Stacked Filtration Team Detailed Task List

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Control system hydraulics study

The current full-scale stacked rapid sand filter (SRSF) includes a siphon/air valve system to set the mode of operation of the filter. This system controls the level of water over the sand in the filter, and thus allows the SRSF to switch between filtration and backwashing without the need for valves on all of the inlets and outlets. We have built a lab-scale system to test the hydraulics of the siphon and to gain some insight into how it works. Important tasks include:

1. Perfect the effectiveness of preventing flow through the siphon during filtration mode by forming an air trap.
2. Determine the time required for the air valve to remain open to switch between modes.
3. Identify physical parameters that are important to improve the siphon.
4. Work with the design team to re-design the siphon system if simple changes cannot be made to prevent flow during filtration.
5. Understand the behavior of the filter as it transitions between modes and record data to document the hydraulics of this process.
6. Develop a rational procedure for installing pipe stubs in the inlet box, and trouble-shooting problems that may be observed in bringing a new filter online.
7. Assess the possibility of automating the transition between filtration and backwash

Time frame: 3 weeks at the beginning of the semester

Pilot-scale and bench-scale flow distribution study

The pilot scale apparatus uses six layers of sand, each of which is 20 cm deep. Thus far, the flow through each layer is assumed to an even fraction of the total flow, and it is assumed that this will be the case as long as head loss through the inlet plumbing is limited to a small fraction of the head loss through each layer of sand. It is necessary to test this assumption, to test this assumption as a design constraint for a full-scale SRSF.

1. Install two ports in each sand layer spaced evenly along the vertical axis, and place a pressure sensor to measure the pressure drop between the two ports.
2. Determine the hydraulic conductivity and Darcy's constant for the porous sand media.
3. Monitor pressure drop between the sensors and apply Darcy's law to determine the flow through each layer during filtration.
4. Set up a bench-scale experiment with two single-layer filters in parallel with different flow rates, and determine if uneven flow is a "self-correcting" problem.

Time frame: start collecting data during the control system study, continue for 2 weeks

Bench scale upflow/downflow performance study

Up to now we have only measured the total performance of the filtration layer at the aggregation exit channel. We will develop a bench-scale apparatus to determine if there are any systematic differences between upflow and downflow filtration.

1. Customize the bench-scale apparatus currently used for alum/filter interaction studies and set up a 20 cm filter layer in a glass column to test under similar conditions to the pilot-scale unit.
2. Install turbidimeters with a sampling system to measure influent/effluent quality.
3. Record data during a typical filtration cycle, holding all conditions constant and varying only the flow direction through the sand.
4. Analyze the data to see the performance of each of the layer.
5. Identify and test mechanisms that may explain any observed differences in performance.

Time frame: 2-3 weeks, depending on the need for Step 5

Sand media analysis and preparation

The SRSF has been designed and tested using a single sand grain size typical to conventional rapid sand filtration, and the implications of using another sand grain size have yet to be investigated. Sand of a larger or smaller grain size may prove more effective for turbidity removal than that which is currently in use. Furthermore, the effect of sand grain size on filtration and backwash velocity as well as required filter bed depth has yet to be fully investigated. Important tasks include:

1. Determine the relationship between sand grain size and the filter bed depth required to adequately remove turbidity.
2. Determine the relationship between sand grain size and head loss through the filter bed, and relate this finding to expected filter run time.
3. Determine the relationship between sand grain size and backwash velocity.
4. Determine the optimal sand grain size to adequately remove turbidity while minimizing backwash water use.

Time frame: 5 weeks

Filtration Cycle Endurance Study

Up until now we have been experimenting only with suspended clay particles and monitored the filter's performance under that sole input condition. We would like to understand how the filter performs under the conditions found in the field that involve dissolved organic matter (DOM). We'd like to determine what combination of flow, turbidity, and DOM can be accommodated with either a 12-hour or a 24-hour interval between backwash cycles by doing the following:

1. Utilize data from the field to model the turbidity and DOM conditions typical of sedimentation effluent water, and apply those conditions to our bench scale model of the filter.
2. Set up dosing systems for clay and DOM, and experiment to find the best flow rate to accommodate the conditions that we can expect in the field.
3. Check the recommended head loss increase to signal the end of a filtration cycle.

Time frame: 4 weeks

PACl Residual Study

Residual levels of a coagulant improve performance of a rapid sand filter. We would like to explore the addition of a very low PACl dose to improve filtration performance. This will be done by doing the following:

1. Set up equipment to perform a full flocculation/sedimentation step upstream of the filter so that the dosage is reasonably tested.
2. Vary the dosage to determine optimization.
3. Compare results to what is typical of a sedimentation effluent.
4. Recommend a procedure for coagulant addition to the filter in the field – use of existing residual, dosing of alum upstream, or pre-treatment of sand bed.

Time frame: 2 weeks

Construction Implementation Survey

The construction of the first SRSF at Tamara is underway and has been monitored by team members. It is important to take lessons learned from construction and feedback from the plant operators to create recommendations for changes to the design, so that future iterations of the filter will be more efficient.

1. Review the first design.
2. Collect data from the field to document the construction process and initial operation.
3. Mickey – visit Tamara during Fall Break to work on initial operation of the SRSF.
4. Set up a meeting with the design team to review the Tamara design, evaluate what was effective and what was not, and suggest improvements.
5. Correspond with contacts in Honduras about progress on the full-scale filter.

Time frame: 1 week as follow-up to October trip, correspondance continuing through semester

Scaling to Smaller Flow Rates

We would like to develop new construction methods that would make it possible to fabricate a SRSF at dimensions that are not large enough for a human to enter the filter box. It is important that AguaClara maintain versatility to the filtration processes that are used. There are different options and methods that can be applied to extend the flow rate to less than 6 L/s.

1. Reduce the sand grain size so that the filter and backwash velocities are reduced and the area of the filter is larger.

2. Construct the filter box of large diameter PVC pipe and assemble manifolds inside this pipe to be reaching in from above and from below prior to connecting the section of the filter with the manifolds to the rest of the filter box.

Time frame: 2 weeks, following review of Tamara design