Final Report 07-10
February 2007

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Mobilized Film Technology
Pilot Study Report

Final Report

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ABSTRACT

A three-month pilot test was conducted at the City of Oneida Wastewater Treatment Plant (WWTP) to evaluate the potential of using Ecovation's Mobilized Film Technology (MFT) anaerobic pretreatment system at the WWTP to treat both the high-strength waste and process wastewater received from HP Hood Company (HP Hood). The incorporation of anaerobic pretreatment into the WWTP's overall treatment process would 1) reduce the organic load to the WWTP's aeration tanks, 2) increase the volume of biogas produced by the WWTP, which could be used to generate electricity, thereby reducing their overall costs, and 3) provide a more sustainable waste management practice for HP Hood's Oneida facility.

Both the high-strength waste and a mixture of the high-strength waste and the process wastewater were found to be effectively treated in the MFT anaerobic pretreatment system. The processing scheme included pretreating the streams in a dissolved air flotation (DAF) unit to remove the bulk of the fats, oils and grease (FOG) and suspended solids. The DAF float solids were sent directly to the WWTP's existing anaerobic digesters, while the DAF subnatant was sent for treatment in the MFT reactor. Extrapolating the amount of biogas that was produced by the pilot system to a full-scale system, it is estimated that 78.5 MMBTU per day could be produced, which would be enough to run a 250 kilowatt (kW) generator.

Key words: Anaerobic treatment, dissolved air flotation, dairy waste, wastewater treatment

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SUMMARY

In January 2005, the City of Oneida and Bricar Engineering Associates completed an energy reduction feasibility study, which was co-funded by NYSERDA. The study identified six energy conservation measures, including the installation of an anaerobic pretreatment system dedicated to treating wastewater from the HP Hood Company Oneida milk processing plant (HP Hood). HP Hood currently contributes 40-60% of the BOD_5 and TKN load to the city's wastewater treatment plant (WWTP). The predicted annual energy savings for the WWTP associated with this measure was 32,850 MMBTU of natural gas and the predicted annual cost savings was $328,500 due to usage of biogas produced from the anaerobic system to generate heat and electricity. The estimate capital cost to implement this measure was $6,660,000.

The city decided to take a preliminary step in implementing the measure by pilot testing Ecovation's Mobilized Film Technology (MFT) anaerobic pretreatment system. In addition to energy and cost savings for the WWTP, drivers for the project included:

- Improved performance of the WWTP;
- The ability of the WWTP to accommodate regional residential, commercial and industrial growth, which is anticipated as the Turning Stone Casino Resort expands;
- The ability of the HP Hood Oneida plant to expand, which is currently limited in part by wastewater treatment capacity;
- A desire to improve the sustainability of the HP Hood Oneida plant, so it remains competitive with other HP Hood plants (and can maintain/expand production); and
- Public health concerns over failing septic systems in neighboring villages, which may ultimately be incorporated into the city's sewer system.

The pilot demonstration project was conducted at the WWTP from September 2 - December 5, 2006. The objectives of the project were to 1) demonstrate that 90-95% of the five-day biochemical oxygen demand (BOD_5) of the wastewater could be converted to biogas and 2) develop a basis of design for a full-scale facility. The project was performed in three phases:

- Startup and acclimation of the MFT reactor, including an initial characterization of HP Hood's process wastewater and high-strength waste;
- Steady operation of the MFT reactor treating only high-strength waste; and
- Steady operation of the MFT reactor treating both high-strength waste and process wastewater.

During the wastewater characterization, startup and acclimation, it was determined that the concentration of fats, oils and grease (FOG) in the high-strength waste were well above the tolerable level for high-rate anaerobic systems, and would require pretreatment. A dissolved air floatation (DAF) system was added to the pilot system treatment train, prior to the MFT reactor. Upon conclusion of pilot testing, it was

determined that both the high-strength waste DAF subnatant and the combined high-strength waste and process wastewater stream could be effectively treated in a high-rate MFT at a reasonable organic loading rate (OLR).

Based on the results of pilot testing, a full-scale basis of design (for treatment of the combined process wastewater/high-strength waste stream) was selected at average and maximum OLRs of 15 kg COD/m^3-d and 25 kg COD/m^3-d, respectively. It was estimated that this would produce approximately 33 million BTU (MMBTU)/d (at a methane yield of 5.6 scf/lb COD). In addition to biogas generated by the MFT reactor, considerable energy could be recovered from digestion of the DAF float, which was estimated at 45.5 MMBTU/d. At a conservative 28% conversion efficiency, this 78.5 MMBTU/d translates to 6,443 kWh/d of electricity and 268 kW.

Section 1
CHARACTERIZATION OF THE HIGH-STRENGTH WASTE AND PROCESS WASTEWATER

HP Hood generates two waste streams at its Oneida facility, which are both potential candidates for anaerobic treatment; process wastewater and high-strength waste ("slop material"). The process wastewater is stored in an equalization tank at the HP Hood site, then discharged to the City of Oneida WWTP via a dedicated pipeline.

Samples of both waste streams were sent to Ecovation's Technology Development Center and a NYS Certified Contract Laboratory (Life Sciences of Dewitt, NY) for chemical and physical characterization, and to conduct biochemical methane potential (BMP) analysis. (Since there was no data available on the composition of the high-strength waste, the waste stream was sampled for five days and an intensive characterization of this stream was performed.) BMP analysis was performed to determine the maximum amount of the chemical oxygen demand (COD) that could potentially be converted to biogas (methane). Due to the high level of fats, oils and grease (FOG) in the samples, samples were also sent to Ecovation's subsidiary, Krofta Technologies (Dalton, MA), to determine if dissolved air flotation (DAF) should be used prior to anaerobic treatment for removal of FOG and total suspended solids (TSS).

RESULTS OF FIVE-DAY HIGH-STRENGTH WASTE SAMPLING AND ANALYSES

The five-day high-strength waste sampling program was conducted from May 15-19, 2006. The results are presented in Table 1-1. The high-strength waste stream had an average COD of 210,000 mg/L, with a standard deviation of 60,000 mg/L (range of 140,000 - 296,000 mg/L). The soluble COD (sCOD) averaged 32,800 mg/L (range of 24,000 – 40,000 mg/L), or 16.3% of the total COD.

Table 1-1. Results of Five-Day Sampling and Characterization of the High-Strength Waste Stream

Parameter	Units	15-May	16-May	17-May	18-May	19-May	Average	Stdev.
COD	mg/L	296,000	174,000	140,000	176,000	222,000	**201,600**	60,289
sCOD	mg/L	40,000	32,000	24,000	28,000	40,000	**32,800**	7,155
TSS	mg/L	39,000	36,300	32,400	46,600	52,200	**41,300**	8,006
VSS	mg/L	37,500	32,300	28,800	39,800	44,600	**36,600**	6,212
TKN	mg/L	1,080	1,620	1,640	1,810	1,740	**1,578**	289
sTKN	mg/L	448	285	398	286	252	**334**	84
NH_4-N	mg/L	11.5	3.3	2.0	2.2	2.9	**4.4**	4.0
TP	mg/L	1,180	318	268	401	369	**507**	379
Soluble P	mg/L	237	261	188	194	374	**251**	75
FOG	mg/L	5,000	3,700	5,000	8,300	21,000	**8,600**	7,138
Ca	mg/L	446	412	375	792	480	**501**	167
Mg	mg/L	43	43	<50	<50	<50	**43**	

Parameter	Units	15-May	16-May	17-May	18-May	19-May	Average	Stdev.
TDS	mg/L	17,100	18,500	11,500	7,590	17,800	**14,498**	4,754
Alkalinity	mg/L as $CaCO_3$	406	-	196	230	876	**342**	332

The TSS and volatile suspended solids (VSS) averaged 41,300 mg/L and 36,600 mg/L, respectively. The ratio of VSS to TSS of 0.89 indicated that the solids were highly degradable.

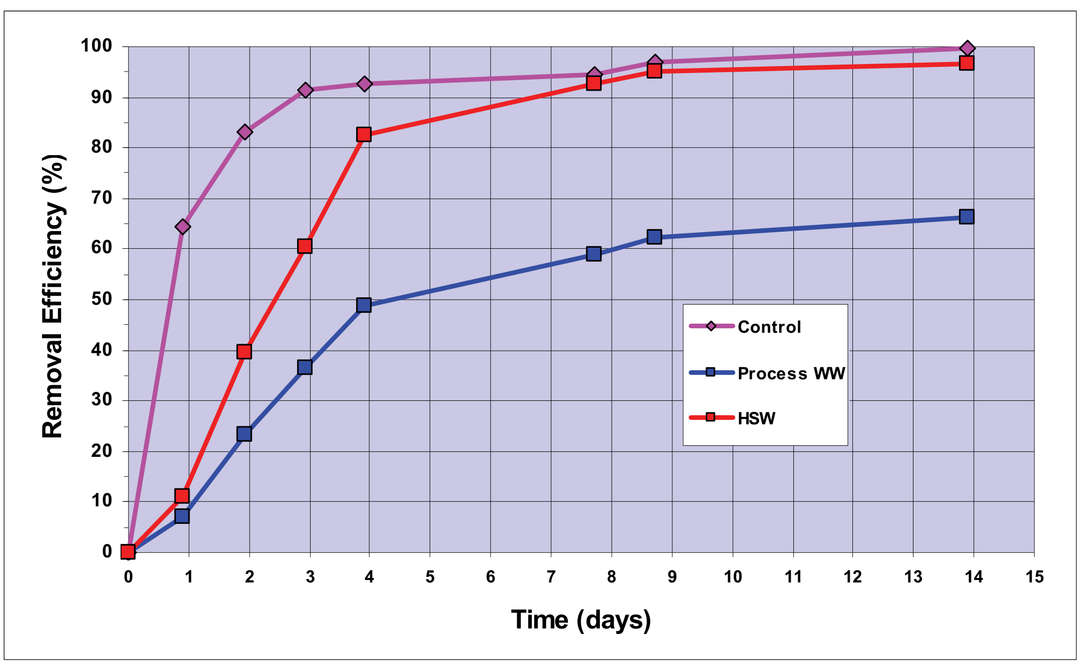
The high-strength waste had a relatively high total Kjeldahl nitrogen (TKN), averaging 1,578 mg/L. The soluble TKN, by contrast, was only 334 mg/L or 17.8% of the total, which indicates that most of the TKN is in the solids portion of the high-strength waste. The ammonium nitrogen (NH_4-N) was low, averaging 4.4 mg/L; virtually all of the nitrogen was organic nitrogen in nature.

Of particular concern were the high concentrations of FOG, which averaged 8,600 mg/L, with a peak concentration of 21,000 mg/L. These concentrations are well above the tolerable level for high-rate anaerobic systems. Therefore, pretreatment to reduce FOG levels was deemed necessary for the high-strength waste stream.

RESULTS OF BMP TESTING

The result of the BMP testing is shown in Figure 1-1. The control (i.e., sucrose) averaged 99.8% conversion to methane. The high-strength waste averaged 96.6%, and the process wastewater averaged 66.2% (after two weeks' incubation at 35°C).

Figure 1-1. Results of BMP Assay Testing



RESULTS OF DAF BENCH-SCALE TESTING

The results of the bench-scale DAF testing are presented in Table 1-2 and Table 1-3 for the process wastewater and high-strength waste, respectively.

Table 1-2. Results of DAF Testing on Process Wastewater

Parameter	Units	Process Wastewater	DAF Effluent	Percent Reduction
pH	s.u.	8.17	4.55	—
TSS	mg/L	407	168	59
COD	mg/L	2,337	954	59
FOG	mg/L	410	90	78
Recycled Flow	%		25	
Rise Rate	inch/1st min.		9	
Sludge Volume	ml/L		40	

The bench-scale DAF testing on process wastewater was performed under the following conditions:

- pH adjustment with 375 mg/L sulfuric acid to pH 4.52;
- Coagulant dose of 200 ppm SRL Sumalchlor 50;
- Mixing for 2 sec at 304 rpm followed by mixing for 60 sec at 31 rpm;
- Flocculant addition of 5 mg/L Cytec Superfloc C-1596; and
- Mixing for 2 sec at 307 rpm followed by mixing for 10 sec at 30 rpm using a Phipps & Bird 7790-400 jar tester.

Table 1-3. Results of DAF Testing on High-Strength Waste

Parameter	Units	High-Strength Waste	DAF Effluent	Percent Reduction
pH	s.u.	4.46	4.68	—
TSS	mg/L	31,640	2,070	93
COD	mg/L	85,300	13,950	84
FOG	mg/L	10,000	950	91
Recycled Flow	%		400	
Rise Rate.	inch/1st min.		8	
Sludge Volume	ml/L		200	

For the high-strength waste test, neither pH adjustment nor coagulant addition was necessary. Only flocculant (Cytec Superfloc A-1883RS; 75 mg/L; mixing for 2 sec at 312 rpm followed by 10 sec at 29 rpm; Phipps & Bird 7790-400 jar tester) was required to remove the majority of TSS and FOG from the high-strength waste stream; however, COD was also removed.

A combination of process wastewater and high-strength waste (at 6% by volume) was also tested. The results are presented in Table 1-4.

Table 1-4. Bench-Scale Testing Results for Combined Process Wastewater and High-Strength Waste

Parameter	Units	Process & High-Strength Waste	DAF Effluent	Percent Reduction
pH	s.u.	6.49	4.47	—
TSS	mg/L	916	155	83
COD	mg/L	8,020	1,400	83
FOG	mg/L	680	39	94
Recycled Flow	%		25	
Rise Rate.	inch/1st min.		12	
Sludge Volume	ml/L		40	

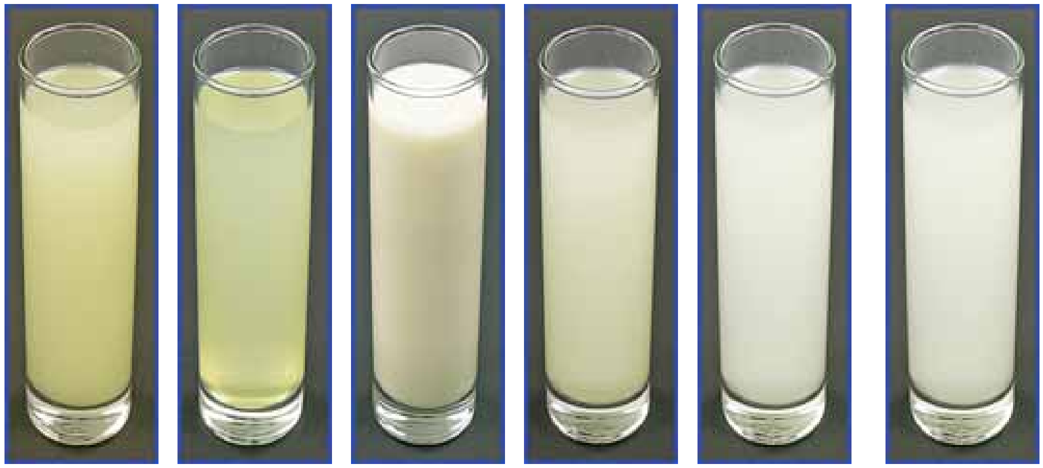
The bench-scale DAF testing on combined process wastewater and high-strength waste was performed under the following conditions:

- pH adjustment with 300 mg/L sulfuric acid to pH 4.56;
- Coagulant dose of 300 ppm SRL Sumalchlor 50;
- Mixing for 2 sec at 306 rpm followed by mixing for 60 sec at 34 rpm;
- Flocculant addition of 10 mg/L Cytec Superfloc A-1883RS; and
- Mixing for 2 sec at 307 rpm followed by mixing for 10 sec at 30 rpm

High removal efficiencies for FOG, TSS, and COD were obtained; however, the amount of polymer required was higher than for the process wastewater alone. High COD removal was also observed, which is atypical for dairy wastewater. Generally COD removal of <50% is observed.

Figure 1-2 shows the process wastewater before and after DAF treatment, the high-strength waste before and after DAF treatment, and the combined streams before and after DAF treatment.

Figure 1-2. Samples of Process Wastewater Before (a) and After (b) DAF, High-Strength Waste Before (c) and After (d), and Combination of the Two Before (e) and After (f)



As was previously discussed, it was not possible to treat the process wastewater or the combined streams without pH adjustment. It was also not possible to partially treat the samples; no removal of FOG was observed until the critical polymer dose was reached, and at this point any FOG that could be removed was removed.

Concerns over high sludge production led to a second round of testing with emulsion polymers, which have proven successful with similar types of wastes. Both Drewfloc 2249 and 2270 (Ashland Chemical) were tried. The results are presented in Table 1-5.

Table 1-5. Bench-scale DAF Testing with Drewfloc 2249 (DAF 1) and 2270 (DAF 2)

Parameter	Units	Process & High-Strength Waste	DAF Effluent 1	Percent Reduction	DAF Effluent 2	Percent Reduction
pH	s.u.	3.97	4.16	--	4.19	--
TSS	mg/L	44,345	10,029	77	1,066	98
COD	mg/L	108,500	47,800	56	16,700	85
Recycled Flow	%		510		520	
Rise Rate.	inch/1st min.		4		10	
Sludge Volume	ml/L		140		110	

The bench-scale DAF testing with alternative polymers were performed under the following conditions:

- Drewfloc 2249 at 160 mg/L
- Drewfloc 2270 at 149 mg/L
- Mixing for 2 sec at 310 rpm followed by mixing for 10 sec at 35 rpm

The sludge volume produced with Drewfloc 2270 was half that produced in the earlier tests. A decision was made to use Drewfloc 2270 for the pilot demonstration.

Section 2

DESCRIPTION OF THE PILOT DEMONSTRATION SYSTEM

SYSTEM SUMMARY

Since DAF pretreatment was required, the larger pilot Mobilized Film Technology (MFT) unit originally identified by Ecovation for use on the Oneida project was replaced by a smaller MFT unit. (This was due to the fact that the DAF pretreatment lead to decreased COD concentrations, which meant that larger than anticipated volumes of high-strength waste would need to be shipped and stored on-site at the Oneida facility if the larger pilot unit were to be used.) A diagram showing the process flow scheme is presented in Figure 2-1. The high-strength waste was delivered by truck to a holding tank of approximately 750 gallons. The material was stored for at least one day before processing, which was done to ensure that the pH level was at or below 4.6, necessary for effective processing, as dictated by bench-scale testing. A picture of the building, raw influent holding tank and anaerobic influent tank is provided as Figure 2-2.

Figure 2-1. Process Flow Scheme for Oneida/HP Hood Pilot

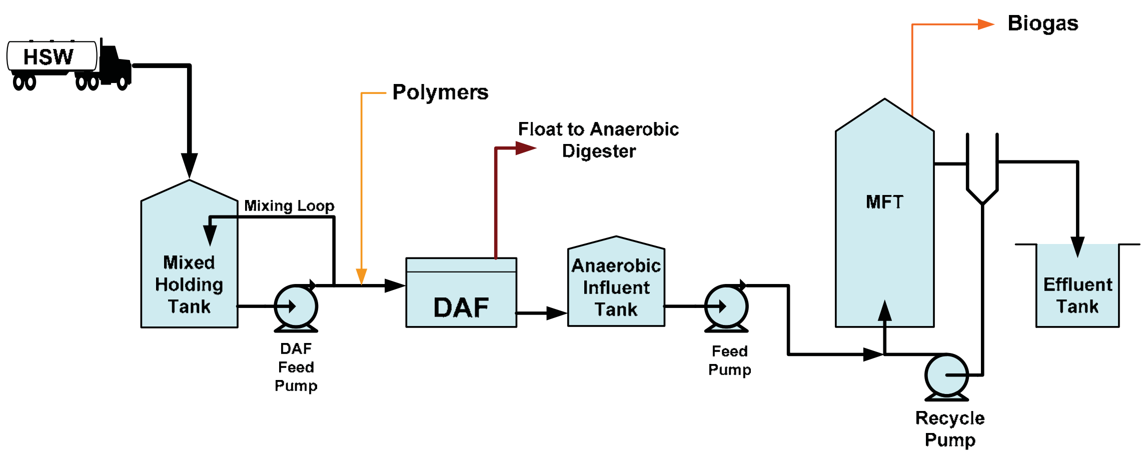


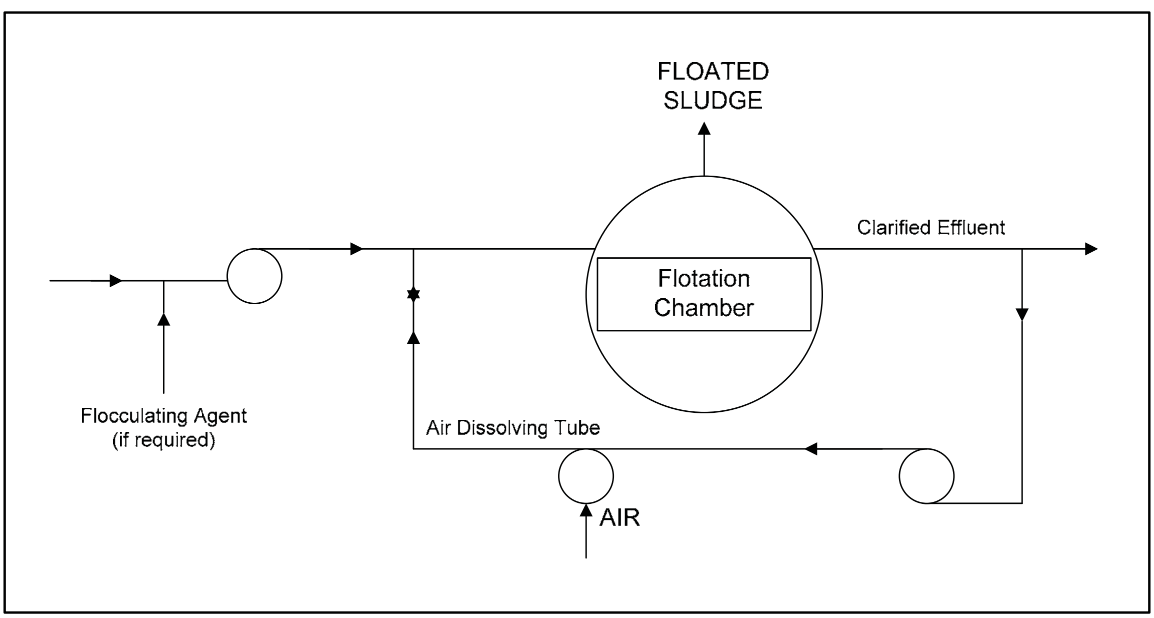
Figure 2-2. Picture of the Building, Influent Holding Tank and Anaerobic Influent Tanks

Every other day, approximately 300 to 400 gallons of high-strength waste was batch processed in the pilot DAF unit shown in Figure 2-3. A three-foot diameter, pilot-scale Krofta Technologies Supracell DAF unit was used. A schematic of the system is shown in Figure 2-4. Ashland Drewfloc 2270 was added to the unit at approximately 150 mg/L. The pilot DAF float was pumped to a sludge storage tank, then to the WWTP's existing DAF, and then to the WWTP's existing anaerobic sludge digesters.

The subnatant from the DAF unit was pumped to the MFT influent tank, a stainless steel 700 gallon tank (Figure 2-2). The MFT tank was mixed using a recirculation pump that drew liquid out of the bottom of the tank and fed it back into the top of the tank. The influent feed to the MFT unit was metered from the tank to the MFT unit by feed pump and recycle loop pump, which provided expansion of the reactor bed in a "trickle and bump" mode of operation. The MFT system and its operation are described in detail in the following section.

Figure 2-3. Picture of the Pilot DAF Unit

Figure 2-4. Recycled Flow Pressurization System – Krofta Supracell



DETAILS OF THE MFT ANAEROBIC PILOT SYSTEM

The pilot MFT system was a 20 inch diameter by 12 feet tall cylindrical reactor constructed using 304 stainless steel (Figure 2-5). The reactor had a maximum working bed height of seven feet, resulting in an empty bed volume of approximately 108 gallons. The reactor was covered with an insulating blanket to reduce heat loss.

The system was initially seeded with biologically active sand (i.e., sand with a biofilm coating) from an Ecovation project site in Canandaigua (Centerra Wine Company) in order to minimize the time required for startup. The initial bed volatile solids (BVS) were measured to be 17,700 mg/L. The starting operating bed height under flowing conditions was approximately six feet.

Flow was pumped into the bottom of the vessel using a two-pump configuration. A "trickle" pump delivered flow just below or at the incipient media fluidization level. The flow rate was maintained between 3.0 and 3.5 gallons per minute (gpm). This pump was operated continuously. The "bump" pump cycled on and off every 30 seconds. During the "on" period, the flow to the reactor was increased to approximately 5.0 gpm, which fully fluidized the media.

Flow exited the reactor through a submerged port into a 12-inch diameter small "swirl" tank (that created a tangential swirl pattern). This allowed capture of media particles exiting the MFT reactor due to gas attachment. The media were returned to the MFT using a positive displacement pump to a point just above the incipient media fluidization level. (In the larger MFT reactors, this is normally accomplished internally using a baffling system.) Recycle flow for the "trickle and bump" pumps was taken from a port about mid height in the swirl tank. Wastewater flow was added to the recycle flow stream just before entering the MFT. Additionally, a bicarbonate solution (0.5 lb/gallon) was added to the recycle flow stream at this point for alkalinity control. Effluent flow exiting the swirl tank via a gravity overflow was captured in a 1,500 gallon effluent tank; flow volume into this tank was measured and recorded daily.

Heating of the wastewater to an optimal mesophilic temperature (95° to 97°F) was achieved by withdrawing a stream of several gallons a minute from the swirl tank, passing it though a submersion heater and sending this flow back into the liquid volume above the media bed in the MFT reactor.

Figure 2-5. Picture of the Pilot Anaerobic MFT System

Section 3

RESULTS OF PILOT-SCALE DAF PRETREATMENT

Upon commencement of the pilot demonstration, additional analyses for COD, sCOD, TSS and VSS were conducted on four batches of high-strength waste. Results are presented in Table 3-1. The raw high-strength waste had an average COD of 124,250 mg/L. This is considerably less than was observed during the five-day sampling period where the COD averaged approximately 200,000 mg/L. Pretreatment via DAF reduced the COD in the DAF subnatant by almost 72%, to 35,100 mg/L. TSS and VSS in the DAF subnatant averaged 503 and 475 mg/L, respectively.

Table 3-1 Pilot-scale DAF Performance Treating High-Strength Waste

Parameter	Units	Raw High-Strength Waste	DAF Subnatant	Removal Efficiency
COD	mg/L	124,250	35,143	72%
sCOD	mg/L	46,525	32,729	29%
TSS	mg/L		503	
VSS	mg/L		475	

Additional testing was performed during Phase 3 of the project (treatment of the combined high-strength waste and process wastewater). During Phase 3, the DAF was operated 3-4 times per week due to the larger volumes required to feed the anaerobic system. Results from this phase are presented in Table 3-2.

Table 3-2 DAF Performance Treating the Combined High-Strength Waste and Process Wastewater

Parameter	Units	Influent	Subnatant	Float Material	Removal Efficiency
COD	mg/L	8,326	6,864	33,218	18%
sCOD	mg/L	5,472	4,873	8,482	11%
TSS	mg/L	2,118	1,103	18,213	48%
VSS	mg/L	1,885	1,028	17,068	46%

As is observed, TSS removal efficiency was just under 50%. (Note: The TSS in the subnatant were colloidal in nature.) COD was reduced by 18% and sCOD by 11%, which is typical for dairy wastewater. The float solids averaged approximately 1.8% (18,213 mg/L), which is low compared to the 4-6% TSS typically observed. A mass balance was performed using COD, TSS, and VSS data and even at this low float solids concentration, the volume of the float accounted for 5.6% of the total flow to the DAF. Treating the DAF subnatant in the MFT reactor was done without issue, as is detailed in Section 4.

Section 4

DEMONSTRATION TEST RESULTS

Results of the three-phase demonstration project are presented below. The three phases were as follows:

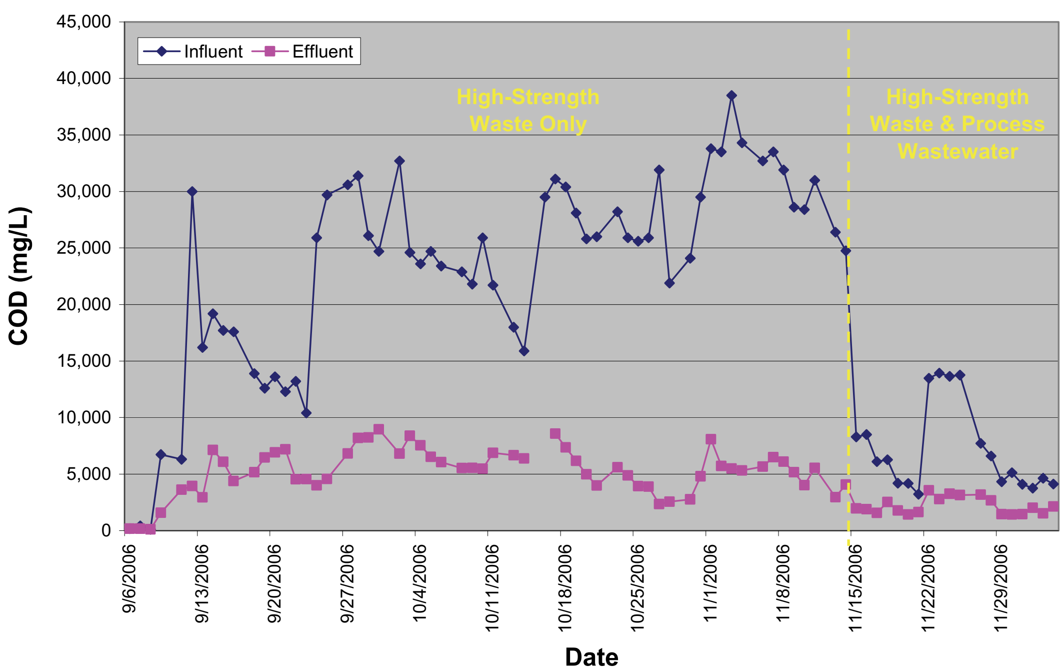
- Startup and acclimation (Phase 1)
- Testing with high-strength waste (Phase 2)
- Testing with combined process wastewater and high-strength waste (Phase 3)

The MFT reactor was placed into service on September 2, 2006. The reactor was seeded with a sand media from an existing reactor used to treat winery wastewater. For the first several days of the pilot test, primary effluent from the WWTP was used to help "reactivate" the microbial population on the media. (The seeded media had been stored onsite for approximately 3 months.) Beginning September 8, high-strength DAF subnatant was fed to the MFT reactor system.

Results from each phase of the demonstration project are presented below. The results are divided into two sections: (1) data gathered during the entire testing phase, and (2) data gathered once quasi-steady-state conditions were achieved (referred to herein as the "evaluation period").

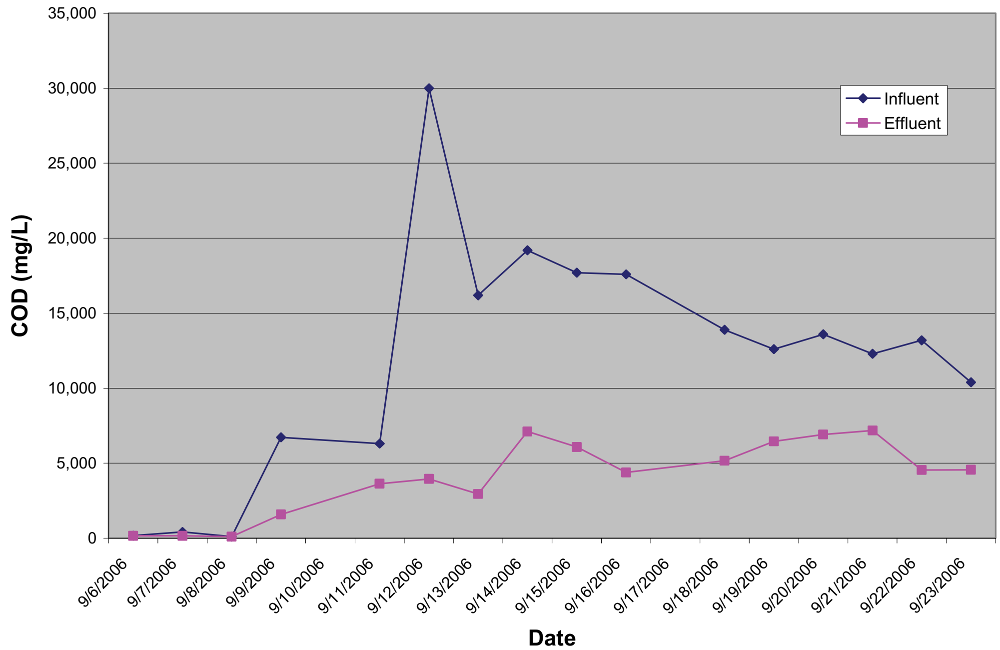
The influent and effluent COD data for the duration of the demonstration project are presented graphically in Figure 4-1. A complete data set is provided as Appendix A.

Figure 4-1. Influent and Effluent COD Concentrations during Overall Demonstration Period



RESULTS OF STARTUP AND ACCLIMATION (PHASE 1)

Figure 4-2. Influent and Effluent COD Concentrations Observed During Phase 1



The MFT reactor was started on September 5, 2006, and operated in a recycle mode for the day. On September 6, primary effluent from the WWTP was fed to the reactor to "reactivate" the microbial population on the sand media. On September 8, high-strength waste DAF subnatant was added to the MFT feed tank. From September 8 - September 11, a mixture of WWTP primary effluent and high-strength DAF subnatant was fed to the MFT reactor. Beginning September 11, only high-strength waste DAF subnatant was fed to the MFT reactor. The system was operated under these conditions through September 23, at which point startup and acclimation were considered complete. Influent and effluent COD data collected during Phase 1 are presented graphically in Figure 4-2.

RESULTS OF TESTING WITH HIGH-STRENGTH WASTE (PHASE 2)

Overall Phase 2 Results

Data on high-strength waste treatment were collected from September 24 to November 14, 2006. The results for COD and sCOD removal efficiency are presented graphically in Figure 4-3, and summarized in Table 4-1. Due to a malfunctioning in-line heater, the temperature of the reactor varied quite a bit during the initial part of Phase 2, as is evidenced in the plot presented in Figure 4-4. As a result, the evaluation period for Phase 2 is defined as the time period between October 19 and November 14, when the reactor temperature maintained a constant value in the mesophilic range (97°F (+/-1°F)).

Figure 4-3. COD and sCOD Removal Efficiencies Observed During Phase 2

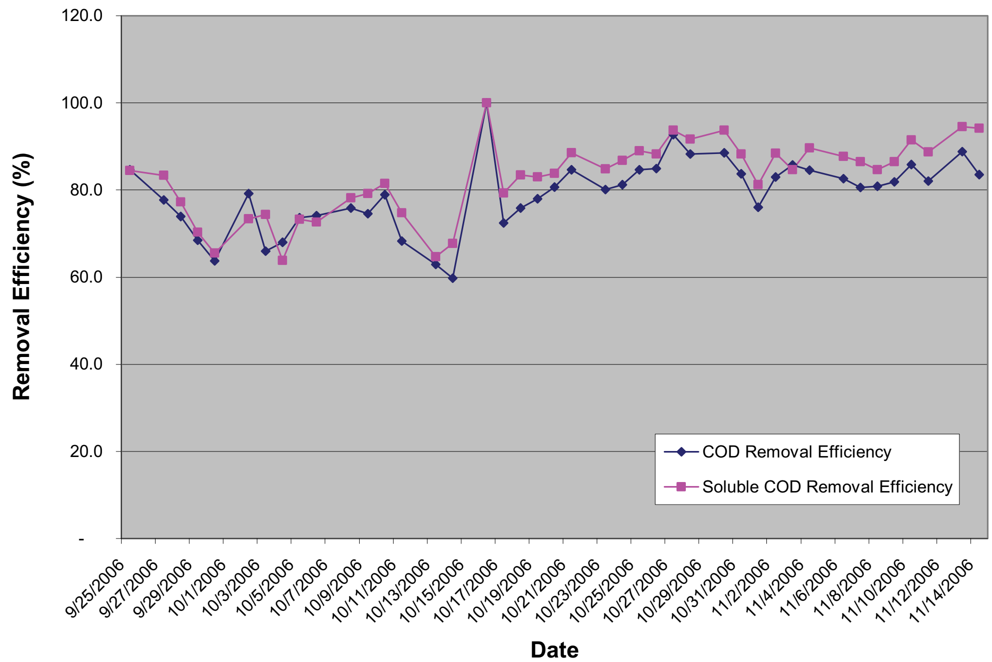
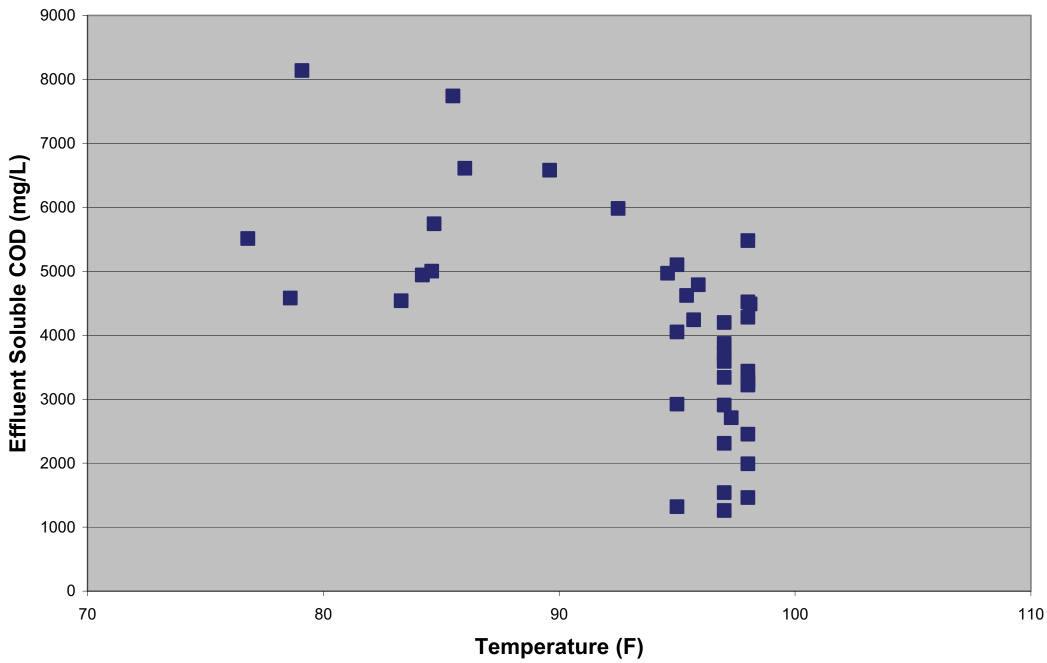


Table 4-1. Summary of all COD and sCOD Data for Phase 2

Parameter	Units	Influent	Effluent	% Removal
COD	mg/L	27,555	5,692	80.7
sCOD	mg/L	25,321	4,219	84.3
OLR	kg COD/m^3-d	21.2		

Despite the difficulty with maintaining an optimum mesophilic temperature, COD and sCOD removal efficiencies averaged 80.7% and 84.3%, respectively, at an average applied OLR of 21.2 kg COD/m^3-d for the entire period, which included a considerable number of days when the reactor temperature was below 90°F. As shown in Figure 4-4, the effluent sCOD concentration increased quickly once the temperature fell below the optimal range. Results for total COD (not shown) produced essentially the same correlation. For this reason, the evaluation period for Phase 2 is defined as the period when the heater was fully operational and capable of delivering optimal and stable temperature control.

Figure 4-4. Effect of Temperature on Effluent Quality (sCOD) During Phase 1



<u>Results for Phase 2 Evaluation Period</u>

A summary of data collected during the Phase 2 evaluation period (October 19 to November 14, 2006) is presented in Table 4-2. Influent and effluent COD and sCOD data are presented as Figure 4-5 and Figure 4-6, respectively.

Bicarbonate was used for alkalinity control during the study. Since the alkalinity in the bicarbonate solution is dilute (0.5 lb/gal), a fairly large volume was required. Therefore, the volume of bicarbonate solution fed to the reactor had to be taken into account when analyzing the data. To do this, the total volume of effluent was measured and the volume of bicarbonate solution was subtracted from this volume to obtain the actual flow of the high-strength waste. The influent concentrations were then corrected based on the ratio of corrected effluent volume to actually effluent volume (that averaged 0.87 and ranged from 0.78 to 0.92).

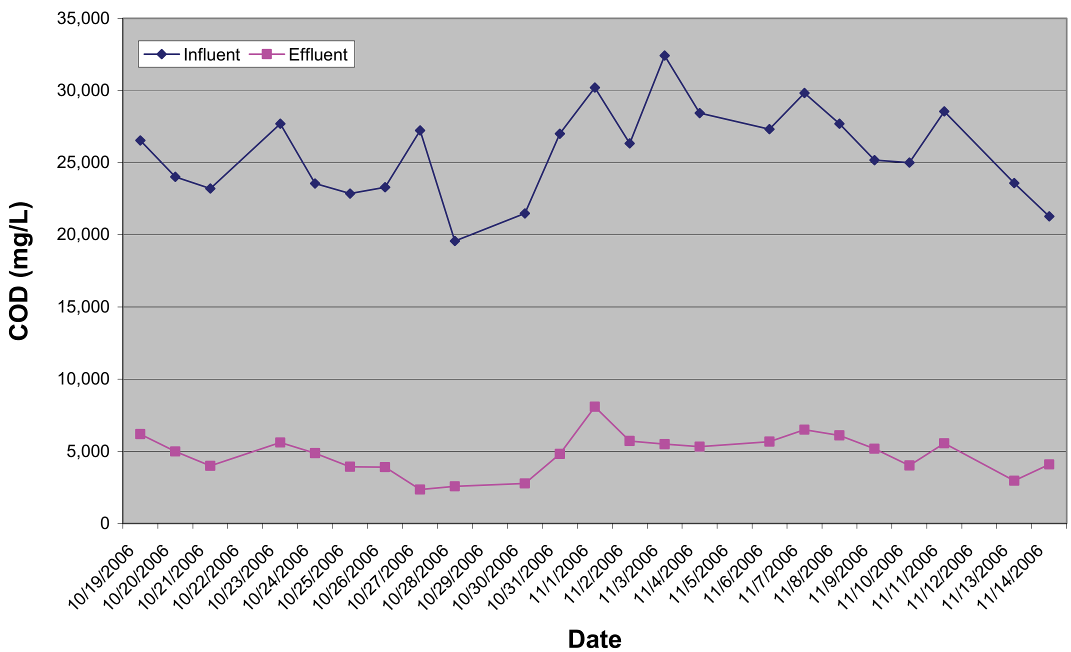
COD and sCOD removal efficiencies, based on corrected volume, averaged 82.7% and 87.8%, respectively, during this period at an average applied OLR of 23.7 kg COD/m^3-d. Note: The actual daily removal efficiencies were calculated based on an MFT mass balance that included mass of COD in, mass of COD out, and the change in reactor concentration (change in the “storage” term).

Table 4-2. Summary of COD, sCOD, TSS, and VSS Concentrations for the Phase 2 Evaluation Period

Parameter	Units	Influent	Corrected Influent	Effluent	Removal (%)*
COD	mg/L	29,141	25,754	4,807	82.7
sCOD	mg/L	26,743	23,654	3,168	87.8
TSS	mg/L	1,667	1,378	3,462	
VSS	mg/L	1,443	1,207	1,648	
OLR	kg COD/m^3-d		23.7		

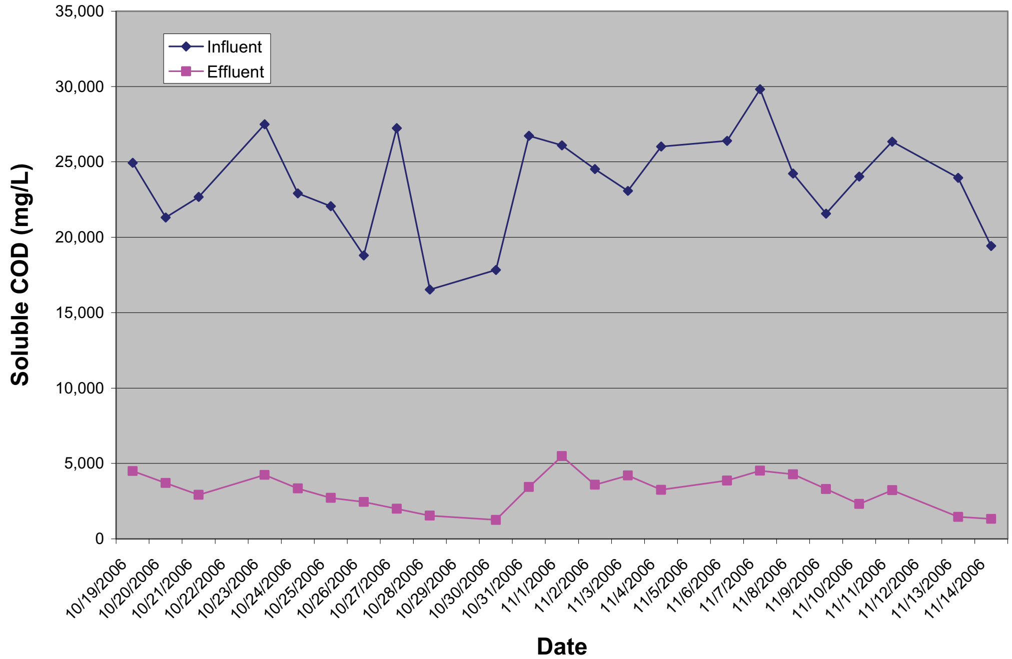
** Note: the removal efficiencies were calculated based on daily mass balance that included influent and effluent COD values and the change in the reactor concentration (storage term)*

Figure 4-5. Influent and Effluent COD from the Final Four Weeks of the Phase 2 Evaluation Period



**Note: influent COD values are corrected for dilution due to addition of bicarbonate for pH control*

Figure 4-6. Influent and Effluent Soluble COD during the Phase 2 Evaluation Period



There are several other interesting observations concerning the Phase 2 COD, sCOD, TSS, and VSS results. The ratio of sCOD to COD averaged 92% for the influent and 66% for the effluent. This indicates that a greater fraction of the effluent COD was due to suspended solids. The ratio of VSS to TSS (% volatile solids) was 87% for the influent. The ratio in the effluent was 48%, which indicates that a significant fraction of the TSS in the effluent were non-volatile. As will be discussed later, it is believed that this was due to precipitation of inorganic compounds, most likely as calcium phosphate and calcium carbonate compounds. There were eight days during the Phase 2 evaluation period when BOD_5 analyses on the influent and effluent were performed. The data are presented in Table 4-3.

Table 4-3. Summary of Influent and Effluent BOD_5 Data During the Phase 2 Evaluation Period

Date	Influent (mg/L)	Corrected Inf. (mg/L)	Effluent (mg/L)	Soluble Effluent (mg/L)
10/26	8,300	7,470	1,100	320
10/27	13,000	11,100	590	350
10/31	17,000	15,560	1,900	1,300
11/2	18,000	14,150	2,500	440
11/6	12,000	10,030	1,700	410
11/7	24,000	21,400	2,900	1,200
11/10	20,000	17,600	860	570
11/13	10,000	8,940	560	240
Average	**15,290**	**13,280**	**1,510**	**604**

As shown, the influent BOD_5 concentrations averaged 15,290 mg/L and the corrected values (accounting for dilution) averaged 13,280 mg/L. The effluent total and soluble BOD_5 concentrations averaged 1,510 mg/L and 604 mg/L, respectively. BOD_5 removal efficiency in the MFT averaged 88.6% for total influent to total effluent and 95.5% for the total influent to soluble effluent. The ratios of BOD_5 to COD averaged 0.50 for the influent and 0.31 for the effluent.

The soluble BOD_5 concentrations averaged 604 mg/L, ranging from 240 mg/L to 1,300 mg/L. This indicates approximately 60% of the residual BOD_5 was particulate in nature and could potentially be removed, if desired, using a post anaerobic solids removal process such as DAF or perhaps feeding the effluent to the primary clarification system. This could further reduce the load on the Oneida WWTP, by sending more organics directly to the existing anaerobic sludge digesters for biogas production.

Limited information was also collected on the concentrations and forms of the major macronutrients, nitrogen (N) and phosphorus (P), during the Phase 2 evaluation period. Three sample sets were processed for TKN and ammonium (NH_4^+-N). These data are summarized in Table 4-4. The increase in ammonium indicates degradation of a portion of the proteins in the high-strength waste. The loss of TKN and organic N is likely due to accumulation of biomass in the reactor during this period. As will be discussed later in this section, the bed volatile solids (BVS) concentration, a measure of the amount of biomass in the MFT reactor, increased significantly during this period.

Table 4-4. Summary of Nitrogen Data Taken During the Phase 2 Evaluation Period

Parameter	Units	Influent	Inf. Corrected	Effluent	Difference
TKN	mg/L	551	485	371	(104)
NH_4^+-N	mg/L	16	14	59	45
Organic N	mg/L	535	471	312	(159)

The concentrations of total phosphorous (TP) and ortho-phosphate (OP) observed during the entire Phase 2 test period are presented in Table 4-5. Although some of the P was likely consumed as a result of cell growth, the amount should be approximately 1/6th of that observed for nitrogen. Based on loss of organic N, this would translate to approximately 27 mg/L of P. The measured difference for average influent (corrected for dilution) and effluent for TP and OP were 119 mg/L and 147 mg/L, respectively. Therefore, it is believed that most of the P loss was due to precipitation reactions (as calcium phosphates), which is common in dairy wastewater under anaerobic conditions. The fact that the reduction in OP and TP are approximately the same indicates that OP was the phosphorus species that was primarily removed.

Table 4-5. Summary of Total and Ortho Phosphorus Data for Entire Phase 2 Test Period

Date	Influent TP (mg/L)	Influent TP Corrected (mg/L)	Effluent TP (mg/L)	Influent OP (mg/L)	Influent OP Corrected (mg/L)	Effluent OP (mg/L)
10/03	750	581	500	302	234	118
10/10	253	206	104	242	197	91
10/17	300	251	150	281	235	120
10/24	350	318	150	288	262	81
10/31	313	286	138	284	260	67
11/7	400	356	240	281	250	83
Average	**394**	**333**	**214**	**284**	**240**	**93**

RESULTS OF TESTING WITH COMBINED PROCESS WASTEWATER AND HIGH-STRENGTH WASTE (PHASE 3)

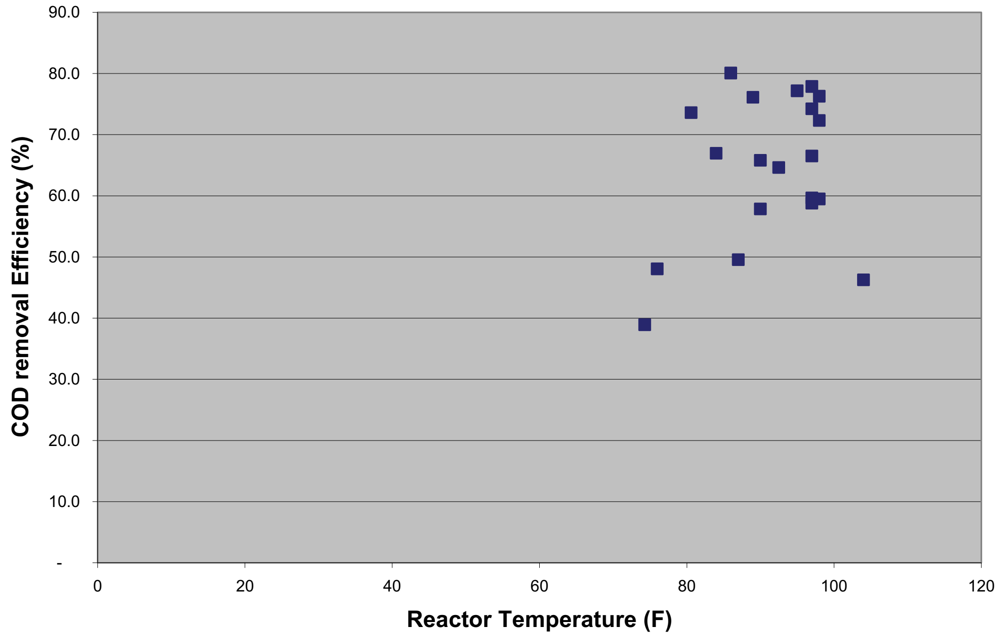
Beginning November 15, 2006, a combination of process wastewater and high-strength waste was fed to the MFT reactor. HP Hood mixed the high-strength waste and process wastewater in approximately 5,000 gallon batches, and trucked the material to the Oneida WWTP, where it was pumped into an existing empty sludge storage tank. The original plan was to dilute the high-strength waste with primary effluent from the WWTP. However, HP Hood subsequently offered to provide the actual mixture of the two streams generated at the HP Hood facility to ensure that any effect due to cleaning agents present in the process wastewater was captured during the project. The two waste streams were mixed in proportion to the average volumetric production at the plant, which is approximately 6% high-strength waste. Approximately 600 to 700 gallons of the mixture was processed through the DAF unit, with the subnatant subsequently fed to the MFT reactor.

Overall Phase 3 Results

Phase 3 operations extended from November 15 to December 4, 2006. During the final days of testing, the low ambient temperatures, coupled with the high volume of wastewater being fed, resulted in the reactor temperature decreasing precipitously; the heating system was unable to maintain temperatures in the optimal mesophilic range. These days were not included in the Phase 3 evaluation period but all data are included in Appendix A.

A plot showing the effect of temperature on system performance is provided as Figure 4-7. The removal efficiency, in general, varied between the mid-60% to mid-70% range. When the temperature decreased to below 80°F, the removal efficiency fell to below 50%. Since a full-scale system would not be operated outside of the mesophilic range, these data were excluded from the evaluation period as mentioned above. The average temperature maintained during the Phase 3 evaluation period was 93°F.

Figure 4-7. Scatter Plot of COD Removal Efficiency as a Function of Temperature



The influent and effluent concentrations for COD and sCOD over the entire Phase 3 testing period are depicted in Figure 4-8 and Figure 4-9. During this period, the OLR averaged 17.1 kg COD/m^3-d and the empty bed hydraulic retention time was 12.9 hours.

Figure 4-8. Influent and Effluent COD During Phase 3 Testing

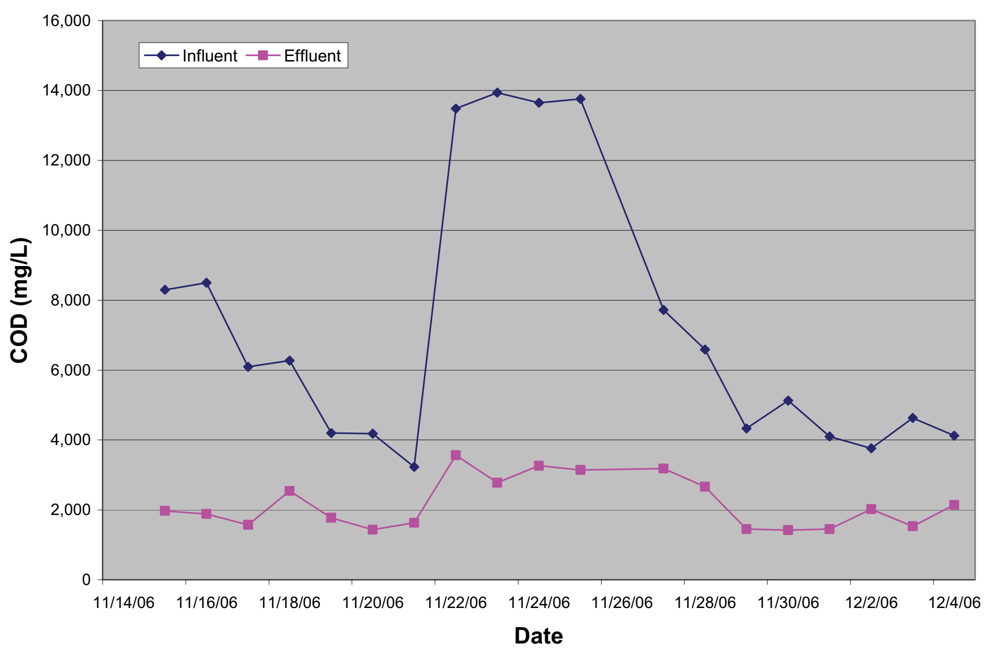
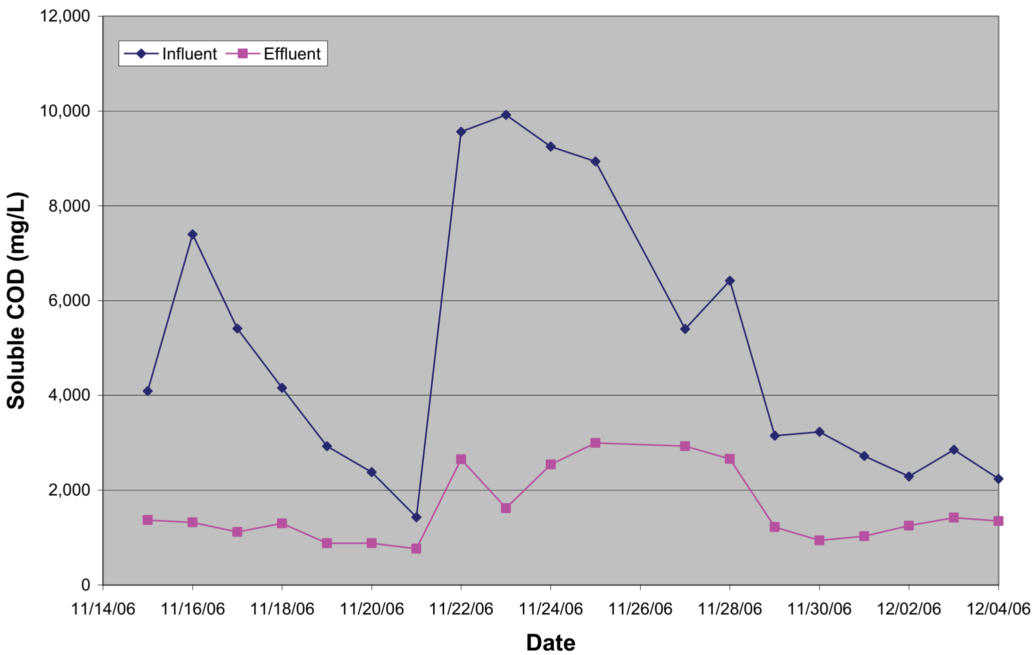


Figure 4-9. Influent and Effluent Soluble COD During Phase 3 Testing



As can be seen in Figures 4-8 and 4-9, the inlet COD concentrations varied widely during Phase 3. Because of this, the data was evaluated for the overall period and then separately for the higher concentration period (Phase 3a) and lower concentration period (Phase 3b). The results for COD and suspended solids for Phase 3 are presented in Table 4-6. During Phase 3, bicarbonate powder was added directly to the MFT feed tank to eliminate any dilution.

Table 4-6. Phase 3 Overall Results for COD, sCOD, TSS and VSS

Parameter	Units	Influent	Effluent	% Removal
COD	mg/L	7,717	2,231	71.1
sCOD	mg/L	5,399	1,639	69.6
TSS	mg/L	1,701	733	56.9
VSS	mg/L	1,410	438	68.6
OLR	kg COD/m^3-d	17.1		

The COD removal efficiency averaged 71% and sCOD removal efficiency averaged 70%. Considering that the majority of COD is likely associated with the process wastewater, this represents a relatively high efficiency for the degradable fraction of the COD for the mixture. For example, if it is assumed that the DAF treated portion of the mixture associated with the high-strength waste had a COD of 30,000 mg/L (29,100 mg/L was the Phase 2 average), and the process wastewater had a COD of 6,000 mg/L after DAF, the composite would be 7,440 mg/L, with 76% of the COD from the process wastewater. The degradable fractions for the high-strength waste and the process wastewater from the characterization study BMP testing were 96.6% and 66.2%, respectively. The composite of the two can be calculated to be approximately 73.5% degradable using the above scenario. This agrees well with the 71% observed removal efficiency achieved.

Unlike Phase 2 testing, where TSS and VSS increased due to the high COD concentrations and associated biomass growth, a significant reduction in both TSS and VSS was observed during Phase 3 testing: 57% and 69%, respectively. The ratio of VSS to TSS changed from 0.83 in the influent to 0.60 in the effluent. This indicates that some of the effluent TSS was mineral in nature (i.e. precipitated P species).

Results for Phase 3A Evaluation Period

From November 22 to 25, 2006, the post-DAF mixed wastewater had a COD concentration that was more than double the typical levels. To evaluate whether or not the system could handle a concentration spike, the flow rate was maintained at a more-or-less constant rate; the hydraulic retention time (HRT) was 14.1 hours versus 12.9 hours overall, which led to an increased average OLR of 23.5 kg COD/m^3-d. Results for this evaluation period are presented in Table 4-7.

Table 4-7. Phase 3A Results for COD, sCOD, TSS and VSS

Parameter	Units	Influent	Effluent	Removal
COD	mg/L	13,708	3,185	76.8%
sCOD	mg/L	9,417	2,452	74.0%
TSS	mg/L	3,251	856	73.7%
VSS	mg/L	2,703	439	83.8%
OLR	kg COD/m^3-d	23.5		

Despite the high OLR and low temperature (averaged 88°F), removal efficiencies were quite high, averaging 76.8% and 74.0% for COD and sCOD, respectively. The TSS and VSS removal averaged 73.7% and 83.8%, respectively. No analyses were performed for BOD_5 or nutrients during this period.

Results for Phase 3B Evaluation Period

From November 27 to December 1, 2006, the COD and sCOD concentrations were considerably lower than typical levels. These results, along with TSS and VSS data, are presented in Table 4-8. Note the OLR averaged 15.6 kg COD/m^3-d and the HRT was 10.5 hours. The average temperature was 96°F.

Table 4-8. Phase 3B results for COD, sCOD, TSS and VSS

Parameter	Units	Influent	Effluent	Removal
COD	mg/L	5,574	2,032	63.5%
sCOD	mg/L	4,181	1,756	58.0%
TSS	mg/L	1,286	663	48.4%
VSS	mg/L	1,026	390	62.0%
OLR	kg COD/m^3-d	15.6		

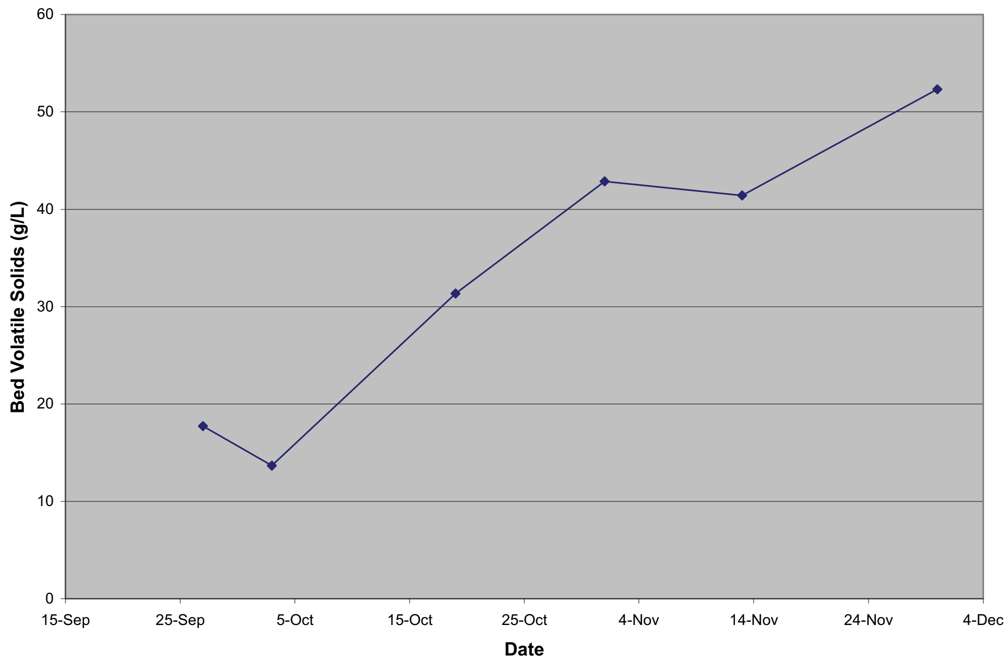
The reduction in COD and sCOD averaged 63.5% and 58%, respectively. The initial BMP testing conducted on the process wastewater indicated that the degradable fraction was 66.2%. The TSS and VSS concentrations during Phase 3B were reduced by 48% and 62%, respectively.

Samples were collected for BOD_5 analyses on the final three days of the period. Unfortunately errors were made at the contract laboratory and no data are available for the influent BOD_5. The effluent BOD_5 and effluent soluble BOD_5 concentrations averaged 253 mg/L (240, <200, 320) and 108 mg/L (84, 120, 120), respectively. This represents a significant reduction in what would be the loading from HP Hood on the Oneida WWTP if anaerobic pretreatment were to be installed.

BED VOLATILE SOLIDS (BVS)

The BVS, a measure of the active biomass in the reactor, were analyzed over the course of the study. The increase in BVS over time is presented in Figure 4-10 for samples taken at the six-foot level in the MFT reactor (measured from the bottom of the bed up). The BVS increased dramatically during the study from approximately 16 g/L to over 50 g/L in the two month period. Samples were also taken at the four-foot level near the end of the study, which averaged between 30 and 40 g/L. The total biomass in the MFT was estimated to be 5.82 kilograms at the start. This increased to 12.15 kilograms by the end of November, which represents a more than doubling of the biomass in the system. Since the biomass levels in the MFT continued to increase over the course of the pilot testing, results generated in the earlier phases have to be considered conservative since they were generated with lower biomass levels. This indicates that the “trickle and bump” flow scheme was effective in increasing biomass in the MFT system.

Figure 4-10. Bed Volatile Solids (BVS) over Time



SUMMARY

Phase 2

High-strength waste DAF subnatant can be effectively treated in a high rate MFT reactor. During the Phase 2 evaluation period, COD removal efficiency averaged 82.9% and sCOD removal efficiency averaged 87.8%, at an average applied OLR of 23.7 kg COD/m^3-d. The corresponding total and soluble BOD_5 removal efficiencies were 88.6% and 95.5%, respectively. On four occasions, the OLR was greater than 30 kg COD/m^3-d, with a peak day of 47.5 kg COD/m^3-d on October 23, 2006. These high spike loading rates resulted in the COD removal efficiency decreasing for that day, but no long-term reduction in removal was observed. When the OLR returned to the normal range, removal efficiencies returned to normal levels. The effect of applied OLR versus removal efficiency for COD and sCOD are presented in Figure 4-11 and Figure 4-12, respectively. Based on the data developed, a conservative OLR for the high-strength waste would be on the order of 20 kg COD/m^3-d.

Phase 3

During the Phase 3 evaluation period, removal efficiencies averaged 71%. During the period when the COD was quite high, averaging 13,700 mg/L after DAF pretreatment, the removal efficiency averaged just below 77% at an OLR of 23.5 kg COD/m^3-d. When the COD was lower, 5,570 mg/L, the removal efficiency averaged 63.5%; the OLR during this period was 15.6 kg COD/m^3-d. Effluent BOD_5 averaged 250 mg/L during this period and $sBOD_5$ averaged 110 mg/L. The effluent TSS averaged 663 mg/L, a 48%

decrease from the influent TSS, indicating a significant fraction of the influent TSS were degraded during anaerobic treatment. Overall results indicate that a combined high-strength waste and process wastewater stream can be effectively treated in a high-rate MFT at a reasonable OLR. This would significantly reduce the overall loading on the Oneida WWTP, while concurrently generating significant biogas that could be used to generate electricity.

Figure 4-11. Scatter Plot of COD Removal Efficiency vs. Applied OLR for Phase 2 Testing

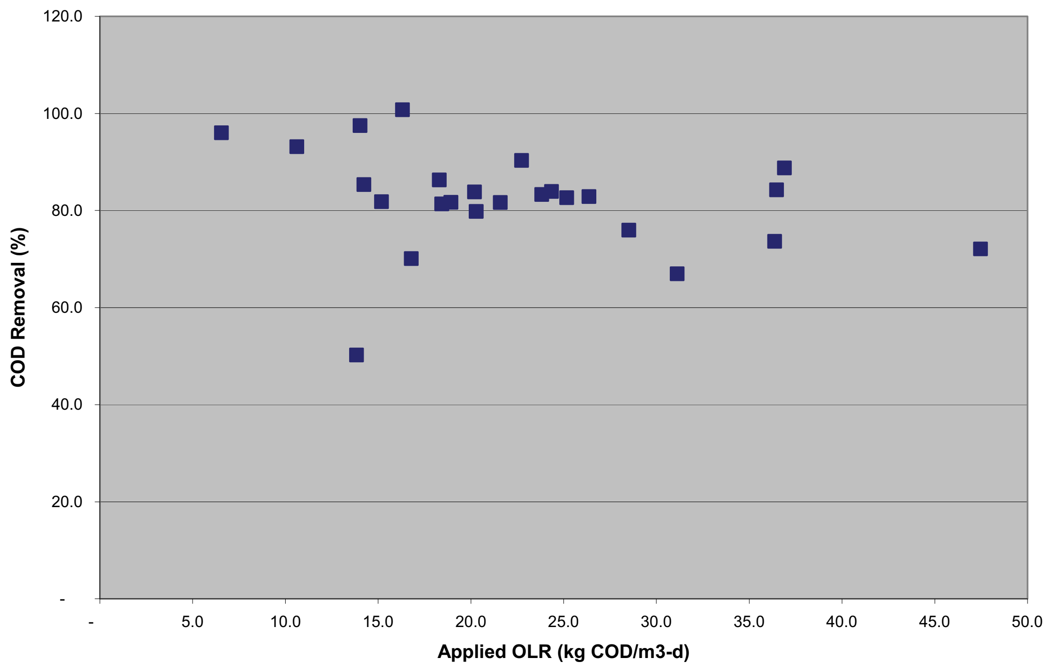
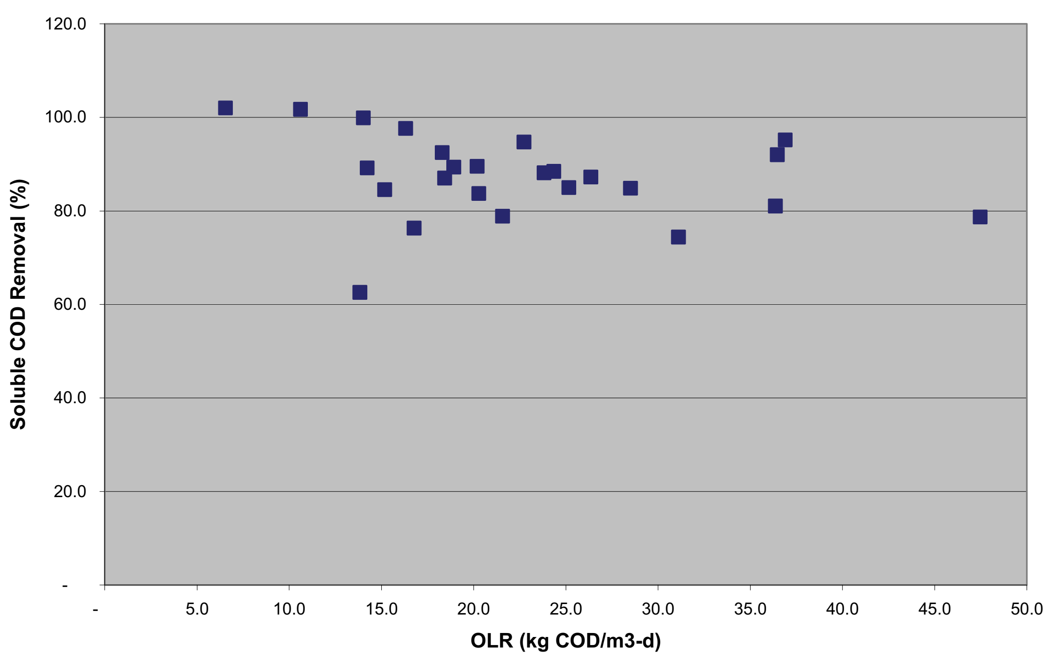


Figure 4-12. Scatter Plot of Soluble COD vs. OLR for Phase 2 Testing

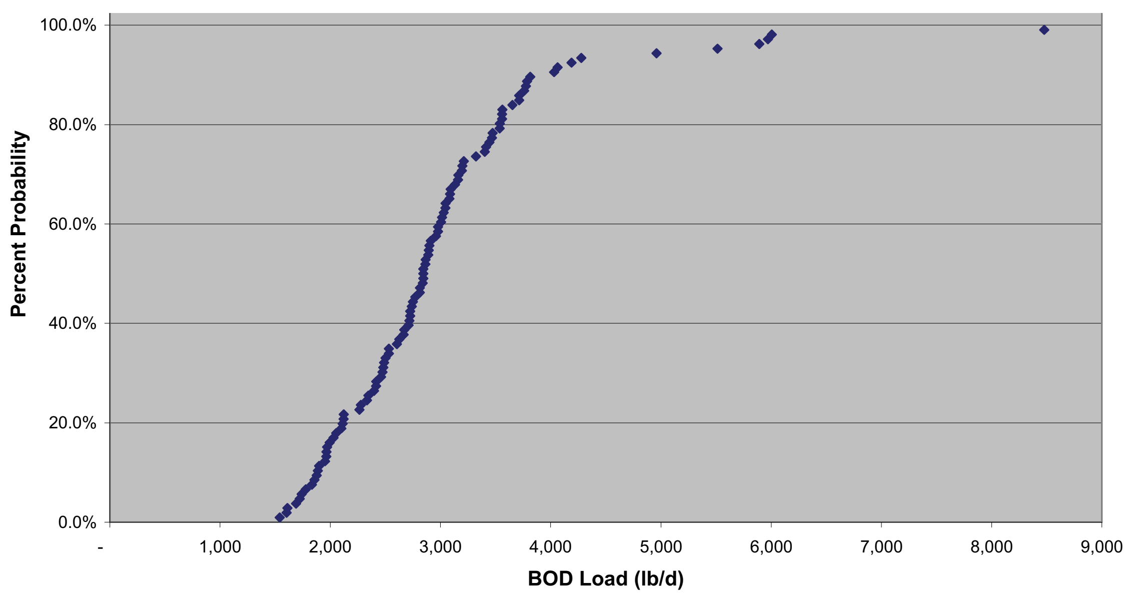


Section 5
FULL-SCALE BASIS OF DESIGN

DEVELOPMENT OF COD MASS LOADING BASIS OF DESIGN

Weekly BOD_5 data of the process wastewater collected over a 105 week period were evaluated. A probability plot of the data is shown in Figure 5-1. The 95th percentile BOD_5 loading was selected as the basis of design for a full-scale system, which is 5,348 lb BOD_5/d. This was converted to COD using a BOD_5/COD ratio of 0.5 (typical for dairy wastewater and observed during the pilot study), which results in a maximum COD design load of 10,696 lb/d. The average BOD_5 loading rate was 2,990 lb/d, which translates to 5,980 lb COD/d for average loading rate from the process wastewater. The average and maximum flow rates were 194,000 gpd and 233,000 gpd, respectively.

Figure 5-1. Probability Plot of BOD_5 in Process Wastewater



Weekly high-strength waste data collected from December 2004 through March 2006 were evaluated. The average flow rate, based on flow averaging for 7 days-per-week, was 76,500 lb/d or 9,170 gpd (calculated at 8.34 lbs per gallon). The 95^{th} percentile was approximately 12,000 gpd. The COD of the post-DAF high-strength waste was 30,000 mg/L. This results in 3,000 lb COD/d contribution from the high-strength waste at the 95^{th} percentile and 2,300 lb COD/d at the average loading condition.

Combining the two streams, the maximum total OLR to the anaerobic MFT would be 13,700 lb COD/d. Based on a total flow of 212,000 gpd, the resulting COD concentration is 7,750 mg/L. Note: The average COD measured during Phase 3 was 7,717 mg/L, which includes the four days of very high COD observed around Thanksgiving. The average after that period (Phase 3B) was 5,770 mg/L. The average loading rate comes out to 8,280 lb COD/d, or 60% of the maximum loading rate. Therefore, an average and maximum

OLR of 15 kg COD/m^3-d and 25 kg COD/m^3-d, respectively, were selected for the full-scale basis of design (for a combined process wastewater/high-strength waste stream).

Note: The COD mass loadings presented herein are somewhat conservative in that the loss of COD in the process wastewater from DAF pretreatment was not taken into account. This is minor, and accounts for approximately 5 to 10% of the load associated with the process wastewater.

Mass Loading with the Inclusion of Whey Permeate from HP Hood's Vernon Facility

HP Hood also wanted to consider the case where 6,000 gallons of whey permeate from the Vernon facility would be trucked to the Oneida treatment plant and treated in the MFT. During the course of the study, three samples of whey permeate and two samples of skim permeate were analyzed for COD, sCOD, TSS, and VSS. The COD averaged 50,440 mg/L, while the sCOD averaged 49,460 mg/L. One load per week of this material would increase the total load to the MFT system by 361 lb/d assuming the permeate is held in a storage tank and metered into the system over the course of the week. Note: Ecovation has considerable experience treating whey permeate including a full-scale system at Breyers Yogurt Company in North Lawrence, NY. Removal efficiencies of approximately 95% are typical. It was calculated that addition of the whey permeate would increase the average and maximum OLR to 8,540 lb COD/d and 14,060 lb COD/d, respectively.

EXPECTED BIOGAS PRODUCTION

Based on the pilot test results, a COD removal efficiency of 71% is assumed for the combination of the high-strength waste and process wastewater and 95% for the whey permeate. Using this assumption, the total COD available for conversion to biogas would be 6,139 lb/d. At a methane yield of 5.6 scf/lb COD, this translates into 33 million BTU (MMBTU)/d.

In addition to biogas generated by the MFT reactor, considerable energy could be recovered from digestion of the DAF float. Using a conservative influent average of the high-strength waste to the DAF unit of 124,250 mg COD /L and an effluent subnatant COD of 35,170 mg/L, removal of COD in the DAF was calculated at 71.7%. Therefore, the total COD of the float removed from the DAF system and sent directly to the anaerobic digesters would be 8,916 lb/d (based on 12,435 lb/d COD at a flowrate of 12,000 gpd). Assuming 95% conversion of this highly degradable material, the amount of methane generated would be an additional 47,430 scf/d or 45.54 MMBTU/d.

The combined total of methane generated would be 81,810 scf/d or 78.5 MMBTU/d. At a 28% conversion efficiency, this translates to 6,443 kwh/d of electricity potential. If a 250 generator were installed by the WWTP (the amount of gas generated could support a 268 kW generator, but these are not commercially available), 6,000 kWh/d of electricity could be produced, which, at a unit price of $0.12/kWh, translates to $262,800 per year.

APPENDIX A
Oneida-Hood Pilot - MFT Daily Log

Date	Time	Trickle Rate (gpm)	Trickle Total (gal)	Bump Rate (gpm)	Bump Total (gal)	MFT INFLUENT PCT: Flow VOL (gal)	Temp (F)	pH (SU)	EC (mS/cm)	TCOD (mg/Ll)	EPA 405.1 TBOD (mg/L)	SCOD (mg/L)	EPA 351.3 TKN (mg/L)	$NH3\text{-}N_F$ (mg/L)	EPA 365.3 TP (mg/L)	OP (mg/L)	TSS (mg/L)	VSS (mg/L)	CHEMICALS ADDED: Alk NaHCO3 (gal)	Alk NaHCO3 (#/gal)	Micros Solution (g)
09/05/06	9:00					120	70	8.38		33		2					56			0.10	0
09/06/06	9:00					60	70	8.50		173		108					58			0.10	0
09/07/06	9:30					60	70	7.89		422		183					158			0.10	0
09/08/06	9:00					60	70	8.41		107		40					48			0.10	0
09/09/06	9:00					0	70	4.14		6,720		2,620									0
09/11/06	9:00					0	70	6.15		6,310		1,840					930				26
09/12/06	10:00					0	70	3.99		30,000		14,430					21100		10.0	0.10	0
09/13/06	8:00					0	70	3.92		16,200		11,200					19000		8.0	0.20	0
09/14/06	10:00					60	70	3.78	4.89	19,200		18,100							12.0	0.20	26
09/15/06	9:00					0	70	3.81	4.31	17,700		14,900					2160		15.0	0.20	0
09/16/06	8:30					0	70	3.89		17,600		14,900					787		15.0	0.50	0
09/18/06	9:30					120	70	4.30	3.22	13,900		9,200					1520		10.0	0.50	26
09/19/06	10:00					75	70	4.25	3.11	12,600		8,100					1660		14.0	0.50	0
09/20/06	10:00					110	70	4.27		13,600		9,800					1100		12.0	0.50	26
09/21/06	9:00					100	70	4.35	3.58	12,300		9,800					1220		14.0	0.50	0
09/22/06	9:00					0	70	4.19		13,200		9,200					1310		12.0	0.50	26
09/23/06	9:30					75	70	4.23	2.86	10,400		7,700					1380		10.0	0.50	0
09/24/06	15:00					75	70	4.22	5.76	25,900		25,500					1240	1130	0.0	0.50	0
09/25/06	9:00					45	70	3.96	6.60	29,700		26,100					1340	1240	11.0	0.50	0
09/27/06	9:30					85	70	3.83	6.54	30,600		30,600					1790	1420	13.0	0.60	0
09/28/06	9:30					50	70	3.76	6.67	31,400		26,300					1720	1490	13.0	0.60	26
09/29/06	9:30					50	63	3.69	5.78	26,100		26,100					1730	1600	12.0	0.60	0
09/30/06	9:30	6.70	123064	8.10	121423	59	65	3.54	5.78	24,700		23,600					1810	1620	12.0	0.60	26
10/02/06	9:30	6.79	129366	8.20	127326	30	68	3.55	6.35	32,700		22,800					1960	1750	2.0	0.60	26
10/03/06	9:30	6.22	136422	7.90	130963	53	71	3.40	6.61	24,600	12,720	25,800		21.6	750.0	302.0	2250	2070	12.0	0.60	0
10/04/06	9:00	6.20	143317	7.90	134638	57	70	3.40	6.47	23,600		18,200					1690	1510	10.0	0.60	0
10/05/06	9:00	6.70	150163	7.80	138300	57	69	3.88	5.16	24,700		21,500					1390	1260	10.0	0.60	26
10/06/06	9:30	6.65	157062	7.60	142101	65	60	3.83	4.56	23,400		20,100					1070	910	12.0	0.60	0
10/08/06	13:00	6.10	170252	7.10	149870	122	72	3.44	4.74	22,900		22,900					1190	1060	12.5	0.60	0
10/09/06	9:30	6.40	175618	7.30	153026	49	66	3.44	4.89	21,800		21,800					1350	1110	10.0	0.54	0
10/10/06	9:30	6.10	181713	7.10	156571	65	68	3.29	5.33	25,900	12,210	25,900	532.0	11.0	252.5	242.0	1370	1110	12.0	0.60	26
10/11/06	9:30	2.80	184850	3.80	159900	76	65	3.32	4.64	21,700		19,700					1410	1190	12.0	0.60	0
10/13/06	9:30	3.74	189358	4.57	166808	160	55	3.44	4.55	18,000		14,000					1930	1700	20.0	0.60	26
10/14/06	12:30	3.40	192298	5.20	170464	76	63	3.64	4.78	15,900		14,200					2460	2180	11.0	0.60	0
10/16/06	9:30	4.62	199355	5.71	177372	114	67	4.23	4.79	29,500		29,500					980	980	20.0	0.60	0
10/17/06	10:00	4.51	203059	5.51	181132	61	60	4.08	5.19	31,100	12,270	31,100		15.0	300.0	281.0	890	830	10.0	0.60	26
10/18/06	10:00	4.80	206651	5.90	184893	27	62	3.96	4.97	30,400		28,000					1040	990	2.0	0.60	0
10/19/06	9:00	4.05	209648	4.95	188524	72	63	3.95	5.14	28,100		26,400					1120	1045	4.0	0.60	0
10/20/06	9:30	4.28	212159	4.86	191989	72	57	3.72	4.78	25,800		22,900					1190	1040	5.0	0.60	26
10/21/06	10:30	3.81	214858	4.50	195941	70	55	3.80	4.99	26,000		25,400					1210	1120	7.5	0.60	0
10/23/06	9:30	3.50	218829	4.22	202079	196	51	3.55	11.09	28,200		28,000					1830	1610	3.5	0.60	26
10/24/06	9:30	3.17	221074	3.86	205714	110	53	4.02	5.23	25,900		25,200	504.0	4.0	350.0	288.0	940	790	10.0	0.60	0
10/25/06	9:00	3.15	223296	3.87	209371	122	51	4.05	4.25	25,600		24,700					1210	1080	13.0	0.60	26
10/26/06	9:30	3.13	225925	3.75	213171	129	52	3.98	4.73	25,900		20,900					1470	1280	13.0	0.60	0
10/27/06	10:00	3.97	229063	5.22	216945	68	58	4.04	4.53	31,900	13,000	31,900					1660	1500	10.0	0.60	0
10/28/06	10:00	3.66	231684	4.48	220659	118	56	4.02	3.95	21,900		18,500					1950	1690	12.5	0.60	0
10/30/06	8:45	3.44	236625	4.20	228066	194	57	4.05	4.80	24,100		20,000					2460	2280	21.0	0.60	26
10/31/06	7:30	3.34	239282	4.30	231635	106	56	4.00	4.87	29,500	17,000	29,200	616.0	27.0	312.5	284.0	1890	1700	9.0	0.60	0
11/01/06	8:00	3.67	242036	4.90	235395	118	69	3.90	5.10	33,800		29,200					2150	1950	12.5	0.60	0
11/02/06	9:00	3.06	244528	3.60	239272	61	59	6.80	9.50	33,500	18,000	31,200					3830	2680	13.0	0.60	26
11/03/06	9:00	3.28	247276	4.38	243035	76	48	6.15	14.24	38,500		27,400					2780	2350	12.0	0.60	0
11/04/06	9:30	3.25	249507	4.30	246815	76	52	4.40	12.88	34,300		31,400					1070	940	13.0	0.60	0

APPENDIX A
Oneida-Hood Pilot - MFT Daily Log

						MFT INFLUENT PCT													CHEMICALS ADDED		
		Trickle		Bump		Flow	Temp				EPA 405.1		EPA 351.3		EPA 365.3				Alk		Micros
Date	Time	Rate	Total	Rate	Total	VOL		pH	EC	TCOD	TBOD	SCOD	TKN	NH_3-N_F	TP	OP	TSS	VSS	NaHCO3		Solution
		(gpm)	(gal)	(gpm)	(gal)	(gal)	(F)	(SU)	(mS/cm)	(mg/Ll)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(gal)	(#/gal)	(g)
11/06/06	9:30	2.80	253507	3.80	254136	152	60	4.12	4.85	32,700		31,600					940	850	25.0	0.60	26
11/07/06	8:00	3.76	255922	4.60	257740	91	60	3.93	4.78	33,500	24,000	33,500		19.0	400.0	281.0	1260	1150	10.0	0.60	0
11/08/06	9:00	3.25	258413	4.00	261624	84	62	3.97	4.72	31,900		27,900					1670	1400	11.0	0.60	26
11/09/06	9:00	3.38	261080	4.00	265326	84	65	3.77	4.88	28,600		24,500					2200	2040	10.0	0.50	0
11/10/06	9:00	3.22	263339	3.91	269089	84	62	3.90	3.55	28,400		27,300					1010	900	10.0	0.50	26
11/11/06	9:45	6.43	266127	7.50	272885	114	64	3.61	3.71	31,000		28,600					910	580	9.0	0.50	0
11/13/06	8:45	6.58	271249	7.68	280183	179	59	3.65	3.52	26,400	10,000	26,800					1450	1240	19.0	0.50	0
11/14/06	8:45	3.34	273884	4.00	283912	57	60	3.78	3.60	24,750		22,600					2150	1970	8.0	0.50	0
11/15/06	9:30	3.53	276311	4.30	287710	129	59	6.85	5.02	8,300		4,090			55.4	18.8	815	770	8.5	0.50	26
11/16/06	9:00	3.47	278670	4.20	291409	312	63	7.43	5.09	8,500		7,400					1180	990	1.5	0.50	0
11/17/06	9:00	3.57	280976	4.30	295051	327	63	7.60	5.44	6,090		5,410					1220	990	2.0	0.50	26
11/18/06	7:30	3.42	281481	4.20	295830	76	56	7.72	5.98	6,270		4,160					1140	970	0.0	0.50	0
11/19/06	13:00	3.61	284513	4.50	300456	426	56	7.46	3.85	4,200		2,930					970	870	0.0	0.50	0
11/20/06	8:00	3.60	286461	4.45	303427	304	49	8.08	3.92	4,180		2,380					1300	1120	4.0	0.50	0
11/21/06	8:00	4.00	289623	4.96	307216	372	48	8.28	7.50	3,230		1,430					1160	910	7.0	0.50	26
11/22/06	8:30	3.82	292715	4.99	310926	228	51	6.64	6.46	13,480		9,560					2980	2550	5.0	0.50	0
11/23/06	9:30	3.79	295480	4.98	314948	175	51	7.02	6.36	13,940		9,920		6.0		118.0	3200	2760	8.0	0.50	26
11/24/06	9:30	3.69	297982	4.79	318682	182	53	7.10	6.37	13,650		9,250					3200	2800	0.0	0.50	0
11/25/06	11:00	3.81	301078	4.97	322725	198	57	7.46	7.50	13,760		8,937					3625	2700	0.0	0.50	26
11/27/06	8:30	6.71	305940	7.81	329914	410	57	7.55	5.70	7,720		5,400					1480	1210	0.0	0.50	26
11/28/06	9:00	3.81	308804	4.97	333786	304	62	8.00	6.93	6,590		6,420	420.0	9.0	100.0	44.0	1560	1220	0.0	0.50	0
11/29/06	8:45	3.92	311689	4.98	337531	106	62	8.07	6.01	4,330		3,150					1130	900	0.0	0.50	0
11/30/06	8:30	3.81	314529	4.99	341348	445	66	7.80	5.30	5,130		3,230					1360	1060	0.0	0.50	26
12/01/06	10:30	3.79	317500	4.98	345467	524	60	8.05	5.88	4,100		2,720					900	740	6.0	0.50	0
12/02/06	9:30	6.91	318201	7.97	346391	160	53	7.93	5.30	3,760		2,290					900	800	0.0	0.50	0
12/03/06	10:15	3.65	321147	4.95	350254	494	51	8.11	5.49	4,630		2,850					1470	1230	0.0	0.50	26
12/04/06	9:00	3.98	323912	4.97	353850	555	44	7.72	2.85	4,120		2,240					1250	1080	0.0	0.50	0
12/05/06	7:30	4.05	326807	4.99	357490	502	40	8.04	3.31	3,290		2,050		6.0		37.0			0.0	0.50	0

APPENDIX A
Oneida-Hood Pilot - MFT Daily Log

		MFT EFFLUENT																	BIOGAS			MFT BED		
				4.5, 3.3 w/H2SO4, 4.0, 5.1 w/ NaOH Alk, VFA Titrations						EPA 405.1		EPA 405.1	EPA 351.3		EPA 365.3						Meter Cum Gas			
Date	Time	Temp (F)	pH (SU)	4.50 (mg/L)	3.30 (mg/L)	4.00 (mL to endpt)	5.10 (mL to endpt)	EC (mS/cm)	TCOD (mg/L)	TBOD (mg/L)	SCOD (mg/L)	SBOD (mg/L)	TKN (mg/L)	$NH3-N_F$ (mg/L)	TP (mg/L)	OP (mg/L)	TSS (mg/L)	VSS (mg/L)	Temp (F)	CO2 (%)	Vol (l)	Attach VS (g-VS/L)	Att+Ent VS (g-VS/L)	Height (ft)
09/05/06	9:00	95	7.75	510					85		55						60							
09/06/06	9:00	95	8.57	1160					166		92						44							
09/07/06	9:30	95	7.68	1020					164		96						118							
09/08/06	9:00	95	7.60	980					110		41						66							
09/09/06	9:00	95	6.51	790					1,590		890													
09/11/06	9:00	95	6.46	940					3,630		1710						710							
09/12/06	10:00	95	6.51	1260					3,950		1350						930							
09/13/06	8:00	95	6.86	1580				5.60	2,940		680						890							
09/14/06	10:00	95	6.17	1840				7.94	7,120		1840						124							
09/15/06	9:00	95	6.91	5440				8.48	6,080		4130						1230							
09/16/06	8:30	95	7.19	4580					4,390		3480						2030							
09/18/06	9:30	95	7.20	5200				14.26	5,160		4580						680							
09/19/06	10:00	95	6.98	4620				12.99	6,460		4940						1040		65	50				
09/20/06	10:00	95	6.94	4160					6,910		5350						1200							
09/21/06	9:00	95	6.91	4080				13.09	7,180		6070						1450		65	55				
09/22/06	9:00	90	7.47	3460					4,540		3920						900		65	23				
09/23/06	9:30	90	7.16	1940				15.96	4,560		3540						1420		65	40				
09/24/06	15:00	95	7.09	1020	1180			10.84	4,000		2920						1020		65	34				
09/25/06	9:00	95	6.89	1260	1500			12.89	4,570		4050						700		65	38				
09/27/06	9:30	95	7.15	1520	1760	6.4	28.4	13.20	6,830		5100						2080	1000	65	56	2,970	15.89	17.74	6.00
09/28/06	9:30	93	7.29	1860	2160	8.2	36.2	18.53	8,200		5980						2170	1280	65	56	4,296			
09/29/06	9:30	86	7.19	1820	2280	8.8	40.0	18.20	8,240		7740						2380	1190	50	60	7,167			
09/30/06	9:30	79	6.89	1680	2300	12.6	59.0	17.15	8,950		8140						2540	860	50	60	10,605			
10/02/06	9:30	59	7.36	2020	2300	9.4	36.8	14.82	6,800		6070						1530	940	57	32	14,867			
10/03/06	9:30	86	7.13	2080	2440	11.5	44.5	19.98	8,380	5430	6610		308.0	66.0	500.0	118.0	5300	1760	50	60	16,496			
10/04/06	9:00	90	7.14	2060	2400	9.6	42.9	20.00	7,550		6580						1670	690	57	58	17,656	11.98	13.68	
10/05/06	9:00	85	7.14	2060	2380	8.9	36.9	18.90	6,520		5740						1390	590	50	52	19,442			
10/06/06	9:30	77	7.14	2100	2420	8.0	36.3	17.84	6,060		5510						1410	380	50	54	20,724			
10/08/06	13:00	85	7.07	2260	2480	7.0	28.0	18.23	5,520		5000						2570	360	86	54	21,417			
10/09/06	9:30	83	7.24	2300	2520	5.7	23.0	19.07	5,540		4540						2640	410	50	48	23,295			
10/10/06	9:30	96	7.35	2280	2520	6.4	24.4	19.87	5,470	3045	4790		364.0	117.0	103.8	91.0	1790	350	50	47	23,514			
10/11/06	9:30	95	7.29	2320	2580	6.2	27.1	16.50	6,880		4970						5620	1460	52	52	25,164			
10/13/06	9:30	84	7.25	1920	2120	5.5	23.5	14.78	6,670		4940						2800	1890	50	38	26,538			
10/14/06	12:30	79	6.95	1700	1920	6.2	28.5	17.62	6,390		4580						4060	2440	64	0	26,668			
10/16/06	9:30	75	7.36					14.61											68	22				
10/17/06	10:00	61	6.97	1960	2280	9.0	39.0	15.64	8,580	4480	6450			76.0	150.0	120.0	3280	1960	68	46				
10/18/06	10:00	95	7.45	2500	2820	7.9	35.9	18.62	7,350		4620						3538	2169	68	47	1,291			
10/19/06	9:00	98	7.11	2640	3100	5.7	25.5	17.81	6,180		4490						2960	1780	68	45	3,322		31.34	6.00
10/20/06	9:30	97	7.14	3280	3720	4.5	20.5	15.82	4,980		3700						6480	1620	50	40	3,218			
10/21/06	10:30	97	7.22	3540	3900	2.9	11.2	15.69	3,990		2910						2400	1360	49	42	3,187			
10/23/06	9:30	96	6.83	2120	2440	4.4	17.2	19.50	5,610		4240						2180	1470	41	42	4,018			
10/24/06	9:30	97	6.96	2140	2460	3.5	14.6	19.76	4,870		3340		364.0	53.0	150.0	81.0	1500	990	40	40	4,812			
10/25/06	9:00	97	7.07	2720	3040	3.5	13.2	13.53	3,930		2710						1790	1150	43	42	5,348			
10/26/06	9:30	98	7.10	2860	3140	2.2	11.2	13.45	3,890		2450						1320	990	44	42	5,269			
10/27/06	10:00	98	7.46	3800	4000	2.4	5.7	11.45	2,340	590	1990	350					3510	900	48	26	1,468			
10/28/06	10:00	97	7.24	3680	3840	2.3	7.8	16.51	2,560		1540						1620	780	46	40	4,158			
10/30/06	8:45	97	7.12	3300	3440	1.8	5.5	15.15	2,770		1260						1780	1280	49	42	10,792			
10/31/06	7:30	98	6.93	2600	2960	4.4	16.2	9.76	4,810	1900	3440	1300	448.0	12.0	137.5	67.0	2220	1500	48	56	6,477			
11/01/06	8:00	98	6.75	2640	3360	8.5	30.0	13.30	8,090		5480						4090	1950	53	54	7,221		31.53	6.67
11/02/06	9:00	97	7.26	4320	4620	4.9	14.8	15.05	5,710	2500	3590	440					6000	2510	49	36	3,747			
11/03/06	9:00	97	7.34	5060	5400	3.4	13.5	39.50	5,490		4200						10600	3140	34	38	3,300			
11/04/06	9:30	98	7.22	5060	5440	4.5	16.2	40.00	5,310		3250						4220	2470	45	44	3,447			

APPENDIX A
Oneida-Hood Pilot - MFT Daily Log

Date	Time	MFT EFFLUENT Temp (F)	pH (SU)	Alk, VFA Titrations (4.5, 3.3 w/H2SO4, 4.0, 5.1 w/ NaOH) 4.50 (mg/L)	3.30 (mg/L)	4.00 (mL to endpt)	5.10 (mL to endpt)	EC (mS/cm)	TCOD (mg/L)	EPA 405.1 TBOD (mg/L)	SCOD (mg/L)	EPA 405.1 SBOD (mg/L)	EPA 351.3 TKN (mg/L)	$NH3\text{-}N_F$ (mg/L)	EPA 365.3 TP (mg/L)	OP (mg/L)	TSS (mg/L)	VSS (mg/L)	BIOGAS Temp (F)	CO2 (%)	Meter Cum Gas Vol (l)	MFT BED Attach VS (g-VS/L)	Att+Ent VS (g-VS/L)	Height (ft)
11/06/06	9:30	97	7.18	6500	7140	5.1	20.5	13.02	5,670		3870						3640	2020	48	42	7,661			
11/07/06	8:00	98	7.13	6000	6800	6.7	27.3	12.47	6,490	2900	4520	1200		29.0	240.0	83.0	3660	2180	46	43	4,389			
11/08/06	9:00	98	7.22	6100	6820	5.6	23.0	13.55	6,100		4280						3660	1840	49	38	4,522			
11/09/06	9:00	98	7.24	5700	6120	3.9	14.0	11.36	5,170		3300						4260	1920	51	36	3,933			
11/10/06	9:00	97	7.18	5580	5940	3.0	10.9	12.36	4,020		2310						2650	1670	46	40	3,601			
11/11/06	9:45	98	7.14	4160	4640	4.0	16.0	8.74	5,550		3220						2940	1950	58	44	4,532			
11/13/06	8:45	98	7.14	4200	4420	2.1	6.8	8.42	2,950	560	1460	240					2380	1340	40	38	8,371		34.76	6.75
11/14/06	8:45	95	7.11	4800	5040			9.08	4,080		1320						3770	1100	48	38	2,055			
11/15/06	9:30	98	7.38	4520	4700	2.3	6.0	9.32	1,970		1370				50.5	19.7	910	560	47	23	1,351			
11/16/06	9:00	97	7.15	2840	3000	1.7	4.4	6.62	1,880		1320						620	440	57	22	2,480			
11/17/06	9:00	97	7.23	3100	3260	1.7	4.1	7.01	1,570		1120						780	620	48	16	2,350			
11/18/06	7:30	98	7.17	3680	3880	2.2	5.8	7.13	2,540		1300						700	480	39	20	548			
11/19/06	13:00	90	7.17	1820	1920	1.1	2.7	5.26	1,770		880						570	465	37	10	1,315			
11/20/06	8:00	90	7.19	2140	2260	1.2	2.8	5.31	1,430		880						715	455	36	10	461			
11/21/06	8:00	87	7.31	3460	3600	1.4	3.1	8.22	1,630		766						700	360	36	8	107			
11/22/06	8:30	81	6.90	3440	4480	3.6	13.6	8.01	3,560		2650						1120	530	29	34	747			
11/23/06	9:30	86	7.22	4100	4360	2.6	8.1	8.95	2,780		1620			36.0		81.0	780	440	33	26	2,165			
11/24/06	9:30	89	7.20	3660	3840	1.8	5.2	8.03	3,260		2540						730	410	40	22	2,243			
11/25/06	11:00	95	7.29	3840	4040	1.7	3.8	8.24	3,141		2997						794	375	47	26	2,063			
11/27/06	8:30	97	7.23	3300	3480	1.6	3.3	8.01	3,180		2930						730	510	41	22	1,333			
11/28/06	9:00	97	7.39	3780	3960	2.0	4.2	7.73	2,660		2660		280.0	79.0	100.0	75.0	620	440	49	18	1,685			
11/29/06	8:45	97	7.21	1450	3260	1.5	3.4	6.99	1,450		1220						670	430	52	18	581		22.01	6.92
11/30/06	8:30	98	7.21	2820	2980	1.6	3.3	6.25	1,420		940						825	300	60	18	1,788			
12/01/06	10:30	93	7.31	3240	3440	1.4	3.5	7.74	1,450		1030						470	270	44	13	1,883			
12/02/06	9:30	104	7.18	2980	3160	1.8	4.8	6.37	2,020		1250						460	300	36	20	571			
12/03/06	10:15	84	7.23	2860	3020			5.28	1,530		1420						870	420	36	8	665			
12/04/06	9:00	76	7.10	1340	1480			3.49	2,140		1350						910	520	25	10	455			
12/05/06	7:30	74	7.10	1440	1540	0.5	2.5	3.50	2,010		1300			31.0		25.0			24	8	47			

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City of Oneida Mobilized Film Technology Pilot Study Report

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