Intensification through Densification:
Using Hydrocyclone Technology for Improved Settling

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ABSTRACT

The Upper Occoquan Service Authority (UOSA) owns and operates the 54 MGD Millard H. Robbins, Jr. Regional Water Reclamation Plant (RWRP) in Centreville, Virginia. In an effort to utilize existing process more efficiently, several interim improvements were recommended in UOSA's phased Capital Improvements Program (CIP) to maintain plant reliability, enhance performance in the short term, and possibly allow for continued deferral of more expensive bioreactor upgrades ($18M - $25M) further into the future. One of the recommended interim actions was to explore options for improving the reliability of mixed liquor suspended solids (MLSS) settleability. The goal of such improvements would be to enable the plant to make the most efficient use of its existing secondary treatment capacity. To this end, UOSA implemented a full-scale pilot study to evaluate the use of hydrocyclones for improving MLSS settleability.

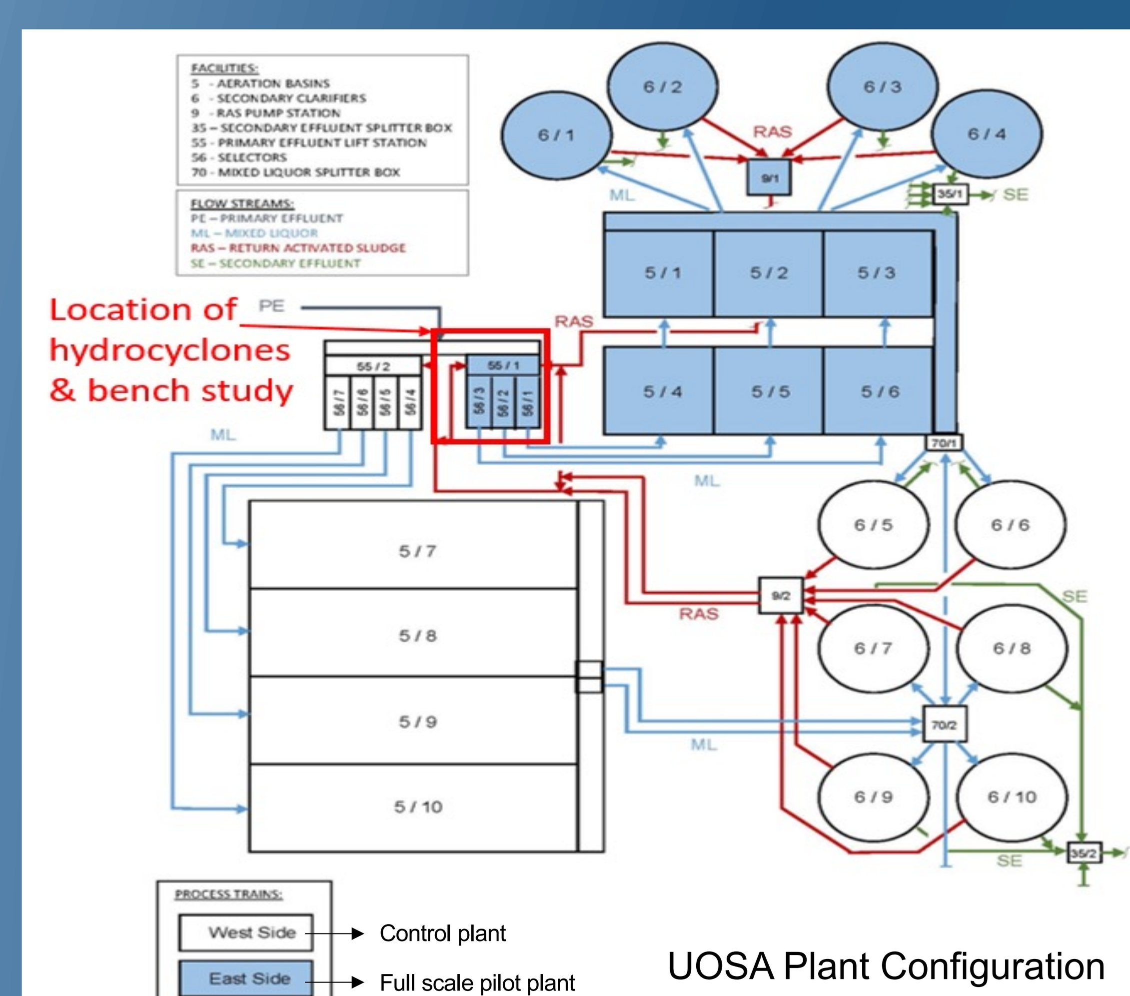
The objective of this study was to identify whether selective retention of denser and faster-settling sludge using waste activated sludge (WAS) hydrocyclones would have a substantive effect on process intensification such that major secondary process modifications may be deferred.

Hydrocyclone Skids

APPROACH

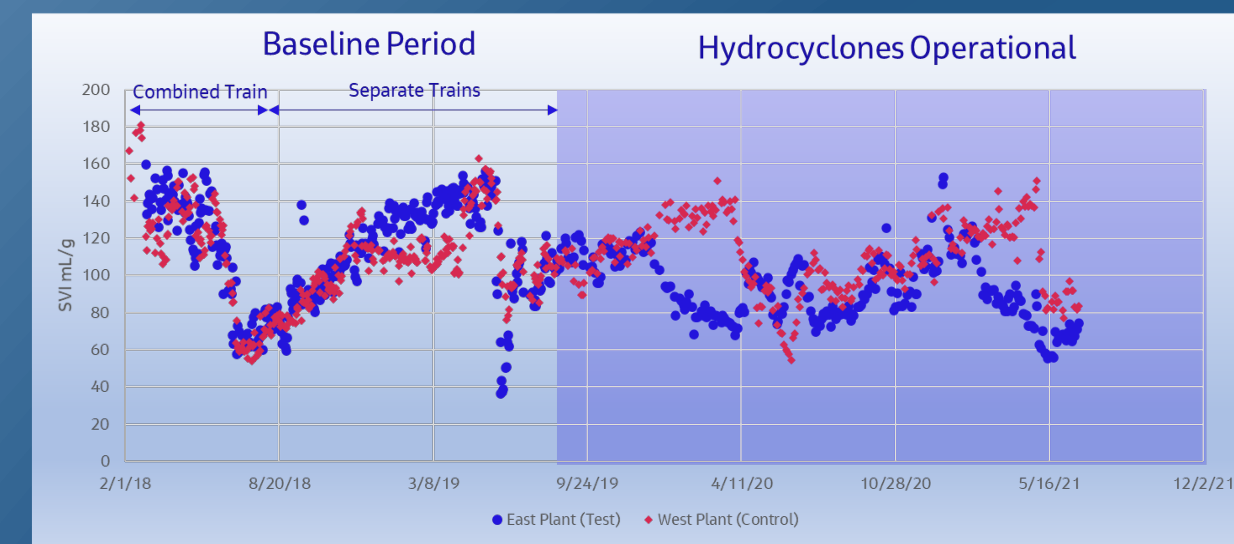
UOSA has two activated sludge treatment trains (East and West), consisting of seven aeration basins (three on the East side and four on the West side) and ten clarifiers (four on the East side and six on the West side). While the plant can be operated as two separate trains, UOSA has typically operated the plant as a combined train. In this mode of operation, the return activated sludge (RAS) from all ten secondary clarifiers is combined, and then split between seven selector basins (one for each aeration basin). In the selector basins, the RAS is combined with primary effluent before flowing back to the aeration basins.

For this pilot study, hydrocyclones were provided for the East train only. The plant was then operated as two independent systems, to the extent possible, wherein the RAS from the East and West train clarifiers are not comingled. Specifically, the East and West train RAS streams are not combined upstream of the selector basins but are returned to the respective selectors dedicated to each train. Separate WAS flows are required when operating in this configuration, resulting in two separate activated sludge populations which can have different characteristics. This configuration allows for side-by-side performance comparison of the two treatment trains.

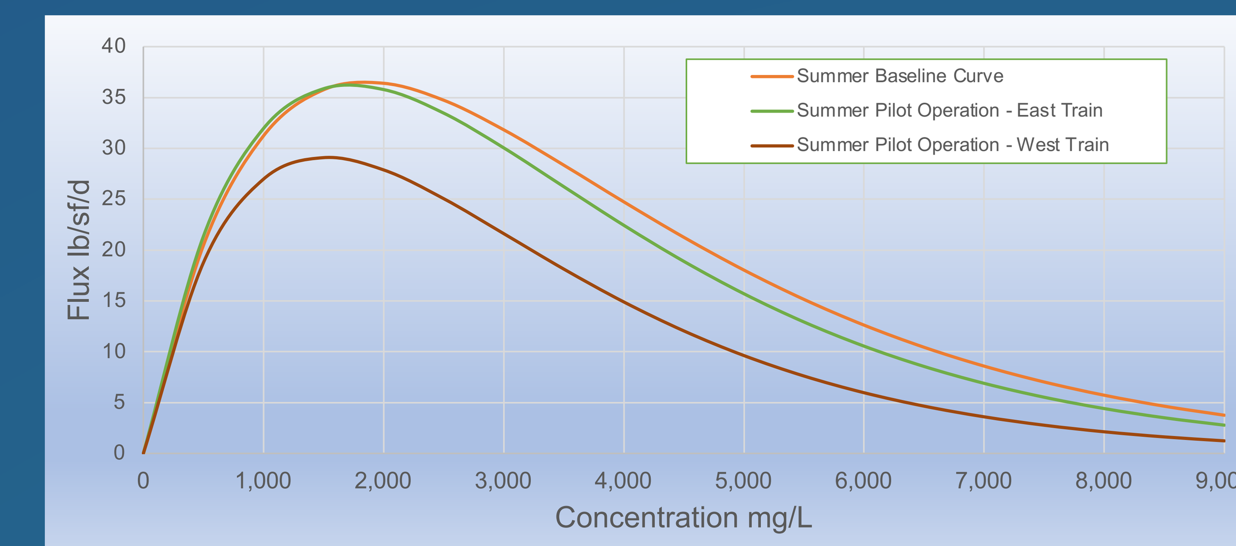


UOSA Plant Configuration

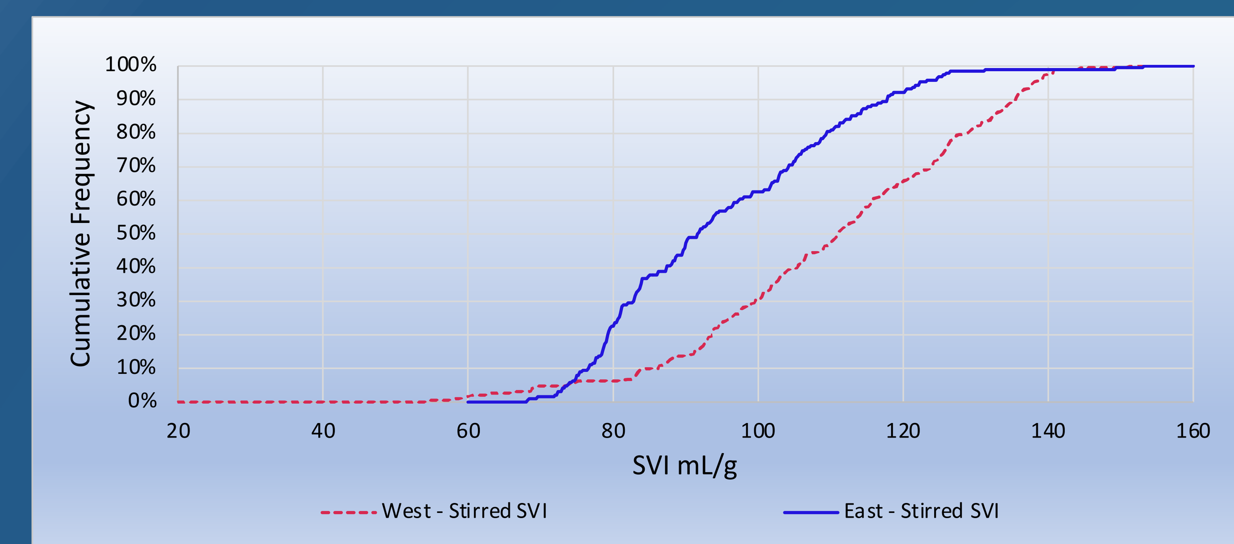
RESULTS



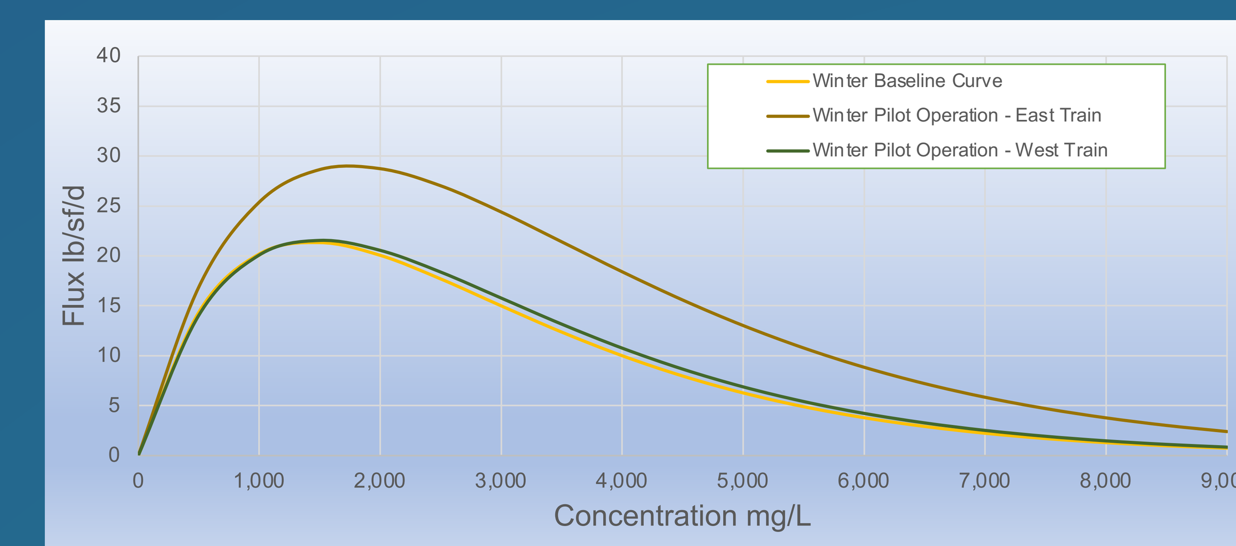
Stirred mixed liquor SVI_{30} trends during pilot operation



Aggregate RAS flux curves during winter operation (December to May)



Stirred mixed liquor SVI_{30} distribution during pilot operation



Aggregate RAS flux curves during summer operation (June to November)

Parameter	Baseline Period [1]		Pilot Operation [2]	
	East Train	West Train	East Train	West Train
Average SVI_{30}, mL/g	116	110	91	110
75th Percentile SVI_{30}, mL/g	136	116	104	126
95th Percentile SVI_{30}, mL/g	141	145	121	139
Maximum SVI_{30}, mL/g	156	163	153	158
Average SVI_{30}/SVI_5	0.56	0.55	0.55	0.56

Summary of mixed liquor stirred SVIs

Parameter	Baseline Period		Pilot Study Operation		Design Values
	East Train	West Train	East Train	West Train	
Flow, mgd	14.0	23.8	13.6	20.4	42
MLSS, mg/L	3,130	3,530	3,790	3,380	3,000
Total SRT, d	16.8	17.3	16.9	19.6	17.2
RAS Rate, % of Influent Flow	84%	78%	103%	93%	93%
Winter NRCY Rate, % of Influent Flow [1]	290%	240%	240%	280%	200 – 300%
Clarifier surface overflow rate (SOR), gpd/sf	319	365	337	320	380
Clarifier solids loading rate (SLR), lb./d/sf	15.5	19.1	21.1	18.2	19 [2]

Average secondary treatment operation during baseline period and pilot operation

CONCLUSIONS

- Overall, there was an improvement in SVI in the East train compared to baseline performance and compared to the West train performance during the pilot study. A comparison of SVI values from the East-side and West-side plants indicates that, on average, the SVI in the West train, without hydrocyclones, was about 21 percent higher than the East train. East train peak SVI statistics (i.e., 75th and 95th percentile) were 16 to 31 percent higher during the baseline periods without the hydrocyclones than they were after the hydrocyclones were installed in the East train.
- The SVI in the East train was 30 to 40 percent lower than the West train during winter months, when maintaining good settleability is most critical for plant performance. The SVI data suggest that the hydrocyclones were effective in avoiding deterioration of settling characteristics during winter months.
- The observed SVI improvements were incorporated into two analytical models for predicting secondary treatment performance. Using the conventional solids loading rate approach, up to a 37 percent increase in allowable winter clarifier SLRs and 11 percent increase in allowable summer clarifier SLRs may be realized, with an aggregate annual increase of near 20 percent. The hydrocyclones provide the nutrient removal benefit without the need to construct additional bioreactors or clarifiers.

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