Report on Piloting of the PWTech Volute Press at the Scarborough Sanitary District, Maine

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PROCESS WASTEWATER TECHNOLOGIES LLC
Process Wastewater Technologies, LLC.
9004 Yellow Brick Road, Suite D, Rosedale, MD21237
Phone: 410-238-7977, Fax: 410-238-7559

Pilot Operator:	Nathan Hovorka
Report Prepared by:	Nathan Hovorka
Manufacturer's Representative:	John Hart, Russell Resources Inc.

Summary

- The Volute Dewatering Press was piloted on blended primary/thickened WAS as well as WAS from a clarifier.

- Cake solids averaged 29.6% and solids capture rates averaged 98.6% using Harcros WWT 3061 polymer between 13.8 – 19.7 lbs/ton on the blended sludge.

- The Volute dewatered the WAS without any operational challenges, producing cake solids averaging 14.1% and capture rates averaging 99.0%

Contents

1. Introduction

PWTech conducted pilot testing of the Volute Dewatering Press, model ES-201, at the Scarborough WWTP in Maine. The pilot unit dewatered a blend of primary sludge and thickened waste activated sludge (TWAS), along with a separate trial of WAS from a clarifier.

The plant treats 1.2 MGD on average, with the treatment process starting at the headworks via screening and grit removal. Wastewater then flows through primary clarifiers followed by aeration basins for biological treatment. Secondary clarifiers remove the RAS/WAS before the effluent is disinfected with sodium hypochlorite and discharged. **Figure 1** outlines the treatment process in Scarborough with the location of the pilot unit.

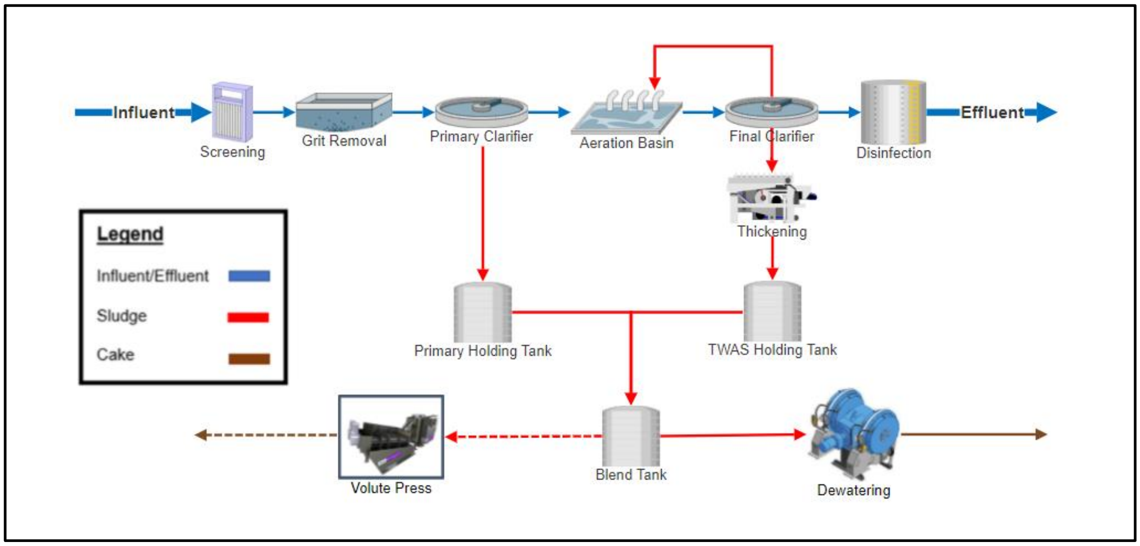

Figure 1: Treatment Process at the Scarborough WWTP

Primary sludge is pumped into a holding tank, and WAS is thickened with a gravity belt thickener and pumped into a separate holding tank before both sludges are blended (70% primary during the pilot) and dewatered with a Fournier fan press at 60GPM for ~20 hours each week. After which, cake solids are hauled to a nearby landfill.

Scarborough is exploring new dewatering technology to improve cake solids and also have the ability to dewater WAS by itself. The option to dewater WAS without thickening would simplify the treatment process and eliminate the need to add polymer twice during sludge treatment. The fan press is not able to dewater WAS without mixing primary sludge, so currently the plant may be limited by the available primary sludge.

PWTech piloted the Volute Press to showcase a simple to operate, low-energy / wash water use alternative that does not sacrifice performance. This report discusses the testing methods used as well as the results achieved during the pilot study.

2. Objective

The objective was to optimize performance on the blended sludge and demonstrate the Volute's ability to dewater WAS without primary sludge addition or thickening.

3. Pilot Set-Up

The trailer mounted Volute, model ES-201, was parked next to the blended sludge holding tank, where a submersible pump was used to supply sludge to the pilot unit. Cake was discharged into a front-end loader and moved to a roll-off dumpster, and filtrate was discharged into a sump tank which pumped to the head of the plant. 480V power and wash water were provided via nearby connections.

During the trial on WAS, a 1,000-gallon tank was periodically filled with sludge from a clarifier and used to refill a 350 gallon tank, so that sludge could be mixed prior to entering the pilot unit (see **Figure 2**).

Figure 2: Sludge supply setup during WAS trial

The ES-201 has a single 8-inch diameter drum with a maximum solids throughput capacity of 120 dry lbs/hour for thick sludge (>3% solids) and a maximum hydraulic capacity of 15 GPM for thin sludge (<1% solids).

4. Testing and Sample Analysis

Following the start-up of the unit, different variables were isolated and altered in order to find the most cost effective and efficient methods of dewatering. The controlled variables were:

- Feed sludge flow rate (and the resulting screw speed)
- Polymer type
- Polymer dose

In order to determine the effectiveness of the unit, samples were taken after an appropriate amount of runtime. Types of samples taken include:

- Cake solids- measured as total residual solids (TS) in weight percent
- Feed solids- measured as total residual solids (TS) in weight percent
- Pressate solids- – measured as total suspended solids (TSS) in mg/L

Feed and cake solids were measured using a moisture analyzer made by Sartorius, which is accurate up to 0.1%. The machine works by recording the initial weight of the sample and heating it at 105 ˚C until the weight of the sample changes less than 1 mg per minute. The total residual solids are calculated as a percent using the equation below:

$$Total\ \%\ Solids = 100 * \left(\frac{A}{B}\right)$$

Where A is the weight of the dry sample and B is the weight of the wet sample.

Pressate samples were collected from the end of the pressate hose, and a TSS analysis was conducted at a local lab. This procedure is best performed in a lab instead of a trailer because vibrations, wind, and other factors affect the accuracy of the test.

Current and voltage readings from each motor were recorded every hour. These were used to calculate the overall power use of the pilot unit, as well as the power use directly related to dewatering.

The polymer system in the trailer was fed the liquid polymer, which was then activated by introducing water. After mixing appropriately, the activated polymer was introduced to the influent sludge inside the mixing tank in order to achieve flocculation.

The polymers tested were:

- Praestol K279 (supplied by PWTech)
- Harcros WWT 3061 (supplied by the plant)

5. Results and Discussion – Blended Sludge

19 sets of samples (referred to as "runs") were collected during the trial on the blended sludge. A comprehensive table containing all of the pilot data can be found in the appendix of this report. The following sections discuss the impact of certain parameters and the results achieved during the pilot.

5.1. Influent Solids

Influent solids from the blended sludge holding tank averaged 3.37%. Diffusers inside the holding tank kept the sludge mixed, which minimized unexpected changes in influent solids and allowed for accurate pilot data to be gathered. **Figure 3** shows the influent solids concentrations for each run during the blended sludge testing.

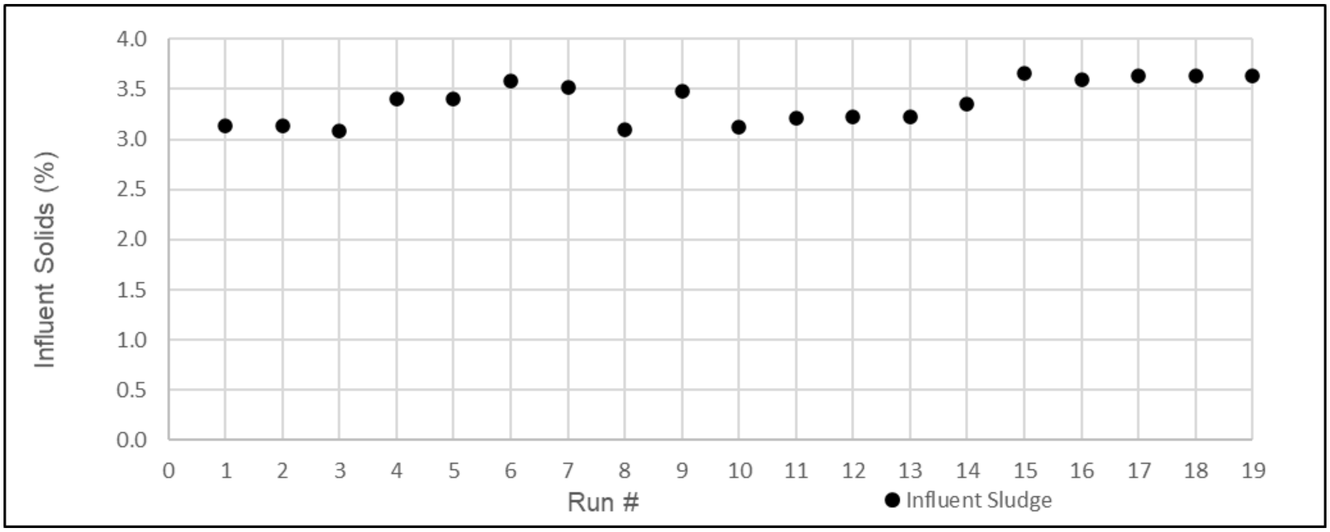

Figure 3: Influent solids concentrations for each run on the blended sludge

5.2. Cake Solids Overview

Cake solids as high as 32.0% were recorded, and cake solids averaged 29.5% excluding runs conducted at low polymer doses. **Figure 4** shows the results of each cake sample taken during this trial.

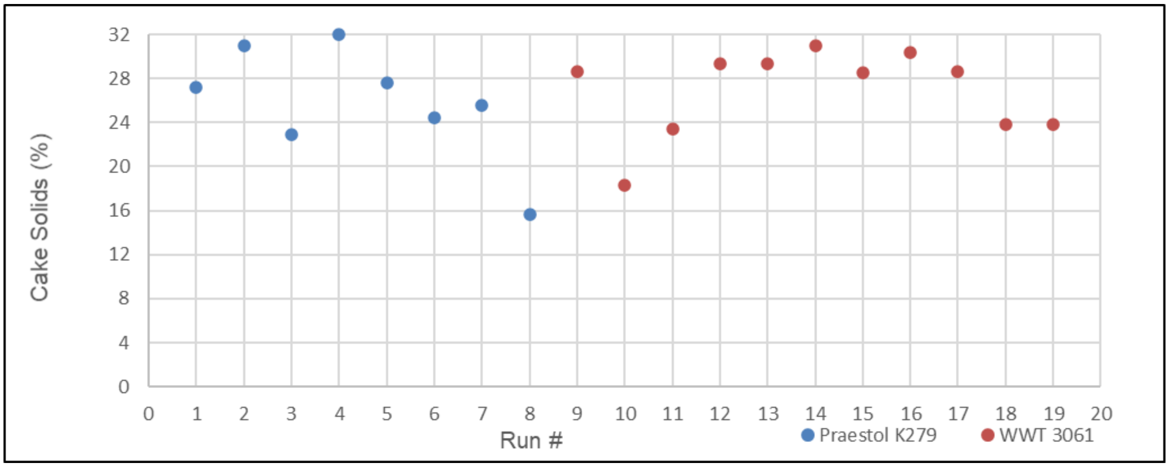

Figure 4: Cake solids results for each run

3 cake samples were taken from the fan press; 31.7%, 28.6%, 28.7%

These cake samples were produced while dosing the fan press between 15.4 – 18.5 lbs/ton.

5.3. Polymer Dosing

Two polymers were tested: Praestol K279 and Harcros WWT 3061. Both polymers were tested across a range of doses to determine the optimal dosing range on this sludge. **Figure 5** displays cake solids results during various doses. Note: each run was conducted while operating between 60-80% of the maximum throughput of the pilot unit.

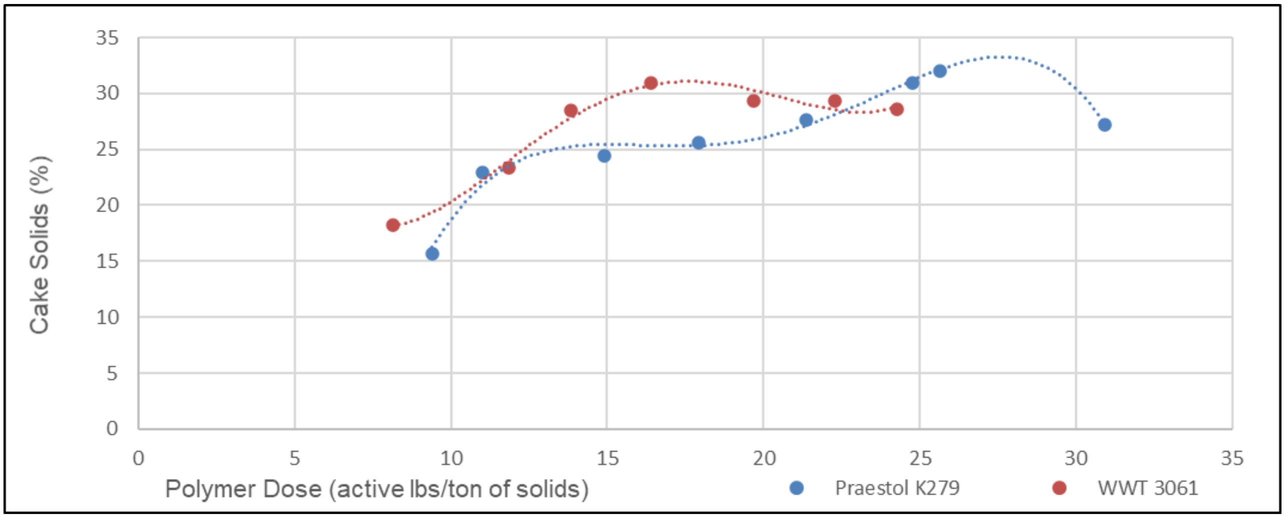

Figure 5: Cake solids vs. Polymer dose

WWT 3061 produced higher cake solids at lower doses compared to Praestol K279. Using WWT 3061, the optimal dosing range was 13.8 – 19.7 lbs/ton, averaging cake solids of 29.6%.

Praestol K279 had a higher dosing range, between 21.4 – 25.6 lbs/ton, averaging cake solids of 30.2%. Above these ranges, excess polymer was present in the filtrate, and below these ranges, solids capture decreased. **Figure 6** shows solids capture rates for these runs, relative to polymer dose.

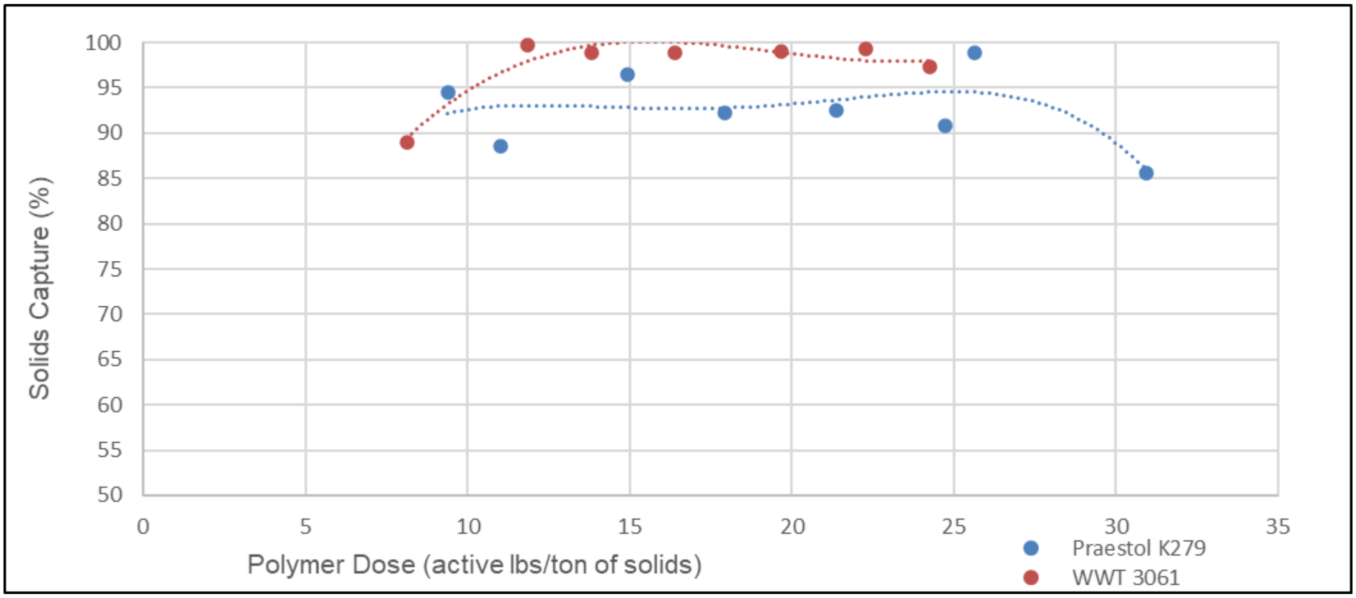

Figure 6: Solids capture rates vs. Polymer dose

Solids capture rates using WWT 3061 between 13.8 – 19.7 lbs/ton averaged 98.9%, which was much higher than 94.1% average with Praestol K279 between 21.4 – 25.6 lbs/ton. Also, the filtrate produced with Praestol K279 had a yellow tint, whereas the filtrate was colorless when using WWT 3061, which further reinforces that WWT 3061 was more effective than Praestol K279.

5.4. Solids Throughput

The pilot unit was operated between 54.0 – 145.6 dry lbs/hour to observe the effects of throughput on cake solids, the results of which can be seen in **Figure 7**. Each run was conducted with WWT 3061 between 15.2 – 16.4 lbs/ton, and the dashed line represents the rated maximum throughput for the pilot unit.

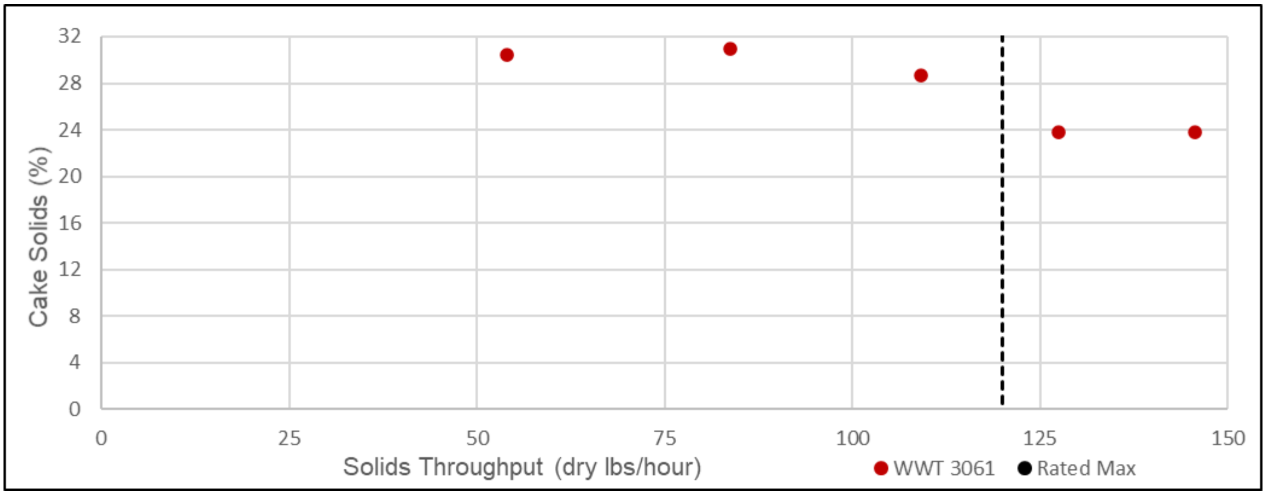

Figure 7: Cake solids vs. Solids throughput

As throughput is increased, the screw must rotate faster to account for more solids. This decreases the amount of time that sludge spends under pressure, which results in lower cake solids at higher throughputs, as seen above.

Cake solids >30% were maintained until the pilot unit was operated at 109 dry lbs/hour (91% capacity) and cake solids of 28.7% were produced. While operating above the rated capacity, cake solids decreased to 23.8%.

5.5. Solids Capture Performance

Including runs conducted at varying throughputs, WWT 3061 produced an average capture rate of 98.6% within the optimal dosing range. The solids capture rates for each run are shown below in **Figure 8**.

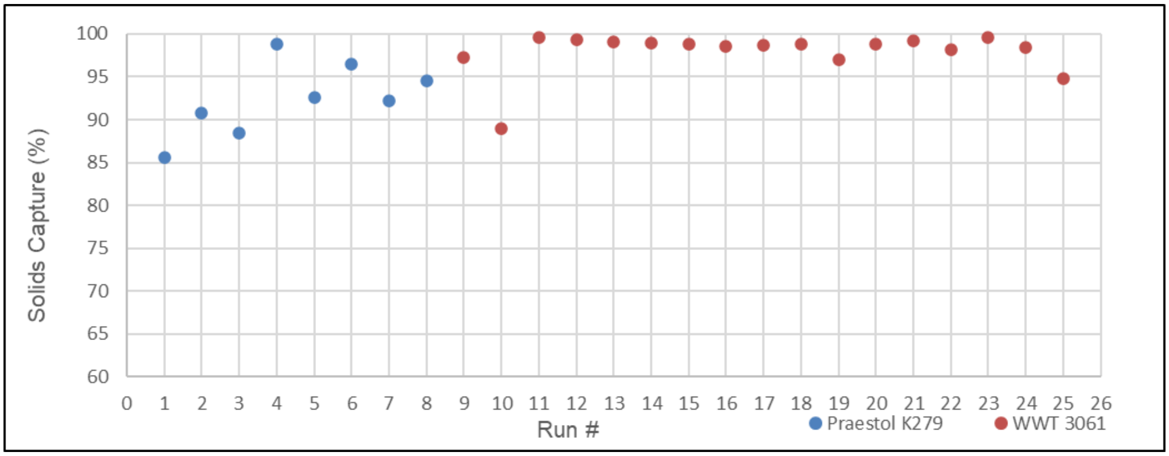

Figure 8: Solids capture rate for each run

A sample of filtrate was taken while the pilot unit underwent a wash cycle to compare the TSS results to the typical grab sample taken between wash cycles. To obtain this sample, a bucket was used to capture the filtrate during the entire length of the wash cycle, and a sample was taken from the bucket. The two results are shown below in **Table 1**.

	TSS (mg/L)
Wash cycle	57
Between wash cycles	110

Table 1: Filtrate sample taken during wash cycle vs. between wash cycles

Although more solids are present in the filtrate during the beginning of the wash cycle, the extra water from the spray bars dilutes the sample. This is why each filtrate sample was taken between wash cycles to achieve an accurate result.

5.6. Power Consumption Analysis

The Volute power use required to dewater solids was monitored using current and voltage readings from motor VFD's within the control panel. Two power uses are reported: the average power used by the dewatering drums (dewatering power use) and the average power used by all components of the Volute (dewatering drums, tank mixers, and feed pump) referred to as total power use. Power use is made scalable to larger Volutes as it is related to the dry tons of solids processed within a run (kWh/DT). **Figure 9** shows both power uses relative to the throughput of the pilot unit.

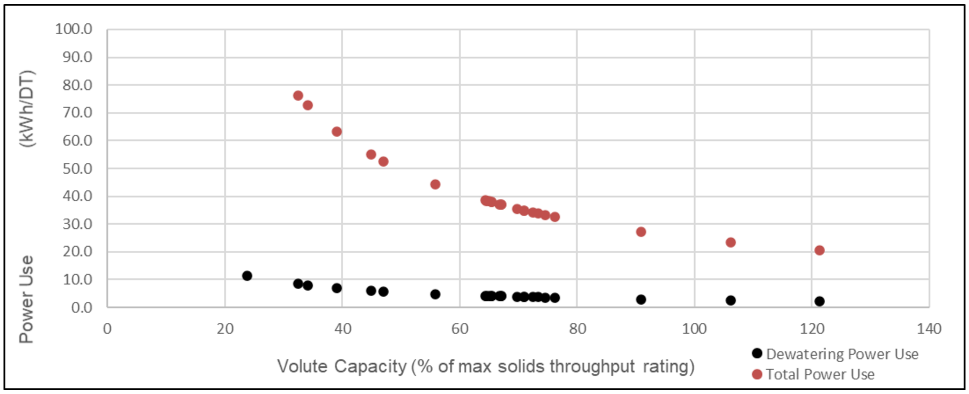

Figure 9: Dewatering power use vs. solids throughput

Power use does not increase proportionally as throughput is increased; therefore, higher throughput results in lower power use per dry ton of solids processed. Dewatering power use averaged 4.8 kWh/DT over the pilot study.

6. Results and Discussion – WAS

The un-thickened WAS did not provide any operational challenges for the Volute Press and 6 runs were conducted during this trial. The effects of parameters and the results from the runs are discussed in the following sections.

6.7. Influent Solids

A second submersible pump was used to mix the sludge inside the 350-gallon tank before pumping to the pilot unit, which created a consistent influent for each run. Influent solids concentrations for the WAS averaged 0.93%, and each result is shown in **Figure 10**. Variations in influent solids can be attributed to solids settling in the 1,000-gallon tank between runs.

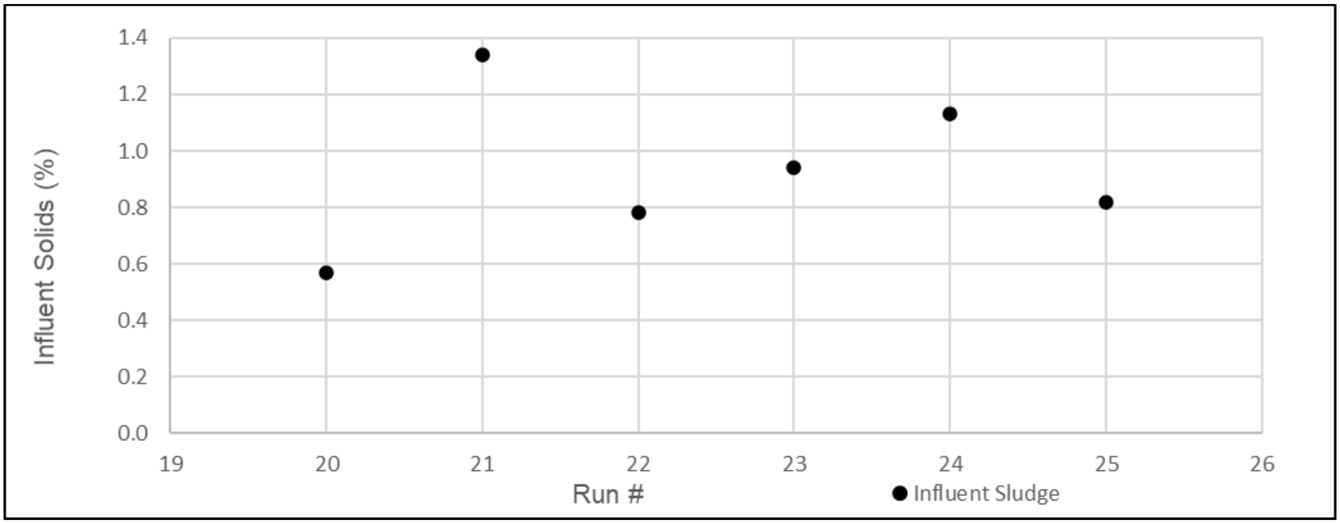

Figure 10: Influent solids for each run

6.8. Polymer Dosing

WWT 3061 was used during the WAS testing, and various polymer doses were tested to determine the effects of polymer dose on cake solids and capture rate. **Figure 11** shows the cake solids produced relative to polymer dose.

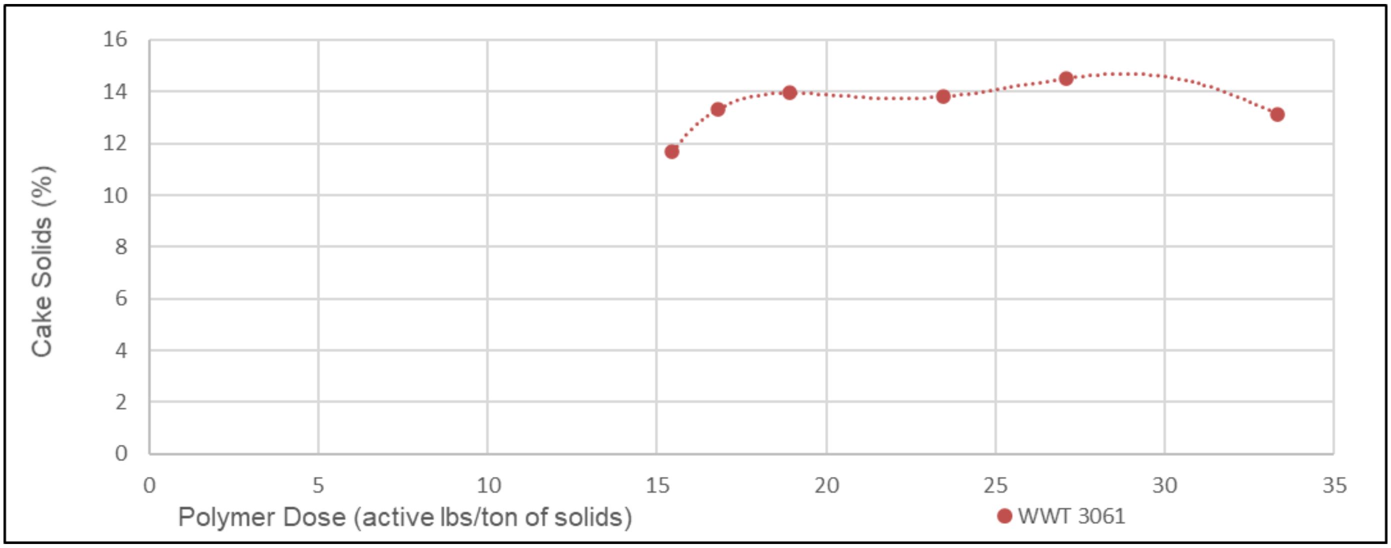

Figure 11: Cake solids vs. Polymer dose for WAS

The highest cake solids (14.5%) were produced at 27.1 lbs/ton, and the optimal dosing range was between 18.9 – 27.1 lbs/ton. Within this range, cake solids averaged 14.1% and solids capture rates averaged 99.0%. The capture rates for each run are shown in **Figure 12**.

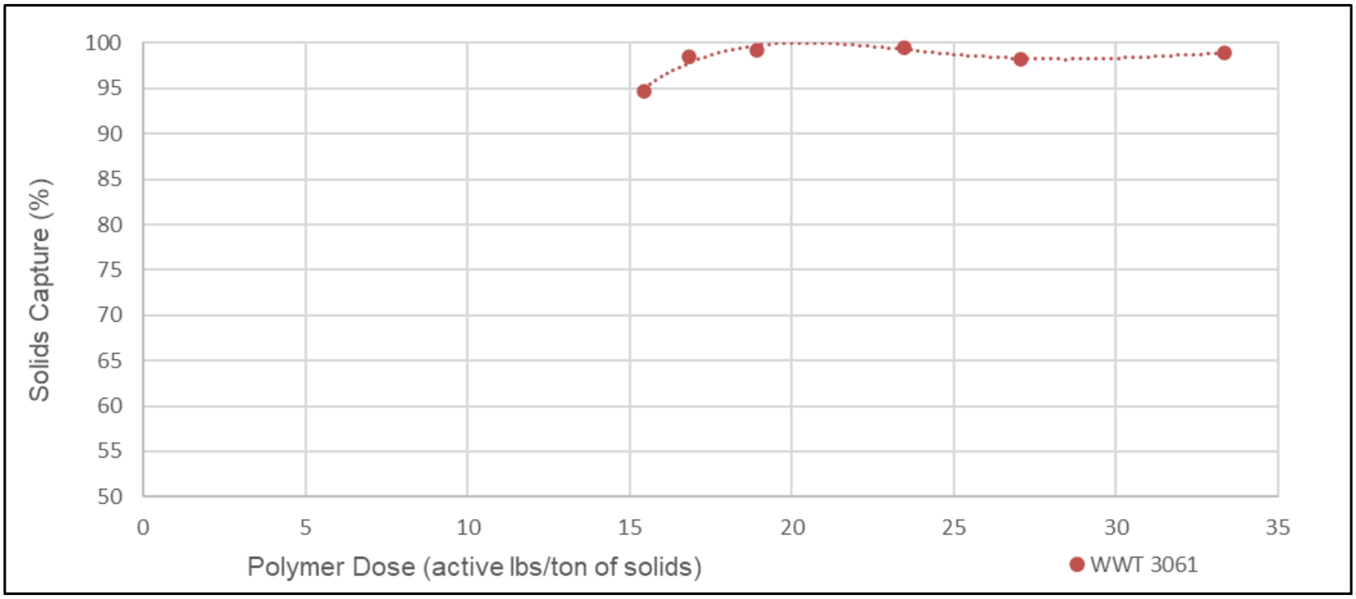

Figure 12: Solids capture rates vs. Polymer dose

7. Conclusion

The Volute Dewatering Press was successfully piloted at the Scarborough Sanitary District on blended sludge and un-thickened WAS. The plant polymer, Harcros WWT 3061, proved to be the most effective polymer during the pilot, producing cake solids averaging 29.6% and capture rates averaging 98.6% while dosing between 13.8 – 19.7 lbs/ton on the blended sludge. While operating at higher throughputs, no significant losses in performance were noticed until the unit was operated above its rated capacity; even at 91% capacity, the pilot unit produced cake solids of 28.7%.

While dewatering the un-thickened WAS, the Volute faced no operational challenges and averaged cake solids of 14.1% and capture rates of 99.0% between 18.9 – 27.1 lbs/ton.

8. Acknowledgements

PWTech would like to thank the Superintendent, David Hughes, and the rest of the plant staff for expressing interest in the Volute Dewatering Press and providing all of the utilities needed for piloting.

9. Appendix- All Results

Sludge Type		Blended Sludge																			Un-thickened WAS					
Run		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Date		9/8/2020											9/9/2020								9/10/2020					
Unit Parameters																										
Endplate Gap	**[mm]**	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	10	10	10	10	10	10
Drum Screw Speed	**[RPM]**	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	3.5	4.6	5.0	5.5	3.5	3.5	3.5	3.5	3.5	3.5
Flocculation Mixer Speed	**[RPM]**	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
Flow	**[gpm]**	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3	6	7	8	10	10	10	10	10	10
Chemical Dosing																										
Polymer		K279								WWT 3061											WWT 3061					
Raw Polymer Flow	**[mL/min]**	20	16	7	18	15	11	13	6	20	6	9	17	15	13	12	8	17	19	21	9	12	10	11	9	6
Percent Active	**[%]**	46	46	46	46	46	46	46	46	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Cost Per pound	**[$]**	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Active Polymer Dose Rate	**[ppm]**	405	324	142	365	304	223	263	122	352	106	159	299	264	229	211	211	257	251	247	86	115	96	106	86	58
Solids Concentration																										
Influent Solids	**[%]**	3.1	3.1	3.1	3.4	3.4	3.6	3.5	3.1	3.5	3.1	3.2	3.2	3.2	3.4	3.7	3.6	3.6	3.6	3.6	0.6	1.3	0.8	1.0	1.1	0.8
Cake Solids	**[%]**	27.3	31.0	22.9	32.0	27.6	24.5	25.6	15.7	28.6	18.3	23.4	29.4	29.4	31.0	28.5	30.4	28.7	23.8	23.8	13.1	14.0	14.5	13.8	13.3	11.7
Pressate Solids	**[mg/L]**	4530	2900	3550	390	2540	1270	2750	1700	940	3440	110	230	300	360	430	540	470	420	1100	64	110	140	44	170	430
Calculated Parameters																										
Solids Throughput	**[#/hour]**	79	79	77	85	85	90	88	78	87	78	80	81	81	84	92	54	109	127	146	29	67	39	50	57	41
Solids Capture	**[%]**	85.6	90.8	88.5	98.9	92.6	96.5	92.2	94.5	97.3	89.0	99.7	99.3	99.1	98.9	98.8	98.5	98.7	98.8	97.0	98.9	99.2	98.2	99.6	98.5	94.8
Active Polymer Use	**[lbs/ton]**	30.9	24.8	11.0	25.6	21.4	14.9	17.9	9.4	24.3	8.1	11.8	22.3	19.7	16.4	13.8	15.6	16.4	15.7	15.2	33.3	18.9	27.1	23.5	16.8	15.5
Dewatering Energy Use	**[kWh/ton]**	4.2	4.2	4.3	3.9	3.9	3.7	3.7	4.2	3.8	4.2	4.1	4.1	4.1	3.9	3.6	6.1	3.0	2.6	2.3	11.5	4.9	8.4	6.6	5.8	8.0
Total Energy Use	**[kWh/ton]**	37.9	37.9	38.6	34.9	34.9	33.3	33.8	38.4	34.2	38.2	37.1	37.0	37.0	35.5	32.5	55.1	27.3	23.4	20.5	104.5	44.4	76.3	60.2	52.7	72.6
Polymer Cost																										
Total Cost per Ton	**[$]**	101	81	36	84	70	49	59	31	91	30	44	84	74	61	52	59	62	59	57	125	71	102	88	63	58

Table 2: All results from pilot testing

10. Appendix- Table 2 Calculations expanded

Active Polymer Use relates polymer used to solids generated. It is the ratio of active polymer used to solids throughput and is commonly calculated as pounds of active polymer per dry ton of solids. In order to show this calculation, solids throughput and active polymer flowrate are calculated first. Sludge is assumed to have a specific gravity of 1.

Solids Throughput: calculated for one hour.

$$Sludge\ Flowrate\ (gpm)\ *\ 60\ \frac{min}{hour}\ *\ 8.35\ \frac{lb}{gallon}\ =\ pounds\ of\ sludge\ per\ hour$$

$$\frac{influent\ solids\ \%}{100} * \frac{lbs\ of\ sludge}{hour}\ =\ lbs\ of\ solids\ per\ hour$$

Active Polymer Flow for one hour is calculated from Raw Polymer Flow:

$$\frac{mLs\ of\ raw\ polymer}{minute}\ *\ 60\ \frac{min}{hr}\ *\ \frac{\%\ active}{100}\ *\ .0022\ \frac{lbs}{mL}\ =\ lbs\ of\ active\ polymer\ per\ hour$$

Active Polymer Use is the ratio of Active Polymer Flow to Solids Throughput:

$$\frac{lbs\ of\ active\ polymer\ per\ hour}{lbs\ of\ solids\ per\ hour}\ *\ 2000\frac{lbs}{ton} =\ lbs\ of\ active\ polymer\ per\ dry\ ton\ of\ solids$$

Polymer Cost per Ton of Solids is calculated from Active Polymer Use and Solids Throughput:

$$\frac{lbs\ of\ active\ polymer}{dry\ ton\ of\ solids}\ /\ \frac{\%\ active}{100} =\ lbs\ of\ raw\ polymer\ per\ dry\ ton\ of\ solids$$

$$\frac{lbs\ of\ raw\ polymer}{dry\ ton\ of\ solids}\ *\ \frac{\$}{lbs\ of\ raw\ polymer} =\ \$\ per\ dry\ ton\ of\ solids$$

The total and dewatering energy consumption in kilowatt-hours (kWh) of the Volute pilot unit can be calculated using the current and voltage obtained from the drum, flash tank mixer, and flocculation tank mixer motor VFDs within the Volute control panel. Amperage and Voltage readings are obtained during each hour-long run. The energy consumption can be scaled to larger production models by relating this value to the calculated solids throughput (dry lbs/hour) the unit was operating at.

Power use of each component (drum motors, flash tank mixer motor, flocculation tank mixer motor, feed pump) of the Volute:

$$Motor\ Amperage\ (A) \times Motor\ Voltage\ (V) \times \frac{1\ kW}{1000\ W} = Motor\ Power\ Usage\ (kW)$$

Total Energy Consumption (kW) is obtained by adding all Volute component motor power usages:

$$\begin{aligned}Total\ kW = [&Feed\ Pump\ Motor\ Power\ (kW) + Drum\ Motors\ Power\ (kW)\\ &+ Flash\ Mixer\ Motor\ Power\ (kW) + Floc\ Mixer\ Motor\ Power\ (kW)]\end{aligned}$$

Total Energy Use (kWh/dry ton) is obtained by dividing the total power by the Solids Throughput per hour:

$$\frac{kWh}{ton} = [Total\ kW/(\frac{lbs\ of\ solids}{hour} \times \frac{1\ ton}{2000\ lbs})]$$

The Dewatering Energy Use is similarly calculated using the Drum Power:

$$\frac{kWh}{ton} = [Total\ Drums\ kW/(\frac{lbs\ of\ solids}{hour} \times \frac{1\ ton}{2000\ lbs})]$$

Example calculations for Sample # 14:

Note: Numbers in the spreadsheet are rounded to the nearest tenth place and nearest integer to keep it neat and easily readable. Numbers may vary slightly from the example calculations below.

Solids throughput:

$$5\ gpm * 60\ \frac{min}{hr} * 8.35\ \frac{lb}{gallon} = 2{,}505\ \ lbs\ of\ sludge\ per\ hour$$

$$\frac{3.35\%}{100} * \frac{2{,}505\ lbs}{hour} = 83.9\ lbs\ of\ solids\ per\ hour$$

Active Polymer Flow for one hour is calculated from Raw Polymer Flow:

$$\frac{13\ mLs}{minute} * 60\ \frac{min}{hr} * \frac{40\%}{100} * .0022\ \frac{lbs}{mL} = 0.69\ lbs\ per\ hour$$

Active Polymer Use is the ratio of Active Polymer Flow to Solids Throughput:

$$\frac{0.69\ lbs\ polymer}{83.9\ lbs\ solids} * \ 2000\frac{lbs}{ton} = 16.4\ lbs\ of\ active\ polymer\ per\ dry\ ton\ of\ solids$$

Polymer Cost per Ton of Solids is calculated from Active Polymer Use and Solids Throughput:

$$\frac{16.4\ lbs}{dry\ ton\ of\ solids} * \frac{100}{40\%} = 41.0\ lbs\ of\ raw\ polymer\ per\ dry\ ton\ of\ solids$$

$$\frac{41.0\ lbs\ of\ raw\ polymer}{dry\ ton\ of\ solids} * \frac{\$\ 1.5}{lbs\ of\ raw\ polymer} = \$61.50\ per\ dry\ ton\ of\ solids$$

Power use of each component (drum motors, flash tank mixer motor, flocculation tank mixer motor, feed pump) of the Volute:

$$Drum\ 1\ Motor\ Power\ = 0.7A * 234.8V * \frac{1kW}{1000W} = 0.16\ kW$$

$$Floc\ Tank\ Mixer\ Motor\ Power\ = 0.8A * 235.3V * \frac{1kW}{1000W} = 0.19\ kW$$

$$Flash\ Tank\ Mixer\ Motor\ Power\ = 0.8A * 239.4V * \frac{1kW}{1000W} = 0.19\ kW$$

$$Feed\ Pump\ Motor\ Power\ = 4.0A * 235.9V * \frac{1kW}{1000W} = 0.94\ kW$$

Total Energy Consumption (kW) is obtained by adding all Volute component motor power usages:

$$Total\ Energy\ Consumption\ (kW) = 0.16kW + \ 0.19\ kW + 0.19kW + 0.94kW = \ 1.48\ kW$$

Total Energy Use (kWh/dry ton) is obtained by dividing the Total Energy Consumption by the Solids Throughput per hour:

$$\frac{1.48\ kW}{(\frac{83.9\ dry\ lbs}{hour} * \frac{1\ ton}{2000\ lbs})} = \frac{35.2\ kWh}{dry\ ton}$$

Dewatering Energy use (kWh/dry ton) is obtained by dividing the Total Drum Power by the Solids Throughput per hour:

$$\frac{0.16\ kW}{(\frac{83.9\ dry\ lbs}{hour} * \frac{1\ ton}{2000\ lbs})} = \frac{3.8\ kWh}{dry\ ton}$$