Reducing Dewatering Costs Through an Optimization Program

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ABSTRACT
The centrifuge dewatering systems operated by the Eastern Municipal Water District (District) in Perris, California, were assessed and an optimization program was developed to improve performance and reduce operating costs. The District implemented recommendations for improvements in operations, polymer, equipment, systematic optimization tasks, and recordkeeping. Sludge characteristics were tracked and monitored relative to dewatering performance so that the impacts of upstream processes could be determined. Operational observations led to changes in upstream processes that increased primary sludge content in digester and dewatering feed, which subsequently yielded better dewatering performance. Between the various operational, performance tracking, and process changes at the two plants and the successful optimization measures, the District has reduced its annual dewatering costs by approximately $200,000.

KEYWORDS
Centrifuge Optimization, Dewatering Performance, Dewatering Costs, Sludge Characteristics, Cake Dryness, Polymer Demand

INTRODUCTION
The Eastern Municipal Water District (District) in Perris, California, operates four regional water reclamation facilities (RWRF). The San Jacinto Valley RWRF (rated for 53-MLD (14-mgd) average annual flow) and Perris Valley RWRF (rated for 83-MLD (22-mgd) average annual flow) are the subjects of this paper. Both facilities include primary clarifiers that are used to thicken primary sludge, conventional activated sludge processes, waste activated sludge thickening, anaerobic digestion, and dewatering (duty centrifuges and standby belt filter presses).

During the early 2000s, population in the District's region was rapidly increasing and each facility was expanded for additional capacity and changing regulatory requirements. These expansion projects modified the plants to provide nitrification/denitrification (NdN) and Title 22 reuse effluent rather than the previously practiced carbonaceous biochemical oxygen demand (CBOD) removal only. Various projects also changed thickening equipment from gravity belt thickeners (GBTs) and dissolved air flotation thickeners (DAFTs) to rotary drum thickeners (RDTs). Dewatering centrifuges were installed as duty units with existing belt filter presses (BFPs) as standby.
Dewatering and subsequent transport/land application (hauling) of biosolids represented an annual District-wide operating cost of $3.7M from 2011-2014. The monthly dewatering costs for the San Jacinto Valley RWRF (SJVRWRF) and Perris Valley RWRF (PVRWRF) for that period, broken down between power, polymer and hauling are shown Figures 1 and 2, respectively. "Hauling" costs in these figures and throughout this paper represent the costs of hauling and land application, as provided by third party contracted firms. Because the facilities do not have the ability to separately measure power consumption by the centrifuges, power costs are conservatively estimated assuming full power draw based on nameplate horsepower on centrifuge motors. In late 2014, the District embarked on a concentrated effort to reduce dewatering costs across its facilities by 5 to 10-percent, resulting in annual savings of $185,000 to $370,000.

Figure 1: 2011-2014 San Jacinto Valley RWRF Monthly Dewatering Cost Breakdown
Figure 2: 2011-2014 Perris Valley RWRF Monthly Dewatering Cost Breakdown

METHODODOLOGY
The initial dewatering optimization program included several steps. First, the project team studied the existing operations, system equipment, data collection and tracking, maintenance procedures and history, and performance metrics. Recommendations for changes to these items were documented and presented to the District. This was followed by onsite staff training on centrifuges, polymer systems, and field optimization. Plant staff then implemented a number of recommended changes in an ongoing effort to increase cake dryness and reduce polymer consumption and minimize dewatering costs. This paper documents the major recommendations made by the project team, those changes that were successfully implemented, and the subsequent performance metrics at the San Jacinto Valley and Perris Valley RWRFs.

RECOMMENDATIONS
The primary performance metrics for the District's dewatering program include cake dryness, polymer consumption, power, and percent solids capture by the centrifuges. The project team determined each facility's baseline performance, associated costs, and suggested changes to improve performance and tracking of metrics. As shown in Figures 1 and 2, power represents a relatively small portion of overall dewatering costs so the team's power-specific recommendation was for the District to continue operating their centrifuges during off-peak periods to the extent possible. The centrifuges consistently exhibited excellent percent capture (>95%), so the suggested modifications focused on improving cake dryness and polymer consumption.

The suggestions centered on four key parameters:

1. Feed sludge characteristics - The team emphasized the importance of primary sludge (PS) in the feed sludge. The facilities were encouraged to track the mass-based primary
sludge-to-thickened waste activated sludge (PS:TWAS) ratio and operate in a way that maximizes the PS in the digester and dewatering feed sludge.

2. Polymer - The District had a long-term contract with a polymer supplier based on jar testing from several years prior. New jar testing to identify optimal, separate polymers for thickening and dewatering was recommended to address changes in plant processes over the years. To accommodate future changes in sludge, a shorter term and the flexibility to use a primary and alternative polymer supplier were suggested for the new polymer contract. The team recommended that aging polymer blending equipment be replaced and load cells be used to track polymer consumption from totes. Additional recommendations included field optimization relative to polymer solution concentration, injection location, dose, dilution water characteristics, and pressure.

3. Systematic Optimization - A systematic approach to optimization and key parameters to test were developed with staff. In addition to the polymer-specific parameters noted above, it was suggested that regular testing be done to determine the impacts of centrifuge throughput (hydraulic and solids), bowl speed, torque/pressure, and pond depth on polymer dose and cake dryness.

4. Performance Tracking and Monitoring - Each of the District's facilities tracked dewatering performance differently, with some using written records in notebooks and others tracking specific metrics electronically. A standardized District-wide, electronic tracking system to input and monitor specific operational and performance parameters on a daily basis was recommended. This information was used to track and publish both operational targets and performance results on a monthly basis in a location that all staff regularly utilize (e.g. lunchroom bulletin boards).

The SJVRWRF and PVRWRF management implemented many of the recommended suggestions. Results and observations from their efforts are presented below.

RESULTS AND DISCUSSION
The most dramatic impact on cake dryness and polymer demand at the facilities is associated with the PS:TWAS ratio in feed sludge. Figure 3 summarizes dewatering performance metrics and the proportion of sludge that is PS for each of the District's four facilities. As shown in Figure 3, the SJVRWRF has maintained a feed that exceeds 60% PS from 2011 through 2016 and the PVRWRF increased its ratio to a similar value in the 2015-2016 period by changing its primary sludge thickening and pumping operations. The SJVRWRF maintained cake at 24% solids with polymer doses between 19 and 20.5 kg/dry solids tonne (38 and 41 pounds (lbs) active polymer/dry ton (lbs act/DT)). Once it increased its PS:TWAS ratio, the PVRWRF improved cake dryness from 20% to 23% with a polymer dose of approximately 19.5 kg/dry solids tonne (39 lbs act/DT). In comparison, the District's other two facilities with PS:TWAS ratios that favor TWAS (35% to 38% PS) require more polymer at 21.5 kg/dry solids tonne (43 lb act/DT) and achieve approximately 20% cake. The impacts of the PS proportion are further evidenced in Figure 4, which illustrates the differences in cake dryness at the PVRWRF for both centrifuge and belt filter press when the PS proportion increased from 36% (2011-2014) to 59% (2015-2016).
Figure 3: Facility Comparison Showing Performance Impact of PS Proportion in Sludge Feed

Figure 4: PVRWRF Changes in Dewatering and PS Proportion in Feed
In addition to the increase in PS:TWAS ratio, plant staff found that two other parameters impact dewatering performance: polymer solution concentration and the temperature of the sludge feed. The digested sludge at the PVRWRF is thicker than typical digested sludge - averaging 2.5% TS, which dewateres better with thinner polymer solution concentration. Dewatering sludge when it remains hot also helps its dewaterability. Plant staff at both the PVRWRF and the SJVRWRF determined that dewaterability suffers when the digesters are operated to maintain 35-degree C (95-degree F) rather than 37.8-degree C (100-degree F). Digested sludge is stored in a digested sludge storage tank prior to dewatering, but staff minimized the time the sludge is held before dewatering to minimize loss of heat. Figure 5 shows not only how cake dryness has improved between the 2011-2014 and 2015-2016 periods, but also how polymer consumption has reduced as staff has worked to optimize the dewatering system through such operational optimization.

As shown in Figures 6 and 7, cake dryness has remained consistent throughout the 2011 through 2016 period at the SJVRWRF. This is notable because the facility has undergone a wholesale plant expansion that changed the process from carbonaceous biochemical oxygen demand (CBOD) removal to nitrification/de-nitrification during that time. Figure 7 shows that the plant modifications have caused a drop in the PS:TWAS ratio and fluctuations in the solids load. However, plant staff has strived to maintain average cake dryness above 22% and polymer dose below 20.5 kg/dry solids tonne (41 lb act/DT). In addition to operational vigilance regarding polymer dilution and sludge characteristics, staff tried two different polymers, as indicated by the polymer active content in Figure 7. Although the 46% active polymer produced drier cake, doses
were higher and the District's contract did not allow a switch between polymer suppliers at that time. The current contract has now expired and jar testing is underway at each of the District's facilities to select the most appropriate polymers for thickening and dewatering, separately for each plant. The next contract will be based on the polymers that minimize overall cost as determined through impacts on both hauling and chemical costs. It will have a 3-year term, with options to renew each year for two years. This will give the District flexibility to test and switch polymers again if needed.

Figure 6: SJVRWRF Dewatering Performance from 2011-2016
Improvements to the facilities' dewatering systems have not been solely due to operational changes and optimization. Dewatering data are now tracked daily on standard spreadsheets that automatically calculate specific performance metrics and associated costs. These metrics are published and posted, along with the names of operators on duty during the shift. Operators that meet performance targets are recognized, which has encouraged other staff to emulate the success. Management has changed shift rotations to keep operators posted to the dewatering process for extended periods so that they gain better understanding of the entire system and optimization measures.

CONCLUSIONS
All of the District's facilities continue their efforts at reducing dewatering costs, with specific focus on primary sludge pumping strategies that maximize the PS:TWAS ratio and polymer selection. Figure 8 shows the impacts thus far at the SJVRWRF and PVRWRF between the 2011-2014 and 2015-2016 periods. Between the various process changes at the two plants and the successful optimization measures, the District has reduced its annual dewatering costs by approximately $200,000. Such success has not been based solely on equipment modifications. Rather, complete system optimization has included process and operational changes, close tracking of sludge characteristics and performance parameters, revisiting polymer selection and contract terms, and recognition of operators' success at meeting performance targets.
Figure 8: Changes in Monthly Dewatering Costs