Optimizing Operations to Reduce WRRF Costs:

A Case Study of the City of Richmond

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Richmond is located 15 miles southwest of Houston on the Brazos River and serves a population ~24,000

Customer Base

- Residential – 87%
- Commercial/Institutional – 13%

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The Richmond Regional WWTF is a Conventional Activated Sludge Treatment plant permitted for 3 MGD

Reuse System Capacity 1.5 MGD

An assessment of the Richmond WWTF

New management of facility operations

Young staff, relatively inexperienced with optimizing process control

Persistent foaming issues – previous 5 years

Poor historical process control records

No pretreatment program

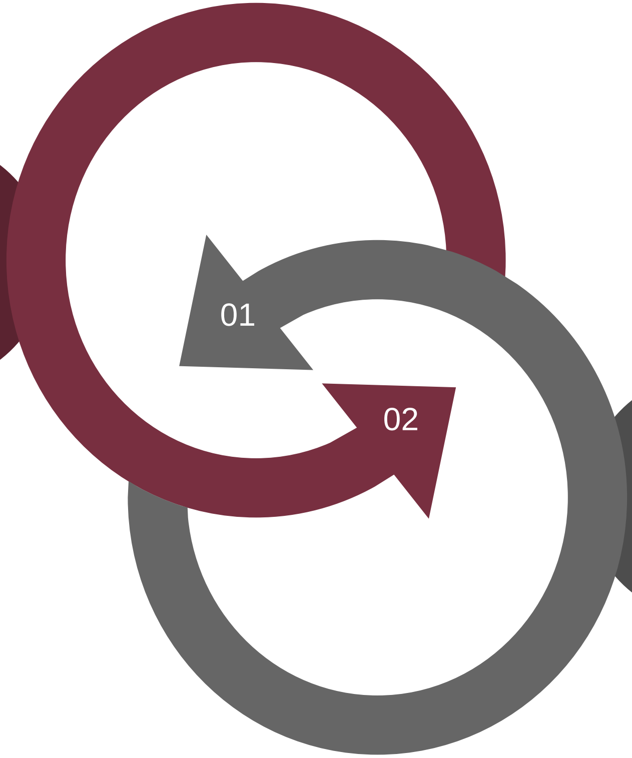
No SCADA

Still meeting permit

Garver’s study addressed two main objectives

Objective 1

Foam Mitigation



Process Optimization

Objective 2

OBJECTIVE #1:
Identify solutions to eliminate foaming issues

Multiple factors were investigated to identify the root cause of foaming

- Low DO
- High DO
- Chlorinated mixed liquor return
- Surfactants
- Toxicity
- Nutrient Deficiency
- Filaments (Low F:M)
- High Oil & Grease

Historical data was used to pinpoint the cause(s) of foam at the Richmond Regional WWTF

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1		Aeration Basin Volume	1,343,920			gallons											
2		Aeration Basin Volume	179,668			cu.ft.				Avg. Inf BOD	197						
3		Total Clarifier Volume	1,066,225			gallons				Avg. Inf NH3	30						
4		Total Digester Volume	1,008,872			gallons				Avg. Inf TSS	232						
5																	
6						Permit Effluent BOD (mg/L):	10			Permit Effluent NH3-N (mg/L):	3			Permit Effluent TSS (mg/L):	15		
7		Date	Flow (MGD)	Avg. Flow (MGD)	Permit Flow (MGD)	Influent BOD (mg/L)	Effluent BOD (mg/L)	Average Effluent BOD (mg/L)	Permit Effluent BOD (mg/L)	Influent NH3-N (mg/L)	Effluent NH3-N (mg/L)	Average Effluent NH3-N (mg/L)	Permit Effluent NH3-N (mg/L)	Influent TSS (mg/L)	Effluent TSS (mg/L)	Average Effluent TSS (mg/L)	Permit Effluent TSS (mg/
8	1	3/29/2018	1.988	1.404134	3		2	2.8492537	10		4.75	0.33014925	3		2.8	4.48552239	1
9	2	3/28/2018		1.404134	3			2.8492537	10			0.33014925	3			4.48552239	1
10	3	3/27/2018	1.634	1.404134	3	198	6.8	2.8492537	10	35.7	4.23	0.33014925	3	2400	5.4	4.48552239	1
11	4	3/22/2018	1.276	1.404134	3		2	2.8492537	10		2.16	0.33014925	3		7.2	4.48552239	1
12	5	3/20/2018	1.325	1.404134	3	173	3.6	2.8492537	10	4.65	2.87	0.33014925	3	70	2.2	4.48552239	1
13	6	3/16/2018		1.404134	3			2.8492537	10			0.33014925	3			4.48552239	1
14	7	3/15/2018	1.257	1.404134	3		2.5	2.8492537	10		0.1	0.33014925	3		6.8	4.48552239	1
15	8	3/13/2018	1.237	1.404134	3	186	2	2.8492537	10	28.8	0.1	0.33014925	3	107	4.2	4.48552239	1
16	9	3/12/2018		1.404134	3			2.8492537	10			0.33014925	3			4.48552239	1
17	10	3/8/2018	1.583	1.404134	3		3	2.8492537	10		0.1	0.33014925	3		1.32	4.48552239	1
18	11	3/6/2018	1.755	1.404134	3	221	2	2.8492537	10	18.1	0.1	0.33014925	3	308	3.6	4.48552239	1
19	12	3/1/2018	1.114	1.404134	3		2.1	2.8492537	10		0.1	0.33014925	3		6	4.48552239	1
20	13	2/27/2018	1.63	1.404134	3	364	2.3	2.8492537	10	27.8	0.1	0.33014925	3	90	4.4	4.48552239	1
21	14	2/26/2018		1.404134	3			2.8492537	10			0.33014925	3			4.48552239	1

Data Summary - Regional | SRT Calculations | Flow | Inf BOD | Eff BOD | Inf NH3-N | Eff NH3-N | Inf TSS | Eff TSS | ...

Ready 85%

Additional sampling was recommended to increase data resolution

- Influent BOD
- WAS flow and conc.
- MLSS and MLVSS in aeration basins
- Total RAS flows
- Digested sludge %solids
- Flow to Belt Filter Press (BFP)
- Dewatered sludge %solids

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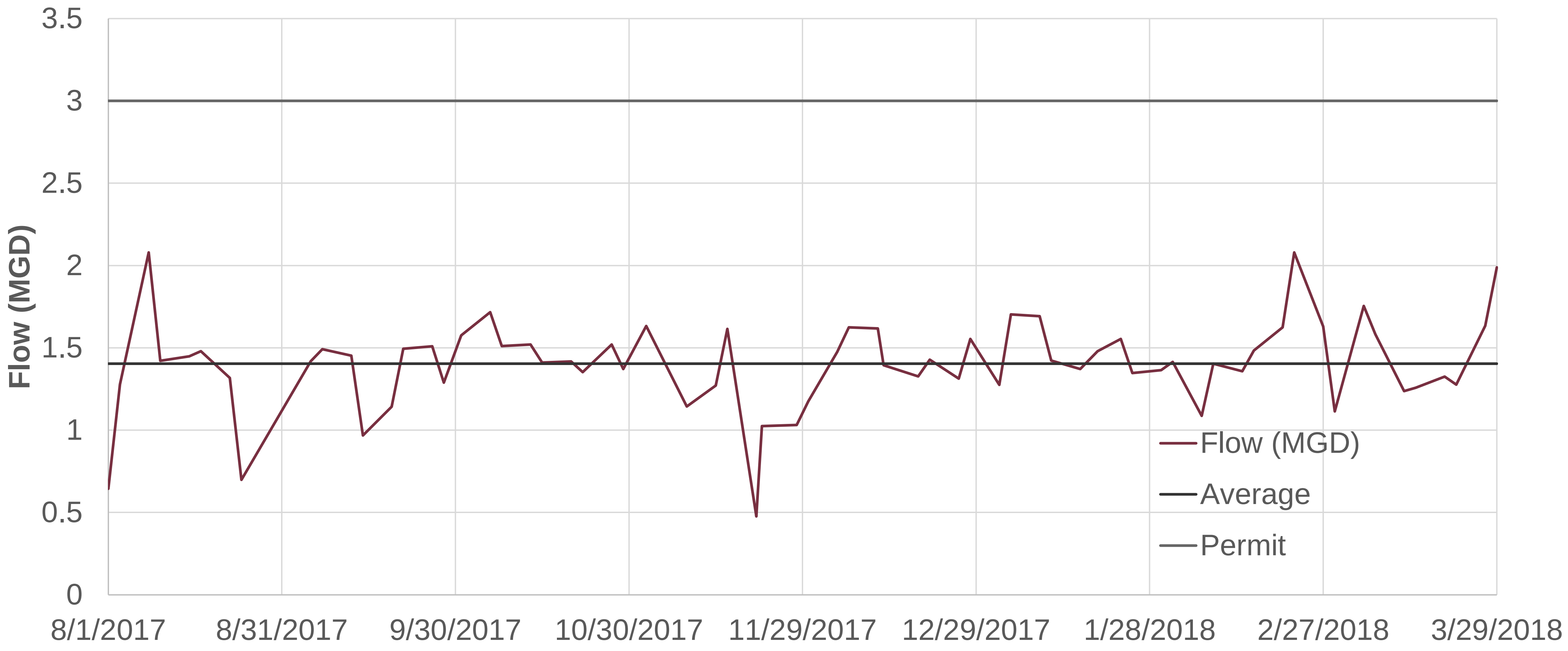
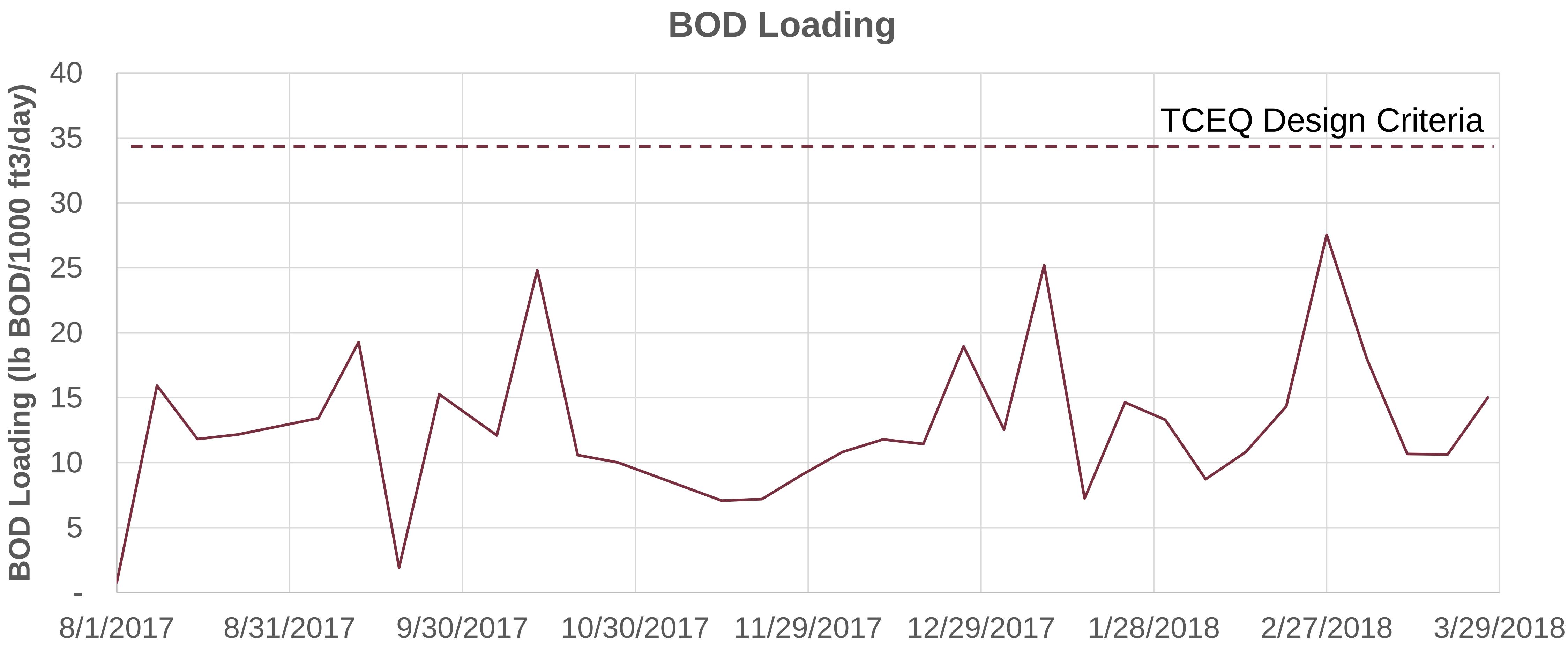
Analysis & Findings

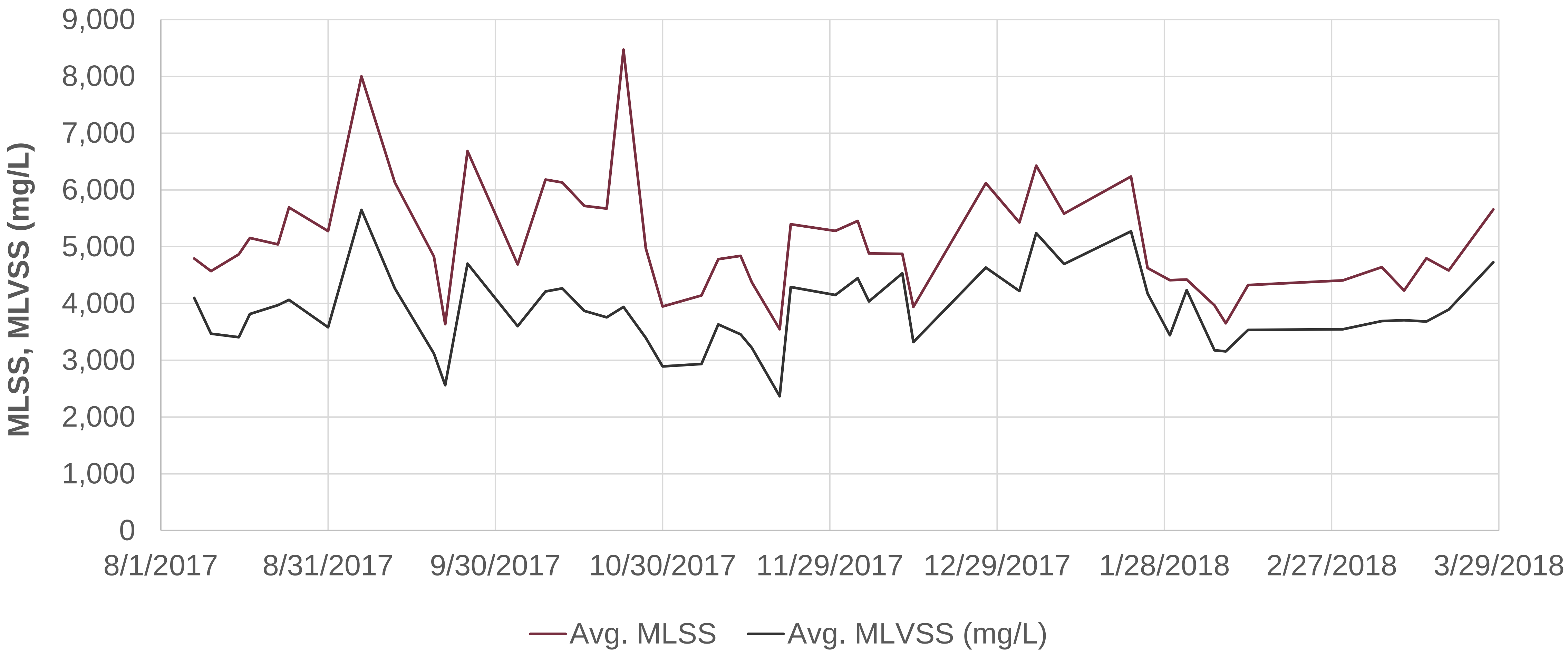
Flow to the WWTF was within the permitted design capacity of 3 MGD



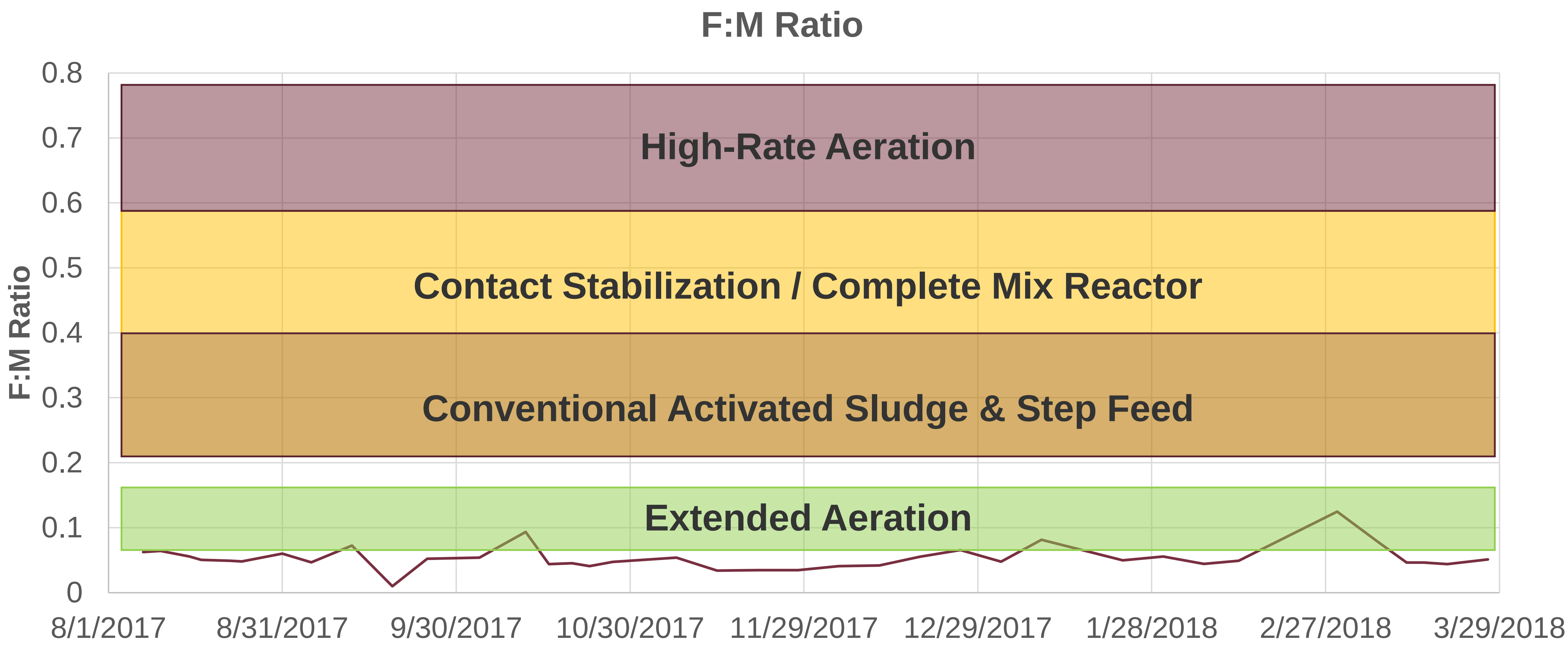
Influent BOD loading was also within the design capacity of the plant



Average MLSS and MLVSS were relatively high for the application



The moderate BOD loading combined with high MLVSS resulted in a low F:M ratio



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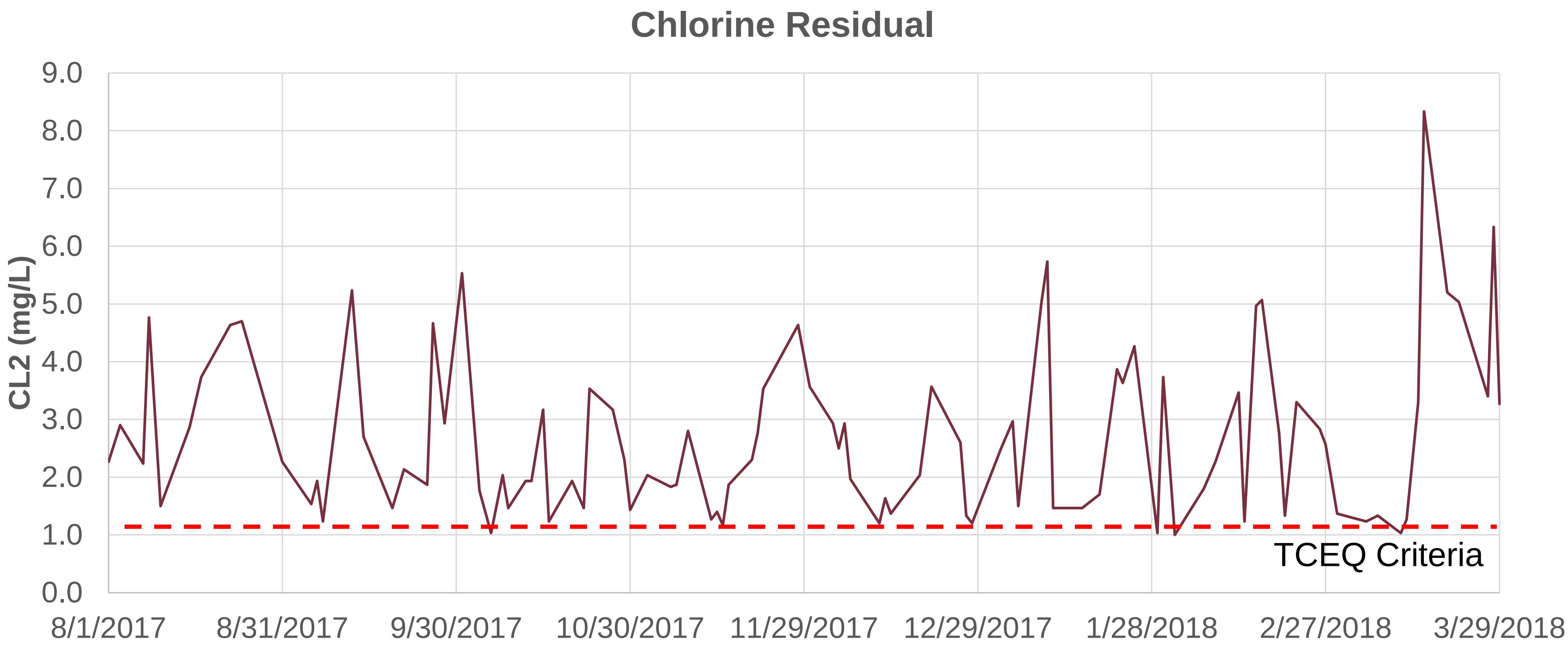
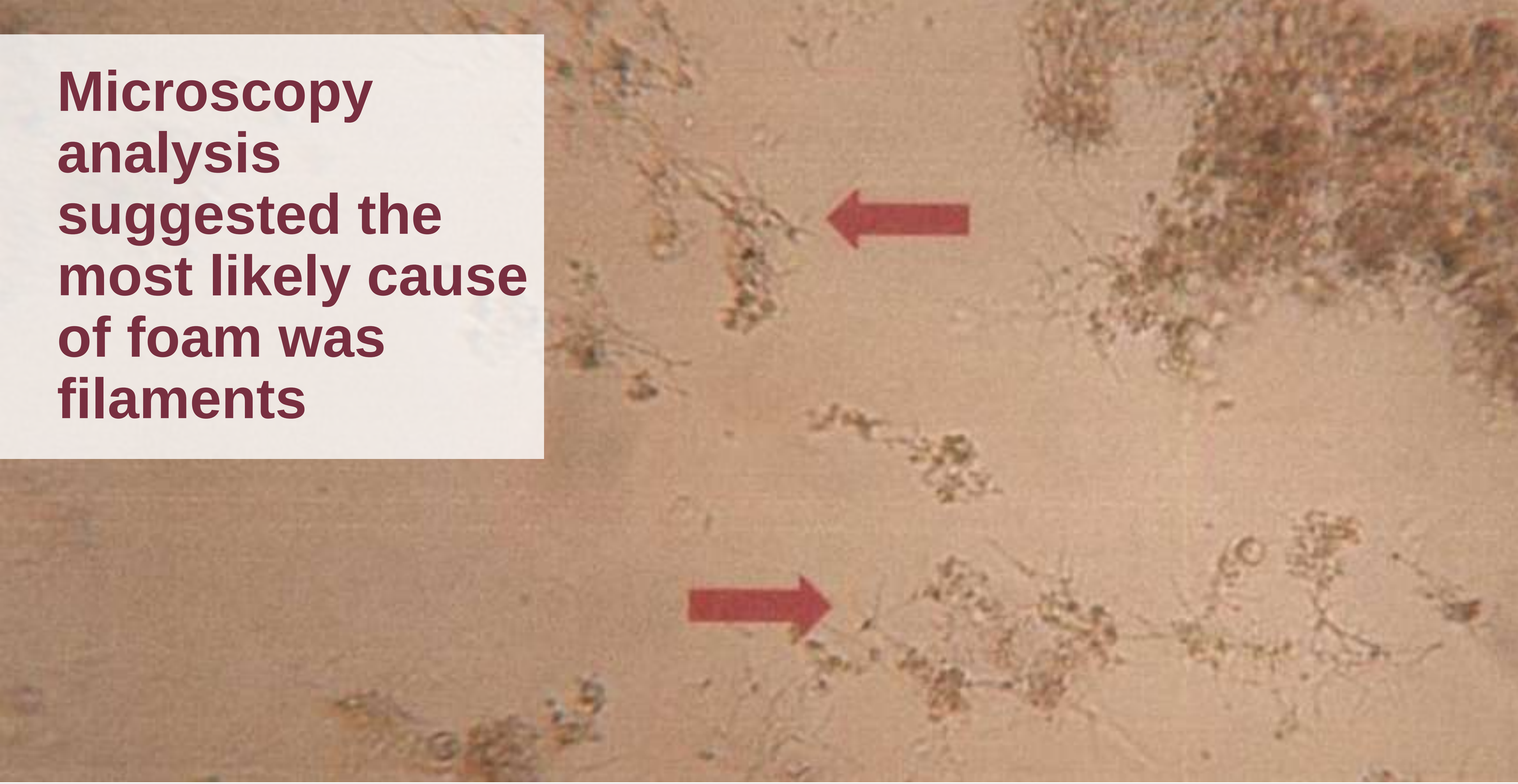
Chlorine feed rate was high to combat poor distribution of chemical in the CCBs



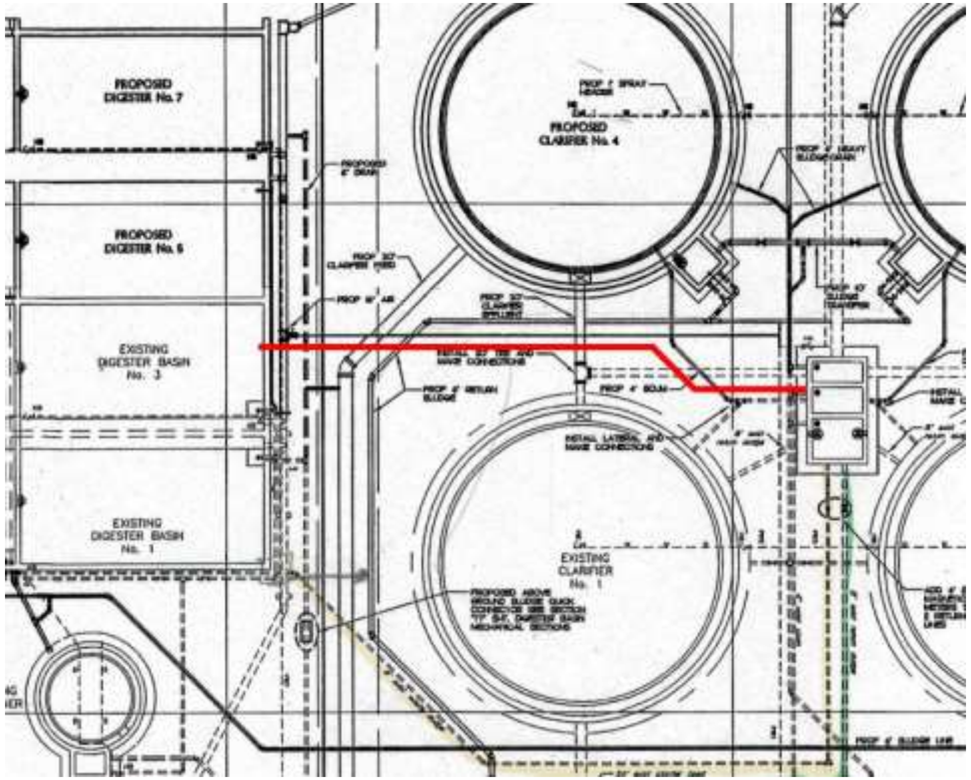
Microscopy analysis suggested the most likely cause of foam was filaments



Recommendations

Immediate recommendations focused on removing foam-causing substances from the basins

Divert Scum Line to Digesters



Waste Solids to Reduce SRT and Increase F:M Ratio

The result of these changes was immediate improvement in foam accumulation

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OBJECTIVE #2

Process optimization focused on lowering the overall operating cost to the City

Multiple plant process units were identified for improved consistency through process control

Aeration

Blower Operation on D.O. Control

Clarifiers

Waste Continuously to Maintain MLSS

Chlorine Contact

Improve Chemical Mixing and Avoid Over-Feeding

Solids Processing

Increase Efficiency of BFP

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Plant operating costs were broken down into three categories

Chemicals

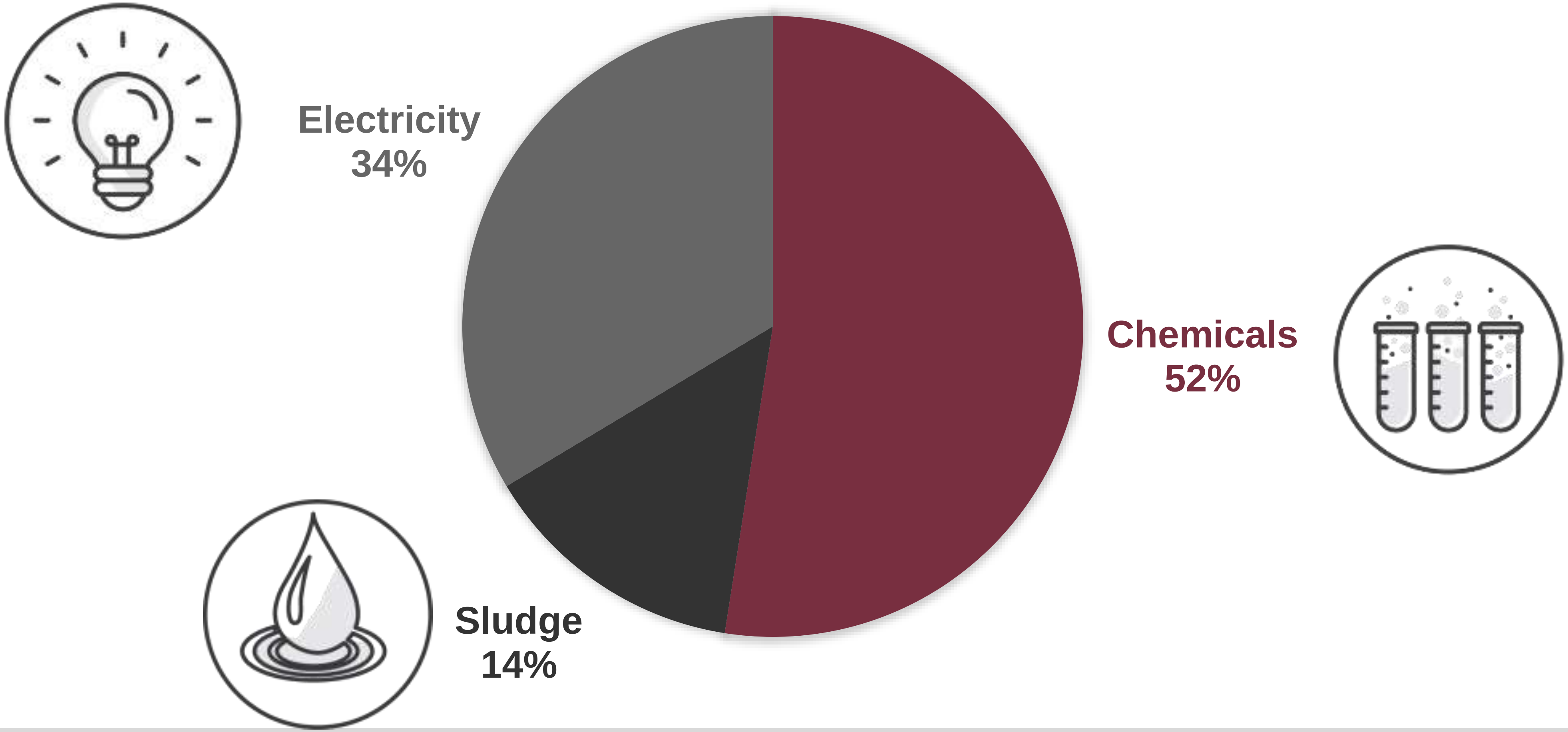
- Sodium Hypochlorite
- Sodium Bisulfite
- Polymer
- Defoamer

Electricity

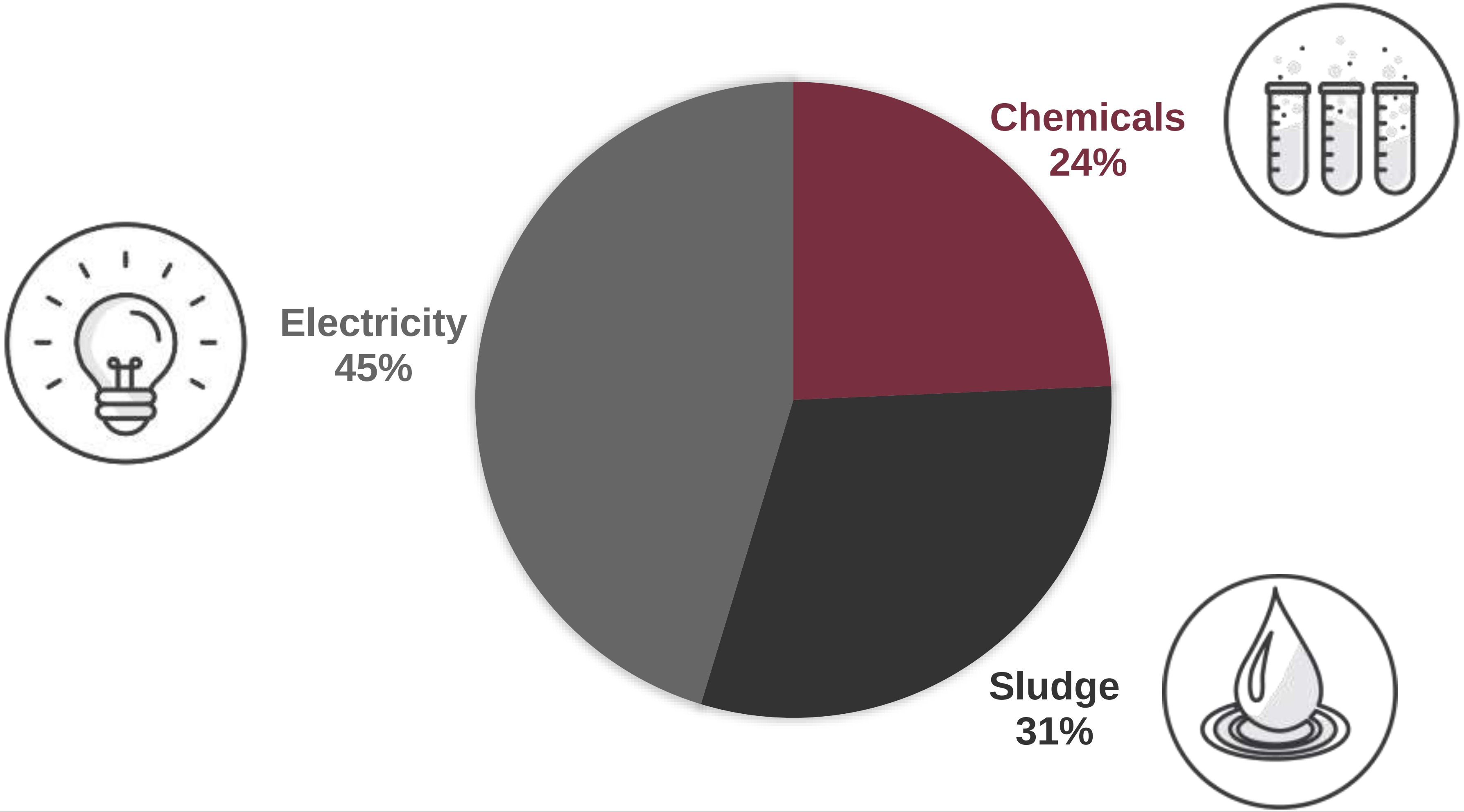
Sludge

- Dry Sludge Hauling
- Wet Sludge Hauling

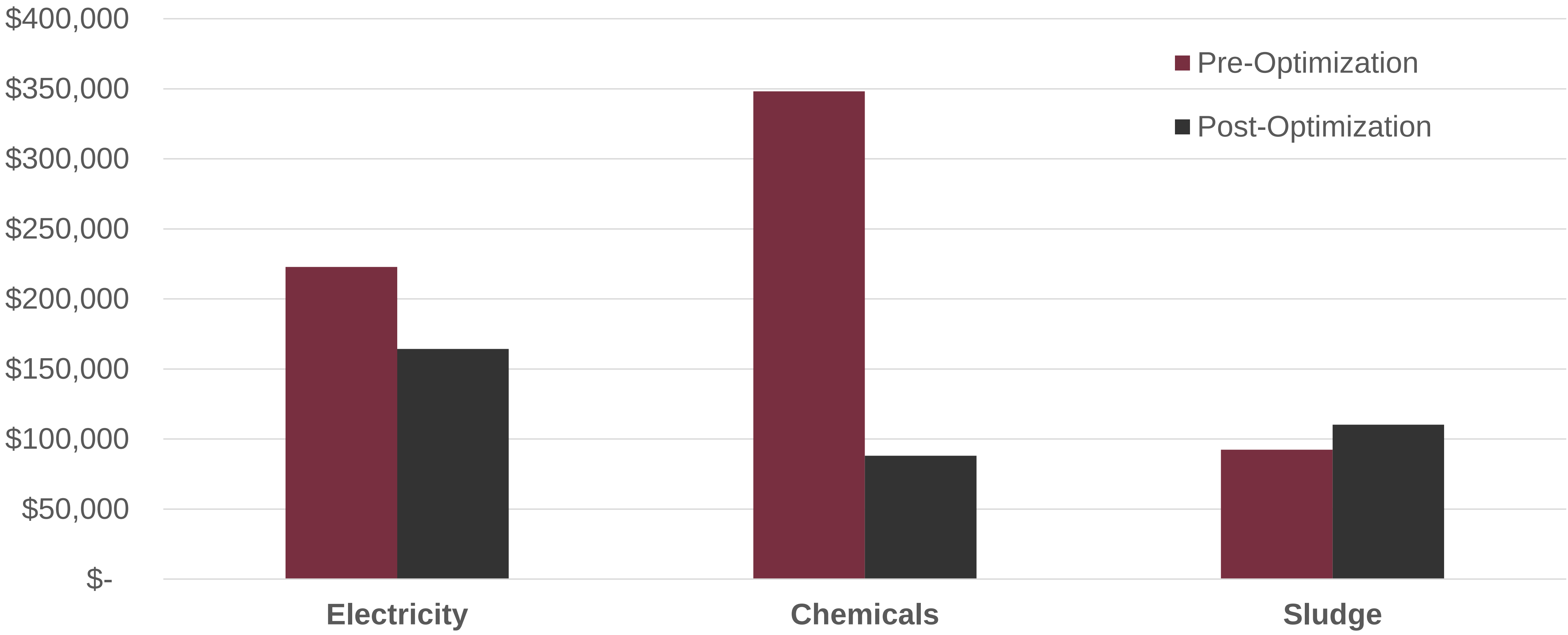
Prior to the study, the plant's operating budget was dominated by chemical costs



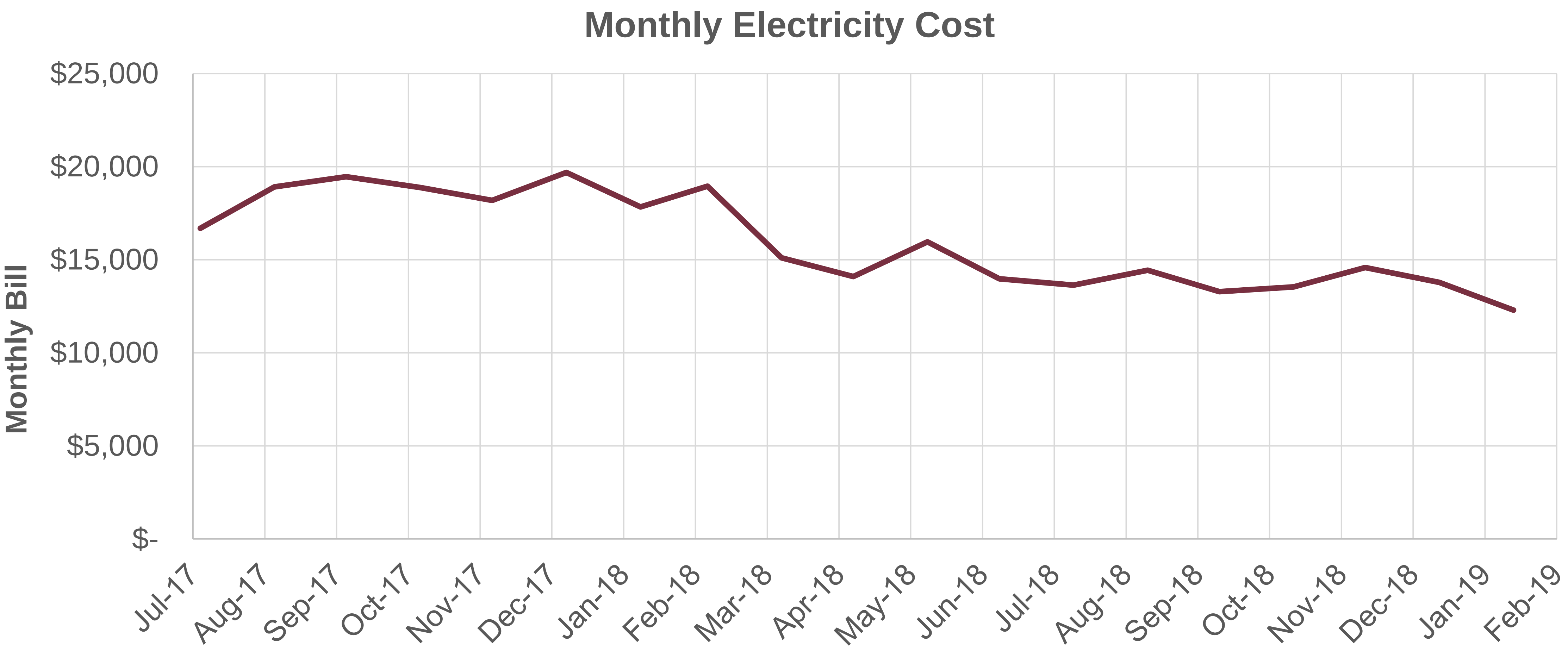
Eliminating the foam reduced the proportion of operating costs that go to chemical purchases



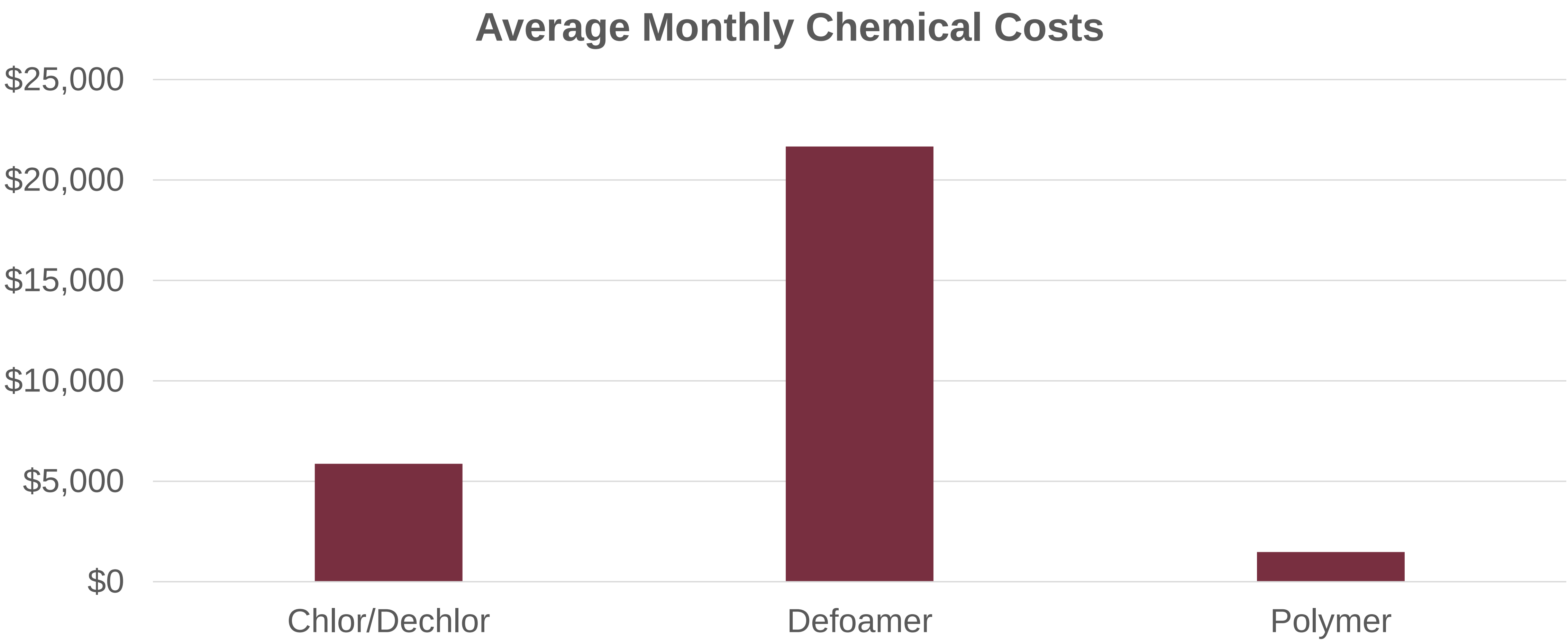
More importantly, it significantly reduced the total annual operating costs of the plant



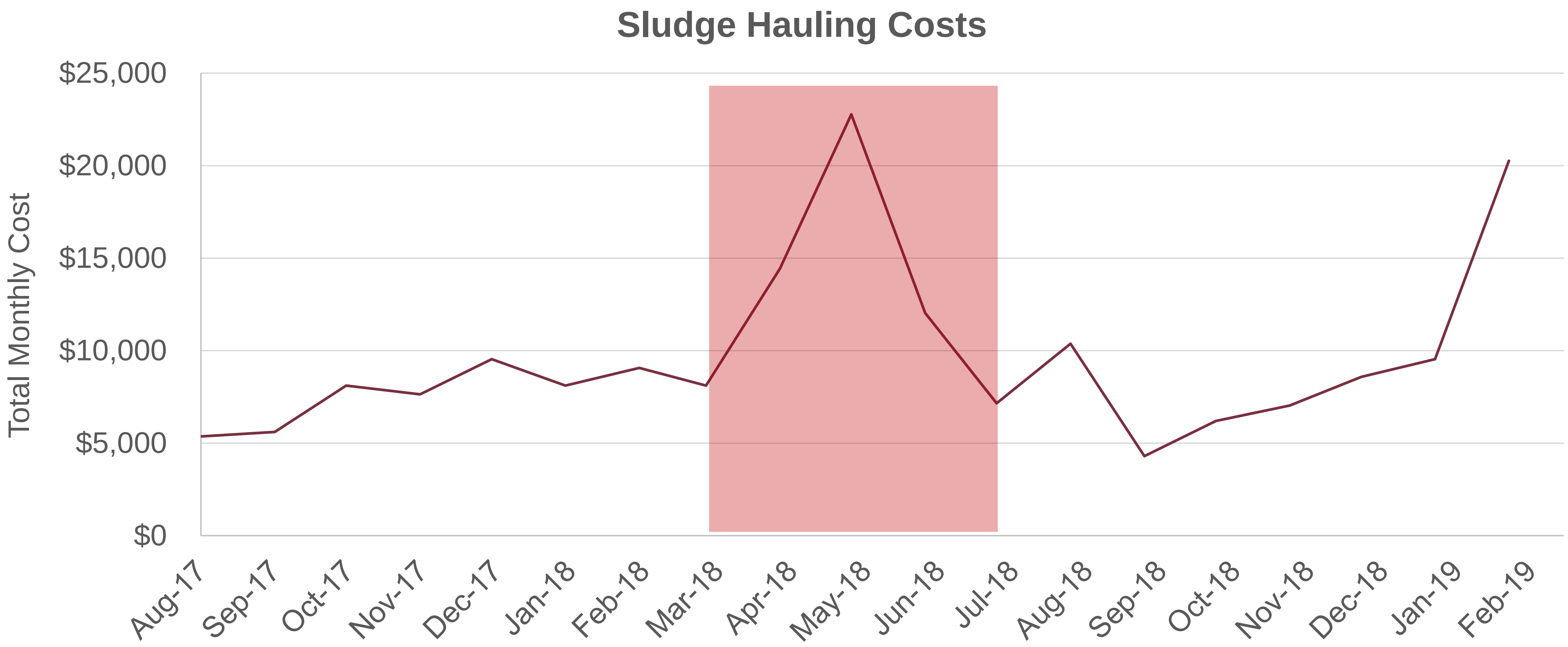
Electricity costs decreased with blower controls tied to dissolved oxygen sensors



A majority of chemical costs were associated with defoamer, which was eliminated



Sludge hauling costs increased as a result of the increased solids wasting from the aeration basins



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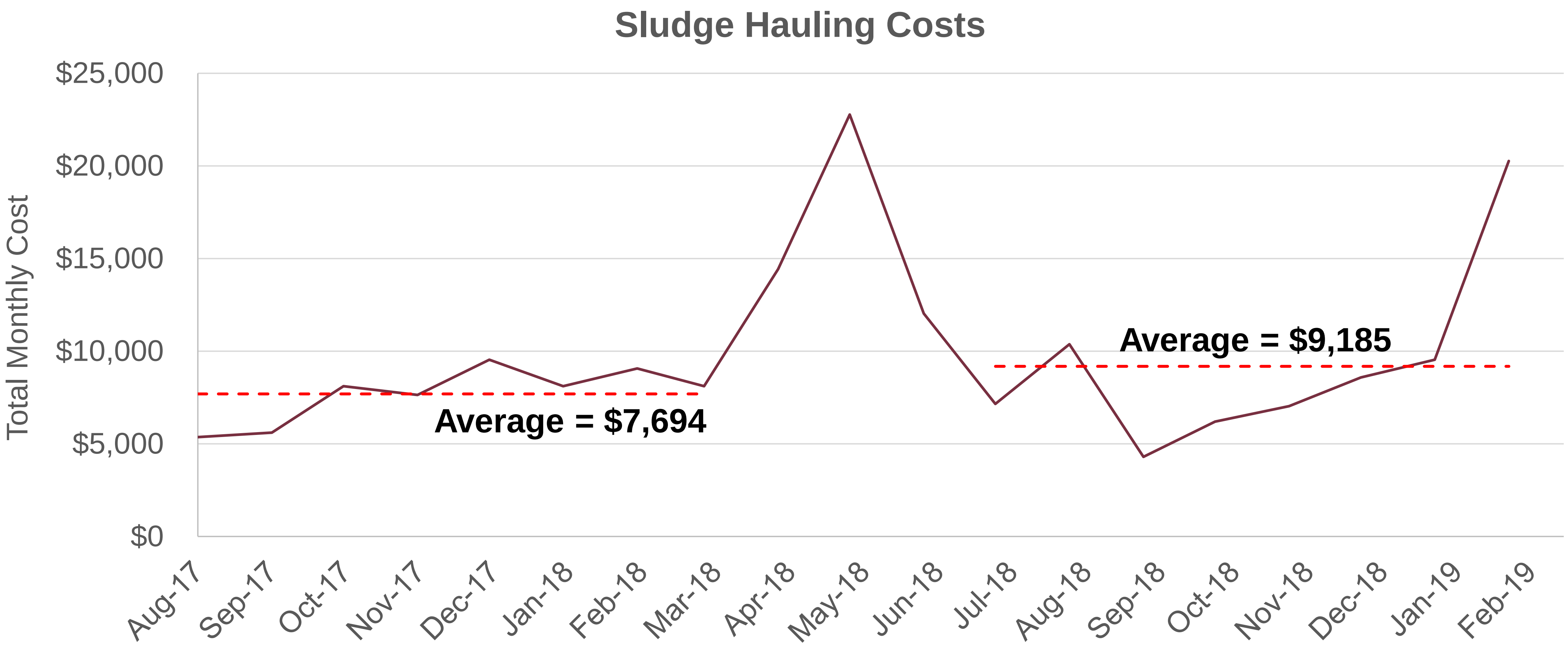

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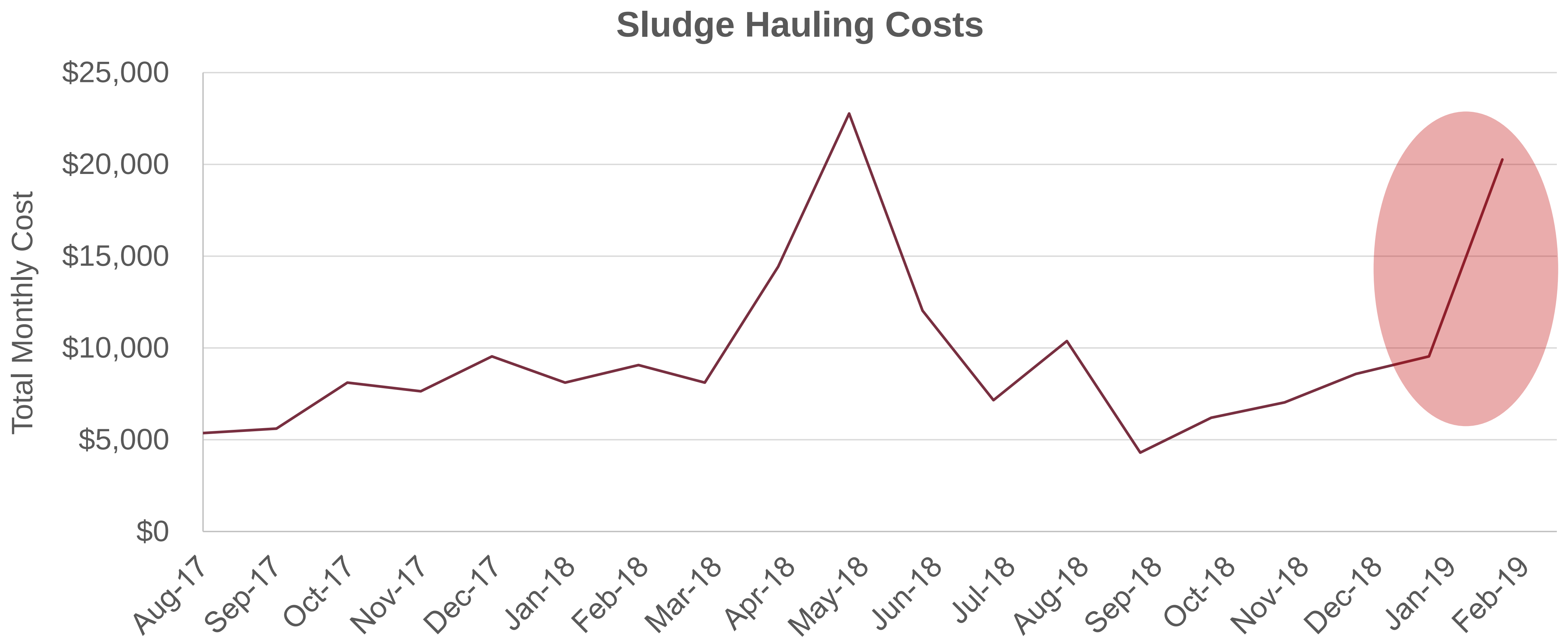

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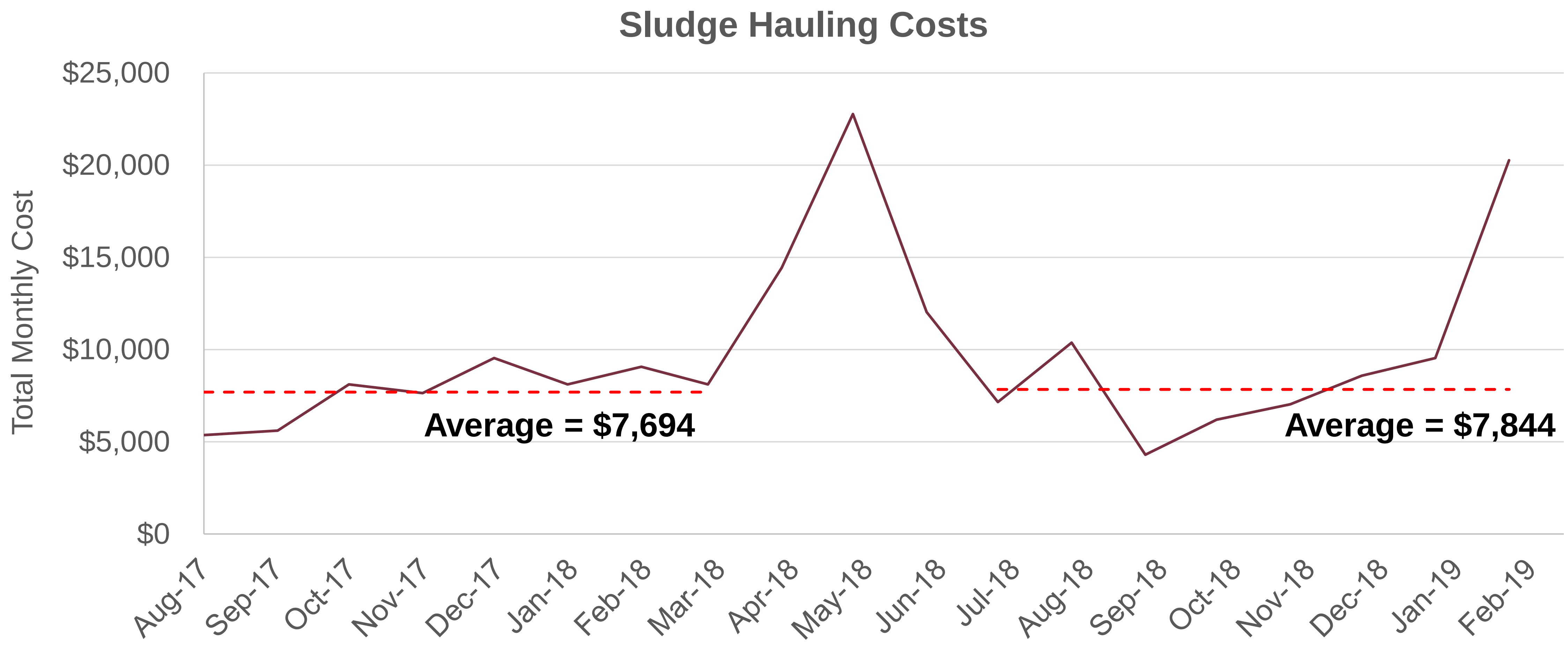
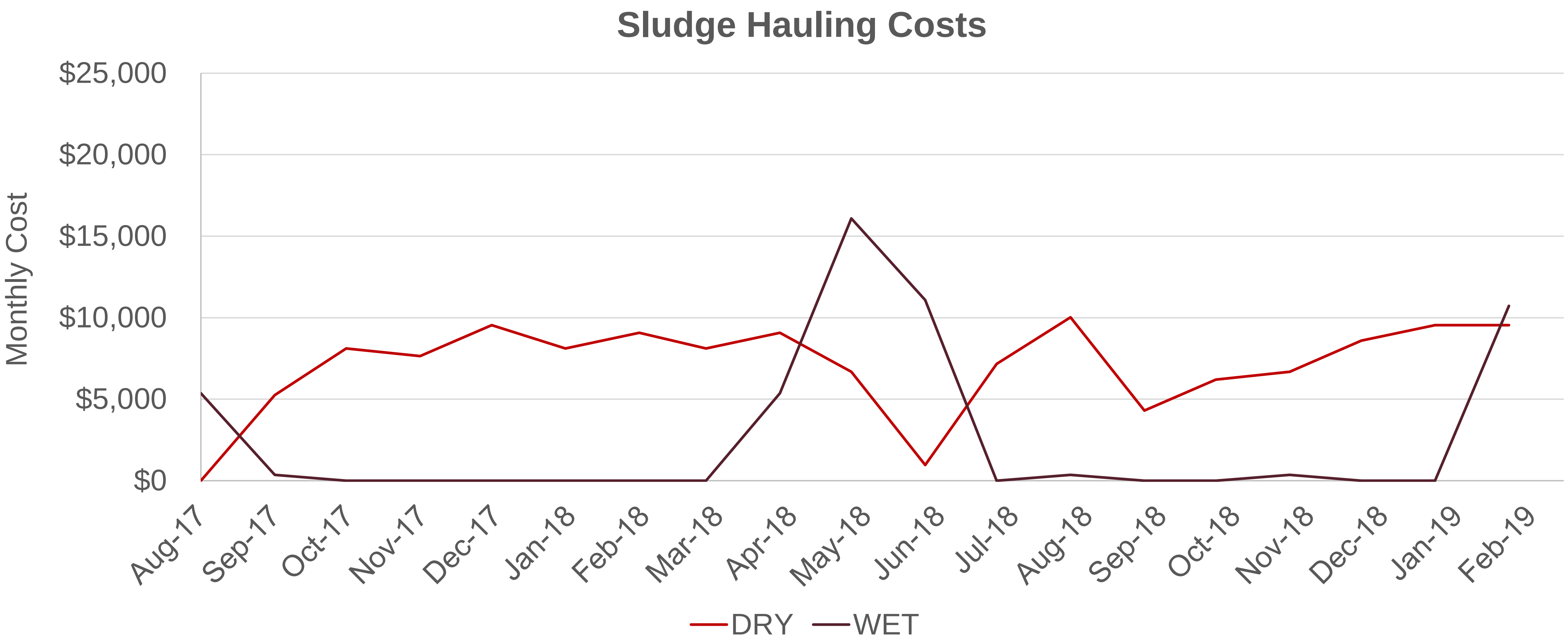


Wet sludge hauling occurred during BFP outages or when solids wasting exceeded BFP capacity



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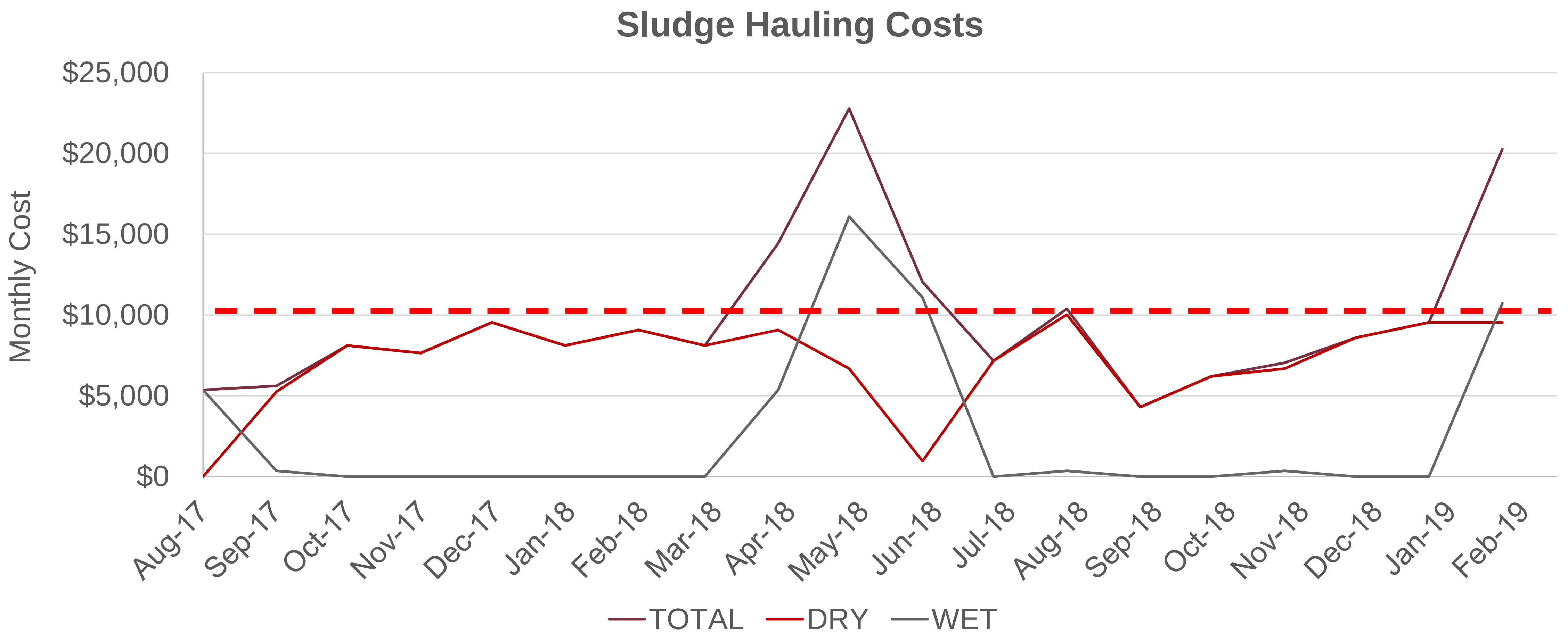

Logistics issues with the current sludge hauling configuration limit # of loads/day

- **1 Belt Filter Press**
- **1 Conveyor**
- **1 Dumpster**
- ***Inability to fill more than one dumpster at a time***

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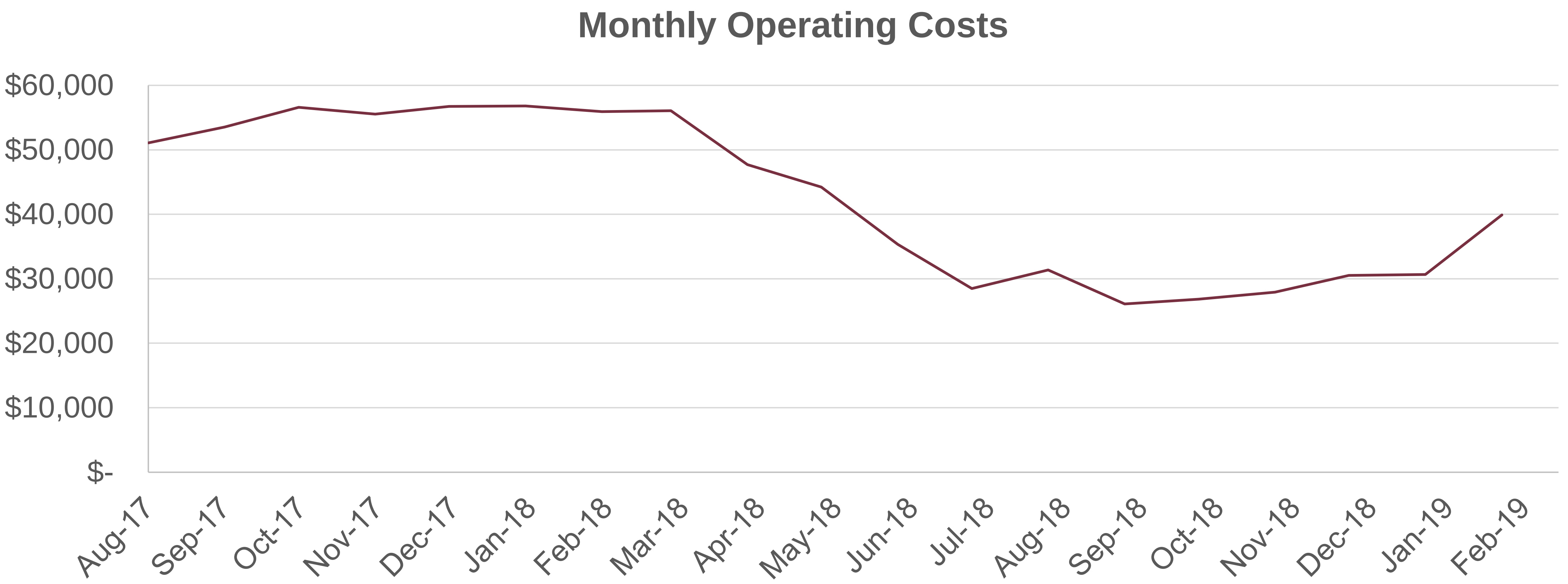
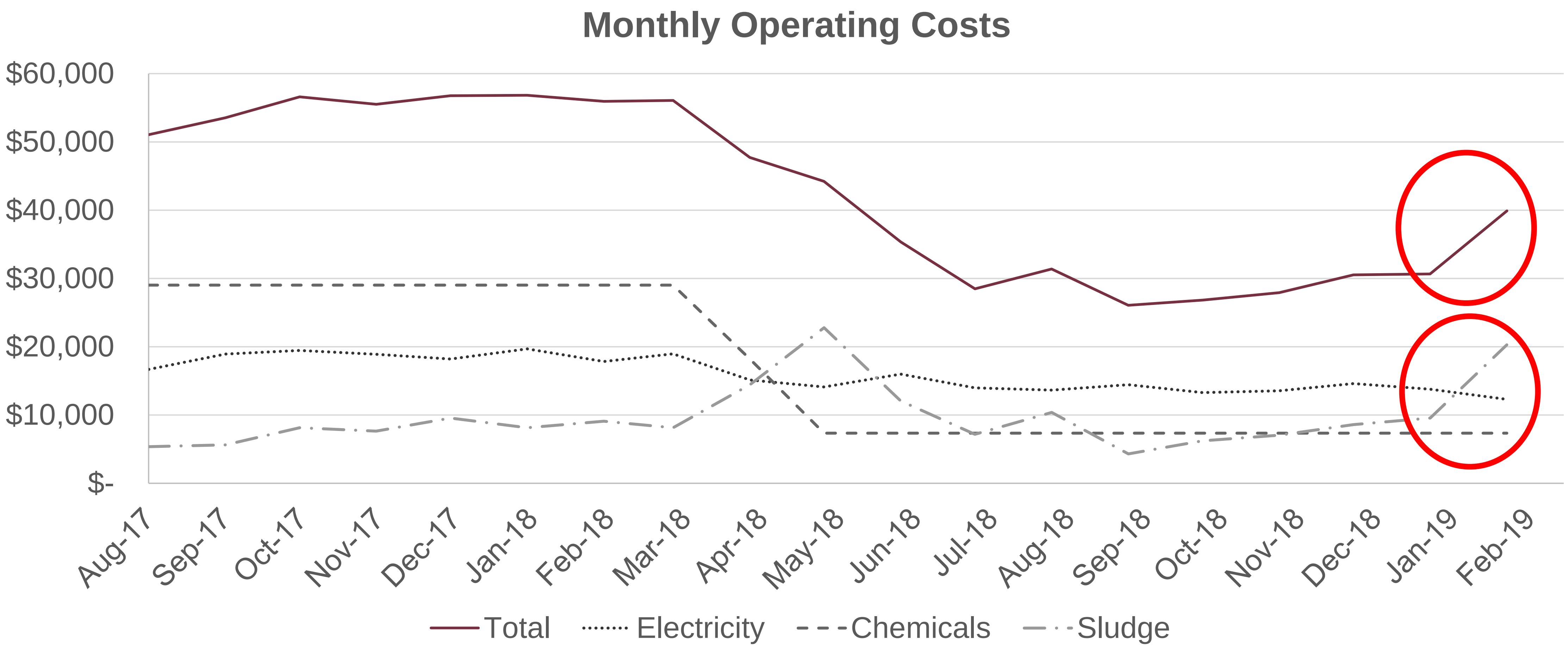
Conclusions & Next Steps

Plant-wide operating cost reductions were achieved with minimal capital investment



The study procedure identified targets for additional cost reduction



Garver updated plant SOPs and provided an operator dashboard for ease of implementation

Richmond Regional WWTF WAS & RAS

Instructions: *Enter values in grey boxes. Fixed values are indicated by maroon cells. Spreadsheet calculates values in navy boxes*

Flow	1.5	MGD	Calculated RAS Flow	1.46	MGD
Aeration Basin MLSS	5,100	mg/L	Calculated WAS Flow	0.06	MGD
Influent TSS	230	mg/L	WAS Daily Loading	2,546	lb/day
RAS MLSS	5,000	mg/L	Calculated SRT	23	Days
Effluent TSS	13	mg/L	Recycle Ratio	1.0	
Target SRT	25	days			
Recorded WAS	0.06	MGD			
Aeration Basin Volume	1.34	MG			

Process Control Parameter	Typical Range
F:M Ratio	0.05 - 0.15
BOD Loading (lb/day/1000 ft^3)	10 – 25
Aeration Basin HRT (hours)	18 – 24
Aeration Basin SRT (days)	20 – 30
Recycle Ratio	0.75 – 1.50
BOD Removal Efficiency	75 - 90%

Relevant Equation(s):

$$SRT, days = \frac{(Aeration\ Basin\ Volume, MG) * (8.34) * (Aeration\ Basin\ MLSS, \frac{mg}{L})}{(WAS\ Flow, MGD) * (8.34) * (WAS\ Suspended\ Solids, \frac{mg}{L})}$$

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Acknowledgments

- Howard Christian, City of Richmond
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- Gary Sober, Garver

Questions?

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