Next-Generation Coagulation Optimization for Drinking Water Treatment Plants: A Case Study

UNC CHARLOTTE

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Introduction

This poster presents results from a case study where a next-generation jar test procedure was used to optimize coagulation conditions (i.e. dose and pH) at an existing drinking water treatment plant (WTP) in North Carolina.

Problem Statement

In 2017, the WTP doubled their coagulant dose simply as a result of failing to conduct jar tests and using the streaming current monitor to determine their "optimum" coagulant dose (Figure 1).

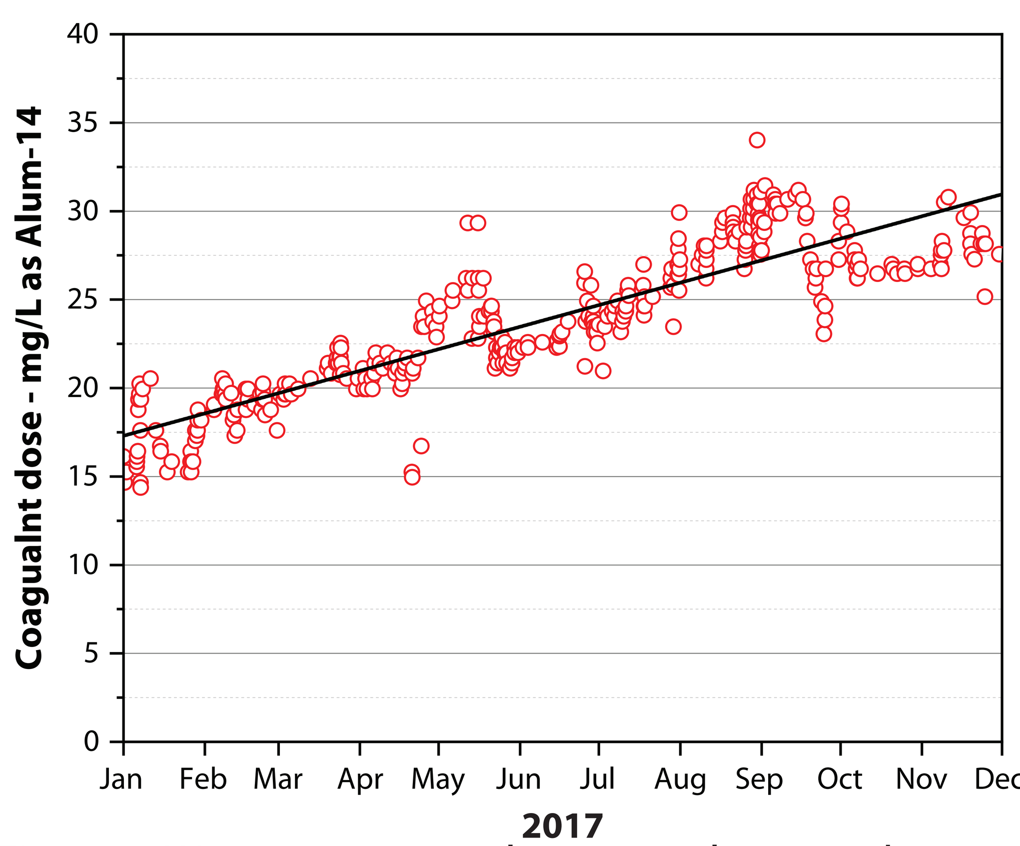

Figure 1. Water treatment plant 2017 alum trend

Research Questions

The goal of the study was to answer the following questions using the approach outlined in Figure 2:

1. Where are the optimum treatment zones?
2. What are the optimum coagulation conditions?

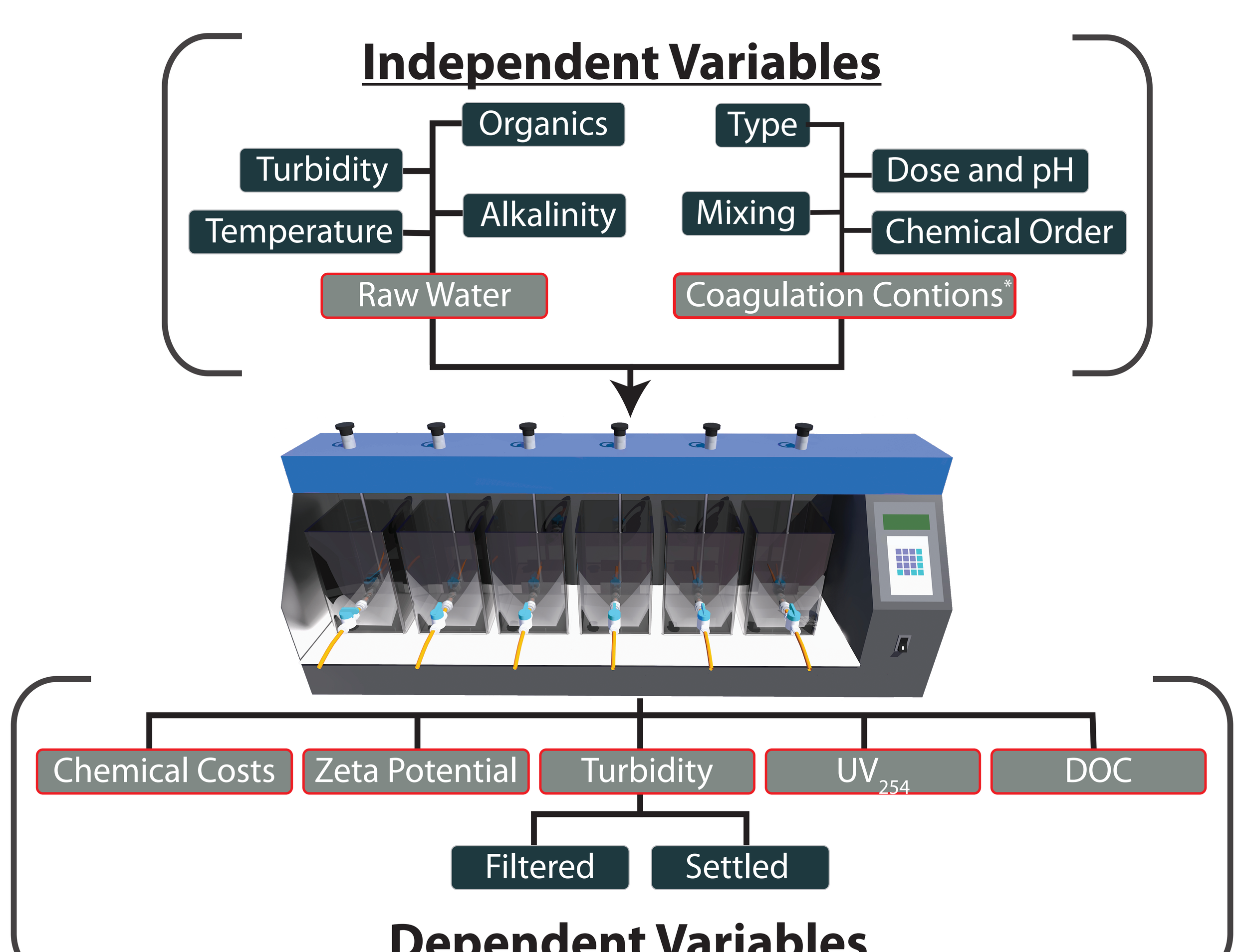

Figure 2. Research approach
* only dose and pH were investigated in this experiment

Methods

A new jar test procedure was followed where the pH was held constant as the coagulant dose was varied. Filtration was performed using a novel granular media filtration system (Figure 3).

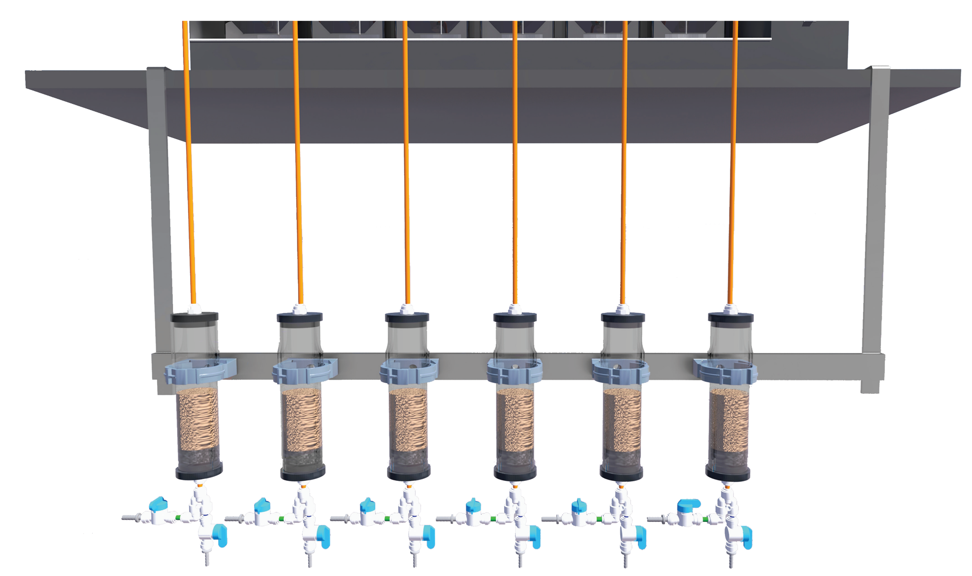

Figure 3. Granular media filtration system

A total of 14 jar tests were conducted with the coagulant dose ranging from 3 - 100 [mg/L as $Al_2(SO_4)_3$-14 H_2O] and pH from 5 - 8 (Figure 4).

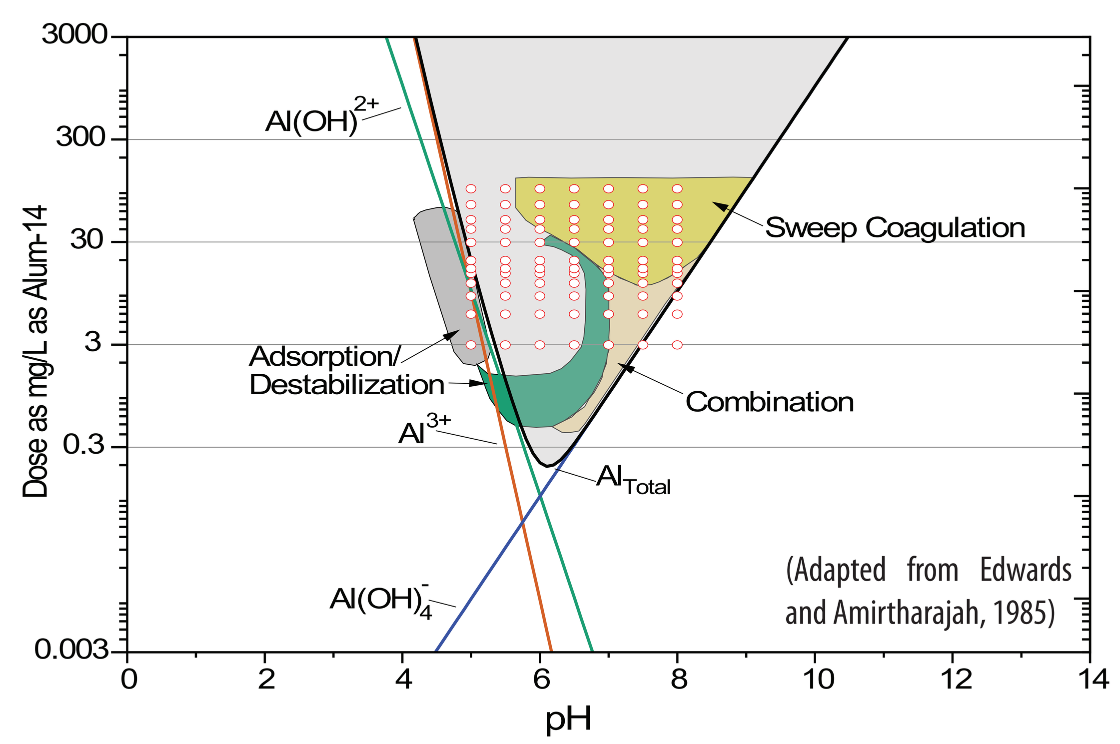

Figure 4. Investigated coagulation conditions

Experimental Results

Table 1 shows the raw water characteristics measured during the study.

Table 1. Raw water characteristics

Parameter	Turbidity [NTU]	UV_{254} [1/m]	DOC [mg/L]	SUVA [L/mg-m]	Alkalinity [mg/L as $CaCO_3$]	pH
Average (Range)	5.8 (3.0 - 7.1)	4.3 (3.9 - 5.1)	0.8 (0.7 - 0.9)	5.4 (4.5 - 6.0)	18	7.1 (6.9 - 7.3)

Figure 5 shows the cost to treat a million gallons at the investigated conditions. The region where the plant operated in 2017 is highlighted by the gray area.

Optimum coagulation conditions for single and multiple removal criteria were identified using contour plots generated using OriginPro 8.5 (Table 2, Figure 6). An optimum was defined as the cheapest coagulation condition that met a given optimzation criteria.

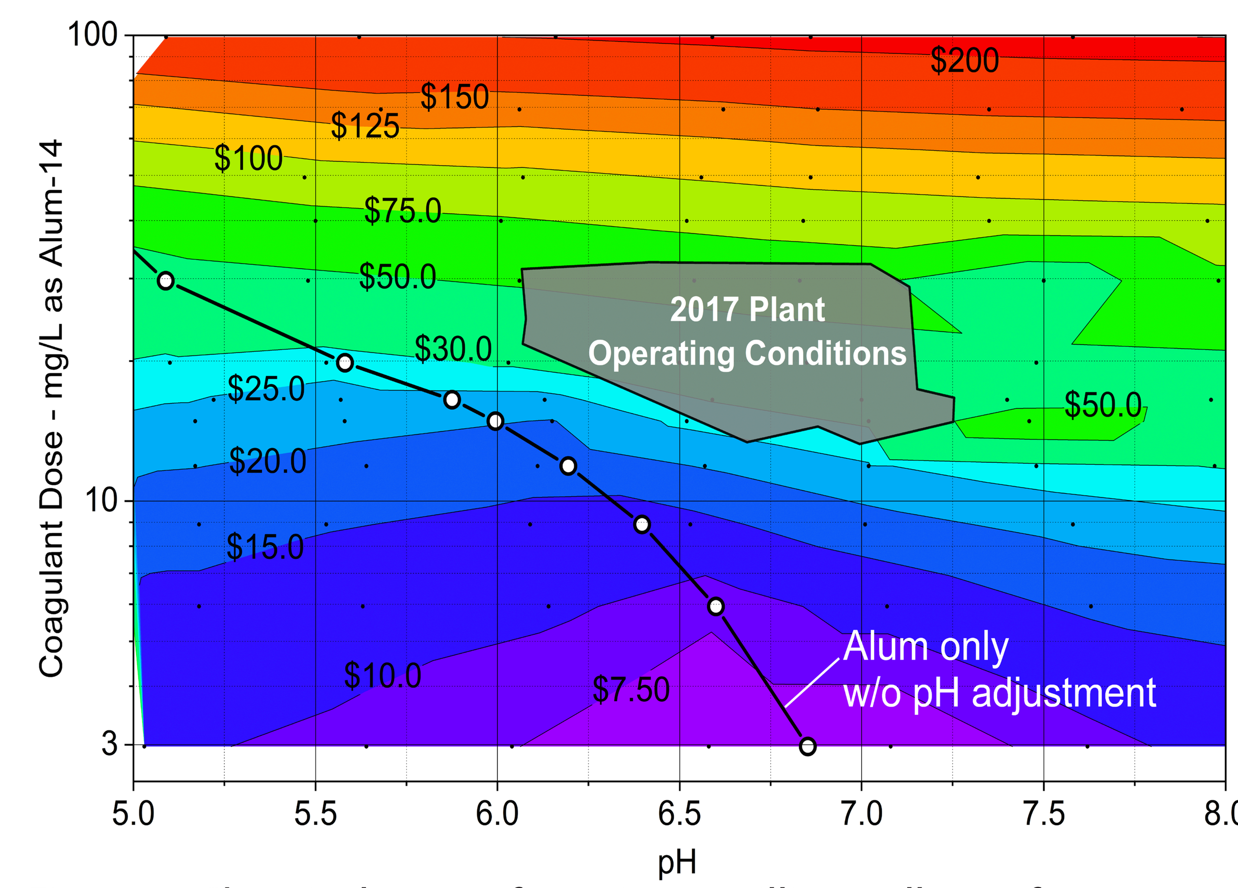

Figure 5. Chemical costs of treating a million gallons of water

Table 2. Optimum coagulation conditions

Optimization Criteria	pH	Coagulant Dose [mg/L as alum*]	Cost / Mgal [$]
Filtered	6.6	7	$ 10
DOC	5.6	5	$ 11
Filtered + UV	6.6	9	$ 14
UV	6.6	9	$ 14
Filtered + DOC	6.6	12	$ 20
Filtered + UV + DOC	6.6	12	$ 20
Filtered + Settled	7.3	19	$ 43
Settled	7.3	19	$ 43
Filtered + Settled + UV	6.8	27	$ 55

* $Al_2(SO_4)_3$-14H_2O

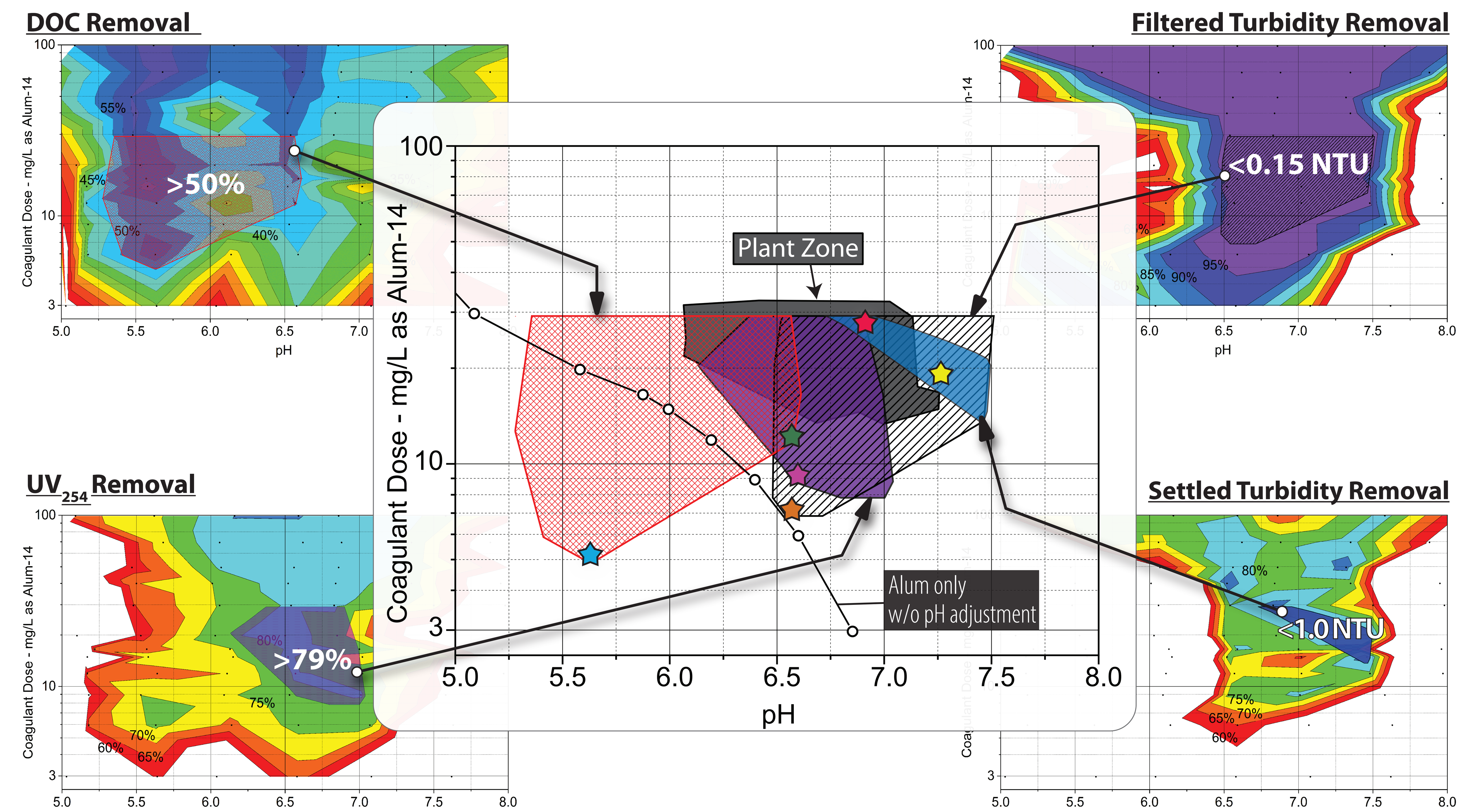

Figure 6. Removal contour plots and optimum boundaries (stars represent optimum coagulation conditions shown in Table 2)

Conclusions

Based on the results obtained from the next-generation jar test procedure, the following conclusions could be made:

1. **At least six different "optimum" coagulation conditions** were identified.
2. Greater than 95% filtered turbidity removal was achieved at 7 mg/L as alum at pH 6.6. This dose was **50 – 80% lower and 2.5 – 6 times cheaper** than the conditions used by the plant in 2017.
3. Using settled water turbidity as an optimization criterion **more than doubles the chemical costs** without any added benefit to the overall filtered turbidity or organics removals.

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