# PSS Summer 2009 Experiments Varying Alum Concentration

## Overview of Methods

Robustness of our plate settler design is defined as the ability of the plate settlers to produce 1 NTU water over a variety of non-ideal conditions. One set of non-ideal conditions was building a floc blanket with underdoses and overdoses of alum to measure performance through effluent turbidity from the tube settler.

In these experiments the alum dosage supplied to the flocculation system was varied in order to study how properties of flocs and the floc blanket affect the effluent turbidity produced by the tube settler. The influent water in our system had a turbidity of 100 NTU. Varying alum doses were then added to this influent.

The experimental set-up is identical to the one used in Spring 2009, and from our results we hoped to analyze velocity gradient thresholds and possibly investigate how changing influent water chemistry affects the setter's efficiency.

The alum dosage significantly affects flocculation, and thus plays a direct role in the success of the system (in the future, cite someone here either Matt, Ian's, or Monroe's fractal floc paper). The properties of floc particles combined with upflow velocity in the floc blanket will have a direct impact on effluent performance in the tube settlers (cite Matt's thesis here).

Plate settler spacing is an important factor in determining the height of the plant clarifiers. Theoretically, if we could find a way to maximize their performance at the lower-limit of spacing and height it would be possible to decrease height of the sedimentation tank and lower plant costs. +(This paragraph is out of place. Please put it in the appropriate spot)+

Alum Dosing Theory

## Results and Discussion

Using the Spring 2009 team's process controller methods, we subjected an ideal geometry to non-ideal conditions. Specifically we altered the alum dose to see how different alum doses affected the effluent turbidity. Though the Spring 2009 team had success with a 9.5 mm diameter tube, due to what we think was ineffective air bubble traps in the flocculator, or the addition of a flow accumulator to the method, we experienced failure with this geometry. In our system, failure is defined as an effluent turbidity of above 1 NTU. We achieved an acceptable effluent turbidity with a 15.1 mm diameter tube that had a length of 30.5 mm. With the good experimental results, we then subjected this tube settler to varying alum dosage to investigate the affect of dosing on tube settler performance. At each alum dosage, the tube settler was tested at a variety of capture velocities and at two different floc blanket levels: the lower level is when the height of the floc blanket falls below the bottom of the tube settler, the high floc blanket level is when the floc blanket height is above that of the bottom of the tube settler.

**Experiment 1: Alum Dose = 45 mg/L**

**Experiment 2: Alum Dose = 35 mg/L**

**Experiment 3: Alum Dose = 65 mg/L**

**Experiment 4: Alum Dose = 15 mg/L**

**Experiment 5: Alum Dose = 105 mg/L**

**Process Controller Files**

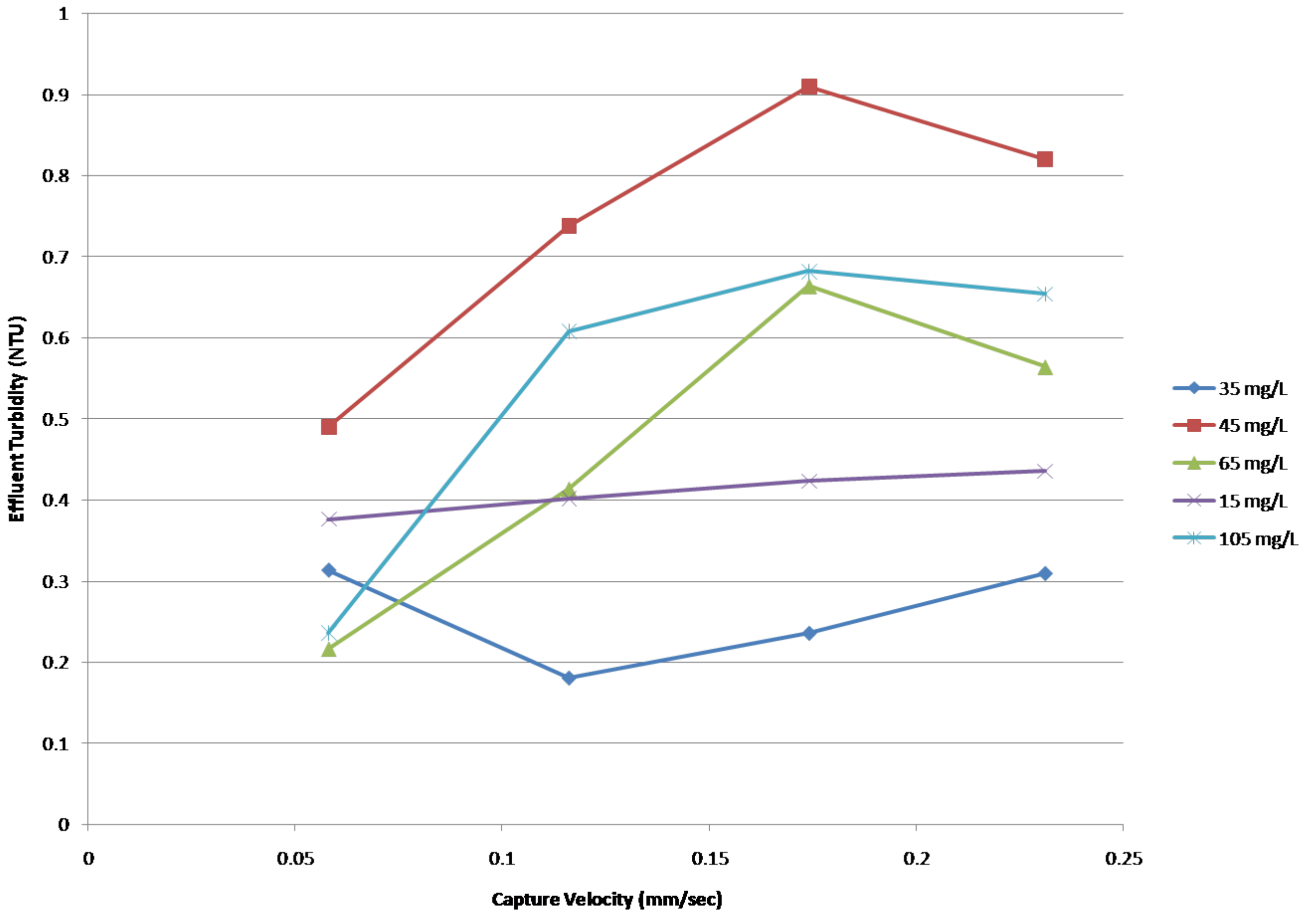


**Figure 1**: *Capture Velocity vs. Average Effluent Turbidity* shown for each alum dose at low floc blanket level.

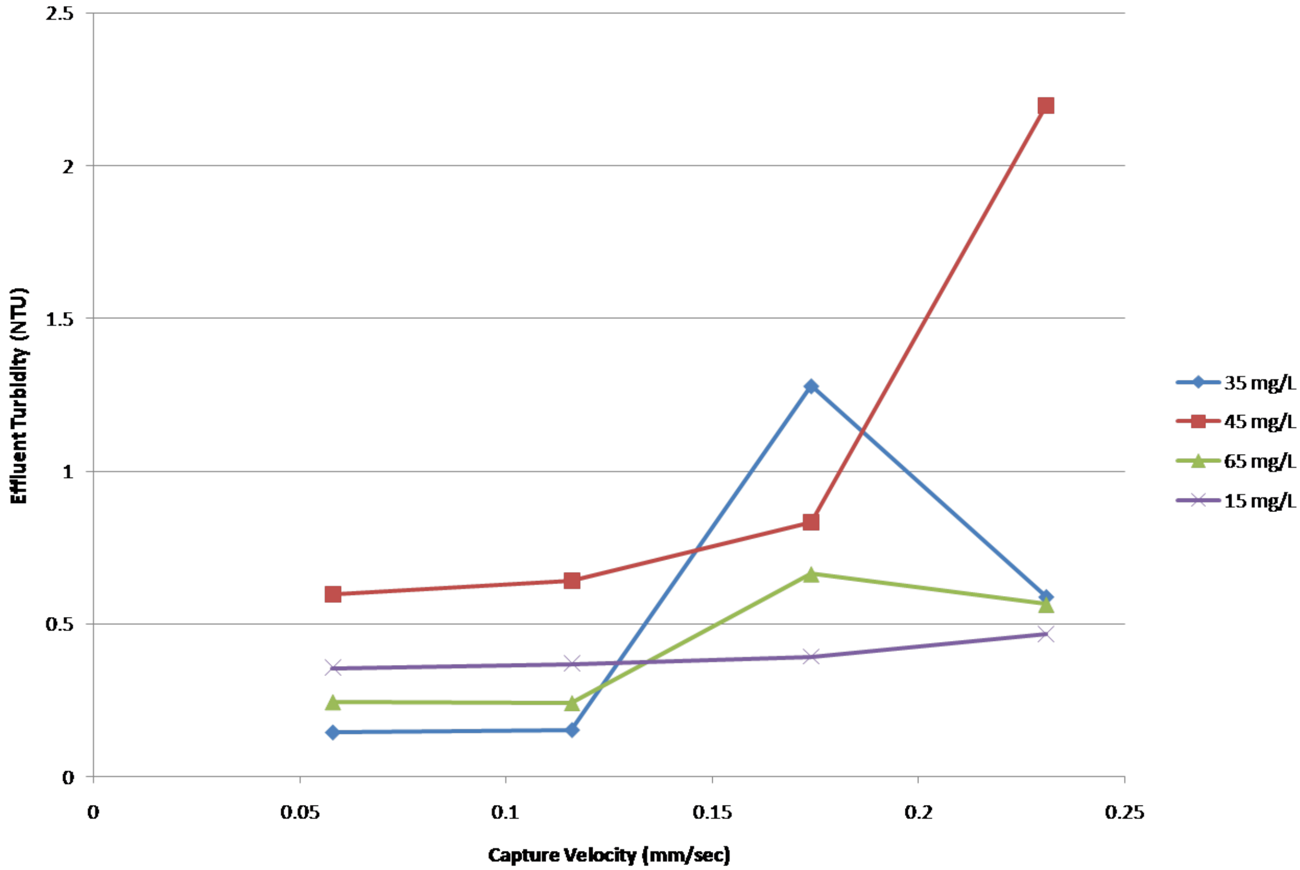


**Figure 2**: *Capture Velocity vs. Average Effluent Turbidity* shown for each alum dosage at high floc blanket level.

## Conclusions

Overall, this system performed well and most of the effluent turbidities were below 1 NTU. The thesis on evaluation on parameters affecting steady-state performance of a floc blanket found that the ideal dosage was 45 mg/L for 100 NTU influent water. The alum doses of 35 mg/L and 65 mg/L performed best. Because the slight underdose and overdose peformed well (average effluent turbidities were under 1 NTU), what was thought to be extreme under and over doses were also tested. We tested 15 mg/L and 105 mg/L to observe how the floc blanket formed under severe non-ideal conditions. The dose of 105 mg/L, despite averaging at less than 1 NTU, resulted in failure since the average effluent turbidity frequently spiked above 1 NTU. The 15 mg/L dose, however, had average effluent turbidity of less than 1 NTU, meaning that cannot be considered a failure.

Originally, an alum dose of 45 mg/L was thought to be an ideal dose, meaning that it was supposed to produce the lowest effluent turbidity. However, this alum dose did not perform as well as was expected. In comparison to the other average effluent turbidities, 45 mg/L should either perform slightly better than an alum dose of 35 mg/L or somewhere between 35 mg/L and 65 mg/L. As shown in the above graphs, 45 mg/L performs worse than all of the other alum doses, including what was supposed to be extreme under and over doses (15 mg/L and 105 mg/L). This should not have happened; possible reasons for these results include air bubbles in the tube settler
and the fact that the 45 mg/L experiments were run with an old apparatus with a flow accumulator. Experiments at this alum dose should be re-run.

### What is failure?

The system will fail in different ways based upon the alum dose. The major cause of failure for an underdose is an incomplete floc blanket as a result of smaller flocs that are formed. Thus, we expected that the underdose of 15 mg/L would fail. However, the effluent turbidity fell within the acceptable range, which demonstrates success. This is because in our system, the increased residence time in the flocculator creates larger flocs, which form a floc blanket more quickly and more effectively.

In contrast, an alum overdose forms a less dense, more "fluffy" floc blanket, which is not as effective because the flocs are weaker. The floc blanket breaks up in the floc blanket and causes spikes in the effluent turbidity. The extreme overdose of 105 mg/L shows higher turbidity as a result of these weak flocks in the floc blanket.

Because the effluent turbidity using the alum underdose of 15 mg/L was acceptable once the floc blanket had formed, it seems that the dosage can be reduced once the floc blanket is completely formed, within a certain range of alum doses. It appears that as long as the floc blanket is fully formed, which should occur with a higher dose so that it forms quickly enough, the alum dose can be lowered while still experiencing the same results. However, the alum dose does needs to be within a certain range for an effective floc blanket to form.

### Water Chemistry

Prior to investigating the water chemistry in our system, the results we acheived were not what we expected. These unexpected results include the poor performance of the system with the alum dose at 45 mg/L and good performances with what was thought to be an exterme under and over dose. The reason for these results is that the water in the lab is much more alkaline than the water in Honduras. The pH of the water in Honduras is therefore more sensitive to changes in alum dose. There is an ideal range of pH values where flocculation occurs most effectively, and this range is harder to achieve in Honduras. Thus, the water in the lab allows the system to be more robust and able to achieve acceptable effluent turbidity even with a large range of alum dosages. This observation means that even though the system appears to work successfully regardless of the ranges of alum doses that we tested, the same will most likely not be true in Honduras. A future study could include changing the alkalinity of the water to make the water pH more sensitive to changes in alum dose to confirm the applicability to Honduras.