

Demonstration Plant User Manual

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Construction

Components

Below is a picture of the plant frame. It consists of 14 80/20 aluminum bars, 26 80/20 connectors and fittings, 9 push-to-connect pieces, 31 pieces of tubing, 12 valves, 4 bottles, and 5 unit processes. A catalogued list of all of the components is below, as is a list of abbreviations used in labeling items, and the required tools. Each bar, connector, and piece of tubing is labeled with clear tape. Some components of the unit processes are labeled.

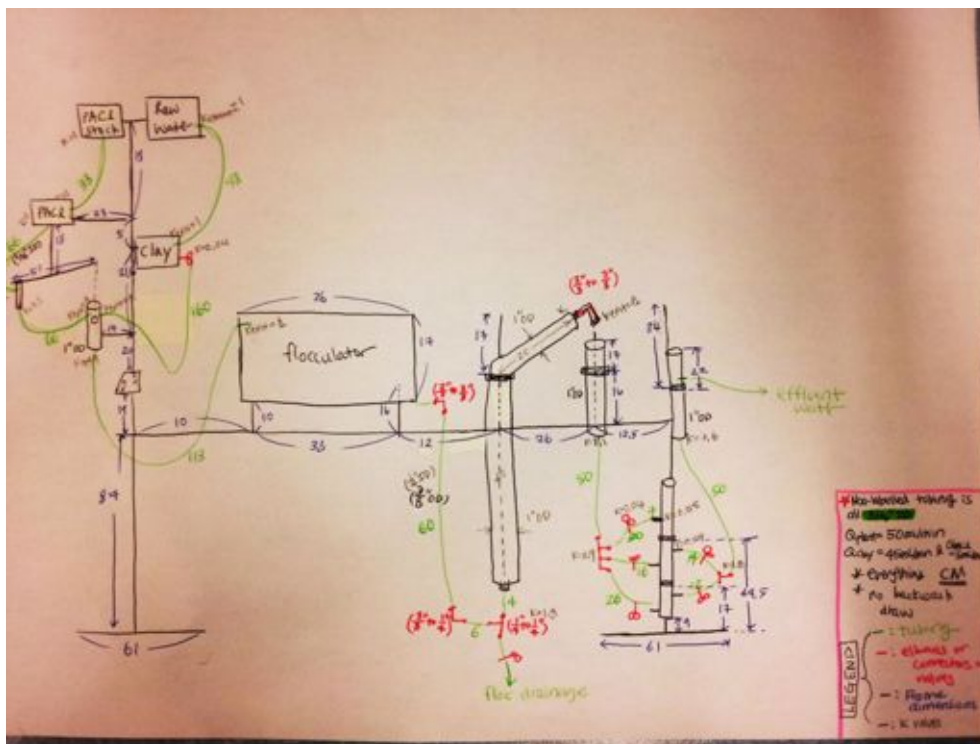


Figure 1: Diagram of Demonstration Plant



Figure 2: Demonstration Plant



Figure 3: Stock Arm and Doser Close-Up



Figure 4: Cross-Piece and Processes Close-Up

Abbreviation	Meaning
PS	PACl Stock Tank
PCH	PACl Constant Head Tank
CS	Clay Water Stock Tank
CCH	Clay Water Constant Head Tank
D	Doser
ET	Entrance Tank
F	Flocculator
ST	Sedimentation Tank
EFD	Emergency Floc Drain
FD	Floc Drain
DT	Drop Tube
SRSF	Stacked Rapid Sand Filter
CW	Clearwell
W	Waste

Table 1: List of Abbreviations

Quantity	Item
2	Leg
2	Foot
1	Bucket Arm
1	Lever Mount
1	Lever Cross-piece
1	Entrance Tank Mount
1	Entrance Tank Cross-piece
1	Main Cross-piece
2	Flocculator Support
1	Sedimentation Tank Support
1	Drop Tube Support

Table 2: Catalogue of 80/20 Bars

Quantity	Item	Notes
6	Bucket Mount	
7	Broomhandle	3 padded to fit filter
7	Large Trapezoidal Support	
2	Small Trapezoidal Support	1: drop tube; 1: lever cross-piece
2	Large Bracket	1: lever mount; 1: entrance tank mount
1	Small Bracket	entrance tank mount
1	Lever Mount	

Table 3: Catalogue of 80/20 Connectors and Fittings

Quantity	Outer Diameter (in)	First Connection Point	Second Connection Point
1	1/4	PACl Stock	PACl Constant Head
1	1/16	PACl Constant Head	Doser
1	1/4	Doser	Entrance Tank
1	1/4	Clay Stock	Clay Constant Head
2	1/4	Clay Constant Head	Entrance Tank
1	1/4	Entrance Tank	Flocculator
1	3/8	Flocculator	Emergency Floc Drain
3	3/8	Emergency Floc Drain	Sedimentation Tank
1	1/4	Sedimentation Tank	Floc Drain
1	1/16	Floc Drain	-
1	1/4	Drop Tube	SRSF (Adapter)
1	3/8	SRSF (Adapter)	SRSF Inlets
6	1/4	SRSF Inlets	-
4	1/4	SRSF Outlets	-
2	1/4	SRSF	Clearwell
2	1/4	SRSF	Waste
2	1/4	Clearwell	Waste

Table 4: Catalogue of Tubing

Quantity	Item
1	PACl Bottle (1 L)
1	Clay Water Bottle (4 L)
1	PACl Constant Head Bottle (700 mL)
1	Clay Water Constant Head Bottle (700 mL)
2	Float Valve
1	1/4" Valve
4	Hose Clamp
1	Wooden Spoon
1	Funnel

Table 5: Stock Tank Components

Quantity	Item
1	Lever
1	PACl Drop Tube
1	Float
1	Entry Tank
1	1/4" Stopper w/ 1/16" hole
2	Metal Slider

Table 6: Chemical Doser Components

Quantity	Item
1	Flocculator
2	Clamp
1	3/8" Elbow

Table 7: Flocculator Components

Quantity	Item
2	PVC-Tubing Fitting
3	1" PVC Pipe (Column, settler, & DT)
1	45 1" PVC Elbow
1	3/8" Elbow (for EFD)
1	3/8" T-Connector (for EFD)
1	3/8" Tubing Barb (for EFD)
1	3/8" Valve (for EFD)
1	1/4" Valve (for FD)
1	1/4" Tubing Barb (for FD)
1	3/8" T-Connector
1	3/8" Stopper
2	Hose Clamp

Table 8: Sedimentation Tank Components

Quantity	Item
5	Slotted Pipe Fitting
7	1/4" Valve
1	1/2" Acrylic Pipe
1	1" PVC Pipe (CW)
1	1/4" to 3/8" Adapter
1	1 to 3 tube adapter

Table 9: Filter Components

Tools Two different size Allen wrenches (kept with the plant) and a flat-head screwdriver are required for assembly.

Assembly

Using 80/20

Pieces of the 80/20 frame are connected using a screw/slider assemblage. Place a screw through its designated hole, and loosely tighten the slider. Make sure that the ridged part of the slider is facing out. The slider can then be slotted

on to a bar, slid until the connector is in the correct position, and the screw tightened with an Allen wrench.

Frame

Start by sliding each bucket mount fitting into the frame in the correct position, if they are not already so located. The bottom of each mount fitting should line up with a black line on the side of the bar to which the mount is affixed. The approximate location of the top of the fitting is also marked.

Then mount the other connectors on the rest of the frame, if not already affixed. Black lines on the bars mark the edges of each connector.

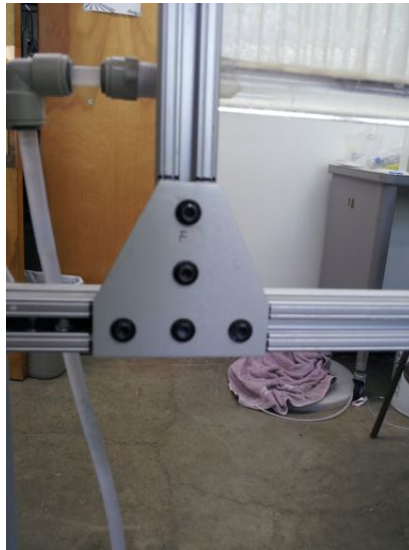


Figure 5: Connector With Markings

Make sure to slide the flocculator, sedimentation tank, and drop tube supports onto the main cross-piece before attaching the legs to the cross-piece. Note that the sedimentation tank support connector is connected to the sedimentation tank support 'backwards': that is, the connector is mounted so that two sliders are used to attach the connector to the cross-piece, and two to attach the support piece, rather than the 3-1 distribution for the other large trapezoidal connectors.



Figure 6: Sedimentation Tank Connector

When attaching the bucket arm bar to the left leg, the lines on each bar should line up with each other. The hinge handle should be tight, so that the bars lie flat against each other.



Figure 7: Bucket Arm Position

Use a square to make sure all bar connections are at right angles.

Stock Tanks

Each stock tank should be mounted with a hose clamp onto its bucket mount fitting. Each hose clamp fits between two black lines marked on the back of

its respective bucket. Use the respective pieces of tubing to connect the stock tanks to the corresponding constant head tanks.

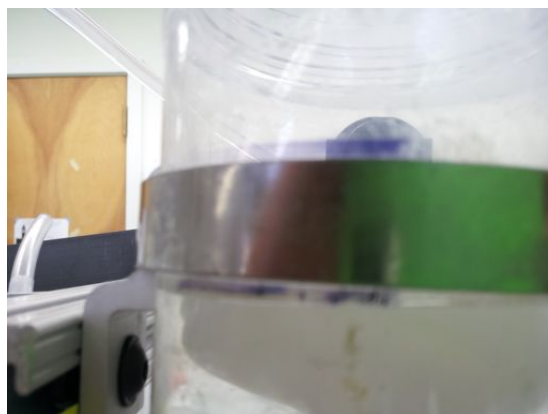


Figure 8: Hose Clamped Bottle With Markings

Create the stock solutions: 1g/L of clay water and 150 mg/L of PACl solution. Fill the raw water tank with clear tap water, for approximately 4 liters of water. Using the metal spoon, scoop a level spoonful of clay, which will be ~ 4 g. Add the clay amount to the 4 liter water stock tank to create 500 NTU water. Fill the PACl stock tank with water for approximately 1 liter of water. On the plastic scooping device provided, use the side indicated with blue tape (the larger) to scoop PACl. The amount of PACl that stays balanced on the scoop (in a small mound) will be ~ 150 mg. Add the PACl to the water in the stock PACl tank.

Note: don't fill the stock bottles until all the tubing is connected, since otherwise all the water will drain out.

Chemical Doser

Assemble the lever: place one plastic washer onto the mounting screw. Place the screw through the hole in the center of the lever arm, followed by a second plastic washer, creating a sandwich of the lever arm between the two washers. Attach the lever arm to the frame by screwing it into the hole in the lever fitting. Tighten it, making sure the fitting is loose enough that the lever arm can swing easily. Attach one metal slider to each side of the lever by sliding them on to the arm and then tightening the red screw. The left hand slider has a plastic drop tube attached, and is the alum feed. The right hand slider serves to balance the weight of the drop tube slider. The locations for a 5 mL/min and an 8 mL/min coagulant dose are marked on each side of the lever. The right side of the left hand slider should line up with the left side of the tape marking used, and the left side of the right hand slider should line up with the right side of the tape marking. Make sure both sliders at the same dosage level.



Figure 9: Lever Arm Fitting

Hook the metal wire and bob to the small hole on the lever arm and feed the bob into the entrance tank. Snap the entrance tank into the two broomhandle supports. The broomhandles should each fit between two black lines on the back of the tank. Make sure that the tank is oriented so that the hole on the left (for the coagulant feed) is lower than that on the right). Find the two metal sliders that look like a hollowed out rectangle piece of metal with a bottom side missing and has a screw with a red top on it. Stopper the PACl constant head tank exit with the stopper with the hole in it. Then push the PCH-D tubing into the stopper and attach it to the doser drop tube. Push the end of the D-ET tubing with the rubber/tape connection into the end bottom of the drop tube, and push the other end slightly into the hole in the left side of the entry tank column. Using the the CCH-ET tubing, connect the clay constant head tank to the hole in the right side of the entry tank. Make sure that neither piece of tubing impedes the motion of the float through the entry tank.

Flocculator

Using the larger Allen key, loosen the flocculator clamps, and slide one onto each end of the flocculator. Tighten the clamps. The clamp with the handle in it will not be snug against the flocculator, but the other one will. The flocculator should still stand upright when full of water and mounted properly unless a force is applied to it.

Making sure that the flocculator is oriented with the exit fitting on the right (to feed into the sedimentation tank), slide each clamp onto its respective support. This might be difficult, and require small sliding of the supports to be closer or further apart, so make sure they aren't locked into place. The location of the top and bottom of the clamps is marked on the supports, which should be oriented such that the flocculator is as high as possible; when in position, if the clamps and the connector were on the same side of the support bar, the clamps' lower sliders would just touch the connector's upper sliders (note, in practice, the clamps and connector are on opposite sides of the support bar).



Figure 10: Flocculator Support Location

Connect the ET-F tubing to the entry tank, and drop the other end into the flocculator so that the exit point of the water is level with the black line labeled 'water entry point'.

Sedimentation Tank and Drop Tube



Figure 11: Sedimentation Tank and Drop Tube

Attach the end fittings to each end of the sedimentation tank. Start by sliding the white connector onto the tank column. Then slide the black O-ring onto the column, about one inch from the end.



Figure 12: Attaching Sedimentation Tank Fittings

Screw the two halves of the end fitting together. Repeat these steps for the tube settler end fitting. If not already connected, plug the T-connection into the end of the tube settler end fitting.

Place a hose clamp around the elbow connection and the white connector of the floc blanket column. The hose clamps should rest between the two black lines marked at each connection point. Mount the hose clamps on the bucket mount fittings on the sedimentation cross-piece.

Assemble if necessary, and plug in the emergency drain to the sedimentation tank column, and connect the flocculator to the sedimentation tank with the F-ST tubing. Plug in the regular operation floc drain to the fitting on the side of the sedimentation tank column.



Figure 13: Emergency Floc Drain



Figure 14: Floc Drain

Snap the drop tube column into place on its cross piece. The broomhandle should fit between the two black lines on the back of the drop tube. Connect the drop tube to the filter with the DT-SRSF tubing.



Figure 15: Broom Handle with Marks

Once operation begins, make sure that the T-connector and drop tube are positioned relative to each other such that water drains from one to the other without spilling. Likewise, make sure that a bucket is positioned below the two floc drains.

Stacked Rapid Sand Filter and Clearwell

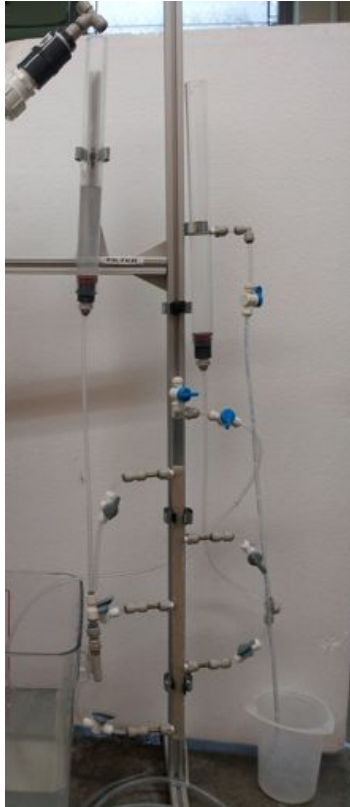


Figure 16: Stacked Rapid Sand Filter

Connect all tubes, connectors, and valves as shown in diagram. Be careful while handling the main filter column (it is made of acrylic while is brittle. The most delicate areas are the threaded connections).

Fill the column with sand: close all 6 valves. Unscrew top manual valve. Fill entire column with water. Slowly add sand through top of filter using a funnel. Filling the column with water first helps minimize the number of trapped air bubbles. Add sand until the sand height is 0.5-1 inch higher than the top slotted pipe. Screw on the top manual valve.

Connect the filter to rest of the Demonstration Plant: snap the SRSF into the top two broomhandles. Make sure the clamp ends are not right next to any slotted pipe connections. The broomhandles are snug so you should pull the sides apart while putting SRSF rather than just pushing the filter into place.



Figure 17: Example Location of Filter Fittings Relative to Broomhandle

Connect the 3-way connector to the bottom of the drop tube. Snap the clearwell into its broom handle on the side of the leg, lining up the broomhandle with the markings on the clearwell. Connect the outlet tubes of the filter to the fitting in the side of the clearwell column. Make sure the clearwell outlet goes to effluent water bucket. Make sure backwash tube goes to waste bucket.



Figure 18: Clearwell

Operation

Stock Tanks

Mix the stock solutions of 1g/L clay water, and 150 mg/L PACl solution. Fill both the PACl and clay stock tanks with their respective solutions. Make sure that neither empties during the course of operation. If either constant head tank begins to overflow, check the operation of the float, and manually close it if necessary. After the stock solutions are mixed, open the valve from the clay constant head tank to the entry tank. If the coagulant feed from the doser has not been plugged into the entry tank, attach it to allow coagulant flow into the plant.

Chemical Doser

Verify that the tube leaving the constant head PACl tank has no air bubbles. If there are air bubbles, detaching one end of the tube and lowering it until water flows through will eliminate them. Verify that the weights on the lever are at the correct dosage level. After the plant is turned on, make sure that the D-ET tubing has no air bubbles (again, detaching and lowering the tubing should

eliminate them). It may take a few minutes for the alum to start flowing, as the alum level must rise enough to give sufficient head in the drop tube. Make sure that the float is responding properly to the water level changes.

Flocculator

Once the plant is turned on, the flocculator should not need any adjustments.

If water doesn't flow from the entrance tank into the flocculator when the plant is turned on, check for and eliminate air bubbles in the tubing: take the tubing out of the flocculator and lower it until water begins to flow, then replace it. If the flocculator begins to back up with flocs, check flow through the sedimentation tank. Floc back-up is likely due to floc build-up in the sedimentation tank. If the flocculator begins to overflow, turn the water off, and check flow through the sedimentation tank. Also check to make sure the relative height of the sedimentation tank is not too high: the center of the T-connection sedimentation tank should be about level with the desired height of water in the flocculator. That height should be about 1-2 cm above the baffles in the flocculator, in order to prevent floc break-up. This includes the last column of the flocculator, which will be lower than the rest of the levels until the sedimentation tank fills up. After the plant has been running long enough that the sedimentation tank is full, the water level in the flocculator should be essentially constant across its width, with a decrease of <1 cm from its highest point at the entry to its lowest point at the exit.

Sedimentation Tank and Drop Tube

Once the plant is turned on, remove the stopper from the sedimentation tank. Leave the floc drain closed until the tank is full, and water is flowing into the drop tube. At that point, open the floc drain until the notch on the valve is between the two black lines marked on the side. Make sure that this does not stop water flow through the sedimentation tank. If it does, close the valve a tiny bit: it shouldn't be visibly noticeable (the notch will still be between the two markings), but after a few minutes, the water will begin flowing out of the T-connection again. Leave it in that position for all operation.

If the flow through the sedimentation tank stops, it is probably due to either air in the tube from the flocculator, or floc build-up in the bottom of the tank. It may also be due to the floc drain being slightly too open (if it was adjusted at the beginning, this will only be the case if the main flow through the plant was modified somehow (i.e., slowed or stopped for other purposes). Close the regular floc drain, and check the F-ST tube for air bubbles by detaching and reattaching it at each connection point. If that does not solve the problem and/or there is visible floc back-up in the flocculator, open the emergency drain for a few seconds, and close it. The resumed flow should be immediately noticeable.

When operation stops, close the floc drain and stopper the T-connection, to prevent drainage of the sedimentation tank and/or overflow in the drop tube.

Stacked Rapid Sand Filter and Clearwell

Confirm that the 3-way connector is connected to the bottom of the drop tube after the sedimentation tank. Close all valves. Make sure all connections are watertight (especially the manual valve at the top of column. Make sure this valve is screwed tightly enough to the column to prevent leakage).

Start in backwash to get rid of air bubbles: open only the middle inlet tube and the backwash valve. Then move the filter into backwash position (the lower two broomhandles: this can also be the normal operating position). Open and close the middle inlet tube valve, adjusting as air bubbles leave and the height of fluidized sand fluctuates. Make sure that the sand doesn't get high enough to get washed out through the backwash tube. After you see the fluidization of the upper two layers of sand by only opening the middle inlet tube, close the middle inlet tube. Open only the bottom inlet tube. To help remove air bubbles more efficiently, gently tap the column or remove it from the clamps and hold it horizontally while gently shaking it. Be careful to not let any sand out. You may have to open and close the bottom inlet tube while doing this. Once you observe that all layers of sand are fluidized with only the bottom inlet tube open, you are ready to start filtration.

Start filtration: if desired, move the filter up to the filtration position (upper two broomhandles). Open all three inlet tubes and the two outlet tubes. Close the backwash valve. There should be no other required adjustments. If water drains out of the drop tube for some reason, close the inlets to the filter so as to prevent air bubbles being sucked into the filter.

Switching from filtration to backwash: close the upper two inlet tubes and the two outlet tubes. Open the backwash valve. Only after the valves have been changed, move the filter to the lower position. You should observe dirty water exiting through the backwash tube. Make sure the backwash tube leads to waste bucket to prevent spills. Time of backwash is dependent on clay and alum concentrations fed into demo plant. Under our dosing conditions of 1 g/L of clay water and 150 mg/L of PACl solution, it should last approximately 7 minutes.

Troubleshooting: keep an eye on the height of water in the drop tube. Make sure it is not empty. If necessary, pour additional water to prevent air bubbles from entering the filter. If drop tube is about to overflow, turn off flow through plant or redirect flow from the sedimentation tank to the waste bucket.