Challenges Fall 2010

Fall 2010 Challenges

Design (15) in Accel
Inlet Manifold (4) in B60
Lime Feeder (4) in B63 along wall next to the door
Tube Floc (4) in B60
Stacked Filter (6) in B63 along window: two team members as joint members of Design team
Foam Filter (4) in B63 on left end of bench top
Plate Settle Spacing (4) in B60
Chemical Dose Controller (6) in B60: two team members as joint members of Design team
Outreach (3-5)
(estimated number of students per team)

Team organization survey

Design Team Fall 2010 Challenges

Designs for Honduras

- Coordinate with the team in Honduras to create detailed designs for Marcala, Jalaca, and Atima. Add these sites to the project sites page including design flow, population served.

Wiki Documentation

- Update the wiki documentation (convert to Word documents and follow the updated Wiki Organization Guide)
- Create and document a better method of exporting CAD drawings for use in MSWord and the wiki. One possibility is export as a wmf (windows metafile). This creates a vector based drawing that can be imported into MSWord. It can be converted to a editable drawing object.
- Archive old files from the design part of the wiki (there is now an archive space in our wiki)
- Create a new wiki page with a series of tables of designs showing the variety of designs that can be created by the ADT. Parameters to vary are Q.Plant (5 L/s, 10 L/s, 25 L/s, 50 L/s, 100 L/s), N. SedTanks of 2 for the 5 L/s otherwise increase to 3 or more for large plants, N.SedBayEst (1 for small flows, increase as the flow increases and try different numbers of bays for larger flows to vary the plant layout). For each design, list the input parameters from the online ADT in a table and then provide links to the AutoCAD, xls, and PDF documents.

Variable Naming Guide

- Add a function naming guide to the variable naming guide. Review the naming guide with the team and then implement the naming guide
- Confirm that all variables in the VNG follow the naming convention and edit and update and noncompliant variables
- Extend the naming convention if there are additional types of variables that don't fit in the existing categories
- Check for consistency with variable names in the specifications document
- Confirm that all variables that are returned to the client in the spreadsheet are defined for all design cases. If there are variables that can't always be defined, then the LabVIEW code will need to be modified to not report variables that aren't defined. It is important that we eliminate errors in the spreadsheet that we return to the client so they don't assume there is a problem with the design.

Online AguaClara Design Tool

- Add language specific email responses that include the requirement that the design be reviewed by a professional engineer and that Cornell is not liable for any damages due to the design. These could be simple text files with a naming convention that includes the identifying number of the language (English is 0, Spanish is 1)
- Update the language data that goes with the ADT so that all labels are translated correctly. Determine if we need to add any new languages.
- Update the language data in the variable naming guide.
- Review input parameters. Consider adding the slab thickness as a separate input parameter.
- Should there be an option for designing individual unit processes rather than always designing the entire plant? Consider how this will work when filtration is added.
- Considering adding an option for specifying the length of a flocculator channel. Handle this parameter in the same way that the depth of the flocculator is handled.

Creating layouts and adding dimensions

- Create key 2-D views of the plants using the flatten capabilities of AutoCAD. Work with Monroe to determine how to send these 2-D views to the client.
- Create layouts showing views in paper space as required by the engineer and possible as required for the design specifications document. Create the <u>layouts of standard views based</u> on the suggestions by Gonzalo.
    - Finish debugging the new functions related to creating layouts.
    - Find a way to create and edit multiple view ports in one layout. Alternately (and Monroe recommends this approach) only create one viewport per layout. Keep the layouts simpler and less cluttered.
- Add dimensions and elevations to the layouts
- Add a scale to the layouts
- Add the AguaClara logo and disclaimer to each layout page
- We do not have a simple method for adding text descriptions in the user specified language. We need to determine if it is going to be necessary to add text to the layouts. If it is necessary to add text to the layouts then we need to devise a method to do this. We would need a database of text blurbs and unique codes that identify each of the blurbs. The database would have a column of text blurbs for each language. The LabVIEW Design Server would need to send customized commands for each text entry based on the user selected language.

Documentation

- Remove the many unused variables from the VNG
- Update all variables to follow the VNG conventions.
- Determine what drawings are needed to supplement the written information.
- Carefully review the document and double check all reported values against the CAD drawings to make sure that all variables are described correctly.
- Make sure that all dimensions are accurately specified to avoid confusion between inside and outside dimensions and center to center or space between.
- Request documentation review from field engineers
- Translate the document into Spanish.

Design Review (Error Testing – contact Julie Pierce for guidance)

- Check all elevations as drawn to see if they are correct. There appear to be problems with the rapid mix pipe elevation and the stock tank elevation equations need to be revised based on the actual head loss through the float valve orifice plus a factor of safety (perhaps 20%).
- Create a MathCAD document that executes at the end of the design process (at the bottom of the list of references in the master program)
- Devise a series of independent calculations (with equations that don't rely on ANY other MathCAD files) to check the design
- One goal is to create an error message explaining what went wrong if the design tool produces a design that is incorrect or if there are variables that are out of range. This error message would be returned to LabVIEW and included in the email to the client.
- Design checks would include
    - Energy dissipation rate in the flocculator
    - Collision potential based on total flocculator head loss, flocculator residence time, collision potential efficiency based on H/S.
    - Head loss through the launder orifices
    - Head loss in the waste channels
    - Energy dissipation rate in the inlet manifold ports
- The design checks could also be used to calculate parameters that are reported to the client in the specifications document.

Plant Design for Operator Access

Draw the walkways and any necessary stairs at appropriate elevations so it is easy for the operator to access plant controls. Make sure the operator can easily access the CDC and the chemical stock tanks as well as the tank drain valves. The walkways should be quite high (perhaps 50 cm below the tank walls) on the upper side of the plant near the chemical stock tanks. The walkway covering the drain canal could be at the same high elevation or it could be lower and hence closer to the drain valves. The operator must be able to control the valves and observe the sludge/water exiting into the drain canal from the walkway. Perhaps this walkway needs to be built using a metal grate so the operator can see the drain.

The stock tanks need to be accessible for filling with water and chemicals and for stirring.

There needs to be a place to fill a bucket with clean water from the exit channel. This should be a 1.5 inch pipe through the wall with a valve. The walkway must be low enough so that the bucket fits under this valve.

Chemical Storage Tanks

- Evaluate the feasibility of creating a plastic pipe database. Rotoplast is a likely source of plastic tanks in Latin America.
- Determine how the chemical addition and mixing will be done especially as the tank sizes increase. What is the upper limit for mixing using a paddle?
- Draw tank outlets, which should be located 10 cm above the base of the tank to allow for sedimentation.
- Add dimension calculations for the chlorine stock tanks to the "ChemStorageTanks" MathCAD file. The existing algorithm to calculate Alum stock tank dimensions can be useful to figure out how to do this.
- Edit "Chlorinestock" in the "AutoCAD Scripts" folder so that it draws the stock tanks (refer to the "Alumstock" file that contains design algorithm for the alum stock tanks).

- Note that the chlorine tanks could be located lower than the alum tanks since the chlorine is applied in the exit channel. If we set the chlorine tanks lower, then it won't be possible to prechlorinate. It may be better to set the chlorine tanks at the same elevation as the alum tanks so that the CDC can be used to control both alum and chlorine (and base).
- Draw pipes connecting the storage tanks to the float valve in the constant head tank.
- Include a T in a horizontal section of the line with a drain valve that can be used as a sediment trap to reduce the amount of sediment that gets to the float valve orifice

Entrance Tank/Rapid Mixer

Entrance Tank Coordination with CDC

- Determine if the CDC should also control the chlorine and base chemical feeds.
- Determine how the stock tanks for the various feeds should be positioned to make access and plumbing easy.
- Determine if the CDC is going to continue to be positioned directly on top of the entrance tank or if there is a method to move the dosing half of the CDC lever off to the side to reduce the risk of spills into the entrance tank and to make the CDC more accessible.
- If the CDC continues to fit directly on top of the Entrance Tank, then make sure that the entrance tank is wide enough for the CDC to fit. Devise means for the CDC to fit on larger entrance tanks for larger flows.
- Coordinate with the CDC team to add the Kerick valves (mini and larger sizes) to a database so that the correct valve can be selected based on the valve orifice size. Note that the flow ratings providing by Kerick are for high pressure and are irrelevant for us. We need to use the orifice equation based on the difference in elevation between the stock tank outlet and the float valve. The orifice sizes are given for each valve and are not to be confused with the thread size!
- Draw the CDC in the correct position.

Entrance Tank improvements

Consider sloping the bottom of the entrance tank at 60 degrees like a cone to the drain. Or add a drain system that is similar to the drain system in the bottom of a sed tank. This drain would be opened daily to flush out accumulated solids

Use a minimum of 3” drain valve (the 2” drain valve at Marcala clogs). However, clogging might not be as big of a problem if this is purged at least every day. Perhaps the drain valve should be large enough to handle the entire plant flow so that the purge velocities are high and the large sediment can be scoured out of the tank. A valve to handle the entire plant flow will be large and expensive. How can we create a reasonable design algorithm for this valve?

Consider adding

- inlet manifold - (to eliminate short circuiting). The inlet manifold would be directly connected to the LFOM that is in the Raw Water Control Box. In this case the bottom of the Entrance Tank would be a valley identical to a sedimentation tank bay.

- plate settlers - It would be good to test this in a facility. It wouldn’t take many plate settlers in an entrance tank and we could determine if they make any difference in water quality. Their effectiveness would depend on the raw water composition.

- launder – how would this connect to the rapid mix pipe and alum dosing line.

The alum feed line must be installed securely because it can’t be easily checked during operation.

Eliminate the macro/micro mix orifices and replace with a single orifice that generates 1 W/kg of energy dissipation. This will eliminate or significantly reduce clogging problems. Design the rapid mix orifice /alum feed line so that it can easily be accessed and removed for inspection.

Raw Water Control Box

All of our plants should be designed so that the transmission line is allowed to run continuously even when the plant is shut off. This way when there is dirty water coming to the plant the plant can be turned off and the transmission line will eventually clear itself of the very dirty water. This will be accomplished with a raw water control box. The overflow will be across a sharp crested weir. This will make it impossible to send more flow to a plant than it can handle.

The raw water control box will be a small shallow tank inside the entrance tank. The raw water control box should contain the screen that is used to catch large debris to protect the control orifices from clogging. It must be easily accessible to the operator because the screen will need to be cleaned.

Water will exit the RWCB through a pipe that goes through the bottom of the RWCB. This pipe will serve as an inlet manifold into the entrance tank.

Low Flow Rapid Mix Design

- Create a micromix orifice interface on the coupling.
- Create a method to adjust the total head loss through the plant by adding more small orifices to the orifice plate. This is necessary to get the desired relationship between head loss and flow for the entire plant. It is done once at plant startup.
- Determine how to calculate the number of micromix orifices. This number is constrained by the goal of being able to easily add more orifices to adjust the total plant head loss at plant startup

High Flow Rapid Mix Design

For plant flows that require rapid mix pipes larger than 8 inches in diameter it probably makes more sense to build the entrance tank sharing a wall with the flocculator. The rapid mix would then be a constructed square duct. The micro mix orifice would be the inlet at the bottom of the floc tank wall.

- Create the algorithm to select which plant layout is used
- Create the design logic to draw the two different plant layouts
- Determine how to choose the entrance tank dimensions and location. Should the entrance tank be a channel that is similar to a flocculator channel? Or should the entrance tank have geometry that is closer to square? Do an analysis of construction materials. Note that the entrance tank is higher than the flocculator and thus if it shares a wall with the flocculator, that wall will need to be higher. Should the entrance tank be along the side of the flocculator or along the end of the flocculator channels? Consider the plumbing connections to the stock tanks and operator access.

Air entrapment in vertical rapid mix tube below micro mix orifice

We have strong evidence that air is being trapped in the vertical section of the rapid mix tube below the micro mix orifice at Agalteca. The head loss in the rapid mix tube increases causing the entrance tank to overflow even though the flow rate is less than the design flow rate.
We hypothesize that the air slow accumulates below the vena contracta because the velocity in the vena contracta is too high for air bubbles to travel upward. Below the vena contracta where the velocities are lower the water velocity is too low to carry the bubbles down and into the flocculator. In addition, the pressure in the middle of the vena contracta can be reduced significantly. At Agalteca the dosing tube was hanging down into the vena contracta. The low pressure in the vena contracta (The Bernoulli equation can

be used to show this.) may have caused air to flow through the dosing tube into the vena contracta. To solve these problems we need to make several changes.

1. The dosing tube should not be in the vena contracta. The dosing tube should be centered at the very top of the rapid mix tube.
2. We need a low velocity escape route for air that is caught below the vena contracta. We are proposing that a 1/2" PVC pipe be inserted inside the rapid mix pipe against the inside wall of the pipe and down to a hole in the micro mix orifice plate. This 1/2" pipe will extend up through the maximum water surface in the entrance tank. It will provide a stagnant water path for air bubbles to travel up and out of the rapid mix pipe.
3. It may be better to have the orifice plate attached to a pipe coupling rather that have the orifice cut into a pipe cap that is at the very top of the pipe going to the flocculator. The plate would be submerged further below the water surface and the dosing tube would not be so close to the orifice. That would provide some opportunity for some mixing before reaching the micromixing orifice.

Drain Systems for Entrance Tank and Stock Tanks

- Add a drain for the entrance tank that can be opened by pulling a pipe nipple (that protrudes through the water surface) out of a coupling embedded in the entrance tank slab.
- Connect drains from the stock tanks and the entrance tank to the drain line that runs along the side of the plant to the drain channel.
- Add a 2 inch nominal diameter drain port under the perpendicular weir that will connect the inlet and outlet channels to the control box. The drain port will consist of 2 elbows connected by a short pipe nipple that is buried in the concrete beneath the perpendicular section of the weir. The top of the elbows will be flush with the channel floor and will provide a means to drain the part of each of the channel that currently can't be emptied into the control box. A pipe nipple that extends through the water surface will be used in the control box to plug these drain ports. This addition may require the control box to be made slightly larger or may require that the existing ports in the control box be relocated.

Drain Channel (Dchannel)

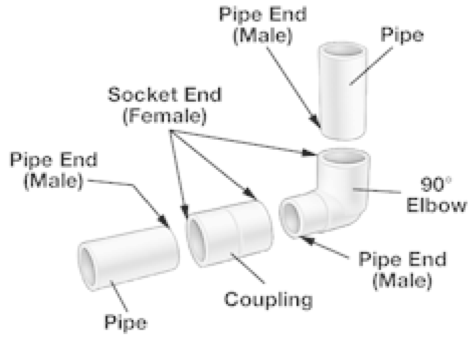
- Draw the drain channel along the inlet channel side of the sedimentation tank and flocculation tank.
- The channel should be sloped with the high end at the floc tank and the low end at the sed tank.
- Devise method of building channel when the flocculator tank slab is higher than the sedimentation tank slab.

Plant Pipe Plumbing

Identify high level drawing procedures that are frequently used and create high level functions with easy to use inputs to execute these procedures. One possible high level plumbing procedure could take a series of points in 3D and draw a pipe and elbows to connect those points. To get from the line connecting one pair of points to the line connecting the next pair of points would require a 90 degree bend – an elbow.

PVC Pipe Couplings

- Couplings are currently drawn to a user-specified length, but in reality come only in lengths dictated by the pipe geometry and pipe specifications. The coupling length is **approximately** twice the socket depth plus the pipe wall thickness.



Research at McMaster to find coupling lengths, add to the pipe database, and update so function calls pre-specified lengths. Compare the coupling function with the functions that are used to create tees, elbows, and caps and make sure that they use a consistent approach with similar inputs.

- Update all couplings to coupling subtract function so we do not have to keep both files/functions.

PVC Pipe Male Adaptors (female socket to male National Pipe Thread)

- Add PVC Pipe Male Adaptors to the pipe database.

- Make sure that all drawings of male adaptors (to connect to threaded components) are done using a high level function call that references the pipe database for dimensions.

Flocculation Tank

- Adapt the code used to create the plate settler modules to create baffle modules for the case where the baffles are plastic.
- Review the construction photos from Agalteca to see how the baffle modules are constructed. Note the use of a large cap to provide an easy way for one module to connect to the next module.
- Make sure that the hydrostatic force of the water (caused by the head loss across a channel full of baffles) is transferred to the wall by the PVC connector pipes at the downstream end of the channel. Thus direction matters in how these baffle modules are placed in each channel.

Sedimentation Tank

- Add a constraint for the minimum flow per sed tank bay. Override the user inputs for both the number of bays and the number of tanks if the user specified values cause flows that are too small. The sed tank design fails for very small flows because the tanks get so short that there is no space between the channels.
- Insert MathType equations to show how the algorithm is solving for the various geometries.

Inlet Manifold

- Use a flexible coupling based on the new design that will make it possible to remove the Inlet Manifold given the tight space constraints in the sedimentation tank and the goal of having the manifold extend the entire length of the sedimentation tank.

Launders

- Launder connection at exit channel end needs to be updated to a flexible coupling: a short piece of tubing will extend out of the coupling that is embedded in the wall which will connect to the flexible rubber coupling connecting to the launder.

- Maximize length of launder to extend tight against the inlet channel wall.
- Code and place small concrete ledges on the inlet channel wall of the sedimentation tank to support the end of each of the launders. Take into account the outside diameter of the pipe cap on the end of the launder.

Floating Floc Skimmer (Potential addition)

This item should be evaluated through discussions with the team in Honduras.

A drain pipe that makes it possible to skim flocs from the surface of the sedimentation tank. We have these installed at Marcala and Tamara. We need to assess whether they are necessary and useful or whether the new submerged chemical feed system at Agalteca makes these skimmers obsolete.

Floc Hopper (Potential addition)

This item should be evaluated through discussions with the team in Honduras.

This option may become necessary if we succeed in creating a floc blanket. The floc hopper would be used to control the depth of the floc blanket.

Filtration

We are in the process of evaluating filtration (either foam or stacked rapid sand filters) for addition to the AguaClara plants. Although we are still early in the research stage it would be useful to begin creating the design algorithms and the drawing tools for the eventual addition of filtration. This team needs to work very close with the filtration research teams. Given the concerns about long term durability of foam Monroe suggests focusing this early design effort on the stacked filtration approach.

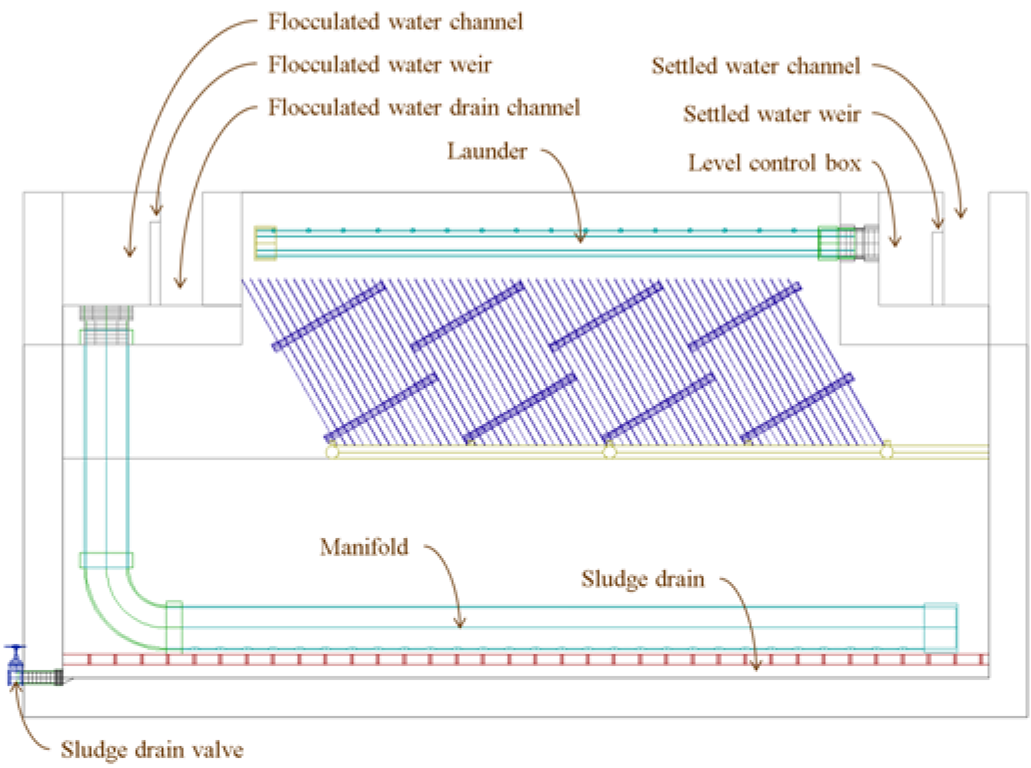
- Create algorithms for determining critical elevations
    - bottom of the filter
    - backwash gutter elevation relative to water source coming from exit channel of sedimentation tank
    - Distribution tank inlet elevation
- Add backwash velocity equation to fluids functions
- Add clean filter head loss equation to fluids functions
- Experiment with new plumbing functions for drawing the required manifolds, valves.
- Determine what new user inputs will need to be added to the ADT. For now include these inputs at the top of the MathCAD filtration file.
- Determine what new expert input will be needed. For now include these inputs at the top of the MathCAD filtration file.
- Create preliminary automated drawings.

Inlet Manifold Challenges for Fall 2010

The overarching goal is to optimize the design of the inlet manifolds that are used to deliver and distribute uniformly the flocculated water into the sedimentation tanks. The requirement that flocs be safely delivered without breakage means that the orifices (or ports) in the manifold pipe need to be large. The large port area (total port area large relative to pipe area) makes it impossible to get a uniform flow distribution from the ports.

Hydraulic analysis of the manifold flow suggests that pressure recovery as the fluid in the manifold slows down should result in the highest flow coming from the downstream end of the manifold. There is some evidence from Agalteca that this is indeed the case with more flocs rising through the plate settlers at the end of the sedimentation tank near the settled water channel.

Full scale studies of the inlet manifold pipe in the DeFrees Hydraulics laboratory during the spring of 2010 were inconclusive. The first question that needs to be resolved is whether pressure recovery is indeed the dominant mechanisms determining port flow variability in manifolds with large port area/pipe area ratio. If pressure recovery is indeed significant, then we can taper the inlet manifold to reduce pressure recovery.



The failure of full scale tests in the DeFrees Lab suggests that we should try a different approach. The hydraulics of manifold flow should scale quite easily. We should be able to design a manifold system at a reduced scale that can be studied in a small aquarium.

The first task of this team will be to design an experimental setup that can be used to accurately measure the flow from each of the ports. The scale model should be turbulent for the majority of the manifold pipe. It might be reasonable to reduce the number of ports to as few 5. A goal is to have the pressure recovery term be large compared with the head loss. Both pressure recovery and head loss will be increased if the flow velocity is increased. A higher flow velocity could thus be used to make it easier to measure the pressure changes along the pipe.

We will conduct tests on the uniformity of flow from constant diameter ports with a much smaller hydraulic system (perhaps 1/2" diameter pipe instead of 6") and with much higher flow velocities to make it possible to measure the pressure changes in the manifold pipe using pressure sensors. Preliminary calculations support this experimental approach.

The flow can be controlled with a peristaltic pump or a small centrifugal pump (fewer pulsations). The pressure change in the manifold can be measured with pressure sensors. The flow rates from the ports could be measured directly from the height of the water jets that will be produced if the manifold isn't submerged.

Assuming this first test is successful and there is evidence of pressure recovery, then the next step could be to build a tapered manifold to see if that can produce more uniform port flow.

Challenges ANC Fall 2010

Summary of Work

AguaClara plants rely on sweep flocculation to achieve high performance requiring a pH between 6.5 and 7.5 even after the dosing of alum. The low alkalinity of Honduran source waters requires the addition of acid neutralizing capacity to buffer against changes in pH from the precipitation of aluminum hydroxide after alum addition. The summer 2010 ANC Control team has continued to investigate the possibility of using a lime feeder with AguaClara plants to deliver saturated calcium hydroxide solution to the plant flow. Slaked lime (calcium hydroxide) is inexpensive and readily available in Honduras because it is used there in the process of making tortillas. However, it is not as soluble as other proposed bases such as sodium carbonate, and lime feeders are not widely used because simple models fail prematurely and tend to clog with coalesced material. The team now believes that the inability of the lime feeder to produce saturated effluent for long periods of time is primarily due to the precipitation of calcium carbonate which inhibits $Ca(OH)_2$ dissolution. Experimental runs with distilled water and Honduran lime have produced better results than those seen in past semesters, but only 15% to 20% of the total lime dissolves to give a saturated effluent, too little for the lime feeder to be economically viable compared to sodium carbonate dosing. The team has added effluent recycle to remove carbonates from the reactor influent, which will be tested by future teams. In addition, the team is closer to determining the composition of the lime using the Total Carbon Analyzer.

Challenges

Experiment with Effluent Recycle System

The team hypothesizes that the most significant source of carbonates leading to failure is in the source water, even when distilled water is used. The future ANC team should experiment with a pre-treatment reactor which removes carbonates from the influent water using high-calcium recycled effluent from the lime feeder to cause calcium carbonate to precipitate out (Figure 1). There are several variables to consider here: how much residence time is required to fully remove carbonate from the system, what initial conditions are going to aid in precipitation, and a viable way to capture solids using lamellar sedimentation (we may need to determine an ideal capture velocity).

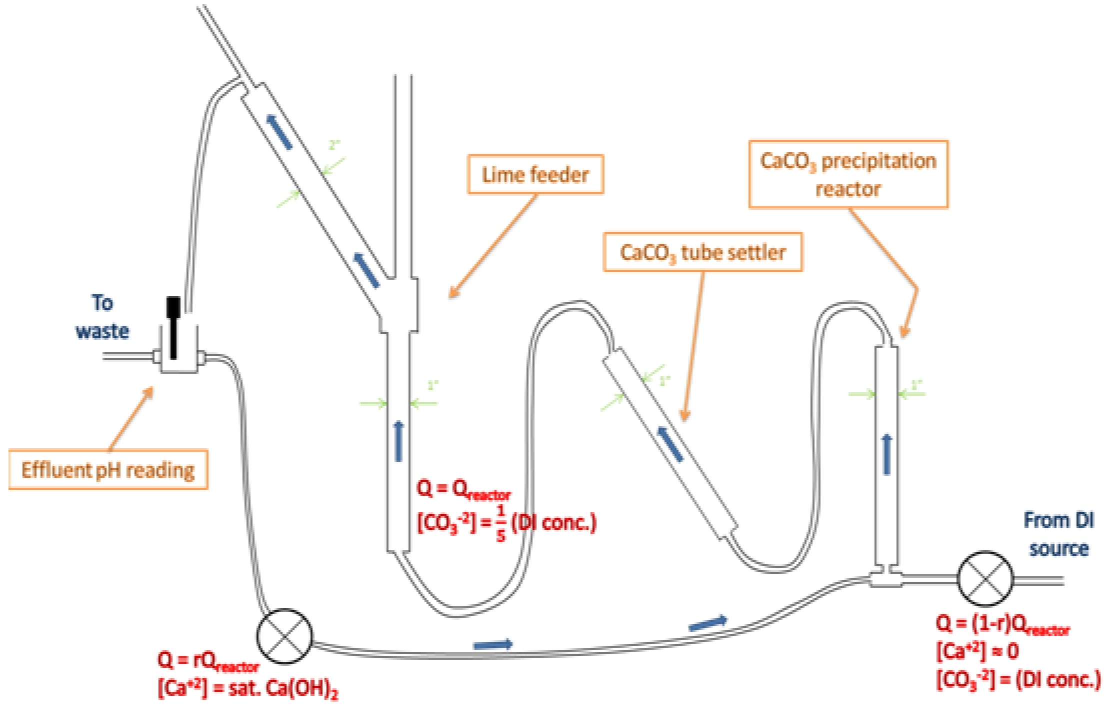


Figure 4. The propsed setup with a recycle line delivering concentrated calcium hydroxide to a pre-treatment reactor is meant to cause carbonates to precipitate from the source water before it reaches the main reactor.

Determine Lime Composition

Available calcium hydroxide, or slaked lime, is not pure and likely contains a significant amount of calcium carbonate. It will be useful to know the exact composition of the lime in order to evaluate what effect it may have on the lime feeder performance. Progress using the TC analyzer should make the process of determining the carbonate content of the Honduran lime relatively easy. Test runs have already been successful; now data needs to be collected and analyzed. An additional challenge may be to determine what fraction of the total carbonate is soluble, and what fraction is in the form of calcium carbonate (?).

Determine Change in Carbonate content over run time

We would like to determine the amount of carbonate that is in the lime before and after an experimental test is run. It is anticipated that if our recycle is efficient that there should be very little difference as the carbonate in the solution will not be supersaturated and should not precipitate out. A TSS test should be sufficient to determine carbonate content. If there is a change in carbonate content and the reactor underwent failure then we have some proof that

Replicate Results

As future teams narrow in on the mechanisms which are most important for the lime feeder's performance, they should gather enough data to make confident conclusions. Due to the rapid evolution of ideas and the difficulties of using the experimental apparatus, past teams have relatively few experimental runs to analyze.

Accurately determine pH of saturated solution over several time points

It will be necessary to measure the pH utilizing both an ANC (alkalinity) and carbonate measurement from (liquid-TOC). From these two data points we can determine the pH value and compare this to the pH probe value. Hopefully, we can then "calibrate" our pH probe values this way for each subsequent run we test. Refer to previous reflection reports (Summer 2010) for more information on pH probe measurement issues.

Experiment with using the recycle system with higher carbonate contents

If we are able to establish a more efficient lime feeder system with the recycle system, the next step is to understand and characterize how to remove or bring down the carbonate content in much more highly concentrated solutions (i.e. lower alkalinity water and Ithaca tap water). This will test the viability of our system and trade-off efficiency of a lime feeder system and under what conditions is the lime feeder applicable.

Experiment with other Parameters

Although the lime feeder's fluidized bed and ability to capture particles seem good for the experimental parameters the team has used in the past, it will be useful to experimentally determine the ranges of upflow velocities and initial masses of lime which produce the best performance before the lime feeder is implemented in Honduras, if it is found to be economically and practically viable. In addition, past teams' experiences are insufficient to determine how the lime should be added to the reactor physically. Future teams should determine whether adding the lime as a blended slurry instead of dry powder has a significant effect on lime feeder performance.

Challenges Tube Floc Fall 2010

Overall Challenges for the Tube Floc Team

The goals of this team are to provide an experimental basis for the design and operation of flocculators. This includes performing experiments that vary alum dose, required collision potential and energy dissipation rate as well as processing the raw data in a reliable way that produces meaningful results. These results will guide the design of flocculators and will help us understand the tradeoff between performance and flocculator residence time.

The challenges as described below don't provide sufficient detail to guide the research program. Thus the first challenge is to develop a matrix of experiments that will be conducted. The baseline conditions of the experiments need to be clearly described and then the parameters that are varied, the range, and the increment, need to be specified for each experiment. Some experiments need to be replicated to assess the reproducibility. For each experiment the measured parameter is effluent turbidity as a function of sedimentation time. These measured values can be transformed into a floc sedimentation velocity distribution and a curve of residual turbidity as a function of alum dose.

Future Challenges

Organize experiments and the team

The very first thing you need to do is read the summer team's final report . It provides valuable information about the specific tasks that remain to be done. The experimental apparatus was used extensively to perform experiments, all of which are listed in the final report. Look at the analysis of the results and determine which experiments you would like to repeat and which datasets are outliers. Pay particular attention to the minimum alum dose that results in a transition from no flocculation to reasonable flocculation. Confirm that the transition alum dose can be measured accurately. Proceed until you can provide substantiated conclusions about the correlation between alum dose, hydraulic residence time, and influent turbidity. Look for evidence of floc breakup as well. Floc breakup produces a second source of particles with a distinct peak in a probability distribution function.

Team members should create efficient methods to work together in small groups and to work in parallel with other members of the team. Each team member ideally will be able to run experiments in process controller and analyze data by Week 3 in the fall. The apparatus should be run as much as possible and schedules should be coordinated in advance to avoid delays in running experiments.

Data Processor

The data processor has been the subject of many modifications this summer. The bimodal distribution was tentatively successful- producing excellent results for only one data set. It seems that the program is extremely sensitive to the guess values provided. The data processor, including the bimodal distribution, should be as robust as possible, working for all good datasets.

Laminar Flow Relationships

Derive and document the equations for maximum and mean energy dissipation rate in laminar flow and in the tube flocculator with its figure eight coil. Always report these values with your results so that your results can be compared with the energy dissipation rates used in full scale flocculators.

Head Loss Measurements

Make sure that head loss is ALWAYS measured across the flocculator to compare with theoretical valves. Head loss that is higher than theoretical could indicate pinched tubing or a clogged tube.

Experiments after initial repeatability studies

- What is the effect of the energy dissipation rate on the final particle size distribution? We hypothesize that flocs will be smaller and that residual turbidity will increase as the energy dissipation rate increases. The current maximum energy dissipation rate used by AguaClara is 6 mW/kg. Consider increasing that to 60 mW/kg (check experimental feasibility). Note that this is the maximum energy dissipation rate (ie what you would get from = Gwall^2). If you can't increase the maximum energy dissipation rate to 60 mW/kg, then increase it to the maximum that the apparatus will handle. Note that it would be possible to reduce the inner diameter of the tubing to create higher energy dissipation rates.
- We hypothesize that almost all of the residual turbidity is caused by floc-floc collisions that break off floc fragments. This abrasion process could be reduced if the flocs were all made much tinier (by sending them through a high energy dissipation zone). The floc breakup should be done close to the end of the flocculator. You can use the fractal flocculation model to get an estimate of how much to break up the flocs and how long it will take them to regrow to the size where abrasion will again become significant.
- There is a great deal of uncertainty about the exact mechanisms responsible for particle aggregation in aluminum mediated flocculation. Similarly there is no understanding of the particle aggregation /precipitation/adsorption processes that occur in the first few seconds during and after rapid mix. One hypothesis is that aluminum hydroxide molecules need to aggregate and form roughly spherical nanoflocs that are able to approach the flat clay surfaces and form Van der waals bonds. Close approach of the nanoflocs to the clay surfaces could be more favorable than clay to clay because of reduced hydrodynamic drag and electrostatic repulsion. In this hypothesis adsorption of aluminum hydroxide to clay is a parasitic reaction. We can test this hypothesis several ways. We could combine the alum with a clean tap water fed to neutralize the alum, run it through a rapid mix tube and then combine it with the raw water. The size of the nanoflocs could be controlled by controlling the rapid mix time and the time after rapid mix before the raw water is added. Another possibility is to neutralize the alum in the alum stock container. The coagulant stock would need to be stirred because it will contain aluminum hydroxide floc. This preneutralization approach is likely to produce larger nano or microflocs that will not be as effective at removing turbidity. Carefully measure the transition alum dose required to get good flocculation using the microflocs and compare with previous experimental results.
- Investigate tapered flocculation designs. The first four AguaClara plants were designed such that the energy dissipation rates incrementally decrease over the length of the flocculator. Beginning with [Agalteca] this tapered design has been abandoned because there was a lack of experimental evidence showing that it improves performance. Begin with an experimental setup that has two energy dissipation rates and determine if there is any benefit. The energy dissipation rate in the second section of the flocculator

can be independently controlled by using a peristaltic pump to remove a fraction of the flow. Thus the same size tubing can be used for both sections of the flocculator.

- Investigate the influence of microscale mixing. For these tests use a well designed flocculator that produces very low residual turbidity. It is unclear what influence rapid mix parameters have on plant performance. Compare performance of systems with no rapid mix to systems that have a high energy dissipation rate in the rapid mix (of at least 1 W/kg). Measure the effects of changing the energy dissipation rate (perhaps 0.1 W/kg to 10 W/kg) and the residence time (1 s with a single orifice mixer to 100 s with a long small diameter coil) in the rapid mix unit.
- Measure the potential impact of poor mixing by adding 90% of the turbidity AFTER the rapid mix process.

Later Challenges

Test the effects of pH and organic matter on flocculation

Measure the effects of organic matter and pH on the sedimentation velocity distribution and residual turbidity. Varying the pH of the influent may help elucidate changes in floc strength as a function of pH. It is possible that floc strength (as measured by floc size) is well correlated with optimal alum dose and pH. Raw water that contains a high concentration of organic matter relative to the concentration of clay may produce flocs with lower sedimentation velocities. An understanding of this effect on floc sedimentation is critical in designing plate settlers. The effect of pH on floc strenght and residual turbidity may help develop a more fundamental understanding of how to optimize the flocculation process.

Turbulent flow flocculator

A laboratory scale hydraulic flocculator that operates under turbulent conditions that are relatively homogeneous and easy to characterize could go a long way into understanding turbulent flocculation. Comparison of residual turbidity and floc sedimentation velocity from turbulent and laminar flow flocculators could be used to validate flocculation models. Design a turbulent tube flow flocculator by using a larger diameter tube. Determine the required flow rates and assess the capabilities of the temperature controlled water source and the peristaltic pumps to deliver the required flows. Design an upgrade to the experimental apparatus to deliver the higher flow rate if needed. A turbulent tube flocculator that uses minor losses to generate energy dissipation could be created by inserting a string of spheres into a tube. This simple geometry could be a reasonable model of the full-scale baffled flocculators.

Fall 2010 Challenges for Stacked Filtration

Summary

This team will work best if there is a very tight integration between the design team and the research team. To accomplish that integration this team will include members from the design team (who will go through the design training) and members from the research team (who will go through the research training). The team has many, many tasks, so it is important that you from the beginning prioritize and understand what has been done and what needs to be done on a week to week basis.

Research Goals for the fall

1. Prepare the preliminary design for EPA P3 Competition Phase I. Start by reviewing the design file in MathCAD and setting up a brainstorming meeting with Monroe. He will be able to direct you on this design and what is still missing and needs to be updated.
2. Design and install a backwash waste system that is robust and won't leak. Review the design from the summer and see what elements can be improved on this design before everything is set up.
3. Evaluate methods to prevent backwash water from entering filtered water manifolds. For example, would there be a way to generate a low flow of settled water into the filtered water manifolds during backwash? As a first step, look at the pictures of design and then think about ways that this could be accomplished. There are undoubtedly other ways of solving this problem. Brainstorm!
4. Create a movie showing a red dye pulse passing through the filter to demonstrate how the water flows up and down in the filter layers. This is crucial in showing that water is being even distributed through the filter bed.
5. Demonstrate the feasibility of switching between filtration and backwash without ever changing the incoming flow rate. This is how it will be done at full scale. Make sure the new system is designed to handle this.
6. Create a movie of the entire backwash process (showing the switch between filtration and then all of the steps to get back to filtration again.
7. Compare performance of standard filter of same depth with stacked filter. (This has been done with 20 cm of sand. The data is available and should be analyzed, please see Sarah or Matt for more information).
8. Consider using a smaller size of sand to enhance performance. Note that a different sand size will COMPLETELY change the design because backwash velocity will change and that will decrease the filtration rate (assuming we keep 6 layers). Filter run time and filter head loss will change as well. Evaluate the tradeoffs and provide us with some guidance on how to choose the best sand diameter.
9. Become experts on filter underdrains and guide the design of the full scale underdrain system.
10. Review the stacked filter paper as it is so far. There are some issues as far as integrating graphics with the text AND there still needs to be some documentation work. There is a bulleted list of what needs to be done and an integrated design should be present in this first paper along with potentially other variables such as changing sand grain size and the use of natural organic matter. As you run experiments and analyze them, integrate these analyses into this paper.

Design Goals for the fall

1. Prepare for EPA P3 Phase 1!
2. Finalize the automated design algorithms for integration with the design tool. This must include hydraulic and component dimension constraints for all of the channels
3. Create a design option that minimizes head loss between sed tank and clearwell. This design may need some valves to run through the normal backwash, filter to waste, filter cycle.
4. Create a design that has the shallowest filter box, shallowest channels and the same water level in the filter box for backwash and for the end of the filter run. This design should not need ANY valves to run through the normal backwash, filter to waste, filter cycle.
5. Create designs that minimize the risk of backwash water contaminating the finished water

Yellow is from the summer…

We have a preliminary idea of how we want to set up our stacked filtration system. The first task is to build a robust, laboratory stacked filtration system to test the feasibility of backwashing a filter containing multiple inlet and outlet manifolds and to test the particle capture efficiency.

Constraints:

- We are going to utilize the 4” ID column that was previously utilized for demonstration of rapid sand filtration in the environmental teaching lab
- The filtration system will need to be redesigned and then modified.
- Valves to switch between backwash and filtration will have to be operated manually
- We are going to utilize the tap water supply to deliver a flow rate of 2000 mL/min for rapid sand filtration. A clay stock suspension and an alum solution will be combined with the tap water to provide a test suspension.
- A backwash flow rate of approximately 4800 mL/min will be supplied and we suspect that this can be accomplished as a direct line from the tap
- A diagram of the system is shown in Figure 1.

Future Challenges

Determine the hydraulics and flow characteristics of the slotted pipe

A slotted pipe will be put in the 4” ID column to act as a manifold for the water such that the raw water is evenly distributed into and out of the filter. The percent “open” area of the slotted pipe seems to be a bit low. Calculations should be done to determine the head loss through the slots at the experimental design flow rate.

Test and troubleshoot the experimental apparatus

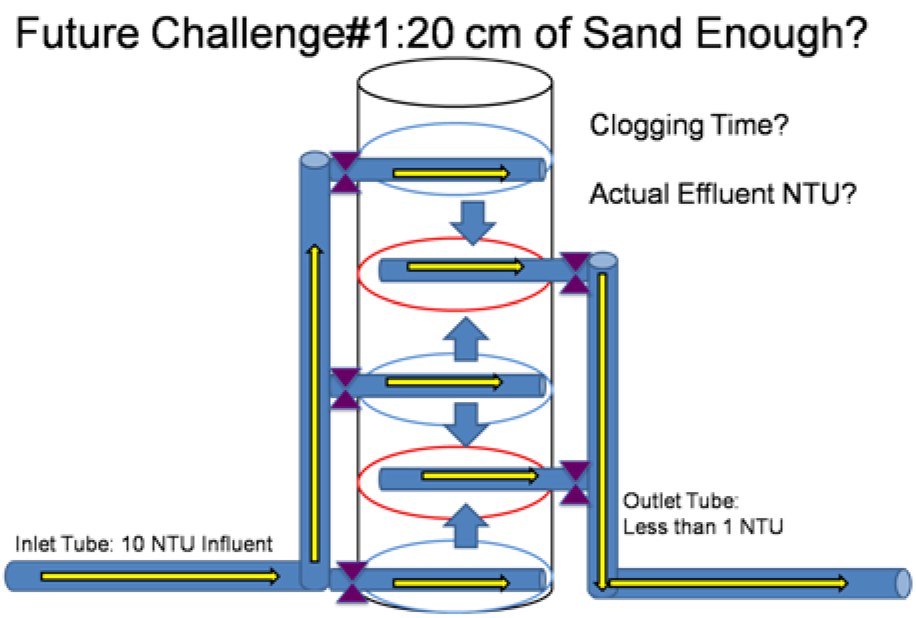
After you have built the experimental apparatus, the next step is to verify how it works. Check that all connections are water tight, and that backwash is sufficient to fluidize the sand bed. Backwash will be controlled by manual valves. The backwash sequence steps are…

1. Close all effluent manifold valves
2. Open the valve that takes backwash water from the top of the filter to waste
3. Close the inlet manifold valves starting at the top of the filter and progressing to the 2nd inlet manifold (counting from the bottom). This will force all of the water to enter the filter through the inlet manifold at the bottom of the filter.

Test the performance and efficiency of 20 cm sand

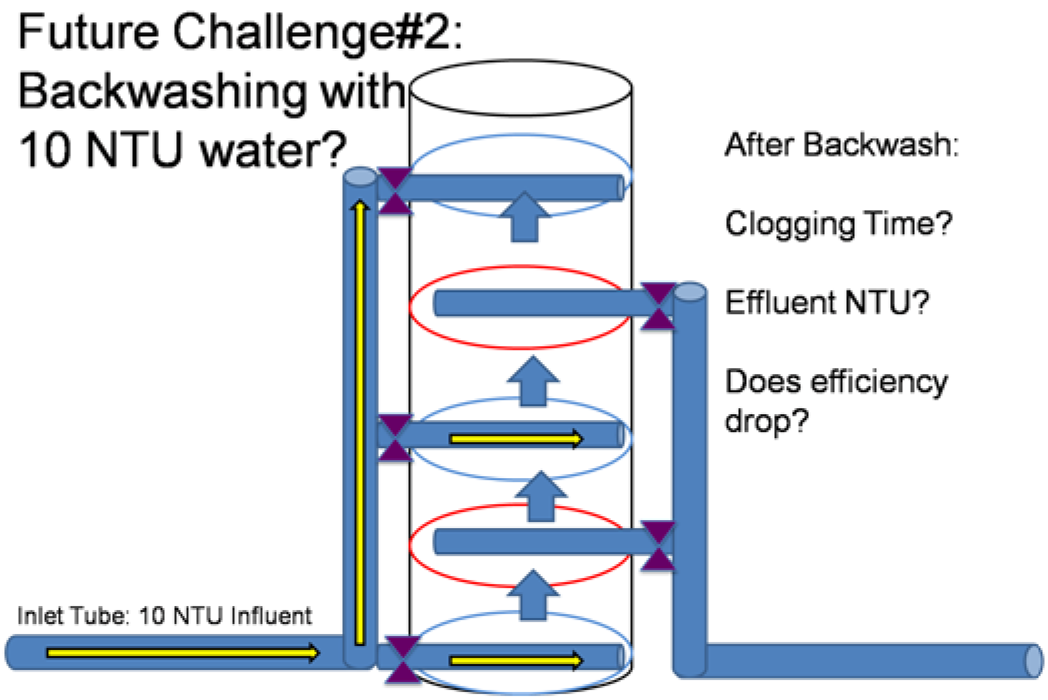
Ensure that process control is set up and that both the influent and effluent turbidity is appropriately sampled. Build a continuously stirred stock tank containing a concentrated suspension of clay. Design this to last at least 26 hours. The stock tank can probably be a few liters in volume. Use small diameter tubing to connect the stock tank to the peristaltic pump and to the point where it blends with the tap water. The peristaltic pump should also be running at high rpm so that the velocities in the tubing are high to prevent sedimentation. Dose with alum at a concentration of approximately 3 mg/L (30 mg/L per 100 NTU).

A second goal is to measure head loss within the filter as a function of time.



Backwashing with 5-10 NTU water

We need to find out the implications of backwashing the sand filter with water that is normally used as the influent. Does the filtration efficiency eventually decrease over time? Using this model, we can also simulate backwash with 5-10 NTU water dosed with 30 mg/L per 100 NTU alum and then rerun the first experiment to see how backwashing with the unfiltered water effect the filtration efficiency as backwash cycles are repeated .

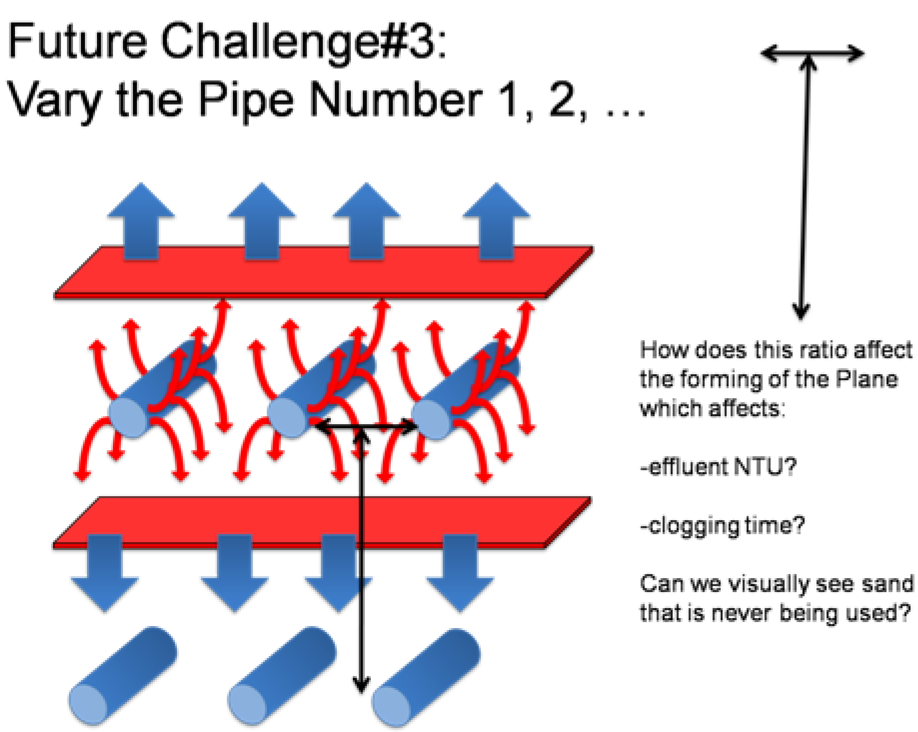


Later Challenges

Decrease the spacing of the sand layer or increase the spacing of the sand layer depending on results

Increase Natural Organic Matter content (NOM) and/or increase/decrease pH

Vary the pipe number utilizing a larger diameter reactor if possible (detailed in Figure 3)



Advice to the Future Filtration Team Member:

1. If you are not proficient in process controller, MathCAD, and wiki, find help early and learn.
2. I ntroduce yourself to Paul Charles and Tim Brock at the shop early. Who are they? Go find out.
3. Even when you are split into various different sub teams, meet every week to share progress and get feed back.   We found that members from different subteams can provide insight and synergy and fair, fresh, and impartial evaluations. We also ended up switching team members between sub teams so it is good for team members to periodically meet each other.
   Set up a rountine where you meet with Monroe and Matt and Karen periodically as you make progress. They can catch mistakes that you miss and save you a lot of time and headache. This is a good way to avoid group think.
4. This search engine is great for articles related to hydraulics and filtration: http://www.jstor.org/action/doBasicSearch?Query=water+wire+filtration&wc=on&dc=All+Disciplines
5. If possible, take Monroe's Sustainable Water Supply Class and Professor Bisogni's Physical Chemical Process class. If not possible, get the notes.
6. Be flexible and proactive! It is hard doing all this initial research, but stay on top of it and document through out the process, otherwise it will be hard at the end .
7. Stay in constant communication with Monroe and Matt and Karen - they are filled with great ideas and will keep you focused.

Challenges Foam Filtration Fall 2010

Summary

Past research has demonstrated that foam filtration is an effective form of turbidity removal. However, given the manual labor required for its operation, it is best when implemented at a smaller scale than AguaClara currently operates at. The viable scale of implementation would fall between municipal scale, and point of use. This could be a great for use in schools, apartment or office buildings, or even small towns. There are two immediate goals: prepare this project for submission as a EPA P3 Phase 1 Design for point of use system and complete the paper that was begun Summer 2010. This novel target area could open new windows (or faucets) to the spread of AguaClara!

Immediate Challenges

Determine the head loss through a clean filter

Install an attenuator with a flow control valve, where the head loss through the valve is significant, so that the revolutions of the pump will not affect the readings of the pressure sensor since the pressure difference due the pump revolutions will be small in comparison to the pressure in the attenuator. We may also achieve constant head utilizing elevation.

Determine the head loss over time and the measured head loss that causes compression

Design a system similar to before where pulsations caused by the peristaltic pump do not affect the pressure sensor results. Such a value is necessary and a high priority so that we can establish when the foam compresses so that perhaps we can recommend cleaning before this happens and so there is a value in the paper we submit. We cannot submit the paper until we have a good understanding of the range and pressure that causes compression.

Determine the range of influent turbidities under which the filter will perform under US EPA Standards of 0.3 NTU

This will be important if this filter should be marketed as a stand-alone treatment option. Can this material effectively filter 100 NTU water? 10 NTU? We should know the bounds of the design.

Determine the effect on run time and effluent turbidity if a layered porosity filter is used instead of a single porosity.

Past experiments have shown that the majority of clay particles are trapped in the uppermost layers of the foam material. We may be able to achieve more uniform particle removal over the depth of the filter media by layering porosities throughout the depth (say 3 inches of 60ppi, followed by 7 inches of 90 ppi). Achieving a more uniform clay distribution over the depth of the filter will likely result in longer experimental runtimes, which means the filter might require less frequent maintenance and cleaning.

Design a foam filter unit for implementation

The design will need to incorporate:

- A filter unit that maintains a tight seal with all edges of foam
  - Must determine desired filter properties from previous research
    - Depth (dependant on porosity)
    - Porosity (even start 30 ppi (pores per inch) perhaps layer 60, then 90)
    - Approach Velocity (3-6mm/s)
- A holding reservoir for incoming dirty water
  - Must incorporate a flow control to regulate the height of water above the filter and the flow rate through the filter
- A holding reservoir for clean effluent from filter
  - A chlorine dose controller
  - It may be necessary to work with the chemical dose controller (CDC) team for help and ideas on accomplishing a simple, effective dosing with a material that does not deteriorate significantly when exposed to chlorine.

Challenges Plate Settler Spacing Fall 2010

The team's future challenges include: finishing the planned velocity gradient experiments using the clay stock and current reservoir system; reviewing settling velocity experiment calculations, setting up and running the experiment; and rerunning the velocity gradient experiments using natural organic matter instead of clay. Following this, the team should organize and prepare documents for publication of the results.

Vary Velocity Gradient with clay as turbidity source

This experiment seeks to differentiate the effects of velocity gradients from capture velocity on plate settler performance. The capture velocity is set to 0.12 mm/s (the value used in AguaClara plants). A range of diameters (5/8", 1/2", 3/8", and 1/4") were chosen to reflect relevant AguaClara spacing. So far, we have tested both 3/8” and ¼” tubing and still need to test ½” and 5/8”. Every tube diameter will be tested at mean upflow velocities of 1 mm/s, 2 mm/s, and 5 mm/s with different lengths of tubing for each to achieve appropriate capture velocities. We are varying lengths so that we can have the same capture velocity for different flow conditions. In some of these experiments, we anticipate that floc roll-up will occur as the dominant mechanism as opposed to capture velocity. You should review the MathCAD document and relevant equations as well as the draft of the paper if you are unclear why we varying length to hold capture velocity constant. Also, make sure that it is

understood that the reservoir is used for experiments where the flow rate going into the turbidimeter is greater than the flow rate coming from the tube settlers and that there is a minimum flow rate necessary so that the turbidimeter accurately reads turbidity values.

Performance is not expected to be dominated by floc roll-up for any of the tests at 1 mm/s upflow velocity, so the team plans to use this set of tubes as a control experiment. For higher upflow velocities, failure is expected to occur. (See the excel file: "Materials List Velocity Gradient Experiments, PSS 5-12-10" for expected failures that is, Pi-V ratio of less than 1)

Tasks

1. Review what has been written in the paper so far regarding Plate Settler Spacing (uploaded on the main page of the PSS team and titled “Characterizing Performance of Inclined Lamellar Sedimentation”)
2. Review the calculation methodology in the MathCAD (titled "spring 2010 new mathcad file, 510" in the PSS_Spring2010 folder under AguaClara team folders.
3. Review the materials list (titled "Materials List Velocity Gradient Experiments, PSS 5-12-10")
4. Tubes have been prepared and we still have to test
5. Familiarize yourself with the process control file developed over the summer (titled "PSS Summer 2010.pcm") under the folder "PSS_Summer2010 "
6. Run experiments, ensuring 3 residence times of the tube settler, manifold, reservoir, turbidimeter system. The residence times have already been entered in the process control file, but were calculated under “PSS Residence Time Calculations Summer 2010” under the folder “PSS_Summer2010”
7. Analyze and summarize results utilizing the template developed in the data analysis folder for summer 2010.

Imaging Entrance Conditions

Surprisingly, entrance conditions contribute to a condition where a large floc sits at the entrance region and seems to alter turbidity readings. We need some way to image or characterize this source. It is recommended because of the circular nature of the reactor that we utilize a mirror overhead the water and then attempt to shoot images from this mirror from a camera. We need to characterize under what conditions this entrance region forms and if it significantly affects performance.

Paper: Characterizing Floc Performance

It is important that as the team collects data, that the data is being analyzed and then written up appropriately in the draft of the paper already started. It is important that we ensure that the methodology for each of our experiments is sufficiently developed for this paper before we submit. The conclusion of this experiment should provide enough data for a research paper. This paper will document the equations of floc roll-up and capture velocity and will show graphs of residual turbidity as a function of the velocity gradient at constant capture velocity.

Paper: Modeling Capture Velocity, Floc Roll-up, and Design for PSS

At the same time, another paper is being written up that considers the floc-roll up model developed in Fall 2009 and Spring 2010 (located under analytical modeling on the Spring 2010 wiki report). There is currently a model being developed for modeling the velocity gradients as they contribute to capture velocity. This paper will most likely be handled by Matt and Monroe for the time being and will not be a priority for the team until the analytical model and approach is better developed.

Vary Velocity Gradient with natural organic matter (NOM)

Such tests will probably not occur until the earliest of Spring 2011 unless all relevant data for clay turbidity experiments is characterized and calculated and a sufficient method for imaging the entrance region has been developed. This experiment is aimed at testing the effects of natural organic matter on plate settler failure. The team will use a natural organic matter (humic acid) in place of a clay stock and rerun the original velocity gradient experiments. NOM tends to produce flocs that are less dense than clay flocs. This leads the team to believe that failure will happen at lower velocity gradients and thus at larger tube diameters. The team hopes that this experiment will provide some justification for larger plate settler spacings.

Tasks

1. If possible, model the effects of NOM on floc formation
2. Create a MathCAD file similar to the velocity gradient experiments with clay stock but for NOM
3. Review the required materials and setup, ensuring that the procedure is adequate.
4. Run the experiment, analyze and summarize results, compare to the clay sedimentation velocity

Settling Velocity Measurements

The team plans to perform this experiment in order to determine the settling velocity distribution of particles in the floc blanket. This information will allow the team to predict the magnitude of failure based on the capture velocity and predicted failure particle size. Furthermore, this test will determine whether different floc blankets produced by the system have similar characteristics. This experiment is performed using a single tube whose dimensions are detailed in the MathCAD file spring 2010 new mathcad file, 510" in the PSS_Spring2010 folder under AguaClara team folders. The capture velocity will be ramped by adjusting the flow rate through the tube settler. Details on the required flow rates are in the MathCAD file.

Tasks

1. Review calculation methodology in the MathCAD file (titled "spring 2010 new mathcad file, 510" in the PSS_Spring2010 folder under AguaClara team folders) to ensure correctness and verify needed materials
2. Order required tubing and make any necessary alterations to the experimental setup
3. Program the necessary Process Controller Method
4. Run experiments, analyze and summarize results

Documentation

The team wants to ultimately be able to provide length and average velocity recommendations for all spacings tested that correspond to effluent turbidities below 1 NTU. The documentation should include supporting evidence from at least the Velocity Gradient Experiments with cay. The subsequent two experiments detailed above will provide supplementary information.

Tasks

1. Review all MathCAD modeling and results from experiments
2. Appropriately format and organize the information
3. Write and submit an article for Journal of Water Supply: Research and Technology-AQUA

Chemical Dose Controller Fall 2010

Semester Overview

During the Fall 2010 semester the CDC team has focused on redesigning the mounting and arrangement of the dose controller in order to make it more accessible and aesthetically pleasing. Instead of being positioned directly above the entrance tank, the team envisions the system's components being mounted on a plywood board on the wall of the plant. The lever arm of the dose controller would then be connected to the float in the entrance tank by a simple pulley system in order to couple the elevations of the orifice and the entrance tank water level. The team has selected parts for the design and constructed a prototype in the lab.

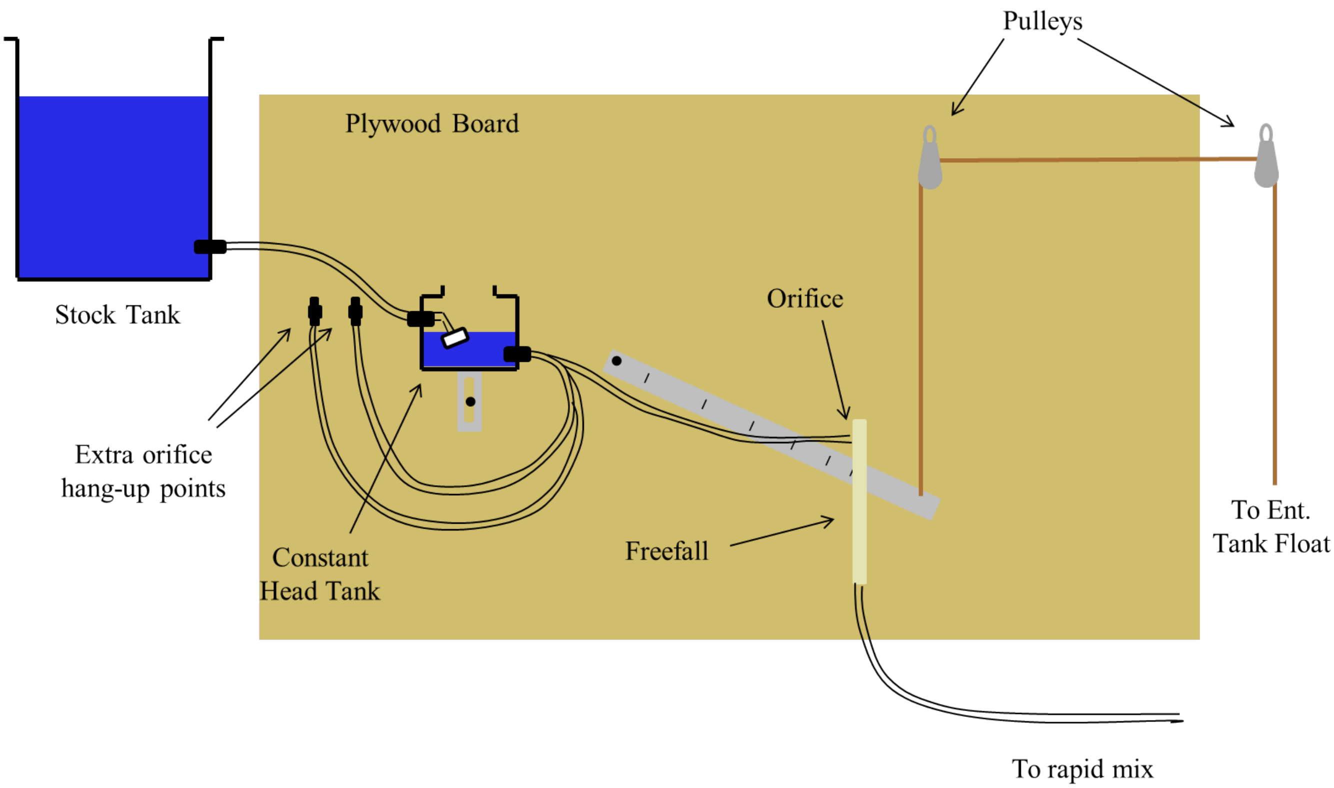


Figure 1. The new CDC will be mounted on a plywood board to make it visually accessible. Note that this schematic does not show the details of the slider assembly or the flow measurement column.

Linear vs. Nonlinear

The team has received feedback from Honduras indicating a preference for the linear chemical dose controller for low flow plants instead of the nonlinear doser which was meant to supersede it for all plant designs, big and small. Although the linear doser does not work for high flow rates because the linear relationship between flow rate and head loss breaks down when flow through the dosing tube becomes turbulent, it still offers several advantages over its nonlinear counterpart.

First, with the original design which uses a Linear Flow Orifice Meter in the entrance tank followed by a freefall, the head loss in the entrance tank is hydraulically isolated from the rest of the plant. For the newer designs in which head loss in the entrance tank is not hydraulically isolated from the rest of the plant, unexpected effects downstream can alter the carefully calibrated water elevation-flow rate relationship on which the dosing system is dependent. In the case of the plant at Agalteca, a build-up of settled grit in one of the flocculator ports has increased the plant head loss and thrown off the CDC's calibration. It should be noted that the head loss in the entrance tank can be isolated from downstream effects through freefall in the case of a nonlinear system. Connection with downstream flow is not inherently a part of the nonlinear design.

In addition, the linear dose controller has a wider range of flow rates which it can accomodate with a single tube than the orifice-based non-linear doser does. The same principle carries over to the entrance tank, where the LFOM has a wider range of flow rates for which it can provide accurate head loss measurement, so the plant has more flexibility in varying its flow rate. The wider dynamic range of the system and the linear scale between tube elevation and flow rate eliminate the need for multiple tubes, simplifying the system for the plant operator. Finally, the linear system does not suffer from the effects of surface tension at low flow rates.

The design of the mounted system which was the focus of the Fall 2010 team is not changed dramatically by a switch between nonlinear and linear systems. The major differences are a change in the scale on the level arm and the use of a single, small-diamter flexible tube instead of three tubes which end in orifice caps. All other components function the same. It seems likely that AguaClara will proceed in the direction of using both systems, choosing between them based on the size of the plant to be designed.

Fall 2010 Design Details

The majority of the team's time was focused on selecting parts for the proposed CDC design and constructing a prototype. Details of the design process as well as listings of part details and McMaster-Carr item numbers for all of the relevant components can be found here.

Pre-semester Context and Goals

The Summer 2010 CDC team provided a detailed discussion of the goals of the Fall 2010 semester. The page also provides background and context for the new design features.

Fall 2010 Task List and Reports

A Detailed Task List was created to lay out the planned research for the CDC team for Fall 2010.

Reflection Report I provides a detailed description of the planned research.
Reflection Report II provides a sketch of what the improved CDC apparatus will look like (using two chemicals and pulleys to control the entrance tank float)
The Final Report details the design process including specific components used, contains the results of the flow test run with the new orifice cap, and makes suggestions for future work.

Outreach Challenges for Fall 2010

Team Leader:

TBD

Number of team members necessary:

3-5, including at least one returning AguaClara member (If there are more, the team could split into sub-teams, specifically Public Relations and Fundraising.)

Important team member skills:

- Good written and oral communication skills
- Creativity
- Ability to work in an effective team
- Knowledge of business, public relations, and fundraising principles

Challenges

Over the past year the funding available for the AguaClara team at Cornell for research, development, and design as well as the funding available for constructing plants in Honduras and for financing AguaClara Engineers has dropped to about 20% of our previous funding levels. Although the financial situation is challenging, the project remains solid because we are based on knowledge creation and dissemination and many of those activities can continue on without significant financial support. Our critical challenges are to

1. Create a sustainable funding source or a new model for AguaClara Engineers (costs approximately $30,000 per year per engineer)

2. Obtain funding for graduate student support (costs approximately $75,000 per year per graduate student).

3. Obtain funding for water treatment plant construction in Honduras so we can continue testing improvements in design. This includes a specific goal of also providing a sustainable funding source for the AguaClara technician in Honduras.

4. Obtain funding to help disseminate AguaClara technology to other countries. Our hypothesis is that strategically placed demonstration plants would serve as catalysts to speed the adoption of the AguaClara technology. The goal is to obtain donor funding to build full-scale demonstration AguaClara plants for small towns that are easily accessible from the capital city.

The AguaClara Engineer funding challenge could be combined with the goal of producing a new NGO that becomes the professional technical support for implementation partners. This professional AguaClara NGO will make it possible for multiple implementation partner organizations to gain the support that they need it beginning to design and build AguaClara facilities without relying on communication with Monroe Weber-Shirk.

The goal is to identify funding sources or to develop new funding sources that would be interested in sponsoring any of the 4 components of the AguaClara program.

- Follow up on possible connections in the
Water Advocates eNewsletter
- Submit a blurb about AguaClara to the Water Advocates eNewsletter
- Follow-up on the corporate and NGO contacts made by Alex Mathews (aem18@cornell.edu) and Will Maher (wjm96@cornell.edu):
  - https://confluence.cornell.edu/display/AGUACLARA/International+NGO+Contacts+Database
  - https://confluence.cornell.edu/display/AGUACLARA/International+Development+Organizations
- Continue to make partnership contacts with new NGOs and corporations
  - See "Corporate Prospect List" and "Instructions for Corporate Fundraising" docs on cuaguaclara google account
- Discuss with Monroe the possibilities for a partnership with "Charity: Water."
  - Consult Eun Gi Chung (ec396@cornell.edu).
- Research the best method for promoting AguaClara to corporations: For example, find cases where NGOs make successful partnership with corporations and benchmark.
- Plan the semi-annual benefit concert
  - https://confluence.cornell.edu/display/AGUACLARA/Public+Relations
- Continue to develop and enhance the new website and wiki. Update Recent News, Student Spotlight, and Countdown on the new website.
  - Consult Karah Conklin (klc263@cornell.edu)
  - Website Resources
- Organize presentations to local schools, organizations, and student groups
- Apply for grants , and update the list
  - https://confluence.cornell.edu/display/AGUACLARA/Grant+Short+List
- Organize presentations for ENGRG 1050 classes
- Send thank-you notes and/or newsletters to donors and alumni