Linking Hydroponics to a 880 Gallon Recycle Fish Rearing System

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Introduction

Hydroponic growing systems can easily be linked to an 880 - gallon recycle fish rearing system. Integrating the two systems allows the system operator to use the waste products from the aquaculture system as a source of nutrient for the plants. The hydroponic growing system also serves as a biofilter: bacteria in the gravel convert ammonia and nitrites to forms that can be utilized by the plants.

Picture 1. Basil and specialty lettuces can be grown in ebb & flow gravel bed systems.

There are many different approaches to linking recycle aquaculture systems to hydroponic growing units discussed in the literature (See suggested references). Commonly used closed loop system designs include gravel beds, raft, and gutter systems (See Pictures 1-3). In a closed loop system, the water is returned to the fish tanks after passing through the hydroponic growing unit. In an open loop system, the water is discharged after leaving the hydroponic growing unit. An open loop system requires a large (low cost) water resource and is more appropriate for cool and cold water systems that do not require heating the water (as continuously discharging heated water is expensive). Open loop systems are used when the grower wants to optimize production of both plants and fish, as the system allows the grower to use supplemental nutrients and pesticides on the plants without worrying about the impact of chemicals on the fish.

Picture 2. Basil and lettuce can also be grown using “thin-film” technique in PVC gutters.

Picture 3. Herbs and specialty lettuces can also be produced using a raft pyramid system.

The following discussion describes the integration of an 880 - gallon recycle fish rearing system with a gravel bed growing system (See Figure 1). A gravel bed growing system was selected because the materials for the system are ready available and a wide variety of plants can be produced in gravel growing media. The necessary materials for linking a recycle system to four gravel beds are listed in Table 1.

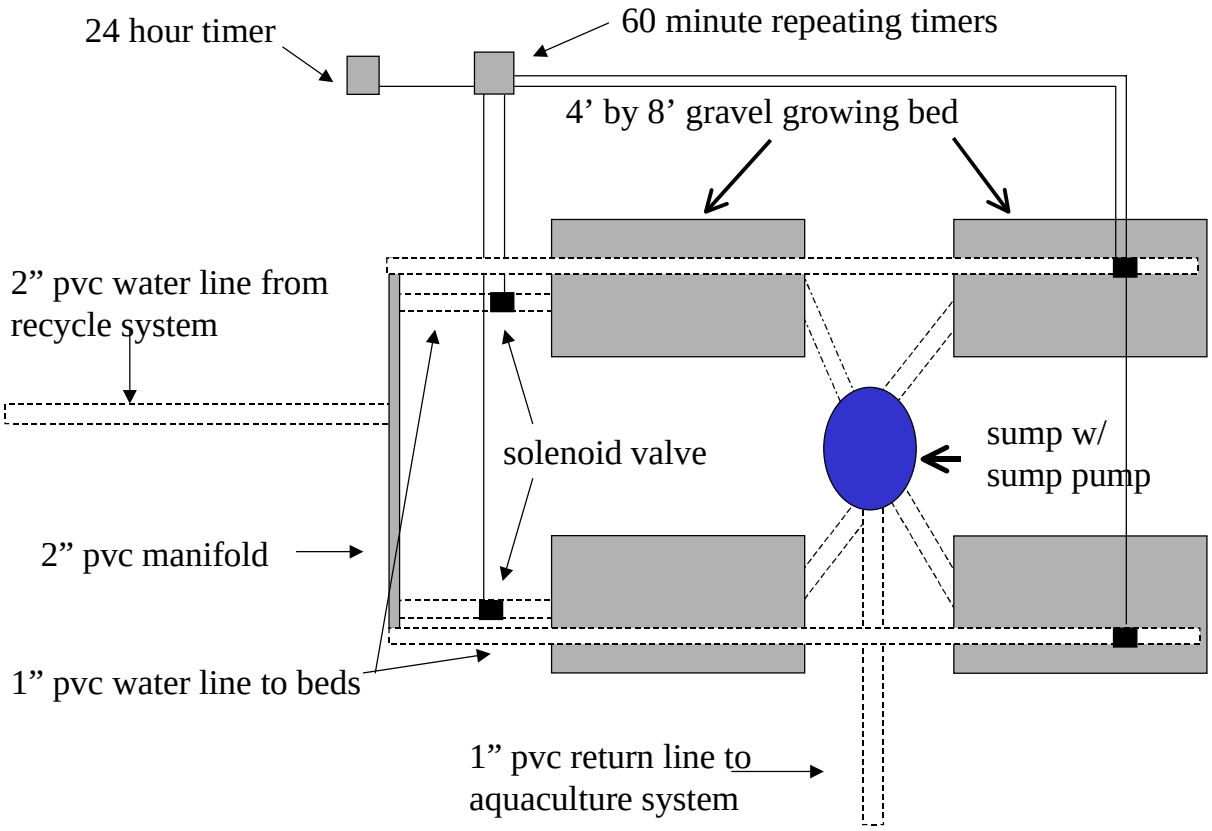

Figure 1. Overview of a gravel bed growing system..

Table 1. List of suggested materials for a four bed hydroponic unit.

System Component	#/Items	$/Item	Estimated Cost
Plumbing & Fittings for Linking Systems:			
2” PVC Tee	1	$1.08	
2” Bronze Gate Value	1	$11.16	
2” PVC Pipe	8’		
Distribution Manifold:			
2” PVC Pipe	8’		
2” PVC Tee	3	$1.08	
2” PVC 90° Elbow	2	$0.55	
2 to 1-1/2” Reducer Coupling	4	$0.79	
1-1/2” PVC Pipe	24’		
1-1/2” PVC 90° Elbow	4		
1-1/2” to 1” Reducer Coupling	4		
1” PVC Pipe	16’		
1” Flexible Hose	8’		
1” PVC Tee	4	$0.50	
1” PVC End Caps	8	$0.31	
Water Control System:			
1” Solenoid Valve	4	$19.50	$78.00
60 Minute Timer	4	$105.70	$422.80
24 Hour Timer	1	$89.75	$89.75
Miscellaneous Wiring (4 to 18 gauge)	100’		
1” Male Adapter	4		
Gravel Growing Beds:			
#8 Quartz River Gravel (pea gravel)	4 tons		
8" Cinder Blocks	72		
20 mil Plastic Liners (15’by 7’)			
4*8'*5/8" Plywood(B/C exterior grade)	4		
2"*12'*8'	12		
2"*4"*8'	24		
Wood Shims 12-5/4"*6"*8'			
2” Ball Valve	4		
Liquid Nails			
2” Slotted Well Screen (5’ length)	4	$30.75	
2” Bulkhead fitting (slip)	4		
Return Sump:			
1/3 hp Sump Pump	1	$125.00	$125.00
100 gal. Rubber Maid Trough	1	$75.00	
Garden Hose	20’		
Miscellaneous wiring (4 to 18 gauge)			

No special tools are required for the construction and installation of a gravel growing bed. However, we strongly recommend that a licensed electrician (or the school electrician) be consulted when wiring the timers and solenoid valves to ensure proper installation in a school environment. We also recommend that GFI protection is installed for all aquaculture equipment.

Recommends Installation Tools:

- Pocket knife or file
- Hacksaw
- Jigsaw
- PVC primer
- PVC glue
- Teflon paste or tape
- Drill
- Wire cutters
- Hole saw
- 4-inch cable ties

Tips for Working with PVC - When you cut PVC, use a sharp blade for best results. Cut at a 90^0 angle across pipe and be sure to cut all the way through before you separate the pieces. This will leave nice sharp edges on the cut pipes. Remove burrs or irregularities with a file or sharp knife. It is usually a good idea to test fit the more difficult sections that you are about to clean and glue together to make sure that you have cut the pipes the proper lengths. Do this before you clean with a primer (the primed pieces of pipe are difficult to get back apart). Clean all joints and pipe with a primer before gluing them (a colored primer will make sure you don't miss any). Once glue is applied (apply lightly to both pieces being glued), you should quickly join the pieces. Make sure they are fully seated and twist a ¼ turn to final position, and hold them firmly in place until the glue sets (there is a tendency for the joints to back out unless constant pressure is maintained for a few seconds). The glue sets quickly, you only have a few seconds to make any last minute corrections once you put the pieces together. All threaded PVC joints should be lubricated/sealed with teflon paste or tape. Take extra care when gluing ball valves so that glue will not accidentally get into the valve and cause it to malfunction. Work in a well-ventilated area and avoid skin contact with glue or primer.

Linking the Systems

Linking an existing recycle aquaculture system to a hydroponic system requires the installation of some sort of water diversion device. The following system design assumes that the system operator has installed a 2' PVC Tee and a bronze gate valve on the return water line after the bead filter so that water can be diverted from the tanks to the gravel growing as shown in Figure 1.

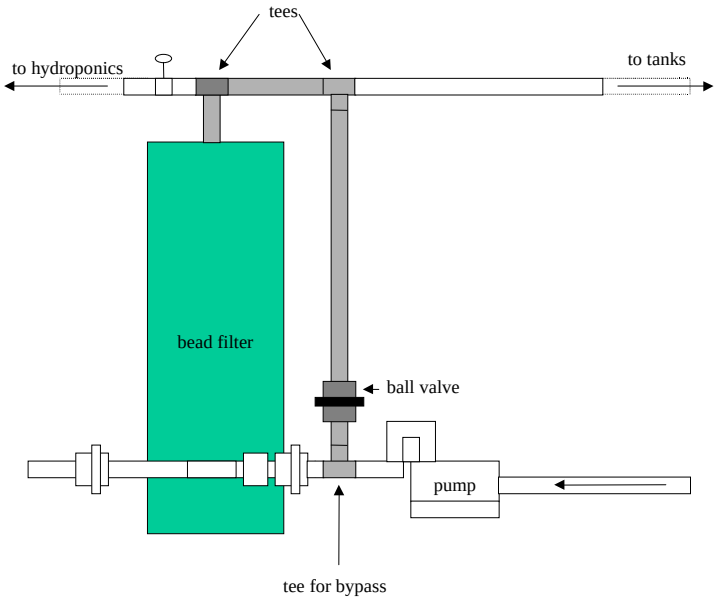

Figure 2. Schematic of required plumbing to divert flow from tanks to gravel growing beds.

The exact nature of the PVC plumbing between the 2” Tee and bronze gate valve at the top of the bead filter and the water distribution manifold for the growing beds will depend on the layout of the system. Two different layouts are shown in Figure 2.

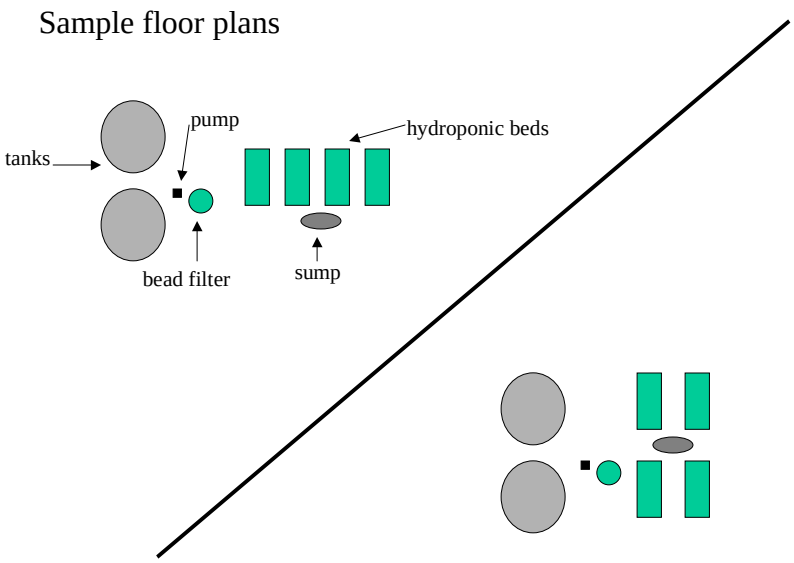

Figure 3. Optional layouts for integrating a recycle aquaculture system with a hydroponic growing unit.

The following discussion on how to integrate a recycle fish rearing system with a gravel growing bed system assumes a system layout as shown in Figure 1. Water is pumped from the bead filter via a 2" PVC pipe to a 2" PVC manifold located above the gravel beds (same height as PVC Tee). To minimize head loss from pipe friction, we recommend that the plumbing between the bead filter and bed manifold be keep as simple (and straight) as possible. All pipe and fittings between the two points should be glued.

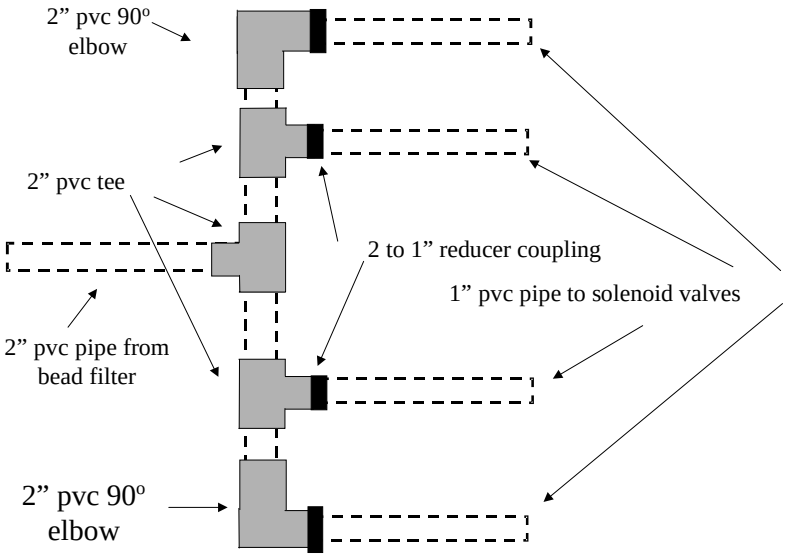

Figure 4. Typical water distribution manifold.

Glue the 2” PVC pipe from the bead filter into the 2” PVC Tee at the mid-point of the water distribution manifold as shown in Figure 4. The 2” water supply line to the manifold will have to be supported from the ceiling with pipe clamps (CLIC™ Brand) or plumbers’ straps. The length of each section of 2” PVC pipe between the 2” PVC elbows and tees will depend on the layout and number of the gravel beds. The manifold and 1” PVC Pipe (to each bed) should be dry fit prior to gluing to ensure that all pipe segments are cut to the proper length.

Glue the 2” to 1” reducer couplings to the two 2” PVC tees and 90° elbows as shown in Figure 4. From the 2” PVC manifold the water flows in a 1” PVC line to the gravel beds. The length of each section of 1” PVC pipe between the manifold and the elbows will depend on the layout of the gravel beds. The 1” water supply line from the manifold to the gravel beds will have to be supported from the ceiling with pipe clamps (CLIC™ Brand) or plumbers’ straps. At the head of each bed, elbow the water line down to the solenoid valve using a 1” 90° Elbow and a 2’ section of 1” PVC pipe as shown in Figure 5.

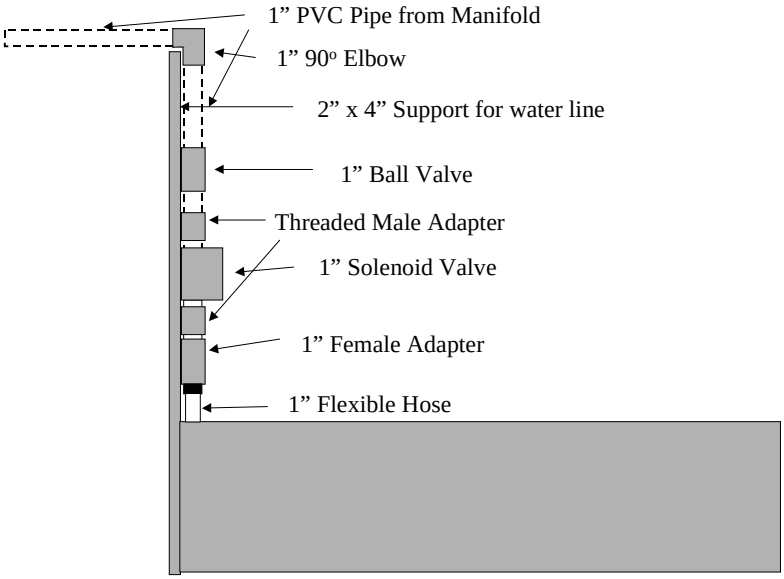

Figure 5. Schematic of plumbing to the solenoid valve.

Attach a ball valve to the 1” PVC pipe, making sure not to glue the valve. The ball valve allows the system manager to shut off flow to a bed when not in use. Glue a short piece of 1" PVC to the ball valve (as shown in picture 4), and then glue a threaded male adapter to the other end of the short section of PVC. Attached the solenoid valve to the threaded male adapter (put teflon tape on the threads). The solenoid valves are mounted on a 2” x 4” attached (screwed) to the head of each bed. Attached a second threaded male adapter to the outlet on the solenoid valve (using teflon tape). Glue a short section of PVC to the threaded male adapter and then glue a female adapter the short section of PVC. The 1” flexible -hosing can be dry fit to the 1”female adapter and to the male adapter on the water spreader bar as shown in Figure 6. The water spreader bar is made up of two 8”

sections of 1” PVC pipe joined in the middle by a 1” PVC Tee and with 1” PVC end caps. A male adapter is glued into the tee. Use a drill with a ½” hole saw to drill holes (evenly spaced) along the water spreader bar.

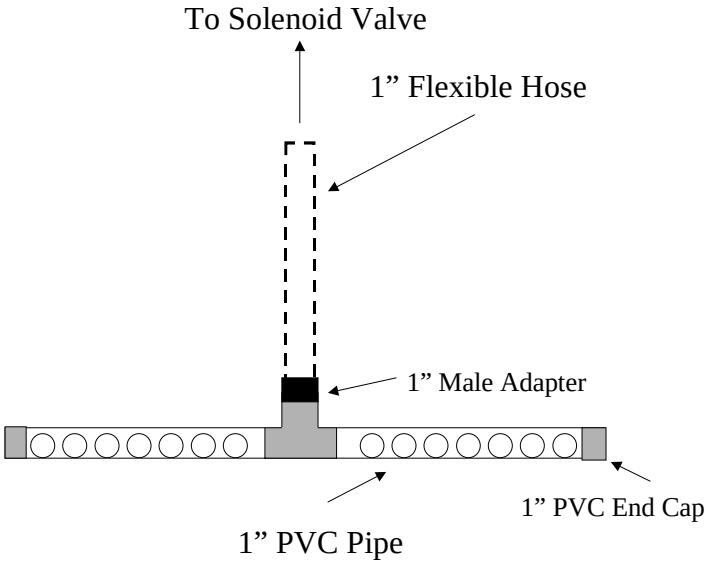

Figure 6. Overview of the water spreader bar mounted at the head of the gravel growing bed.

Flow Control Mechanisms

A solenoid valve and a 60-minute repeating timer (one per bed) control the flow (on/off) to the gravel beds. The solenoid valves are mounted on a 2” x 4” attached (screwed) to the head of each bed. The solenoid valve should be mounted about 2/3 of the way down the 2” x 4”. Each solenoid valve is controlled by a 60-minute repeating timer (one minute intervals). The 60 minute timers in turn are controlled by an optional 24-hour timer. Installation of a 24-hour timer allows the system operator to experiment with different hydraulic cycles. We recommend that the 24-hour timer and the four 60-minute timers be mounted on a panel and conduit used to run the wiring (4 to 18/20 gauge with plastic or vinyl coating) to the solenoid valves (See Picture 4). <u>We strongly recommend that you consult your school electrician regarding the wiring of the solenoid valves to the timers</u>.

Picture 4. Control panel with timers.

Growing Beds

The 4’ x 8’ growing beds are constructed of 5/8 inch plywood sheet (B/C exterior grade) and 2 x 12” boards. The growing beds are reinforced with a 2 x 4” frame across the bottom with boards every 2 feet to more evenly carry the weight (See Figure 7). The beds are screwed together, not nailed. The beds are caulked with “Liquid Nails” and then painted inside and out with an exterior latex paint (do not use an oil-based paint).

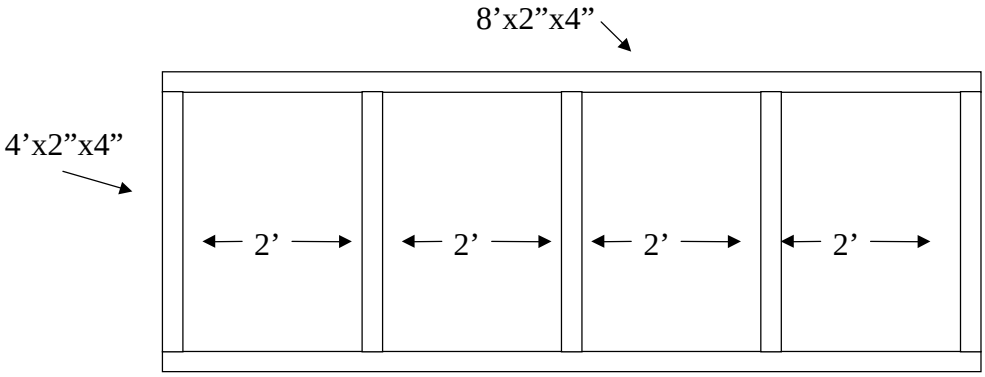

Figure 7. Schematic of wood frame (screwed not nailed) underlying the gravel growing beds.

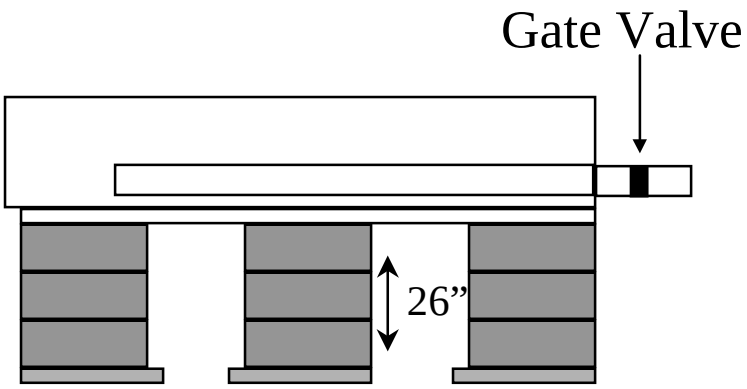

Figure 8. Side view of the raised beds set on paving stones with measurements. Note the shims are not shown in the figure.

Place the growing beds on the concrete blocks as shown in Figure 8. If the growing beds are placed in a greenhouse with a gravel floor, we recommend that the concrete blocks be set on 2’ by 16” paving stones to prevent the blocks from settling into the gravel. The gravel beds are elevated 24” on three 8” concrete blocks to provide a comfortable working height (Figure 8). Two 1-1/4” thick, 6” wide, and 16” long shims are placed at the top end (end with water spreader bar) of the bed between the blocks and the bed frame to promote drainage. One ¾” thick shim is placed on the middle row of blocks. The shims raise the end of the bed receiving the water flow about 2” higher than at the drain end.

The growing beds are lined with plastic to prevent wood rot (see Picture 5). The liners are stapled to the outside edges of the growing beds. Heavy duty plastic or rubber (backyard pond liners) for fabricating bed liners can be obtained from garden supply centers or ordered directly from the manufacturers. Several sources are listed in Appendix A.


Picture 5. Bed with liner and well screen

A collection drain is installed in the bottom of the gravel growing bed. The drain should sit about 1” off the bottom of the bed. The collection drains are constructed of 5’ lengths of 2”

diameter PVC well screen with 0.40" slots (with 2" diameter PVC end caps) cemented to a 2" bulkhead fitting on the lower end of the bed (see Picture 4 and 5). The bulkhead fittings are inset into the center of the 4' long, 2"x12" wall at the low end of the bed; this requires a hole saw and router. Cut a hole the size of the bulkhead fitting in the plastic liner. Silicone caulking is used to improve the seal between the bulkhead fitting and plastic bed liner. The gravel growing beds drain into a 2" PVC drain line that carries the water to the sump tank.

A #8 river-run, washed, pea gravel (approximately ¼") is used as the growing media in the beds. The gravel should be thoroughly washed before being placed in the growing beds. The gravel is placed in the beds so that the beds are to within 1" of the top. The gravel is further washed in the beds and the effluent allowed to drain out of the system (not into the fish tanks). Lava rock can also be used as a growing media. Although lava rock is more expensive than gravel, it is significantly lighter (See Appendix A for a list of suppliers).

To control the rate of flow to the sump, a gate valve (or a PVC knife gate) is installed on the bed drain line (Figure 8). Water from the gravel beds drains to a plastic sump and is pumped back to the fish tanks via a ¼ (or 1/5) hp sump pump; the sump pump is controlled by a float switch. (Uses a standard float switch that comes with the pump).

A short piece of 2" PVC is cemented to the bulkhead fitting and then to a 2" PVC gate (or knife) valve. A short piece of 2" PVC is attached to gate valve and then cemented to a 90° elbow. By not cementing the ball valve, one can access the drain line and, using a piece of doweling, scrape out any roots or sludge that are likely to build up in the well screen over time. A short piece of 2" PVC is dry-fitted to the 90° elbow and then cemented to a second 90° elbow that is cemented a length of 2" PVC pipe which drains to the sump tank set in the floor (Figure 9). To provide additional flexibility in the drain line, attach a fernco coupling to short piece of PVC pipe and then glue it to the elbow.

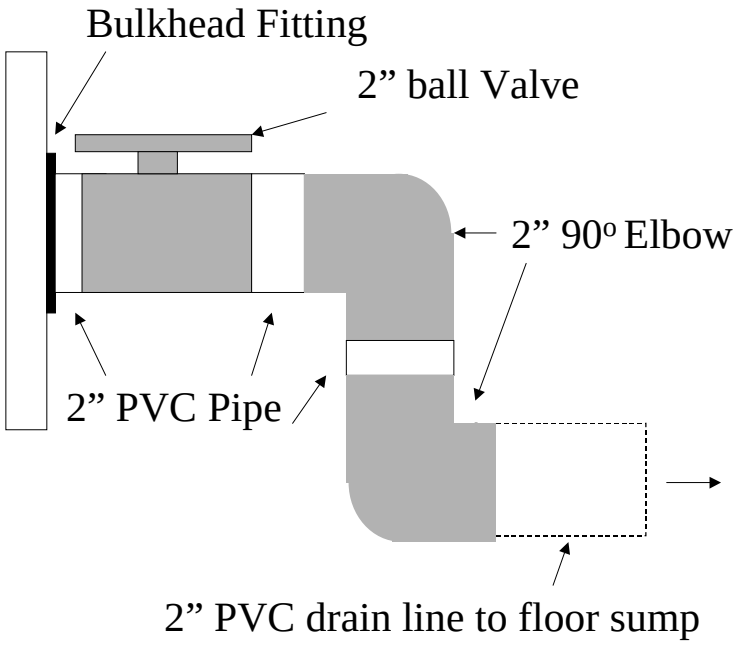

Figure 9. Schematic of drain line from gravel growing beds.

The gravel beds drain to a 100-gallon plastic (e.g. Rubber Maid) cattle watering trough that has been set on the floor. (If the lab has a gravel floor, the sump tank can be set into the gravel floor). The water from the gravel beds is periodically pumped back to the fish tanks via a ¼ hp sump pump set in the bottom of the watering trough. A float switch that comes with the pump activates the sump pump.

Use 1-1/2” PVC pipe to plumb the return water line from the sump pump to the fish tanks. Remember to put a union joint right after the discharge outlet in the sump pump so that it can be swapped out for maintenance and repair (as shown in picture 7). The return line can be plumbed directly to the fish tank.

Suggested References

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Appendix A: Suggested Manufacturers

Table 1 Primary Equipment Manufactures

System Component	Company	Component Supplied
Growing Bed Materials		
Plastic Liners	Yunker Plastics, Inc. 7253 Sheridan Springs Rd., Lake Geneva, WI 53147 (414) 249-5233 TetraPond 3001 Commerce St. Blacksburg, VA 24060-6671 800-526-0650 Colorado Lining Company 1062 Singing Hills Road Parker, CO 80134 303-841-2022;303-841-5780 fax Resource Conservation Technology, Inc., 2633 N. Calvert St. Baltimore, MD 21218 800-477-7724 Environmental Protection, Inc. P.O. Box 333 Mancelona, MI 49659-0333 800-OK-LINER; www.geomembrane.com Watersaver Company, Inc. P.O. Box 16465 Denver, CO 80216-0465 303-289-1818; 303-287-3136 fax www.watersaver.com	
Monitoring and Control System		
Pump Timers	Hummert International 4500 Earth City Expwy Earth City, MO 63045 (800) 325-3055	Tork Repeating Timer
Other:		Growing Media
Lava Rock	Miller Rock Quarry Ph (425) 788-1000 Fax (425) 481-3456 www.alpinerock.com	