Constructing the NCED Delta Box

National Center for Earth Surface Dynamics, February 2007

National Center for Earth Surface Dynamics (NCED)
St Anthony Falls Laboratory
2 3rd Avenue SE, Minneapolis, MN 55414
Phone 612.624.4604 FAX 612.624.0066
www.nced.umn.edu

List of Components:

The Delta Box consists of several components, each of which is composed of a number of separate parts. This guide lists each component, with photographs of its individual parts, notes on suppliers and assembly instructions. At the back of the guide are a few diagrams to assist you with assembly.

Credits:
The Delta Box was designed by Tom Hickson, University of St. Thomas, with assistance from Karen Campbell, Amy Chen, Jon Fults, Craig Hill, Emily Horth, Matt Lueker, Kate Poulter Rosok, Jeff Marr and John Martin, all National Center for Earth-surface Dynamics.

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As of this writing, we are still working with a box constructed largely from spare parts found around St. Anthony Falls Laboratory. When we have had a chance to build a new one from commercially available parts, additional editions of this manual will include parts suppliers and part numbers. In this edition we note which parts those are and supply photos and measurements.

Notes on particular components:

Faucets:
We have been using metal faucets because we have many at the lab, but have begun to find that plastic ones available at Home Depot and similar places work just as well. You may wish to experiment with this.

example plastic faucet

Also, faucets come in at least two varieties: “stop and waste” and “needle”. Right now we have one of each in on our delta box, partly due to what we had available in the lab. The manual notes which we have used where; you may also want to experiment with these to achieve finer flow-rate control.

Wooden components:
We used plywood for various parts of the box, because they were handy and we had access to woodworking equipment. You may wish to experiment with using PVC pipe for some of these components, such as the sediment feeder and constant head tank stand.

Box (see also Diagram 1, page 23)

Components:

Plexiglass sheets
Metal channels, hardware, adhesive, gasket
Wooden supports
Deposit platform ("continental shelf/slope")

Fully constructed box:

Construction notes:

The basic box is the part of the Delta Box that will require the most original creativity on your part. Ours was built by cutting down an existing prototype for a museum exhibit based on flumes in St. Anthony Falls Laboratory. Future editions of this manual will include box parts readily available from suppliers such as Home Depot. For now, below are descriptions of our basic components, with photos and dimensions.

The box is composed of 2 sheets of plexiglass, connected by 3 metal channels laid between three sides of the plexi sheets. These pieces are held together with sheet metal screws. One end has three drain holes drilled into the metal channel. At any given time, the top two holes should be plugged; usually you will only use the bottom one. The box sits on 3 plywood supports and is given further stability by 4 slightly smaller blocks that brace the top together and help support the sediment feed system. We used a piece of pink foam insulation wedged into the corner of the box farthest from the drain holes to provide a pre-existing platform on which to build our deposit. More specific measurements and photos follow this text below

Box Component #1: 2 Plexiglass sheets:

The two plexiglass sheets are each the following dimensions:
Height=15"
Length=45"
Thickness of plex = 3/8"

Box Component #2: 3 Metal Channels and basic assembly

The plex is held together with three metal channels. On one piece of plex, apply silicone to create a waterproof seal between the plex and the channel. On the other side, place some kind of thin rubber between the plex and the channel to act as a gasket. This way, you can disassemble one side of the box easily, should you need to do so to clean it, etc. Everything is held together with machine screws on our box, with 3 drain holes drilled in one end of the box; 2 of them sealed. The three holes have a threaded metal tube inserted into them to allow you to

screw a bolt or other fitting into them. The third one has a “90 degree (plastic) barb” fitting (threaded at the end that attaches to the box) to which to attach the outflow pipe.

All of this was accomplished using machine tools and supplies from St. Anthony Falls Laboratory. A similar set-up should be possible using more readily available parts and tools; documentation of such a set-up will be available in later editions of this manual.

Metal channels:

Channels are 1/8 thick, 2” wide and 1” high on each side.
Cut three pieces to match the plex dimensions: two ~15” long and one 45” long

Additional assembly materials:

Silicone
Rubber sheeting for gasket
90 degree barb fitting
Bolts and nuts (bolts are called “quarter-20 bolts” and heads are ~0.5” in diameter). We used 50.
.

Exterior view of drain holes

Spacing:
bottom hole is ~1” from bottom of box
Next hole is 1” from first hole
Top hole is 2.3”

Interior view of drain holes

90 degree barb (outflow)

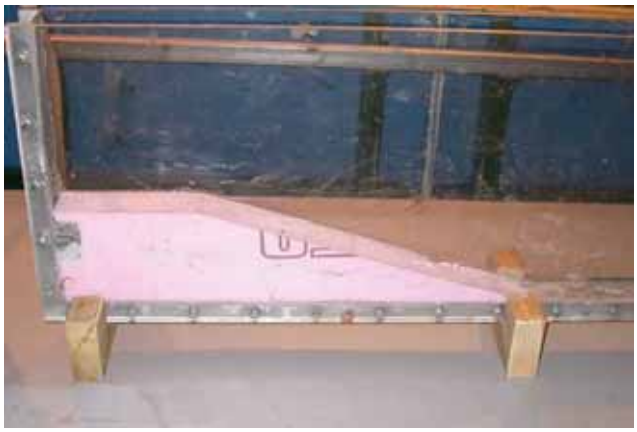
Box Component #3: Wooden supports

We have seven of these; four to brace the top of the box and three to act as a stand at the bottom. Dimensions:

Top blocks (4):
4.75” long, 3” high, .75” thick; notch is 2.75” x 1.25”

Bottom blocks (3) same, but 7” long

Box Component #4: Deposit platform (continental shelf / slope)



We used pink foam insulation and simply wedged it into the box.
Dimensions:
Length= 22.5”
Height at vertical end=5”
Width=2” (inside width of box)
On our slope, the horizontal segment is 7” long and the slope segment is 16.8” long.

Some sediment will leak down between the foam and the plex, which can be distracting. You may want to devise some sort of cover for the outside of the plex to mask this, cut to the same (one-dimensional) dimensions as your platform. We envision experimenting with various platforms, too, so you will probably want to by extra foam insulation.

Water recirculation system

Components

Bucket (see also diagram 2, page 24)
Pump
Sediment trap
Base level control (see also diagram 3, page 25)
Constant head tank (see also diagram 4, page 26)

Construction notes

The water recirculation system allows you to run the box independently from any fixed water source, such as a faucet. It also helps you control flow rates to more precisely calibrate experiments in the box. It's main components are a pond pump, bucket, lots of plastic tubing, various faucets and valves, and a "constant head tank" to ensure a relatively constant rate of flow into the box. We tried constructing one without the constant head tank and discovered that the pumps we use, while very reliable and durable, have a variable flow rate. While the constant head tank adds to the complexity of the set-up, it also provides a focal point for discussing basic hydraulics, if you wish to introduce some of those concepts into your teaching activities. Drawings at the back of this manual will help you set up the recirculation system; this part of the manual simply details the individual component parts and assembly

Water Recirculation System Component #1: Bucket

We recommend having 3 to 4 six-gallon buckets on hand**.** Buckets are used for:

- Holding water and pump for recirculation system
- Mixing and storing sediment
- Elevating constant head tank
- Depending on your lab set-up, it can be useful to have a spare bucket to hold extra water in case you miscalculate what is needed for the recirculation system

Bucket suppliers:

We ordered ours from 'US Plastic' item number 2389 (bucket) and item number 2287 (standard lid). You can also use "Homer buckets" from Home Depot, but they are smaller and less sturdy.

Additional Bucket part: Grit Guard Insert

This is not essential, but it helps to keep the pump elevated in the bucket so it does not absorb any sediment that may end up in the bottom of the bucket. Once these inserts are inside the bucket, they are difficult to remove, so you may want to cut out a couple of the plastic pieces in between the "spokes", on opposite sides of the center to provide thumb and fingerholds to grip and pull the insert out of the bucket

Supplier:

We ordered the grit guard from US Plastic: www.usplastic.com; 'item number 3543.

Water Recirculation System Component #2: Pump

Theoretically any medium pond pump would work. We have also tried small sump pumps in these types of models; pond pumps have the advantage of being more compact. Though we have yet to have one actually cease to function, we have cracked the housing on one by dropping it, so we recommend keeping a spare pump on hand at all times. The ones we use cost appx $70.00.

Supplier:
The pump we use is a Beckett Versa Medium Pond Pump (item number: 7060210; model number: G325AG20). It can be purchased from either www. pondbiz.com or Home Depot (in-store or online at: homedepot.com). Home Depot stocks these in the garden department, so in northern climates they are only available during the growing season.

Water Recirculation System Component #3: Sediment Trap

Finished Picture

Assembling Picture

Parts and assembly

a. 4.5” (outside diameter) ¼” thick PVC pipe cut into a 17.5” long piece

b. 4” (DWVx4SD 30) PVC adapter

c. Screen/filter cut into a 4”diameter circle. This is a fine mesh screen that is flexible—fabric-like. It was material we had available in the lab; we are not sure of the source. Theoretically, any mesh fine enough to trap the sediment mix that can be cut into a circular shape should

work. We have also found that a piece of "flour sack" dish toweling will (heavy-duty muslin) will work.

d. 4" Drain Grate (styrene) *25* "C"

Supplies & tools you will need–
Regular Clear PVC Cement
NSF Purple Primer
Saw and cutting device for screen
The primer and the cement work together. To attach two pieces of PVC material together, first apply a very thin coating of the primer to both the piece being attached and the piece you are attaching. Then apply a second thin coating of the cement to both pieces. Fuse the two pieces together by giving them a little twist. Set the pieces aside until they are completely dried.

Assembly:
Attach **(a)** to **(b)**. Some amount of force may be required to push the two together.
Fit **(c)** in **(b).**
Put **(d)** together with the rest of the pieces. Use the *finished picture* to find the right orientation.

Suppliers:
Except for **(c)**, everything on the parts list and on the supply & tool list can be found in your local hardware store, although one store may or may not carry everything. The PVC pipe does not usually come in the above mentioned length, so you will need to find a way to cut it, either at the hardware store or yourself with a saw (the pipe is hard). See note above about (c).

Water Recirculation System Component #4 Base Level Control System

base-level control clipped to tank

close-up of base-level control, showing 3-way valve

Parts :
Flexible clear vinyl tubing in 2 sizes:
1 piece is 3/8 inches wide and 18 inches long
2 pieces are 5/8" in diameter and 1/8" thick—
One piece should be cut long enough to connect the drains on your tank to the 3-way valve, placed at any possible base-level.

The other should be distance from any possible position of your 3-way valve to the bucket. It is important that neither ever have any kinks or have to sit higher than the base-level control (3-way valve).

Velcro—adhesive on one side, cut to height of delta box
1 3-way valve

This is a plastic threaded device, with the center tube smaller in diameter than the other two. Ours measures 2 3/8" inches across the "T" part and 1 3/8" "tall". The openings on the "T" part are just under 0.5"; the smaller tube is 3/8" in diameter. Ours is black, which is of no consequence but may help you identify it in the photos.

2 Velcro-backed plastic squares with cinching device (see photo—the white piece behind the 3-way valve)

Assembly

Connect the tubing to the 3-way valve. Attach the Velcro strip to the drain end of your box (on the plexiglass, vertically). Attach one of the plastic squares to the very top of the metal channel (on the END of the box) and insert the narrower tube into this device and secure it. This is an "air escape"—the tube should be left open at this end. Attach the other plastic square to the back of the 3-way valve (see photo above, right). In theory, you can now control base-level by moving the 3-way valve up and down the Velcro. We have not been particularly successful at having the Velcro really hold the valve device—perhaps we needed industrial strength Velcro?—so we have ended up using a clamp most of the time (see photo above, left). So this is a design area ripe for innovation!

Suppliers:
All of part of the Base-level control should be available at Home Depot or a hardware store.

Water Recirculation System Component #5: Constant head tank

Full assembly

Overhead view

Components of Constant Head Tank

Tank
Plumbing
Stand

1. Constant Head Tank – Nested Tanks

Parts

2 PVC Pipes, both 6” tall and 0.25” thick
Inner - 4.5” in diameter,
Outer - 8.75” in diameter
Plexiglass circle: 9.5” in diameter, 0.5” thick, with 0.75” holes drilled in center and inbetween 2 pipes (refer to photos below)
Regular Clear PVC Cement
NSF Purple Primer
(see Sediment Trap instructions)

Tank Assembly

Drill 2 holes in plexiglass base circle, one in the center to drain the inner tank and one off-center to drain the outer tank (note that these are for your water recirculation tubing, so be sure holes fit tubing, see **Plumbing** below). Center the narrow diameter PVC pipe on the plex and adhere with PVC cement (see sediment trap instructions above). Center wider diameter PVC pipe outside smaller one and adhere it to plex. Note: the point is to have a water-tight tank inside another water tight tank, each with an outlet. Water is pumped into the narrow inner tank, and overflows into the wide outer tank. The inner tank maintains a constant pressure which feeds the delta box, and the outer drains the overflow back to the pump bucket. We built ours out of PVC because it was handy—one could probably devise something similar with different parts.

Supplier:
All of these parts should be available at Home Depot or a hardware store.

Plumbing underneath tank

close-up of outflow plumbing (tank inverted for photo)

Supplier:
All of these parts should be available at Home Depot or a hardware store.

2. **Constant Head Tank - Plumbing**

Flow-rate control between pump and head tank

close up of faucet assembly

Parts

2 faucets and pieces to connect them to vinyl tubing

Refer to photos above. In our case, the one between the pump and the Constant Head Tank is a needle valve faucet and the one under the Constant Head Tank is a Stop and Waste faucet. Each needs various fittings to attach it to the tubing and/or tank. Future editions of the manual will detail specific components and parts numbers.

Reinforced vinyl tubing:

0.75" diameter x 1/8" thick. You will need about 20 feet total—lengths of various parts will depend a little on your final set up. Refer to drawings in back for number of pieces to cut.

0.5" diameter x 1/8" thick. You will need a couple feet to connect the valve faucet under the constant head tank to the lower funnel on the sediment feed.

Silicone to cement faucet and out flow tube to Constant Head Tank.

Assembly

From the pump into the constant head tank:

Cut two pieces of tubing to lengths that will allow you to connect the pump to top of the inside tube on the Constant Head Tank. You need two lengths (each half of the full length necessary) because you will insert the needle valve faucet between them to achieve some control on flow rate out of the pump into the Constant Head Tank.

From the constant head tank overflow back to the pump bucket:

Cement a short length of tubing to the off-center hole in the bottom of the Constant Head Tank, cutting it long enough to reach from the bottom of the tank back to the pump bucket.

From the constant head tank to the sediment feeder (and then into the delta box):

After assembling the second faucet system (the one with a red handle in photos above), attach it to the bottom center hole in the Constant Head Tank. Use the smaller diameter tubing to connect this valve faucet with the bottom funnel on the sediment feed (see below).

Suppliers:
All parts should be available at Home Depot or a hardware store.

3. Constant Head Tank - Stand

Support viewed from above

support inverted to show plywood assembly

Parts

Plywood: 0.75" x 2", 8 Feet cut in 1 foot lenghts
8 Screws
9 nails
0.5" think Plexiglass, cut to 10" x 11' "square", with another "square" appx 6" x 9" cut out of it—these are the dimensions of ours—dimensions are flexible as long as it will support your Constant Head Tank and let the plumbing hand beneath it. The inner "square" was cut out in such a way that the final plex is in a "U" shape, to allow maximum flexibility in arranging all the plumbing.

Assembly
Cut the plex as describe in the parts list. Nail the lengths of plywood together in sets of two to form four legs, as shown in photo. Drill 8 holes in plex to allow you to screw plex to legs at corners of stand. Screw plex and legs together.

Suppliers:
All of these parts should be available at Home Depot or a hardware store.

Note: you will need to elevate the constant head tank above the box. It seems to work well to set this up so the base of our head tank stand is approximately in line with or slightly above the top of the delta box. As you can see in the photos, we have used cinder blocks or an overturned bucket with a flat square platform (we used a 1' square stone tile) on top of the bucket to support the head tank). An improvement would obviously be to construct your head tank support stand in some way that would allow you to adjust its height once fully assembled.

Sediment supply system (see also diagram 5, page 27)

Components

Funnels and Feed Regulators
Sediment Diffuser
Stand

Fully assembled sediment supply system

Sediment Supply Component #1: Funnels and Feed Regulators

2 sediment feed funnels, inverted

smaller funnel with holes drilled

Metal frosting tip set

Parts:

2 plastic funnels:

One 5.5" tall and 5.75" in diameter

Once 5" tall and 4.5" in diameter

(Note: metal funnels would also work, if you can drill holes in one of them. Also, exact size is not especially important and two funnels of the same size would probably work just as well as our nested sizes.)

One set of metal frosting tips

Styrofoam

Assembly:

Drill one or more holes in the smaller funnel to allow the water from the Constant Head Tank to feed in to the funnel through one of the reinforced vinyl tubes. The hole should be the same diameter as the tubes (5/8"). You really only need one hole, about half-way between the top of the funnel and the neck; ours has two holes because it took us two tries to determine the right placement. The frosting tips are simply dropped into the top funnel to regulate flow of the sediment, which is fed into the funnel by hand. At the end of this manual is a calibration chart for flow rates through the various tips in our set of frosting tips. The Styrofoam is used to wedge the funnels into the stand (refer to photos below).

Suppliers:

Funnels: any cooking store or general discount/hardware store housewares department. Look for the sturdiest funnels you can find. We bought a "16 Piece Icing Set", manufacutered by Danescook, Champlain, NY 12919. It is part 5053 and cost us $12.95. We bought it at: Let's Cook in Minneapolis (http://www.letscook.com/). They don't have an online store, but might be able to ship you a set if you call them at: 612/623-9700. The Styrofoam for wedging the funnels into the stand can probably be any packing Styrofoam (or any of a number of other possible solutions to this part of the set up could be devised).

Detail of funnels in stand, showing frosting tip protruding from upper funnel and Styrofoam wedging lower funnel into place in stand

Sediment Supply Component #2:Sediment Diffuser

Close-up of sediment diffuser
(note that in this photo, bottom of diffuser is covered in sediment; which it won't be, of course, when you initially construct yours.)

Sediment diffuser in box

Parts:

Rubber bands (strong) or more durable cinching device, such as Velcro ties
Wire mesh of a heavy enough gauge to stand rigid when rolled into a cylinder and a sufficiently small mesh to 1) contain gravel and 2) allow Delta Box sediment to flow through, cut to an 8-10" square.
One or two handfuls of gravel

Assembly:

Roll the screen matieral into a cylinder slightly less than 2" in diameter and secure it with rubber bands or similar device that won't dissolve in water. Diffuser needs to sit in Delta Box vertically, so it should be a size that wedges in securely but can be removed easily. Pinch in one end of the cylinder so that gravel cannot easily escape (note funnel like shape of bottom of cylinder in photo above). Partially fill cylinder with gravel. Note that it is ok for the diffuser to become partially buried in the deposit as you do a "run" in the Delta Box, as long as the "top" of the gravel in your diffuser remains substantially above the top surface of your deposit.

Suppliers:

This is another part we made from things available in the lab; we literally just took the gravel from a pile outside. The wire mesh and securing straps or rubber bands should be available at Home Depot or a hardware store. If you don't have ready access to some mixed size small gravel, the kind sold in garden stores for landscaping should work well—it just needs to be large enough to remain in your diffuser and small enough that it really will slow the flow of the sediment-water mix into the Delta Box.

Sediment Supply Component #3: Stand

Two views of stand

position of funnels in stand

Parts:

Plywood:
2.25” x 1.5” plywood, 6 feet total
8 screws or nails, longer than the thickness of the plywood, so at least 2” long
Drill, with 2” diameter bit

Assembly:

Cut two 2 foot lengths of plywood. Cut two additional lengths 6” long. Drill 2” holes in the center of each 6” block. In the bottom of one 6” block, notch out a space slightly larger than 2” to allow the stand to fit snuggly onto the Delta Box. Screw or nail the unnotched 6” piece to one end of the two 2 foot lengths. Place the stand over your Box to determine exact placement of the lower 6” block before affixing it to the stand’s legs. Be sure to screw/nail the lower block notched side down!

Supplier:

Standard lumberyard/Home Depot supplies.

Wave generator

Parts/Assembly/Supplier:
We used a standard handheld hairdryer that happened to be an appropriate size and shape to rest on the end of the Delta Box. Ours was borrowed from the Guest House at the University of Utah; they could probably supply make and model details, but this is a component ripe for improvisation!

Sediment:

Component # : sediment

Parts

Silica sand and anthracite dust, mixed at roughly 90% sand and 10% coal.
Amount:
It is difficult to dry this mix for re-use and wet sediment will not work in our sediment feed system. So it is useful to have enough to get you through as many demos/experiments as you anticipate running in a term/year. A five gallon bucket will hold ~ 65 lbs of the mix. At the Utah workshop in July, 2006, four runs in the box only made a small dent in a similar amount of sediment.

Suppliers
Silica sand is F110, 120 micron silica sand

We get it from:
U. S. Silica Company
P. O. Box 187
Berkeley Springs, WV 25411
Phone: 800-243-7500 Fax: 304-258-8295 email: sales@ussilica.com
http://www.u-s-silica.com/

Coal is PC6, 190 micron anthracite coal

We get it from:
Anthracite Industries
P. O. Box 112
Anthracite Road
Sunbury, PA 17801
Phone: 717/286-2176
Fax: 717/286-2329

Miscellaneous useful but non-essential items

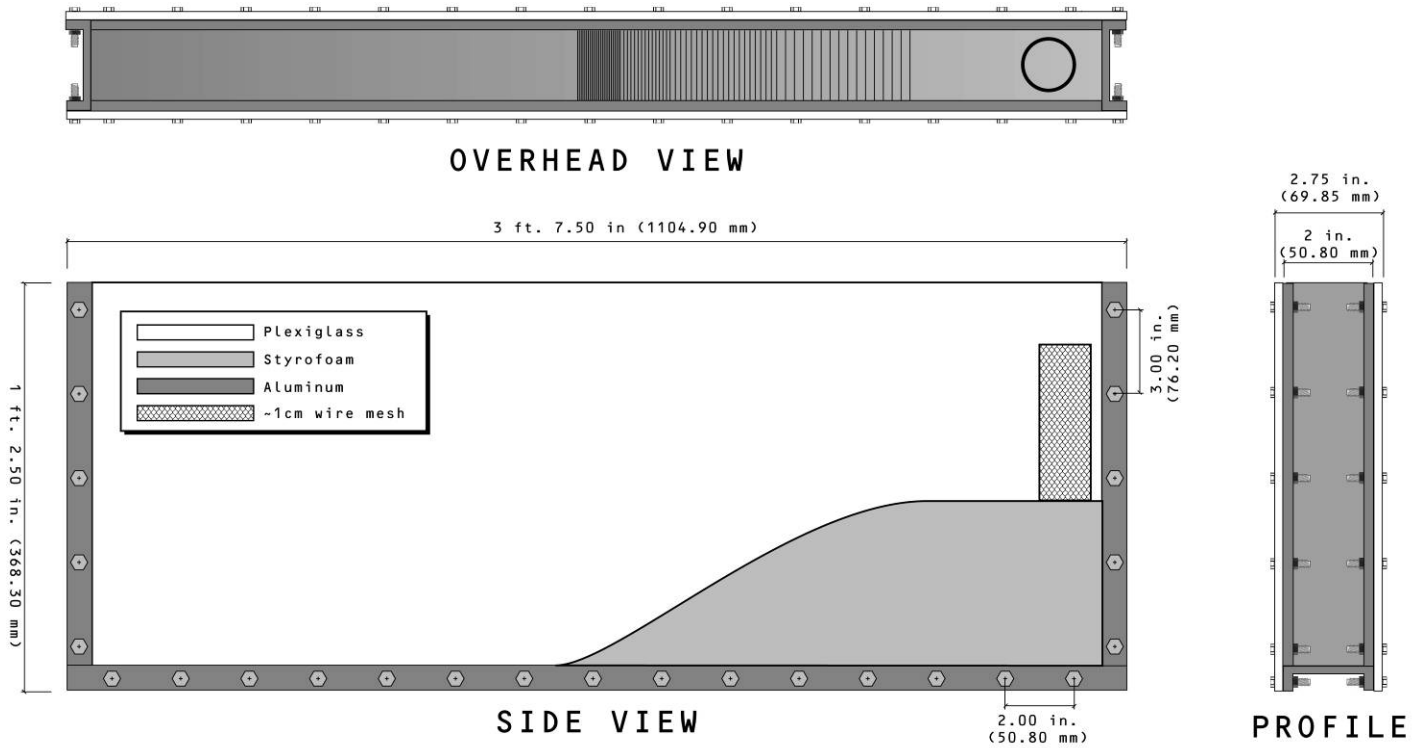
Two towels **Supplier:**These can be found in a Target store.	
Rubber Spatula or scraper	
Carrying box (this is not essential, but the box will lie flat in this box and can be shipped or stored easily, along with most of the components, in this box **Supplier** ORBIS Long StakPak Boxes (blue color) can be purchased from www.labsafety.com (item number 64630B)	
Miscellaneous Clamps These can be purchased at any hardware or Home Depot type store. You will probably need at least 5 and you may want to get various sizes. The large ones pictured here are useful for holding the various vinyl "hose" tubes for the water recirculation in place because they can be clamped to the box or bucket with enough space left to thread the tube through the space between the clamp and its hinge, thus avoiding any crimping of the tubing.	
Extra bucket **For holding wet waste sediment and transporting it to dumpster**	

Full set up (please also refer to drawings which follow)

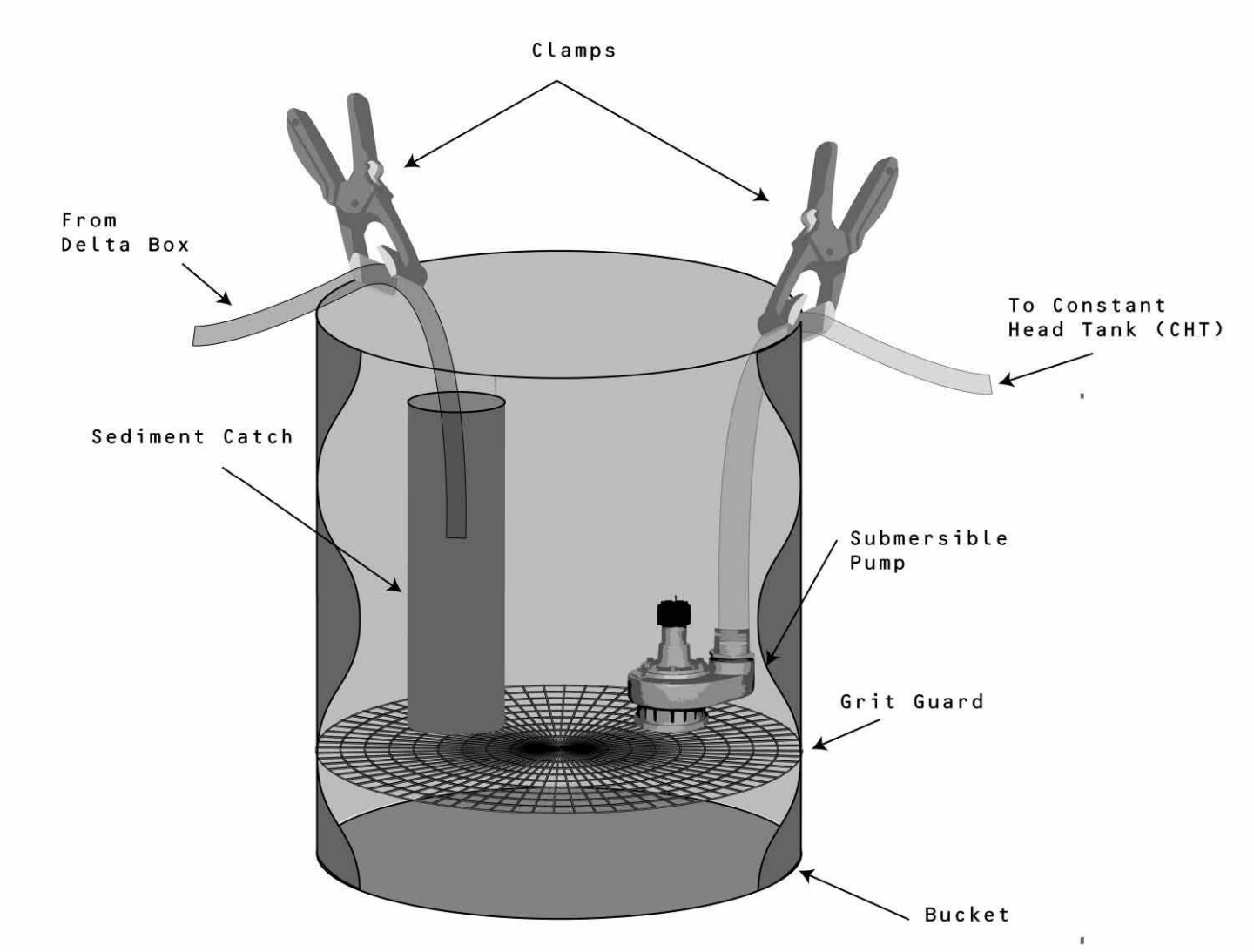
Frosting Tip Flow Rate Calibration

Piece	ml/in	ml/s	
A 4	30	0.5	
B 59	26	0.43	
C 63	100	1.67	
D 24	65	1.08	
E 96	330	5.5	
F 47	65	1.08	
H 61	340	5.6	
I 67	25	0.42	
J 27	35	0.58	
K 98	113	1.88	
L 30	60	1	
G 2	na- small openings, plugs easily		

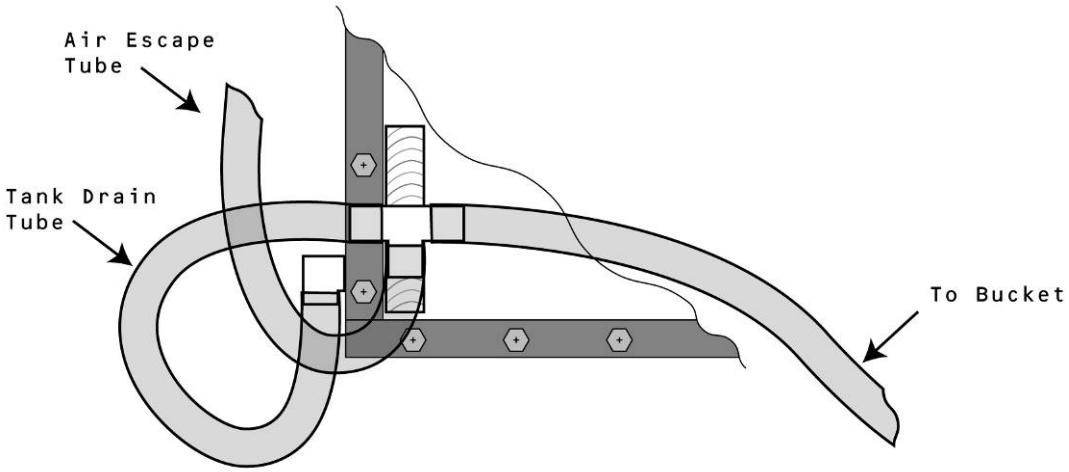
Finished Set-up Diagram 1:
Basic Basin



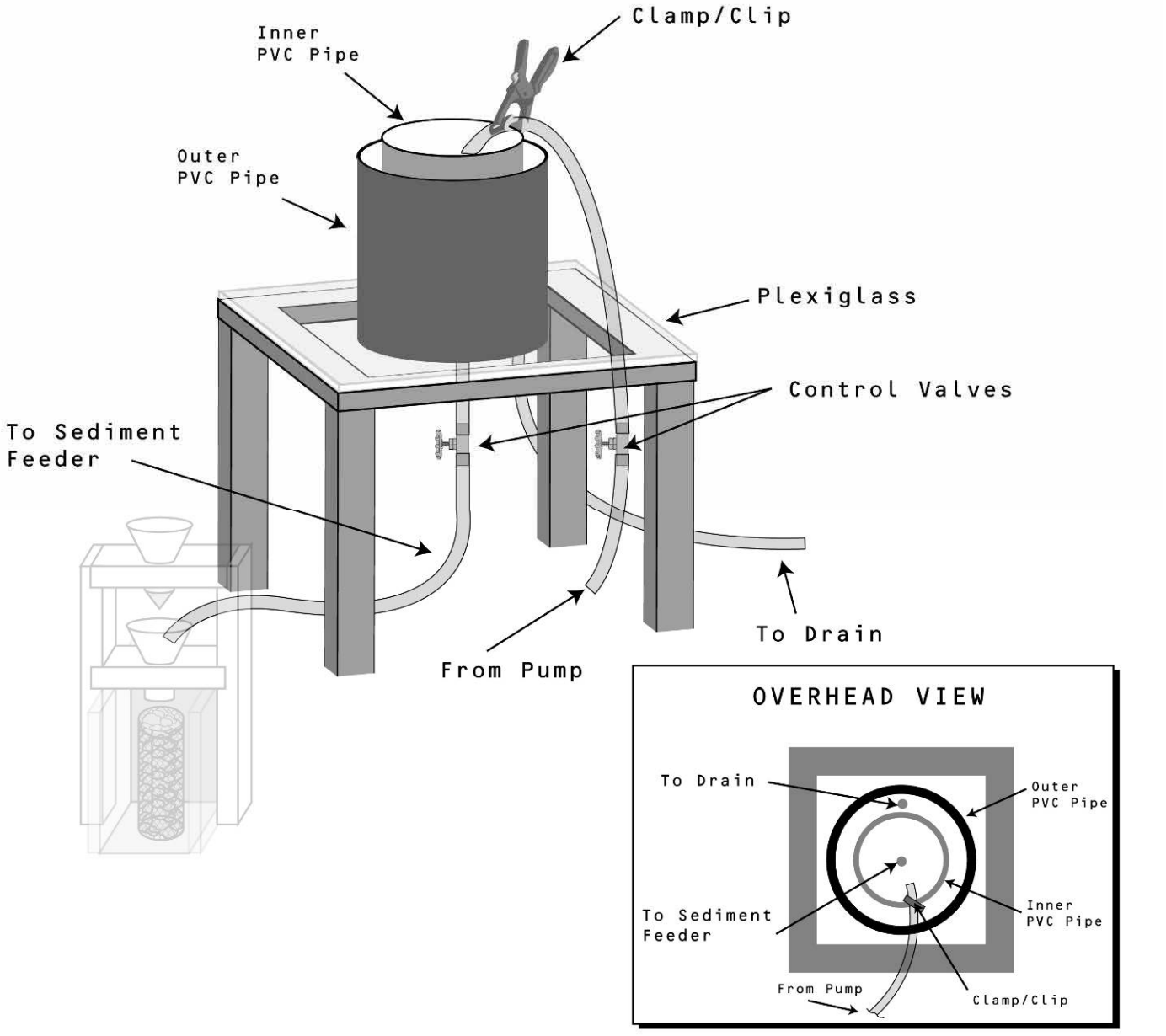
Finished Set-up Diagram 2:
Water Recirculation System Bucket and Pump



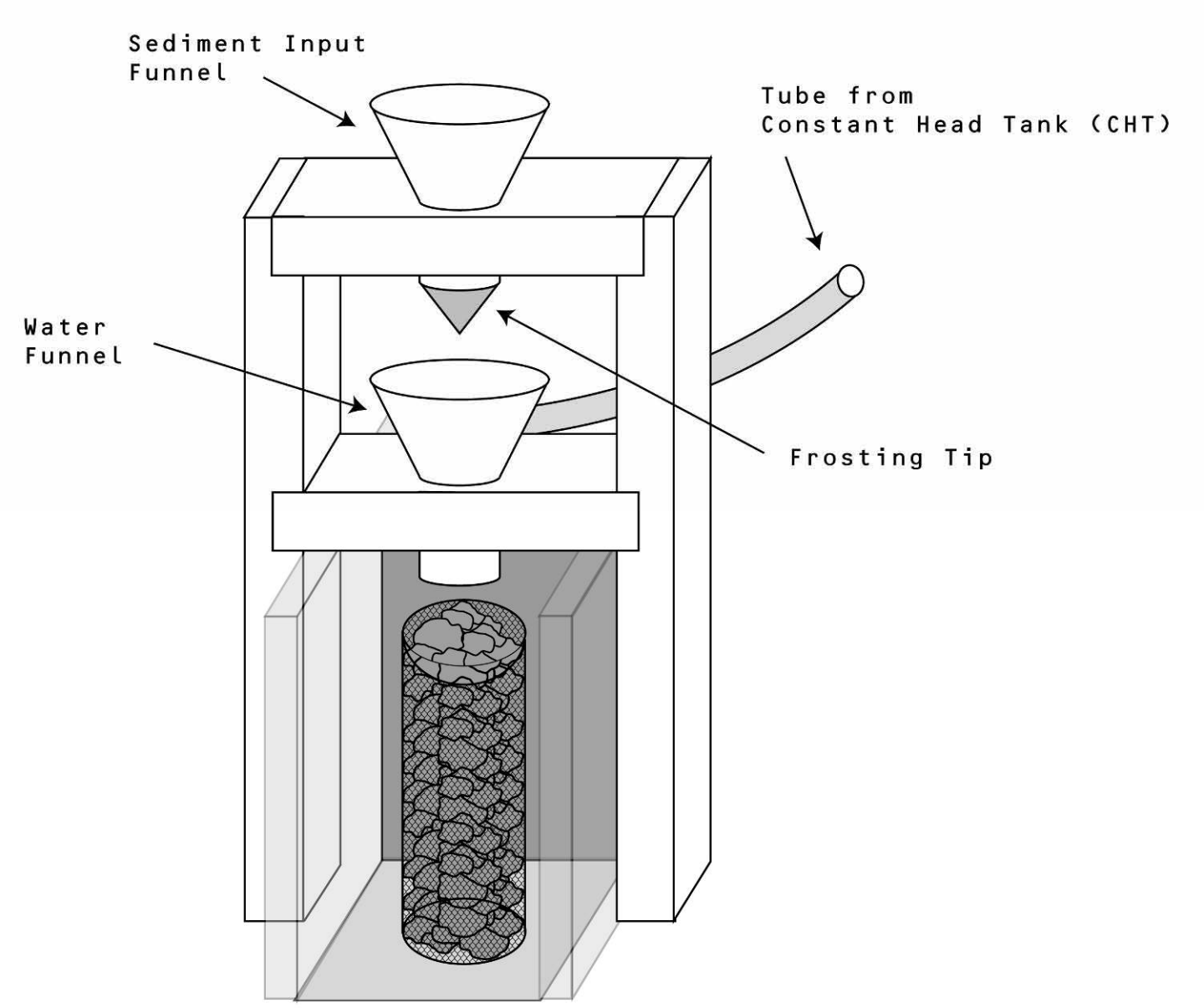
Finished Set-up Diagram 3:
Base-level Control



Finished Set-up Diagram 4: Constant Head Tank



Finished Set-up Diagram 5:
Sediment Feeder



Notes on running and cleaning:

As of February 2007 the delta box has traveled twice. In this section we will discuss recommendations for running and cleaning it.

Parts

Sediment feed: The coal in the sediment mix has coarse particles which clog the frosting tips. We have theorized that an improved system would involve an auger in a tube, turned at a calibrated rate.

Sediment diffuser: We recommend you close your diffuser at both ends.

Running

Achieving deposits: Set your base level and give delta box time to fill to that level before beginning sediment feed. Build out a significant deposit before altering base level. Ideally you have lots of time to watch the delta box fill, and time to clean it out before the next demonstration. This is not well suited for back-to-back demonstrations.

If you are interested in "wow" factor more than stratigraphic sequences, build your delta at a very high water level and then drop base level quickly. Make sure everyone can see both sides of the delta box, to compare.

Cleaning

Drain all the water out of the tank through the base level control outlet, with low sediment disturbance. Use a rubber spatula to scoop the sediment out of the delta box and into the extra bucket. Clean inside of delta box with rags or paper towels. Shake sediment trapped in the sediment trap into the waste bucket.

Take the waste sediment bucket to a dumpster to empty it. We do not recommend dumping the waste sediment into a toilet, garbage disposal, or an inside trash can.