BIOSOLIDS DEWATERING

Analysis: Process Optimization and Evaluation of *Hydro*FLOW™ Technology for Reduced Polymer Consumption and Drier Cake Solids

Trinity River Authority

Denton, TX

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December 2019

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DENTON CREEK REGIONAL WASTEWATER SYSTEM

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Summary

In January 2019, Enpure was engaged to implement a demonstration trial at the Denton Creek Regional Wastewater System (DCRWS), Denton, Texas of the Trinity River Authority to evaluate *Hydro*FLOW technology for polymer reduction and drier cake solids in biosolids dewatering. The trial was performed at no cost or risk to the DCRWS. As part of the trial, Enpure and DCRWS Management initiated optimization procedures with Denton Creek personnel in order to provide baseline data for evaluation of the technology. The objective of the trial was twofold:

- Optimize dewatering operations to achieve maximum cake solids with minimum polymer consumption
- Utilize *Hydro*FLOW technology to reduce polymer consumption by 10% - 20%, while maintaining centrate capture over 90%, and equivalent or improved cake solids %.

Over the course of the trial, it was determined that consistent throughput of 1000 lbs/hr and polymer dosing based on VS% can achieve a 6% reduction in total dewatering costs. A 2.6% reduction was obtained during the 10-month trial, with total costs per dry ton falling from $294.19 in 2018 to $286.41 in 2019. In 2019, polymer dosing was often too high or too low as proper dosing amounts were evaluated. The data demonstrates that a 6% reduction in dewatering costs from 2018 levels is achievable amounting to approximate savings of $50,000 per year, provided throughput is consistent and polymer is dosed at recommended levels.

The *Hydro*FLOW technology was able to achieve annual savings of $13,000 per year, based upon a combination of polymer savings of about 0.8 lbs/DT, and improved cake % of about 0.3%. ROI is estimated at about 18 months.

Biosolids Dewatering Operations

The Denton Creek Regional Wastewater System of the Trinity River Authority is designed to treat 11.5 MGD of wastewater from residents and businesses located within the vicinity. With the Texas Motor Speedway located within the collection basin, the plant includes detention basins to accommodate and treat peak flows from the Speedway. Stormwater runoff is not excluded from inflows into the treatment facility. Contaminant removal is achieved with the activated sludge process and waste activated sludge dewatered utilizing two (2) Andritz D5LC30CHP centrifuges with 620mm bowls.

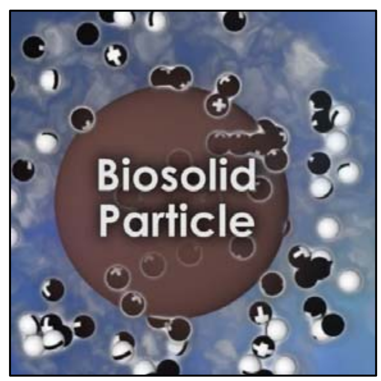
- The centrifuges are operated with one in service, and the other on standby, 24/6, depending on hydraulic loads of the plant. The centrifuges are checked and reset approximately 3 times per day at the beginning of each shift.
- WAS is pumped into one of two sludge holding tanks that is aerated to keep solids in suspension and control odors. One tank is in service feeding the centrifuge, the other is on standby receiving the WAS. The standby tank is decanted to remove excess water to achieve a solids concentration ranging from 1.5% -3.0%.
- Due to the intrusion of stormwater into the plant treatment system, volatile solids as a percentage of total solids is subject to a high degree of variability, ranging from 63% - 82%. Changes is VS%, while variable, do not occur immediately, but trend over a period of weeks.
- The centrifuges are semi-automated with centrifuge setpoints and sludge feed rates controlled by the PLC. Polymer dosing and dilution water rates are manually set at the polymer make-up unit. Operators sample feed total solids and volatile solids at the beginning of each shift, adjusting the feed sludge feed flow in order to maintain the proper solids loading per hour (1000 pounds) and polymer dosing per dry ton. After any adjustments and once the centrifuge has stabilized, cake solids and centrate solids are sampled. Centrifuge setpoints and sample results are record in a database to allow for monthly evaluation, trend analysis, and historical comparison of the centrifuge performance.
- Each centrifuge possesses a dedicated Polymer Make-up Unit (PMU) with polymer feed pump, which is manually adjusted to activate and dilute the polymer. Target dilution for the neat polymer is 0.5%, resulting in activated polymer of 0.22%. Activated polymer is NOT aged and is injected directly into the sludge feed flow via an injection ring.
- Two polymer injection points are plumbed, both located upstream from the centrifuge feed tube: the first, which is not in operation, is located approximately 1' upstream (Point A in the previous Figure) from the Centrifuge feed tube. The second is an injection ring, immediately upstream from the Deskins mixer (Point B in the previous Figure).
- Dewatered solids are moved by a dedicated screw conveyor and discharged into a 20 ton open top container trailer.
- Magnesium hydroxide is used to control odor at several points in the plant, contributing alkalinity to the biological process and often raising pH in the dewatering operation. Magnesium Hydroxide is also added to Sludge Holding tank #2 over the weekends (Thursday through Sunday and holding tank #2 only) to control odor.
- During the period of the trial, tipping fees for disposal of dewatered sludge amounted to $57.22 per wet ton and polymer cost of $1.11 per pound, neat.

*Hydro*FLOW Technology

Developed over twenty-five years ago to control lime scale in domestic hot water applications, the *Hydro*FLOW technology has been extended to biosolid dewatering applications, including:

- Reduction of polymer consumption by 10% - 20%, with equivalent solids capture
- Drier cake solids of 1% - 3% cake points
- Struvite scale control: Inhibition of new scale and remineralization of existing scale
- Phosphorus recovery as part of existing dewatering systems

Easily installed on the exterior of any piping system or pipe material, without the need to cut or weld any piping, the *Hydro*FLOW transducer employs a ferrite ring to apply an oscillating 150 kHz radio frequency signal that penetrates the pipe wall and travels both upstream and downstream from the point of installation. The wastewater within the piping system, acts as a conduit to propagate the signal throughout the system, conditioning the water and suspended solids, whether moving or stationary.



In dewatering applications, the oscillating signal suppresses the surface charge of the suspended particles by disrupting the diffuse double layer of counter-ions surrounding the particles, allowing them to coagulate and agglomerate with less polymer, and often as a drier cake. In struvite scaling applications, the *HydroFLOW* signal induces the dissolved magnesium, ammonium, and phosphorus ions to cluster and precipitate as stable struvite crystals that remain in suspension and do not adhere to piping and equipment surfaces. The ability of *Hydro*FLOW to control the precipitation of struvite in suspension allows for the high recovery of phosphorus as micron-sized crystals within dewatered biosolids. Lastly, the signal disrupts the growth of bacteria, causing the cell walls to rupture, aiding in the mineralization of waste activated sludge.

Process Optimization and *Hydro*FLOW Trial – *Hydro*FLOW Installation

Several configurations of the *Hydro*FLOW technology were tested on both Centrifuge #1 and Centrifuge #2 to determine the most effective arrangement for reducing polymer and improving cake dryness. The VFD on Centrifuge #1 failed in late April, taking it out of service for about 2 weeks. In late September, Centrifuge #2 failed and remained out of service for the remainder of the trial. Installation of the *Hydro*FLOW technology is consistent for both Centrifuges, but is shown below for Centrifuge #1.

1. *Hydro*FLOW Model 100i installed on Centrifuge #1 about 2' upstream from the feed tube. A Deskins mixer is installed just after the polymer injection Ring. A second jumper wire is installed about 5' upstream from the polymer injection Ring. (Figure 1)
2. A third jumper wire is installed on the dilution water feed to the PMU from the *Hydro*FLOW Model 100i installed on the Centrifuge. (Figure 2)

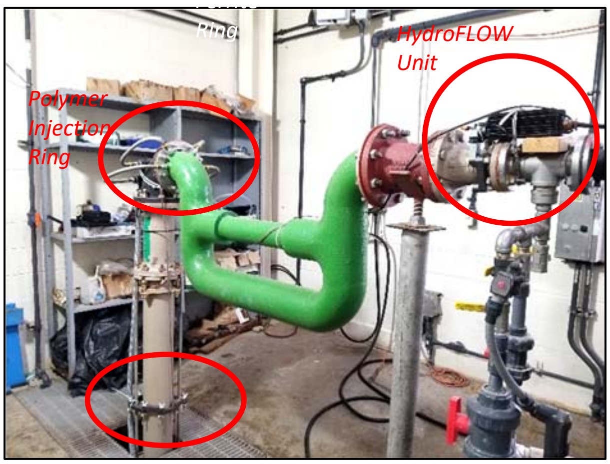


Figure 1: HydroFLOW unit / Second Jumper

Figure 2: PMU Dilution Water Third Jumper

Process Optimization and *Hydro*FLOW Trial – Operations and Testing

Prior to commencement of the *Hydro*FLOW Trial, sludge was dewatered based upon hydraulic loads, not solid loads. Centrifuge feed flow was set to process the liquids (including suspended solids) wasted into the sludge holding tank such that the sludge hold tank was drained to its minimum level. Polymer dosing was set based upon cake and centrate appearance.

During the first two months of the trial, operation of the centrifuges was standardized as follows:

- The operators were trained in the standardized procedures. All data was recording during this period, but evaluation of data did not commence until March 21.
- Throughput was set at 1000 lbs/hour. Each shift, TSS% is sampled and the sludge feed rate is adjusted to maintain throughput at this set point. Data that varies by more than 5% from this setpoint has been recorded, but is excluded from analysis.
- Feed solids %: The concentration is variable, but the target has been between 2.0%-2.5%, which maintains the sludge feed flow within a range of 80-100 GPM. Feed GPM outside of this range was observed to either improve or reduce cake % on an inverse basis.
- Bowl speed was set at 3200 rpm.
- Auto-torque is enabled and set at 80%. Differential speed is adjusted automatically by the centrifuge controls to maintain the scroll loading at the setpoint.
- Operation of the *Hydro*FLOW has been varied, with the unit energized or de-energized for short durations of 7-10 days to capture data sets with similar characteristics. Longer time frames provide impossible to implement due to the variability of volatile solids. The status of the *Hydro*FLOW unit (energized or de-energized) is recorded in the data.
- Polymer dosing and dilution water has been controlled at a certain lbs/dry ton for weekly durations, both with and without the *Hydro*FLOW to evaluate effects on cake % and centrate quality. Once dosing requirements were better understood, adjustments to the polymer pounds per dry ton were initiated based upon changes in volatile solids %.

*Hydro*FLOW Trial – Data Collection and Results

Procedures for data collection and results are as follows:

1. To eliminate variance between machine performance, data sets were compared for a single machine.
2. The *Hydro*FLOW technology was energized and de-energized for a week at a time, to capture data sets with similar characteristics.
3. To eliminate noise, the data sets were collected with similar feed characteristics: VS%, throughput, and polymer dose (lbs/DT). Cake and centrate solids were measured for variance to evaluate the effectiveness of the technology in reducing polymer consumption while maintaining similar cake and centrate solids %.
4. Data Corrections: Both raw and corrected data is accumulated in the working spreadsheet. Some data points were excluded from the data sets for inconsistencies, as noted below. Excluded data points are identified and the reason for exclusion noted.
    a. Data points with incomplete recorded data

   b. Solids loading, with throughput variances +/- > 5%.
   c. Outlier events in which the data point was not consistent with the data set, including:
      i. VS%, cake %, and centrate %.
      ii. Outlier high or low flow due to low or high feed solid variance.
      iii. Cake % measured by one operator is consistently too high for the reported VS%.
5. Data sets: During the data collection phase of the trial, 8 data sets were collected with comparable VS% and polymer dosing with the *Hydro*FLOW ON and OFF. The data sets are labeled “A” through “H”. The performance results, cake %, centrate %, and polymer dosing are summarized on the attached graph, Appendix A, of corrected data.

Trial evaluation: To evaluate the cost / benefit of the *Hydro*FLOW technology the results of each data set was annualized to determine savings with the *Hydro*FLOW technology from reduced polymer consumption or improved cake solids. These results were then weighted-averaged (based upon relative data points) to calculated expected annual savings with the *Hydro*FLOW technology.

1. During the trial, feed VS% varied greatly. Additionally, the VFD on Centrifuge #1 failed in mid-April, and then Centrifuge #2 had to be taken out of service in late September. Both events and the varying feed VS% required establishment of new baseline data to minimize noise and isolate the *Hydro*FLOW affect. From late April through mid-November, nine data sets, “A” – “H”, were identified with comparative data in which the only variable was the state of the *Hydro*FLOW unit, ON or OFF.
2. Each data sets represents a grouping of centrifuge settings and results with consistent process settings, feed VS%, and polymer dosing. Cake and capture % represent the key measurement parameters. The data sets include a total of 142 data points, 80 with the *Hydro*FLOW ON, and 62 with it OFF.
3. The data is presented in two formats:
   a. A graphical summary, Appendix A, showing all data sets from March 1 through November 13. Key variables are graphed: Feed VS%, polymer dosing in lbs/DT, cake %, capture %, centrifuge in service, and *Hydro*FLOW state (ON or OFF), and the number of data points in each group. A total of 376 data points is summarized.
   b. A Cost Savings Analysis table, Appendix B, for the Comparative data sets “A” – “H”., presenting the key variables from the graphical summary. To provide comparison between the data sets with the *Hydro*FLOW ON or OFF, the dewatering costs (polymer consumption and sludge disposal) are annualized. After annualizing each data set, data after July 1 is weighted-averaged by the number of data points to determine expected annual savings from utilization of the *Hydro*FLOW technology.
4. Annual savings from the *Hydro*FLOW technology is estimated at approximately $13,000 per year, based upon a combination of polymer savings of about 0.8 lbs/DT, and improved cake % of about 0.3%, yielding an ROI of 18 months.

Process Optimization – Discussion of Results

In addition to evaluating the effectiveness of the *Hydro*FLOW technology, the trial yielded several key insights into process optimization for biosolid dewatering operations for DCRWS.

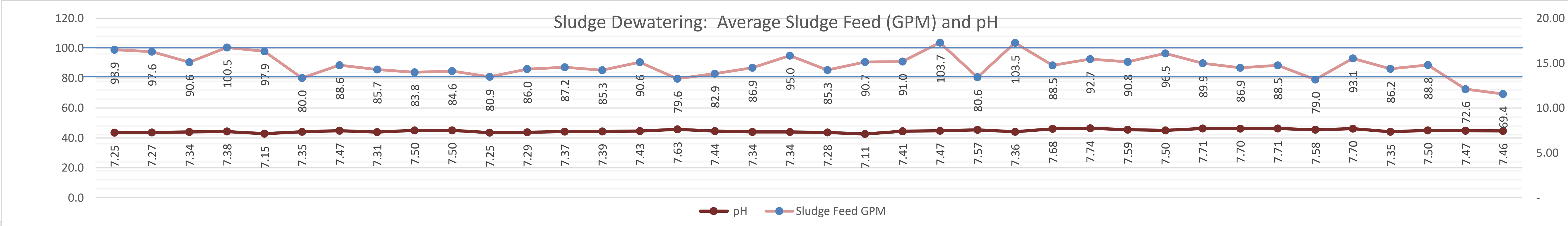
Appendix C is a spreadsheet of key operating parameters and costs from 2016 – 2019, with both full year averages/totals as well as averages/totals for the 10 months from February through November, when the process optimization trial was in place. The key parameters for 2019 and 2018 are summarized in the table below. Appendix D is a spreadsheet presenting a forecast for the 2020 key parameters and costs, which are also summarized in the table below.

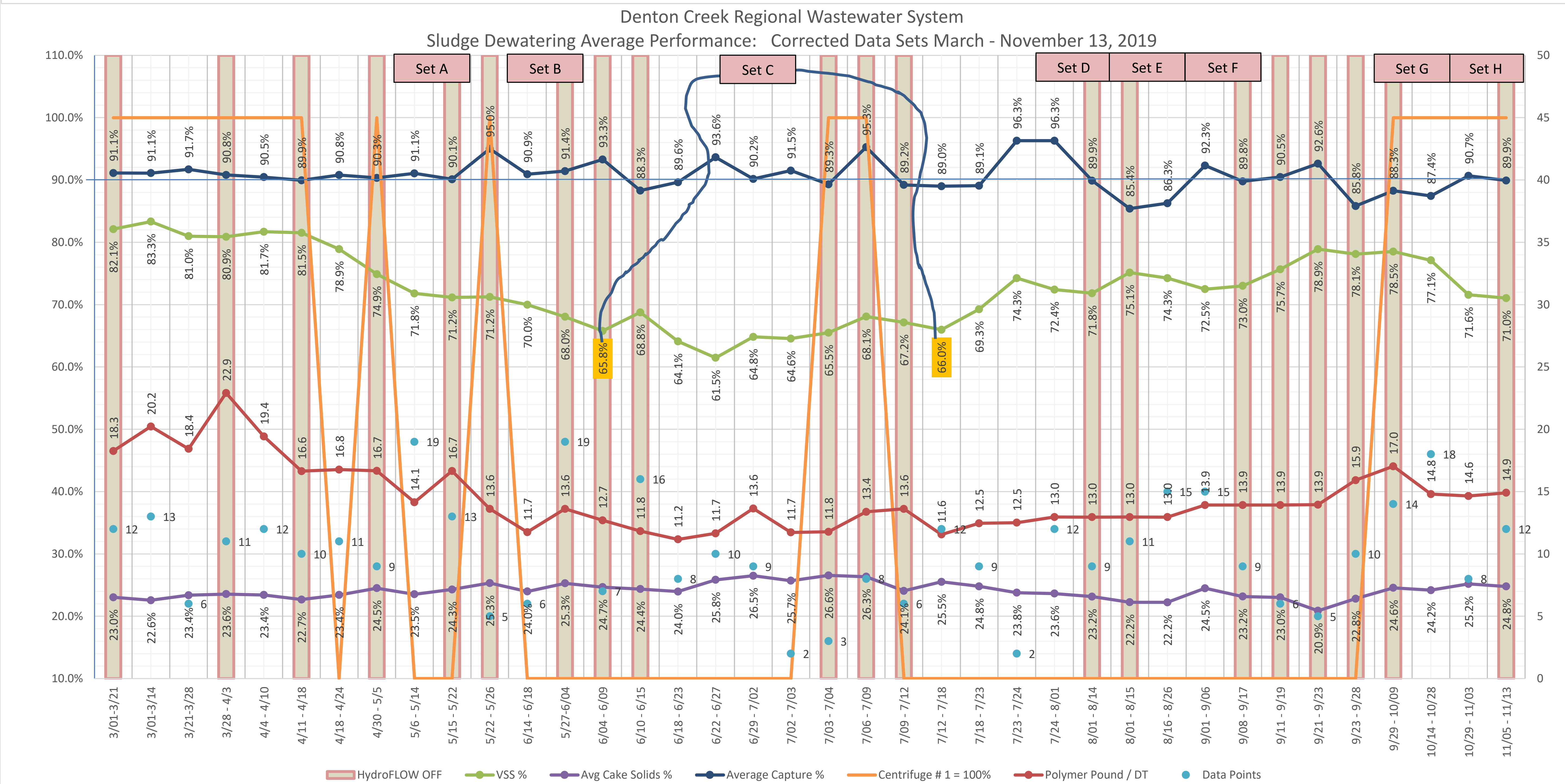
Summary	Actual (10 Months Trial)			Projected
	2019	2018	Variance	2020
Dewatering Costs, Total	$ 620,860	$ 629,206	$ (8,346)	
Wet tons disposed	9,037	9,234	(197)	10,641
Dry solids	2,168	2,139	29	2,607
Cake %	24.0%	23.2%	0.8%	24.5%
Capture %	88.9%	84.0%	4.9%	90.0%
Polymer dosing, lbs / Dry Ton	16.9	15.7	1.2	16.0
Feed VS%, average	74.5%	75.8%	-1.3%	74.5%
Disposal cost / Dry Ton	$ 286.41	$ 294.19	$ (7.78)	
Disposal cost / Dry Ton (full year)	$ 290.31			$ 278.40

Conclusions on process optimization are as follows:

1. Disposal costs per dry ton were reduced by almost $8.00 per dry ton from 2018 to 2019, saving approximately $20,800 per year on an annualized basis. It is estimated that with consistent application of the procedures developed during the optimization trial, that another $12.00 per dry ton can be saved in 2020, amounting to $31,200 per year based upon 2600 pounds in dry solids, consistent VS%, and no price changes for tipping fees or neat polymer.
2. Decanting the sludge holding tank to achieve feed solids over 2.5%, resulted in improved cake dryness, with equivalent polymer dosing. Higher feed solids at equivalent solids loading of 1000 lbs/hr allowed for proportional reduction in feed flow. It is theorized that cake dryness is improved due to less turbulence in the feed flow reducing floc shear as well as longer residence time within the centrifuge for dewatering.
3. When hydraulic loads allow, solids loading can also be reduced by 10% to 900 lbs/hr. Reduced solids loading will allow for reduced feed flow, reducing floc shear and improving cake dryness and/or reduce polymer consumption.
4. Polymer guidelines have been developed to optimize polymer consumption and cake solids based upon VS%. Since VS% does not change rapidly, review of VS% every 3-4 days allows for resetting of polymer dosing rates, without compromising cake dryness. Proposed guidelines for 2020 are listed in the table below:

Throughput @ 1000 lbs / hour						
Throughput, lbs/hr	Auto-Torque	VS% Range		lbs/DT	Polymer GPH	Dilution Water, GPM
		Lower	Upper			
1000	80%	82.1%	+	18.0	2.38	8.0
1000	80%	78.1%	82.0%	17.0	2.25	7.5
1000	80%	74.1%	78.0%	16.0	2.11	7.0
1000	80%	70.1%	74.0%	15.0	1.98	6.5
1000	80%	66.1%	70.0%	14.0	1.85	6.0
1000	80%	60.1%	66.0%	13.0	1.72	5.5
Throughput @ 900 lbs / hour						
Throughput, lbs/hr	Auto-Torque	VS% Range		lbs/DT	Polymer GPH	Dilution Water, GPM
		Lower	Upper			
900	80%	82.1%	+	17.5	2.08	7.0
900	80%	78.1%	82.0%	16.5	1.96	6.5
900	80%	74.1%	78.0%	15.5	1.84	6.0
900	80%	70.1%	74.0%	14.5	1.72	5.5
900	80%	66.1%	70.0%	13.5	1.61	5.5
900	80%	60.1%	66.0%	12.5	1.49	5.0


Sludge Dewatering: Average Sludge Feed (GPM) and pH
120.0
100.0
80.0
60.0
40.0
20.0
0.0
20.00
15.00
10.00
5.00
-
pH
Sludge Feed GPM


Denton Creek Regional Wastewater System
Sludge Dewatering Average Performance: Corrected Data Sets March - November 13, 2019
Set A
Set B
Set C
Set D
Set E
Set F
Set G
Set H
110.0%
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
50
45
40
35
30
25
20
15
10
5
0
3/01-3/21
3/01-3/14
3/21-3/28
3/28 - 4/3
4/4 - 4/10
4/11 - 4/18
4/18 - 4/24
4/30 - 5/5
5/6 - 5/14
5/15 - 5/22
5/22 - 5/26
6/14 - 6/18
5/27-6/04
6/04 - 6/09
6/10 - 6/15
6/18 - 6/23
6/22 - 6/27
6/29 - 7/02
7/02 - 7/03
7/03 - 7/04
7/06 - 7/09
7/09 - 7/12
7/12 - 7/18
7/18 - 7/23
7/23 - 7/24
7/24 - 8/01
8/01 - 8/14
8/01 - 8/15
8/16 - 8/26
9/01 - 9/06
9/08 - 9/17
9/11 - 9/19
9/21 - 9/23
9/23 - 9/28
9/29 - 10/09
10/14 - 10/28
10/29 - 11/03
11/05 - 11/13
HydroFLOW OFF
VSS %
Avg Cake Solids %
Average Capture %
Centrifuge # 1 = 100%
Polymer Pound / DT
Data Points

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12/28/2019

APPENDIX B

Denton Creek Regional Wastewater System

HydroFLOW Trial: Cost Savings Analysis

Data Parameter		Without HydroFLOW Jumper				With HydroFLOW Jumper														Wtd Average "C - H"	
Data Set Group		A		B		C		D		E		F		G		H					
HydroFLOW		ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF			ON	OFF
VSS%		71.8%	71.2%	70.0%	68.0%	66.0%	65.8%	72.4%	71.8%	74.3%	74.9%	72.5%	73.0%	77.1%	78.5%	71.6%	71.0%			72.8%	73.2%
Capture %		91.1%	90.1%	90.9%	91.4%	89.0%	93.3%	96.3%	89.9%	86.3%	85.4%	92.3%	89.8%	87.4%	88.3%	90.7%	89.9%			90.0%	89.1%
Average Feed Flow, GPM		83.8	84.6	86.0	87.2	103.7	85.3	88.5	92.7	96.5	90.8	89.9	86.9	88.8	86.2	72.6	69.4			91.0	84.7
Data points		19	13	6	19	12	7	12	9	15	11	15	9	18	14	8	12			80	62
Dry Tons, annualized		2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500			2,500	2,500
Wet Tons, annualized		10,638	10,288	10,417	9,881	9,804	10,121	10,593	10,776	11,261	11,261	10,204	10,776	10,331	10,163	9,921	10,081			10,401	10,515
Cake %		23.5%	24.3%	24.0%	25.3%	25.5%	24.7%	23.6%	23.2%	22.2%	22.2%	24.5%	23.2%	24.2%	24.6%	25.2%	24.8%			24.1%	23.8%
Polymer, lbs/DT		14.1	16.7	11.7	13.6	11.6	11.7	13.0	13.0	13.0	13.0	13.9	13.9	14.8	17.0	14.6	14.9			13.5	14.3
Annualizedl Processing costs																					
Disposal	$ 57.22	$ 608,723	$ 588,683	$ 596,042	$ 565,415	$ 560,980	$ 579,150	$ 606,144	$ 616,595	$ 644,369	$ 644,369	$ 583,878	$ 616,595	$ 591,116	$ 581,504	$ 567,659	$ 576,815			$ 595,132	$ 601,672
Polymer	$ 1.17	$ 102,890	$ 123,215	$ 85,565	$ 98,916	$ 86,645	$ 83,364	$ 89,741	$ 96,130	$ 100,140	$ 101,195	$ 100,112	$ 102,899	$ 112,570	$ 127,986	$ 107,009	$ 110,179			$ 99,872	$ 106,343
Total Costs		$ 711,614	$ 711,898	$ 681,606	$ 664,331	$ 647,625	$ 662,514	$ 695,885	$ 712,724	$ 744,509	$ 745,564	$ 683,990	$ 719,494	$ 703,686	$ 709,490	$ 674,667	$ 686,994			$ 695,004	$ 708,015
Net Savings / (costs)			$ 285		$ (17,276)		$ 14,889		$ 16,839		$ 1,055		$ 35,504		$ 5,804		$ 12,326				$ 13,011

12/28/2019

APPENDIX C

Denton Creek Regional Wastewater System

Sludge Processing Summary: 2016 - 2019 with 2019 HydroFLOW Trial

At Constant Polymer and Disposal Costs

	Sludge Processing Comparitive 2018 vs. 2019																				
	Volatiles (VSS%)				TONS HAULED (From DCRWS Reports)				Cake %				DRY SOLIDS, ESTIMATED					Disposal Costs			
Month	2019	2018	2017	2016	2019	2018	2017	2016	2019	2018	2017	2016	2019	2018	2017	2016		2019	2018	2017	2016
																		$ 57.22	$ 57.22	$ 57.22	$ 57.22
Dec	79.6%	80.6%	79.5%	No Data	1,042.9	773.6	576.9	No Data	22.5	22.5	22.5		234.7	174.0	129.5			$ 59,677	$ 44,263	$ 33,010	
Jan	80.0%	81.5%	76.5%	No Data	938.3	926.8	870.8	827.2	21.8	21.8	23.7	23.1	204.6	201.9	206.2	191.3		$ 53,690	$ 53,031	$ 49,824	$ 47,331
Feb	81.2%	81.8%	75.9%	No Data	794.7	771.1	697.8	955.4	23.5	22.2	23.8	22.3	186.8	170.8	165.8	212.6		$ 45,473	$ 44,120	$ 39,927	$ 54,667
Mar	82.0%	74.5%	81.3%	No Data	957.9	1,407.3	993.9	855.2	23.0	22.4	22.4	22.7	220.3	314.7	222.2	194.4		$ 54,809	$ 80,526	$ 56,873	$ 48,937
Apr	80.6%	79.0%	72.1%	No Data	937.3	876.9	896.3	876.3	23.2	22.9	25.0	23.1	217.4	201.2	224.0	202.4		$ 53,631	$ 50,176	$ 51,287	$ 50,143
May	71.2%	80.7%	78.5%	59.5%	1,171.1	715.7	877.6	909.9	24.5	22.1	23.7	22.9	286.9	158.5	207.8	208.5		$ 67,008	$ 40,952	$ 50,217	$ 52,065
Jun	63.9%	77.9%	71.0%	64.0%	960.3	920.0	860.1	787.4	24.8	23.2	25.5	25.6	238.2	213.3	219.7	201.5		$ 54,950	$ 52,640	$ 49,217	$ 45,052
Jul	67.1%	77.8%	72.0%	66.3%	954.3	796.5	972.7	808.1	25.1	23.7	24.7	25.2	239.5	188.4	240.6	203.3		$ 54,606	$ 45,576	$ 55,660	$ 46,238
Aug	73.9%	75.0%	73.4%	66.8%	885.4	876.4	758.2	824.6	23.1	24.2	24.6	23.6	204.5	212.4	186.2	194.3		$ 50,662	$ 50,149	$ 43,386	$ 47,184
Sep	75.3%	71.2%	77.4%	72.7%	865.5	902.0	748.5	766.5	23.5	23.5	23.7	23.5	203.5	211.8	177.3	180.0		$ 49,521	$ 51,610	$ 42,831	$ 43,860
Oct	76.7%	66.6%	77.5%	70.8%	637.4	849.3	647.4	707.2	24.2	25.2	23.5	23.7	154.1	214.2	152.0	167.6		$ 36,474	$ 48,596	$ 37,044	$ 40,466
Nov	73.4%	73.9%	79.5%	75.4%	872.9	1,118.7	701.6	1,123.5	24.8	22.7	22.5	22.6	216.5	253.6	157.6	253.6		$ 49,946	$ 64,011	$ 40,144	$ 64,286
Total	75.4%	76.7%	76.2%	67.9%	11,018.0	10,934.1	9,601.9	9,441.3	23.67	23.03	23.78	23.47	2,606.9	2,514.7	2,289.0	2,209.5		$ 570,771	$ 581,387	$ 516,412	$ 540,229
Cummulative: Feb - Nov	74.5%	75.8%	75.9%	67.9%	9,036.7	9,233.8	8,154.3	8,614.1	23.97	23.20	23.93	23.51	2,167.7	2,138.8	1,953.3	2,018.2		$ 517,081	$ 528,356	$ 466,588	$ 492,898
		-1.3%	-1.3%	6.6%		(197.0)	882.4	422.6		0.77	0.04	0.46		28.9	214.4	149.5			$ (11,275)	$ 50,493	$ 24,183

	Polymer Analysis																	Total Polymer + Disposal			
	Polymer lbs/DT				Capture %				Polymer Pounds, Neat				Polymer $					Disposal Costs (constant prices)			
Month	2019	2018	2017	2016	2019	2018	2017	2016	2019	2018	2017	2016	2019	2018	2017	2016		2019	2018	2017	2016
													$ 1.11	$ 1.11	$ 1.11	$ 1.11					
Dec	16.5	18.2	15.8		90.0%	84.6%	88.3%	No Data	9,778	8,496	5,276		10,853	9,430	5,856	-		$ 70,530	$ 53,693	$ 38,866	$ -
Jan	18.0	18.0	15.6	18.9	89.0%	78.4%	88.5%	No Data	9,402	10,530	8,263	9,287	10,437	11,689	9,172	10,309		$ 64,127	$ 64,719	$ 58,996	$ 57,640
Feb	22.2	15.1	16.5	23.3	88.1%	77.6%	76.5%	No Data	10,686	7,540	8,135	12,700	11,861	8,370	9,030	14,097		$ 57,335	$ 52,490	$ 48,957	$ 68,764
Mar	20.1	14.6	17.2	16.4	88.2%	85.9%	72.8%	No Data	11,431	12,146	11,936	8,196	$ 12,688	$ 13,482	$ 13,249	$ 9,098		$ 67,498	$ 94,008	$ 70,122	$ 58,035
Apr	18.6	18.1	13.0	11.3	88.3%	80.0%	89.9%	No Data	10,394	10,367	7,348	5,879	$ 11,537	$ 11,507	$ 8,157	$ 6,526		$ 65,168	$ 61,683	$ 59,444	$ 56,669
May	15.0	21.2	16.3	12.5	88.9%	81.1%	84.1%	86.4%	11,027	9,425	9,151	6,845	$ 12,240	$ 10,462	$ 10,158	$ 7,598		$ 79,248	$ 51,414	$ 60,375	$ 59,663
Jun	12.2	18.9	14.5	12.5	90.7%	86.4%	85.9%	87.9%	7,276	10,639	8,427	6,516	$ 8,076	$ 11,809	$ 9,354	$ 7,232		$ 63,025	$ 64,449	$ 58,571	$ 52,285
Jul	12.7	19.8	15.1	14.1	89.9%	81.8%	85.9%	90.1%	7,724	10,346	9,589	7,214	$ 8,574	$ 11,484	$ 10,644	$ 8,008		$ 63,179	$ 57,061	$ 66,305	$ 54,246
Aug	13.2	16.3	14.4	14.0	88.7%	80.6%	88.2%	87.8%	6,898	9,761	6,910	7,034	$ 7,656	$ 10,834	$ 7,670	$ 7,808		$ 58,318	$ 60,984	$ 51,057	$ 54,992
Sep	14.6	14.4	14.9	13.3	89.7%	88.6%	91.8%	91.2%	7,547	7,838	6,523	5,986	$ 8,377	$ 8,700	$ 7,240	$ 6,644		$ 57,898	$ 60,310	$ 50,072	$ 50,504
Oct	15.8	12.5	17.4	13.0	87.3%	87.3%	85.4%	91.0%	6,331	6,946	7,022	5,457	$ 7,028	$ 7,710	$ 7,795	$ 6,057		$ 43,502	$ 56,305	$ 44,839	$ 46,523
Nov	15.3	14.0	16.0	15.7	89.1%	90.6%	84.7%	85.9%	8,448	8,935	6,783	10,515	$ 9,378	$ 9,918	$ 7,529	$ 11,671		$ 59,324	$ 73,929	$ 47,673	$ 75,957
Adjustment									6,908	(3,719)	86		$ 7,668	$ (4,128)	$ 95	$ -		$ 7,668	$ (4,128)	$ 95	$ -
Total	17.10	15.98	15.62	15.11	89.0%	83.6%	85.2%	88.6%	113,850	109,250	95,450	85,630	$ 126,373	$ 121,267	$ 105,950	$ 95,050		756,821	746,917	655,371	635,278
Cummulative: Feb - Nov	16.87	15.70	15.59	14.75	88.9%	84.0%	84.5%	88.6%	93,495	90,856	81,896	76,343	$ 103,780	$ 100,850	$ 90,905	$ 84,740		$ 620,860	$ 629,206	$ 557,493	$ 577,638
		1.17	1.28	2.12		0.05	0.04	0.00		2,639	11,599	17,153		2,930	12,875	19,039			(8,346)	63,367	43,222
															Cost / DT						
															Full 12 months			$ 290.31	$ 297.02	$ 286.31	$ 287.52
															10 months, Trial			$ 286.41	$ 294.19	$ 285.41	$ 286.21
															Variance				$ 7.77	$ (8.78)	$ 0.80

12/28/2019

APPENDIX D

Denton Creek Regional Wastewater System
Sludge Processing Summary: 2016 - 2019 with 2020 Projection
At Constant Polymer and Disposal Costs

	Sludge Processing Comparitive 2018 vs. 2019																				
	Volatiles (VSS%)				TONS HAULED (From DCRWS Reports)				Cake %				DRY SOLIDS, ESTIMATED					Disposal Costs			
Month	2019	2018	2017	2016	2019	2018	2017	2016	2019	2018	2017	2016	2019	2018	2017	2016		2019	2018	2017	2016
																		$ 57.22	$ 57.22	$ 57.22	$ 57.22
Dec	79.6%	80.6%	79.5%	No Data	1,042.9	773.6	576.9	No Data	22.5	22.5	22.5		234.7	174.0	129.5			$ 59,677	$ 44,263	$ 33,010	
Jan	80.0%	81.5%	76.5%	No Data	938.3	926.8	870.8	827.2	21.8	21.8	23.7	23.1	204.6	201.9	206.2	191.3		$ 53,690	$ 53,031	$ 49,824	$ 47,331
Feb	81.2%	81.8%	75.9%	No Data	794.7	771.1	697.8	955.4	23.5	22.2	23.8	22.3	186.8	170.8	165.8	212.6		$ 45,473	$ 44,120	$ 39,927	$ 54,667
Mar	82.0%	74.5%	81.3%	No Data	957.9	1,407.3	993.9	855.2	23.0	22.4	22.4	22.7	220.3	314.7	222.2	194.4		$ 54,809	$ 80,526	$ 56,873	$ 48,937
Apr	80.6%	79.0%	72.1%	No Data	937.3	876.9	896.3	876.3	23.2	22.9	25.0	23.1	217.4	201.2	224.0	202.4		$ 53,631	$ 50,176	$ 51,287	$ 50,143
May	71.2%	80.7%	78.5%	59.5%	1,171.1	715.7	877.6	909.9	24.5	22.1	23.7	22.9	286.9	158.5	207.8	208.5		$ 67,008	$ 40,952	$ 50,217	$ 52,065
Jun	63.9%	77.9%	71.0%	64.0%	960.3	920.0	860.1	787.4	24.8	23.2	25.5	25.6	238.2	213.3	219.7	201.5		$ 54,950	$ 52,640	$ 49,217	$ 45,052
Jul	67.1%	77.8%	72.0%	66.3%	954.3	796.5	972.7	808.1	25.1	23.7	24.7	25.2	239.5	188.4	240.6	203.3		$ 54,606	$ 45,576	$ 55,660	$ 46,238
Aug	73.9%	75.0%	73.4%	66.8%	885.4	876.4	758.2	824.6	23.1	24.2	24.6	23.6	204.5	212.4	186.2	194.3		$ 50,662	$ 50,149	$ 43,386	$ 47,184
Sep	75.3%	71.2%	77.4%	72.7%	865.5	902.0	748.5	766.5	23.5	23.5	23.7	23.5	203.5	211.8	177.3	180.0		$ 49,521	$ 51,610	$ 42,831	$ 43,860
Oct	76.7%	66.6%	77.5%	70.8%	637.4	849.3	647.4	707.2	24.2	25.2	23.5	23.7	154.1	214.2	152.0	167.6		$ 36,474	$ 48,596	$ 37,044	$ 40,466
Nov	73.4%	73.9%	79.5%	75.4%	872.9	1,118.7	701.6	1,123.5	24.8	22.7	22.5	22.6	216.5	253.6	157.6	253.6		$ 49,946	$ 64,011	$ 40,144	$ 64,286
Total	75.4%	76.7%	76.2%	67.9%	11,018.0	10,934.1	9,601.9	9,441.3	23.67	23.03	23.78	23.47	2,606.9	2,514.7	2,289.0	2,209.5		$ 570,771	$ 581,387	$ 516,412	$ 540,229
Cummulative: Feb - Nov	74.5%	75.8%	75.9%	67.9%	9,036.7	9,233.8	8,154.3	8,614.1	23.97	23.20	23.93	23.51	2,167.7	2,138.8	1,953.3	2,018.2		$ 517,081	$ 528,356	$ 466,588	$ 492,898
		-1.3%	-1.3%	6.6%		(197.0)	882.4	422.6		0.77	0.04	0.46		28.9	214.4	149.5			$ (11,275)	$ 50,493	$ 24,183
2020 Projection	74.5%				10,640.6				24.50				2,606.9					608,854			

	Polymer Analysis																	Total Polymer + Disposal			
	Polymer lbs/DT				Capture %				Polymer Pounds, Neat				Polymer $					Disposal Costs (constant prices)			
Month	2019	2018	2017	2016	2019	2018	2017	2016	2019	2018	2017	2016	2019	2018	2017	2016		2019	2018	2017	2016
													$ 1.11	$ 1.11	$ 1.11	$ 1.11					
Dec	16.5	18.2	15.8		90.0%	84.6%	88.3%	No Data	9,778	8,496	5,276		10,853	9,430	5,856	-		$ 70,530	$ 53,693	$ 38,866	$ -
Jan	18.0	18.0	15.6	18.9	89.0%	78.4%	88.5%	No Data	9,402	10,530	8,263	9,287	10,437	11,689	9,172	10,309		$ 64,127	$ 64,719	$ 58,996	$ 57,640
Feb	22.2	15.1	16.5	23.3	88.1%	77.6%	76.5%	No Data	10,686	7,540	8,135	12,700	11,861	8,370	9,030	14,097		$ 57,335	$ 52,490	$ 48,957	$ 68,764
Mar	20.1	14.6	17.2	16.4	88.2%	85.9%	72.8%	No Data	11,431	12,146	11,936	8,196	$ 12,688	$ 13,482	$ 13,249	$ 9,098		$ 67,498	$ 94,008	$ 70,122	$ 58,035
Apr	18.6	18.1	13.0	11.3	88.3%	80.0%	89.9%	No Data	10,394	10,367	7,348	5,879	$ 11,537	$ 11,507	$ 8,157	$ 6,526		$ 65,168	$ 61,683	$ 59,444	$ 56,669
May	15.0	21.2	16.3	12.5	88.9%	81.1%	84.1%	86.4%	11,027	9,425	9,151	6,845	$ 12,240	$ 10,462	$ 10,158	$ 7,598		$ 79,248	$ 51,414	$ 60,375	$ 59,663
Jun	12.2	18.9	14.5	12.5	90.7%	86.4%	85.9%	87.9%	7,276	10,639	8,427	6,516	$ 8,076	$ 11,809	$ 9,354	$ 7,232		$ 63,025	$ 64,449	$ 58,571	$ 52,285
Jul	12.7	19.8	15.1	14.1	89.9%	81.8%	85.9%	90.1%	7,724	10,346	9,589	7,214	$ 8,574	$ 11,484	$ 10,644	$ 8,008		$ 63,179	$ 57,061	$ 66,305	$ 54,246
Aug	13.2	16.3	14.4	14.0	88.7%	80.6%	88.2%	87.8%	6,898	9,761	6,910	7,034	$ 7,656	$ 10,834	$ 7,670	$ 7,808		$ 58,318	$ 60,984	$ 51,057	$ 54,992
Sep	14.6	14.4	14.9	13.3	89.7%	88.6%	91.8%	91.2%	7,547	7,838	6,523	5,986	$ 8,377	$ 8,700	$ 7,240	$ 6,644		$ 57,898	$ 60,310	$ 50,072	$ 50,504
Oct	15.8	12.5	17.4	13.0	87.3%	87.3%	85.4%	91.0%	6,331	6,946	7,022	5,457	$ 7,028	$ 7,710	$ 7,795	$ 6,057		$ 43,502	$ 56,305	$ 44,839	$ 46,523
Nov	15.3	14.0	16.0	15.7	89.1%	90.6%	84.7%	85.9%	8,448	8,935	6,783	10,515	$ 9,378	$ 9,918	$ 7,529	$ 11,671		$ 59,324	$ 73,929	$ 47,673	$ 75,957
Adjustment									6,908	(3,719)	86		$ 7,668	$ (4,128)	$ 95	$ -		$ 7,668	$ (4,128)	$ 95	$ -
Total	17.10	15.98	15.62	15.11	89.0%	83.6%	85.2%	88.6%	113,850	109,250	95,450	85,630	$ 126,373	$ 121,267	$ 105,950	$ 95,050		756,821	746,917	655,371	635,278
Cummulative: Feb - Nov	16.87	15.70	15.59	14.75	88.9%	84.0%	84.5%	88.6%	93,495	90,856	81,896	76,343	$ 103,780	$ 100,850	$ 90,905	$ 84,740		$ 620,860	$ 629,206	$ 557,493	$ 577,638
		1.17	1.28	2.12		0.05	0.04	0.00		2,639	11,599	17,153		2,930	12,875	19,039			(8,346)	63,367	43,222
															Cost / DT						
															Full 12 months			$ 290.31	$ 297.02	$ 286.31	$ 287.52
															10 months, Trial			$ 286.41	$ 294.19	$ 285.41	$ 286.21
															Variance				$ 7.77	$ (8.78)	$ 0.80
2020 Projection	16.00				90.0%				105,331				$ 116,917					$ 725,771			
															Cost / DT			$ 278.40			