Simplified Aquaponics Manual

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Simplified Aquaponics Manual

Water is becoming a commodity that has become worth more than oil in many situations. There is a finite amount of fresh water available and it seems that the world population is doubling every few years. Already, areas in the United States have surpassed their ability to hydrate the present population. Farming accounts for 75-80% of fresh water usage in the world. Current irrigation techniques waste precious water and the runoff pollutes streams and rivers with leached soil and fertilizers.


Fox Spring

Aquaponics is the gentle blending of Aquaculture, fish farming, with Hydroponics, soil-less production of plants. Aquaculture, as you know, has various problems inherent to its nature, first it takes up a great deal of land and worse, the effluent is toxic downstream to the point of killing other fish and causing massive algae blooms due to the high nitrogen content. Hydroponics, on the other hand, is even worse in that the nutrients or chemicals are difficult to dispose of due to high chemical salts.


Figure 1

Aquaponics solves all of those problems and there are no chemicals or runoff with which to contend. Waste does not exist in an aquaponics system as one portion utilizes the waste from another. Good farmers have always used manure to fertilize crops; aquaponics does it with fish effluent. Water usage is cut 80% as it is recycled endlessly and losses are due to evaporation and removing portions of plants for consumption.

A family of four could do the same type of system within the same space required to park a compact car and meet all their nutritional requirements. With twice that space the same family would be able to sell their surplus and possibly remove the need of one adult to work outside the home. Generally speaking, one ton of fish waste will produce seven tons of edible produce. Paying careful attention to growing plants in succession and multi-tiered planting will result in possible production from 10 to 15 times that of a square foot of garden space. Fish and plants alike can qualify under

current guidelines for “Organic” and thus fetch a higher price at market.

Figure 1 is one type of system which will just about produce enough for one adult (considering minimum nutrition) and is 1/4 the size of a compact and uses 55 gallon barrels which are available almost anywhere in the USA. Aquaponic setups like these can be configured in any number of ways and not limited to those depicted in the pictures shown in this manual.

The system in **Figure 1** was developed & photographed by Travis Hughey of S. Carolina.

How it works

Fish waste is mostly ammonia and when it builds up the fish die. Plants require water, light, co2 and a bunch of trace elements and if any are missing or lacking they either wither or die. Bacteria, like Nitrosamines, eat ammonia and give off nitrites, which Nitrobacterium eat and excrete nitrates. This process consumes oxygen, carbon, inorganic nutrients and generates nitrate. The pH lowers as the nitrifying bacteria multiply. My water runs clear enough to read the lettering on the pump in the bottom of the fish tank. If the water turns cloudy or green then quit feeding for a couple of days and it will clear up. Fish can handle 10-100 times as much nitrate as ammonia and nitrates are the form of nitrogen that plants love to eat.

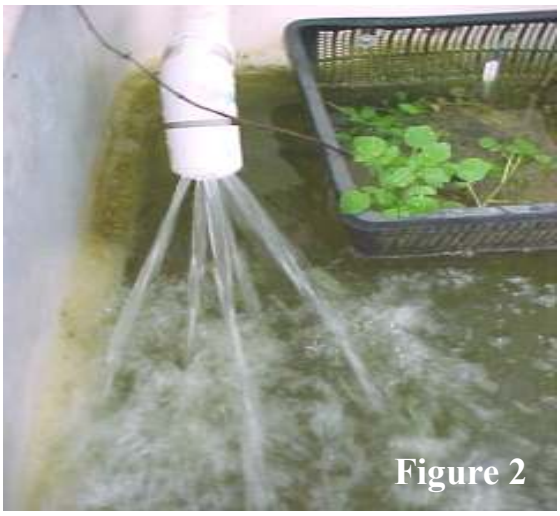


Figure 2

So, simply put, fish produce the ammonia; bacteria in the grow beds break the ammonia down to nitrates which plants feed on to produce food, the water circulates, now cleaner and oxygenated and the cycle never ends. Plants can be eaten by both humans and fish, left over plant parts can feed earthworms which in turn can feed the fish.

Water circulation solves several problems. Stratification tends to occur when water stands still and nitrates settle to the bottom as does the water with the least amount of dissolved oxygen. The oxygen level is also important to fish survival. Recirculation and the subsequent oxygenation of the water conserve local reserves and help decrease demand on aquifers. **Figure 2**.

Total water usage in the system depends on several factors. First, higher temperatures and wind tend to affect the amount of evaporation and second, the amount of vegetation and vegetables being consumed will remove water from the system. Generally, water losses of 10-20% can be expected per month. This is considered minimal compared to conventional farming and cultivation watering methods. Water added to the system should not be from city water sources that are chlorinated as this can adversely affect both fish and plants. If city water is the only water available it should be allowed to sit in an open container for 24 hours if in the

open sunlight, longer if not, prior to adding. Most well water is acceptable and I have found that rainwater works great unless you live under the smokestacks of the local coal fired electric company or factory.

Simplified System

Here are the basics. The simplified system has five components, 1. Fish tank, 2. Dump tank, 3. Grow beds, 4. Drain line, 5. Bilge pump. In many other system designs you had to have a fish tank, two pumps, grow beds, and drain lines for each bed and a sump tank. This one is simpler, as you will see.

Fish Tank

One of the more important components of any aquaponics system is the fish tank. Tanks come in every shape and size, limited only by the imagination. I have used square, rectangular and round tanks, made from everything from plastic to metal, even holes in the ground lined with plastic. Polyurethane tanks seem to work the best with the least problems. Optimally, if the tank does not have a floor sloping to the middle or one side then it should be propped up so everything drains to one corner or side. The pump should then be located over this area if you can. This will facilitate in allowing the pump to remove solids. If this can't be done it isn't a deal breaker.

The tank should be configured to allow easy harvesting of fish and if need be cleaning although mine seems to be self cleaning.

Pump

In this simplified system you only need one very small fountain/bilge pump that has a head height of 6 feet or so and has a variable flow adjustment. You will want to be able to turn the flow down to a trickle; just enough to fill the dump tank every 45 - 90 minutes depending upon what you are growing.


Figure 3

The pump connects to a 3/4 inch PVC line which goes to the top of a plastic 55 gallon barrel with the top cut out. Put a 3/4 inch cap on the line dropping into the barrel and drill 3/8 inch hole in it. This assures that the flow will remain the same. By placing a "T" on the line at the top of the barrel (shown in **Figure 3**) the other side of the line can actually supply another 55 gallon barrel and another complete system. You just want to make sure that your dumps are not going off at the same time. Set them alternate with one going off at the half full mark of the other one. Cap this system, also and drill 3/8 inch hole. Do

not exceed 6 - 8 feet in pumping height.

Dump Tank

Using a jigsaw, cut the top from the barrel, leaving the rim intact. Drill a 7/8 inch hole in the bottom of the barrel 2-3 inches from the side and install a 1 inch siphon system like **Figure 4**. This also shows a vertical barrel dump. Notice that the left side of the self starting siphon is about an inch off the bottom of the barrel. It is a good idea to put some screen netting on that short arm of the siphon. I know that fish shouldn't be able to come through the pump but can't tell you how many times I have found them in the dump barrel! On the right side of the barrel where the pipe goes through the bottom of the barrel, the simple way to do this is to use the two 1 inch connectors with the male and female threads (you can see one and the other is on the bottom side of the barrel) and thread the male connector up from the bottom. Run a bead of good grade silicone sealant around both sides of the bottom of the barrel, put cleaner on and glue one side of each of the 1 inch connectors and screw together until tight. This should push up a small bead of silicone sealant up around the edges of the connectors. Use your finger to smear it around between the bottom of the barrel and the connector to make a good seal. Let this dry a few hours before making the rest of the siphon or it will leak. The dump barrel can also be laid on its side with an access hole in the top to glue in the siphon. If the dump barrel is laid on its side the siphon should be raised 6 inches from the bottom to facilitate proper refill and siphon action. Dump barrels laid on their side tend to deliver water slower to the supply ports in the grow beds so some adjustment will be necessary to insure proper watering. << Figure **5** is of a horizontal barrel dump. >>

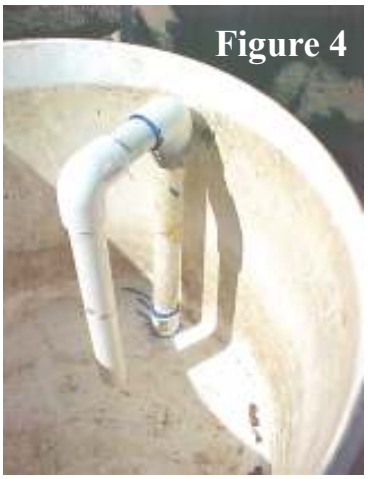


Figure 4


Figure 5

When the sealant is dry to the touch, construct the rest of the siphon and glue all the joints. The measurements for the siphon purposely were not given for the simple reason that not everyone will want to dump 55 gallons of water into their system. By varying the height of the siphon or the height of the intake one can adjust the volume of the dump

Grow Beds

One vertical plastic 55 gallon dump barrel will supply eight to ten 55 gallon barrel

halves. Ten grow beds seems to be the about the upper limit for a 55 gallon vertical dump system. Eight grow beds is the limit for the 55 gallon horizontal system. These barrel halves, once filled with gravel, are known as grow beds.

Do not use any barrels that have had either plant or insect poison in them!! Most other barrels are acceptable. CLEAN THOROURGHLY WITH LOTS OF SOAP AND WATER. Cut along molding line so the barrel halves are lengthwise. Drill a 7/8 inch hole in each barrel half as shown in **Figure 5,** about 2 - 3 inches from either end. Do it closer in if you are doing it the way I show that Travis did it. Drill one hole per barrel. Spread silicone sealant around opening on both sides as before and screw in a 2 inch piece of 3/4 inch PVC nipple until about 1/2 inch protrudes on the inside so loose gravel cannot stop up the hole in the cap. Smear the sealant around on both sides to insure a good seal and let dry. Drill a 1/4 inch hole in a threaded 3/4 inch PVC cap and screw on lightly to the outside part so as not to disturb the seal around the threaded nipple. This is the drain for the grow bed. Once monthly unscrew these caps while the system is cycling and clean the holes. This will insure that the caps remain open and the area under the field drain halves remains clear.

Barrel Racks

Next build the racks to hold the barrels. The barrel halves must be supported along the sides as shown in **Figure 6**, which also shows the drain system for barrels placed end to end. Cut the support legs to the proper height with a 45 degree angle on top as shown in **Figure 6**. The support legs should be 19 inches apart. I have not found the need to support the bottom of the barrels. Leave enough room on the 2X4 brace beneath the barrel half to support standard plastic guttering with enough room to get your hand in to screw on cap drain. I built my racks from scrounged lumber but can be built from any material that will support the

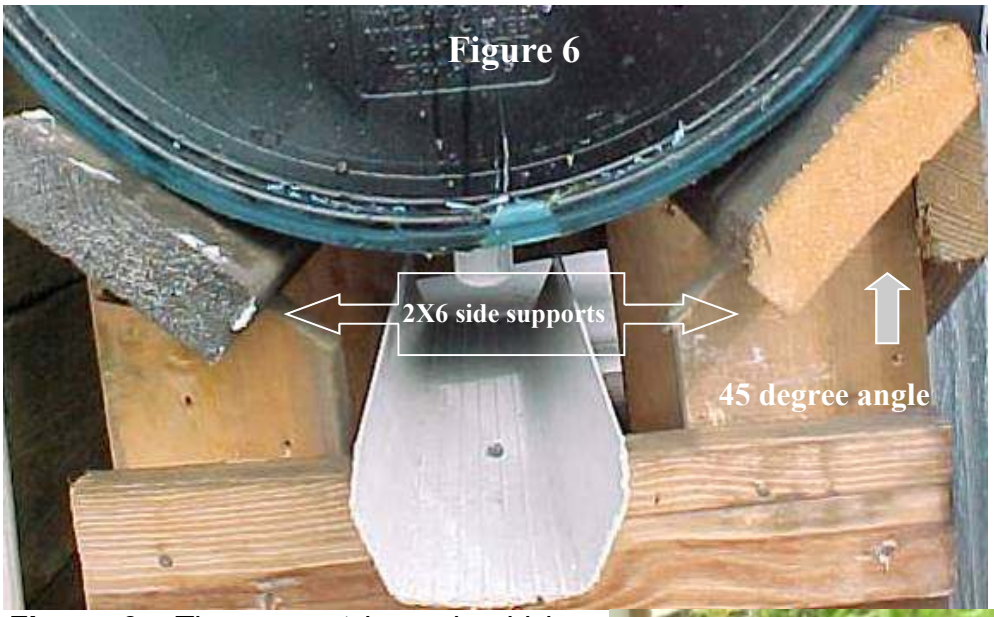


Figure 6

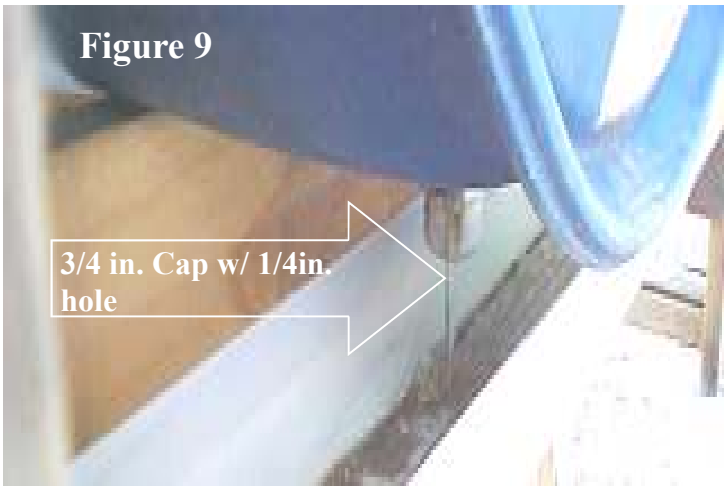

Figure 7

weight of the grow beds. It is recommended that the 2X6 shown supporting the barrel half in the **Figure 6** be continuous for strength when used with barrels end to end. If barrels are placed side by side then use the support system in **Figure 7,** photo by Travis Hughey. Placing the barrels side by side uses slightly more lumber when compared to end to end but takes up less linear space.

When the sides are not supported properly they will tend to push outward as shown here in **Figure 8**. This will tend to let water run over the bulged portion.

Gutters and Drains

Figure 9 depicts hanging the gutter for barrels laid side by side. Once a month during drain cycle remove cap and clean. Notice water flowing from the hole in the cap. This particular drain gutter is being used on barrel halves placed side by side. The dark material in the bottom of the gutter is algae and should be loosened once a month and allowed to drain back into the fish tank where it will be consumed by the fish in the system.



The height of the stand will depend on the amount you want to bend over to tend to plants or adjust flow. It is easier to construct the stands from lumber unless you want to stack one row of grow beds on top of the other and in that case we recommend metal pipe.

The stand should connect to barrels end to end for the easiest operation and the least things to go wrong. Eight barrel halves will stretch 24 feet and you need a stand for the dump barrel 2 feet square. This stand should elevate the dump barrel

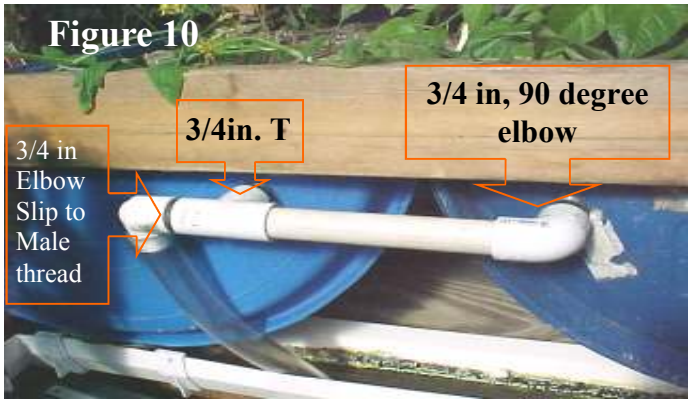
above the grow beds 4 inches for good drainage.

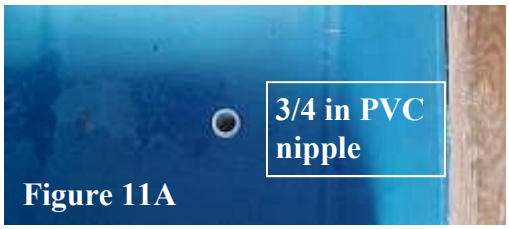
Next, place the barrel halves or grow beds in the racks and align end to end with bung end nesting to bottom end of next barrel. Screw these together at the top edge of the barrel about 1inch down from the edge using coated deck screws. Do not screw together so tightly as to warp the barrels. Snip off any protruding ends of the screws. Once the barrel halves are in the rack straight and level along the top edges use three 1 in coated deck screws along each side of the barrel half where it contacts the 2X6 brace to secure the barrel halves to the rack. These screws will not leak if screwed in, not predrilled.

Overflow drains

Measure down 3 inches from the edge of the barrel ends, center the bit, and drill a 7/8 inch hole. Cut a piece of ¾ inch PVC pipe so 1/2 inch protrudes on each side

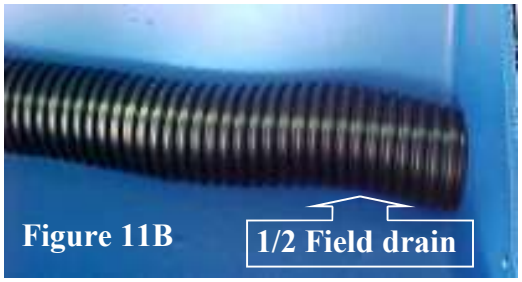
Put silicone around the hole and glue a 90 degree elbow on each end on the inside with the open end down. One inch "T's" will connect each barrel to the next. This will be a drain between each grow bed to keep the water level from exceeding 2 inches from the top of the gravel. Screw on a piece of 1 inch clear tubing to the end of a ¾ slip to ¾ male threads to drain to the gutter. The drain will keep the beds from overflowing and spilling on the floor. At each end of the grow bed row do the same and run a short section of ¾ inch to the top of the gutter to allow drainage of overflow at either end. All overflow and drain lines should run slightly downhill for proper drainage. Clean out any plastic shavings at this time or they will stop up the system at a later date and cause no end of problems. See **Figure 10.**





Drill 7/8 inch hole in the bottom of each barrel half and install 3/4 inch PVC nipple. **Figure 11A**

Purchase a section of flexible drain field line at a home improvement center and cut it along the molded seam lengthwise. Cut to fit snug in the bottom of the barrel half as shown in **Figure 11B**.



<< **Travis Hughey** never ceases to amaze me! He took this idea and did it one better! He jumped on the drain field line but turned a shorter half piece on end around the bottom drain. **BLUE = BARREL, BLACK = SEWER PIPE SECTION, RED = BOTTOM DRAIN, TURQUISE = WATER, GREY = GRAVEL** Don't make fun of my drawing! Bet you all got the idea…>>

GRAVEL

One quarter inch pea gravel should be placed into the grow beds at this time, being careful to hold down the black drain line as the gravel in poured on top. Very little gravel should be allowed under the drain pipe due to possibility of stoppage at a later date. The pea gravel (**Figure 12,** photo by Travis Hughey) should come to within 1 inch of the top of the grow beds and approximately 2 inches above the connecting drains at the top.


Figure 12

If the gravel is dusty or dirty it should be washed before the water is cycling through the tank with fish. This is easily done by just running the water outside the return drainage system. Washing is done by covering the gravel with water and stirring it with a pipe or broom handle. Drain and repeat a time or two.

Dump Lines

Place the dump barrel on top of the stand and connect dump line as shown in **Figure 13**. One inch pipe makes up the dump line and a "T" is placed in the center of each grow bed and a 2 inch piece of pipe is connected to the "T" and a cap with ½ inch hole on the end. The idea is for water to enter the pipe and flow out a ½ inch hole, fill the grow bed to about 2 inches from the top of the grow bed


Figure 13

and drain slowly out the 1/4 inch hole.

Nitrogen rich water is pouring from the outlet in this picture, **Figure 14.** The pipe is laying on the edge of the barrels. All lines should run slightly downhill for proper drainage. Outlets should point slightly uphill so 1 inch pipe cap is slightly above level of supply line. This will insure that when the siphon initiates it will flow rapidly throughout the line.

Operation

Fill the fish tank with non-chlorinated water. Start the pump. When the dump barrel initiates check for leaks. Ideally, each grow bed will drain out and sit before the next dump of water comes in from the dump tank. Using a small fountain or bilge pump and the dump barrel insures that this cycle can be adjusted to 30-90 minutes long. This is enough time for the grow beds to empty. This system is known as ebb and flow. Plants love it!!! The gravel keeps the roots from standing in water and yet moist while providing a home for the nitrifying bacteria. Pump failure will not harm the plants for up to 24 hours; however the fish will start to die within hours.

To visually check the water level in the grow beds we have developed a tool to help. Take a 12 inch piece of 1 inch PVC pipe and insert a 14 inch section of broom stick so that the rounded end sticks out. Simply push the assemblage into the gravel bed either side of the field drain and remove the broom handle section. See **Figure 15.** This will allow visual inspection of the water level. This part of the system is not necessary but a good tool to gage water level. Water level can be adjusted by raising or lowering the “T’s” in the delivery line &/or the size of the outlet hole. This was of course prior to the great improvement that Travis made. Do it that way!

These next photos show how fast growth is using this system.

Catnip on left at 10 days,
Tomatoes with old delivery system.

Peppers and catnip at 30 days with new delivery system.

Catnip at 60 days.

Peppers and tomatoes at 60 days.

Initializing the System

There are several ways of initializing the system. To insure proper balance within the system, nitrifying bacteria needs to be present in the grow beds to convert the nitrites produced by the fish into usable nitrates for the plants. The best way to do this is to gather a five gallon bucket of local water from a creek or pond and pour it into the fish tank. This water will have all the proper bacteria present to initialize the system. It will take two to three weeks for the bacteria to grow enough to handle both fish and plants properly. During this period the system cannot handle large amounts of mature plants or fish. I have found that sowing the beds with some fast growing small seeds like rye grass or Black Seeded Simpson Lettuce will start the process faster. I like to run goldfish in my system because they tend to clean up the algae growth better than some other fish and are cheap if you lose a few due to the inevitable learning curve. The fish tank will run cloudy for several weeks then clear up. The system is properly initialized at this point.

Actually, fish can be eliminated from the system altogether by simply running manure tea instead of fish. The system will run just as well but requires addition of one gallon of manure tea to a 250 gallon tank daily. For those who object to raising or eating animals this is a viable alternative.

Fish

Fish are an interregnal part of this system. Plants require nitrogen to grow and fish provide this with elimination of both urine and feces. As in any system, open or closed, these nitrates must be cleaned from the water or the fish will die.

Just a few of my babies in 4 foot deep tank.

Aquariums require filtering systems that must be either cleaned or replaced on a regular basis. The grow beds of the aquaponics system act as this filter without the hassle of cleaning or replacing. Plants must be present in the grow beds to use the nitrates for this to be true.

Almost any freshwater fish can be raised in the system although the operating temperature prohibits rearing of species such as trout. For those who do not care about either eating or selling the fish we recommend 1/2 goldfish and 1/2 common carp. One fish per 1 gallon water is the maximum the system can handle especially as the fish grow larger. These can be bought cheaply at bait stores in most parts of the country. Carp can be eaten or be sold to restaurants. In Texas, raising tilapia requires special licensing and permits so I stick to carp, Koi, fancy and plain goldfish.

The following is a list of fish recommended for rearing in an aquaponic system along with some helpful sites for information specific to that species:

Walleye	**www.rook.org/earl/bwca/nature/fish/stizostedionvit.html**
Tilapia	**www.ext.nodak.edu/extpubs/alt-ag/tilapia.htm**
Yellow Perch	**www.dnr.state.wi.us/org/water/fhp/fish/3jyperch.htm**
Lake Perch	**www.seagrant.wisc.edu/greatlakesfish/yellowperch.html**
Bluegill	**www.dnr.state.oh.us/wildlife/Fishing/aquanotes-fishid/bluegill.htm**
Channel Catfish	**www.farminfo.org/aquaculture/chancat.htm**
Hybrid Striped Bass	**www.tpwd.state.tx.us/fish/infish/species/swh/swh.htm**
Northern Crayfish	**www.aquanic.org/publicat/state/il-in/as-500.htm**
Largemouth Bass	**www.tpwd.state.tx.us/fish/infish/species/lmb/lmb.htm**
Smallmouth Bass	**www.tpwd.state.tx.us/fish/infish/species/smb/smb.htm**
All Carp	**www.seagrant.wisc.edu/greatlakesfish/carp.html**
Goldfish	**members.aol.com/sirchin/goldfish.htm**
Sunfish	**www.tpwd.state.tx.us/fish/infish/species/sunfish.htm**
Bream	**www.dnr.state.oh.us/wildlife/Fishing/aquanotes-fishid/bluegill.htm**
Crappie	**www.dnr.state.wi.us/org/water/fhp/fish/3cbcrapp.htm**
Pacu	**www.elmersaquarium.com/10pacu.htm**
Koi	**www.euronet.nl/users/w_solarz/koiv.htm**
Most freshwater ornamentals	

Plants

Plants are what this is all about. Without plants the system cannot function properly. Growing plants in soil is fairly easy but takes up valuable space because of moisture and spacing requirements. Dirt farming is kind of a knee jerk response. You see the plants wilting and add water, plants yellowing and add nitrogen or compost. Aquaponics takes care of this automatically, without much thought except to insure the flow of water. If the electricity quits or a pump fails the plants will survive several days up to two weeks depending on the temperature, but of course the fish will die within hours. The solution is to fill the dump tank manually. Yes, that does amount to "work" but there are many systems around the world that function that way miles and miles from the nearest electrical line! You do what you have to do…


New Tomatoes

Even plants needing large amounts of nitrogen, like tomatoes, can exist side by side with plants that require little, like lettuce. The nutrient rich water reaches all plants and because it only passes through, only what is needed is used. Even with good plant coverage there

are a lot of nitrates flowing out the drains back to the fish tank, enough in fact to power up another group of grow beds. This is not a concern unless the water is cloudy in the fish tank.

Transplanting seedlings is easy. Bury the seedling up to the last couple of leaves, removing all others and hand water for a couple of days until established.

Plant List

This is a partial list of plants that do well within the simplified aquaponics system.

Tomatoes	Onions	Squash
Peppers	Cucumbers	Lettuce
Spinach	Pak Choy	Basil
Begonias	Impatiens	Mints
Black Seeded Simpson	Beets	Mustard
Swiss chard	Peas	Arugula
Watercress	Chives	Beans
Watermelon	Cabbage	Taro
Redina lettuce	Endive	Spinach
Amaranth	Celery	Parsley
Tatsoi	Collard	Kale
Garlic chives	Okra	Dill
Cilantro	Recao	Rice
Zucchini	Cantaloupe	Carrots
Common chives	Endive	Stevia

Most common household plants

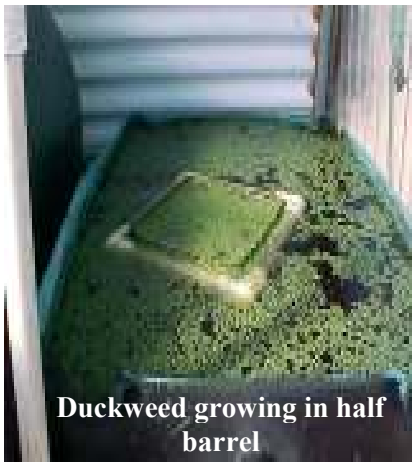
As a matter of fact I have never found anything that does do well in an aquaponics system.

Fish Food

Fish food need not be expensive. Two simple systems exist for creating fish food. First, is raising duckweed in 55 gallon barrel halves.


Duckweed Floating on top of Manure Tea

Duckweed will double itself each 24 hours under the correct conditions. The water temperature needs to be 60-70 degrees F and rich in nutrients. These nutrients can be gotten from manure tea; in my case made from donkey dung. Fish eat duckweed slower than commercial feeds so I feed at the first of the day and if all is eaten by dark then add a little more. If there is duckweed left over from the night before then simply feed less. The nice thing about duckweed is that it just floats around and too much does not constitute nitrate buildup like with uneaten commercial pellets. Eventually it will be eaten and, meanwhile, it is making more duckweed. In nature, duckweed can be found floating in calm waters, either fresh or brackish.


Duckweed growing in half barrel

Virtually all the plant is metabolically active and totally useful as a feed or food. Duckweed has high concentrations of essential amino acids, lysine, methionine, carotene, xanthophylls and trace minerals making it one of the best animal feeds available for either fish or animals like rabbits, sheep, goats or cattle. It can be fed wet or dried without significant loss of nutrients.


Floating container for manure

Nitrogen Ammonium is the preferred form of food for duckweed. This is fortunate for us as the aquaponic system produces an abundance of this material. Therefore duckweed does great in such systems except for trace minerals which because of the soil-less nature in aquaponics, are sadly lacking. This factor can be solved as it exists for not only the duckweed but both the plants and fish as well. I will cover the addition of evaporated sea salt to the system later.

Worm Composting

The second type of fish food that can be done easily is through vermiculture, the ancient art of raising worms. Thankfully, like duckweed, they raise themselves in the proper conditions. Worms like some moisture, something to eat and darkness. Worms can be eaten by fish and humans alike. Nutritional Content: Protein 19%, fat 14%, carbohydrates 4%, fiber 2%, moisture 63%.

Worms to use

Earthworms can generally be classified into three different types. Deep burrowing, shallow dwelling, and litter dwellers. Deep burrowing worms are best known as night crawlers. They need deep undisturbed burrows to live and reproduce. The shallow dwelling worms do not have permanent burrows but keep burrowing through the top twelve inches of soil. The litter dwellers live in the top layer of litter on top of the soil. (Photo by Mrs. Ed Haswell)

The best worms to use for composting are the litter dwellers, Redworms (Lumbrieus rubellus) or Red Wigglers (Eisenia fetida). One pound of these worms can convert on one half pound of food scraps into compost per day.

Constructing a worm bin

Items needed:

Large plastic container (wood can be used also)

Foam scraps that will absorb and hold liquids,

Hardware cloth

Screen or ground cloth, cut to size to fit on top of wire mesh

Paper, computer paper, newspaper or corrugated cardboard works fine. Do not use the colored glossy pages. **Figure 16** photo by Mrs. Ed Haswell

Drill 1/2 inch holes about every 2 inches around bottom of container to allow air flow. **Figure 17** photo by Mrs. Ed Haswell**.** Place foam scraps in bottom of container. These will absorb liquids if they pool in bottom of container so you do not need to have a tray underneath the container. Cut the wire mesh to fit the length of the container and at least 3 inches wider than the width. Fold the wire on both long edges to form a rack to keep wire off of bottom of container and allow air

movement. Place in bottom of container. Cut ground cloth or screen to fit on top of wire rack. This keeps the bedding from falling through to the bottom of container. Shred the paper or tear the newspaper into strips. Newspaper tears easily from top of pages. Cardboard works best when used with paper. Tear cardboard into manageable pieces. Soak the paper in water for about 10 minutes. Pull paper out of water. Paper should feel like a damp sponge. You should be able to squeeze the paper without water dripping out. Fill the worm container with the damp paper. Fluff the paper as you place it in the container to allow for air circulation. Place your worms in a pile in the middle of the bedding. Do not spread them through the bedding. Put the cover on the bin and place your worm bin where the temperature stays between 59 and 77 degrees F.

Feeding your worms

A couple of days later bury food in one corner of bedding. Cover food with at least two inches of bedding. This helps keep the smell under control and pests from getting into the food. Worms can be fed raw and cooked vegetable scraps; coffee and tea grounds (their bags and filters included), crushed eggshells, breads and pastas. Basically you can add anything that does not have meat scraps, fat or dairy products. Some people add small amounts of these things to their worm colony successfully but I have not. I have used large amounts of coffee grounds and citrus peels successfully which some worm growers do not recommend. Start with small amounts of food and increase the amount as your worm bin becomes more mature.

Problems

If your worm bin has a bad odor there could be several causes such as too much food added. Wait a few days before adding more food. Make sure food is covered by at least two inches of bedding this will help control smell and flies. There may be too much moisture in your bedding or it may be too compacted which can cause lower oxygen levels. Add more dry bedding, mix and fluff the bedding to add more oxygen. Meat and dairy products can go rancid if they are placed in the bin. Worms will not try to crawl out of the bin if the conditions are correct. If the moisture is incorrect, the bin is too wet or to dry, the worms will try to crawl out. Some people place a light above the bin to keep the worms in place. I have not found this necessary.

Harvesting

When the bedding in the worm bin has decreased in volume by half add a piece of screen to the bin large enough to fit in the bin and up over the sides. When you put the lid back on it will hold the screen in place, **Figure 18** photo by Mrs. Ed Haswell**.** Fill the screen with new bedding and start feeding in the top layer. The worms will crawl through

the screen to the area where the new food is. **Figure 19** photo by Mrs. Ed Haswell**.** About two months later all of the worms should have moved to the top level. You can then carefully pick up the screen and remove the castings from the bottom of the container. Dump the contents of the container on a tarp or large garbage bag. Sort out any remaining worms and other items that did not compost. Replace the foam, wire rack, cloth or screen cover and dump the contents of the screen in the bottom of the container. Place the screen back into the container and add more bedding. Again feed in the top layer and the worms will move to where the new food is. The worm castings can be used in potted plants or the garden. You can also make a tea with them to spray on plants.

Sea salt

An interesting addition to the nutrients in your system! Mine loves it!

The loss of arable lands due to salt accumulation is estimated by some at 2.5 million acres per year, with even more experiencing significant yield reductions at the margins. Some 30% of all irrigated lands, more than 50% in some countries, are considered economically unproductive. Finding enough arable land and water to meet world needs for food is becoming a crisis. Adding sea salt, or seawater, as the case may be, to vegetables is very controversial to say the least. We have all been taught that salt will kill plants. This is true. **However!!** Without some salt all living organisms die. In aquaponics the water only passes through, not building up as in soils.


Regular White Sea Salt

Your average seawater contains the exact properties of human blood and was used as a substitute for blood in WWII. Sea water has the proper amount of trace nutrients in just the right proportions and is only different from blood by a molecule or two. **http://www.ussl.ars.usda.gov/pls/caliche/SALTT42C**

While salt buildup in the soil has a serious effect on plants, it appears that in an aquaponic system the salinity in parts per million can be much higher. This shows promise to help meet world food needs. Try adding 1 gallon of seawater (reconstituted from evaporated sea salt at point 0.4 pounds per gallon) twice per month and you will notice increased blooms and fruiting without any ill effect at all. As a matter of fact, you will be amazed at the improved flavor and both fish and plants are extra healthy. **http://www.bonniesplants.com/how_to/salt_vs.htm.** This is probably due to the fact that water bearing nutrients pass through the gravel and don't buildup as with soil systems. The plants use only what they need. Another explanation for increased production in moist saline soils with large soil


Red Hawaiian Sea Salt

pores such as gravel is that the condensation of water vapor from salt water might be providing condensed pure water to root hairs that mobilizes the energy available from fluctuating soil temperature. **http://www.curezone.com/foods/saltcure.asp**

It is important to note that as salinity increases that the amount of dissolved oxygen decreases. What this means is that you have to keep the aeration high to obtain the greatest amount of oxygen in the water. With this design there are four points of aeration, pump supply line dropping water into dump tank, from supply line orifices to the grow bed, from the grow bed to the gutter and finally from the gutter to the fish tank. As long as the pump functions there is more than enough dissolved oxygen in the system. If the pump quits then you are in danger of losing all the fish anyway. A good detailed analysis of the trace minerals in seawater can be found at **http://www.cea-life.com/Seawater%20Analysis%20Table.pdf.** *Yes, "cea" not "sea".* Sea Salt photos from cea-life.com

Evaporated sea salt with no additives and hand harvested can be obtained from Tropical Salt Corporation, 726 Route 202 South, Suite 320 #343, Bridgewater, NJ 08807, Phone #877-323-6611 or on the web at **http://tropicalsalt.com/index.html**. I have found that they provide a quality product without all the hype. This product comes from Grand Saline, Jamaica and has been hand harvested by the same family for several hundred years. If you live near the ocean, use sea water gathered most anywhere except in a populated bay or canal.

When "evaporated" sea salt is referenced, please inquire of your source if it was heat evaporated or sun dried. The heat evaporation changes some of the properties of the salt. **I am talking about the sun dried salt and that is the only type that should be used!**

An excellent reference for using seawater or evaporated sea salt in agriculture is: Sea Energy Agriculture by Dr. Maynard Murry, M.D. ISBN: 0-911311-70-X **www.acresusa.com**

Parts Needed

To build an 8-half barrel aquaponics system you need the following:

Barrels end to end system

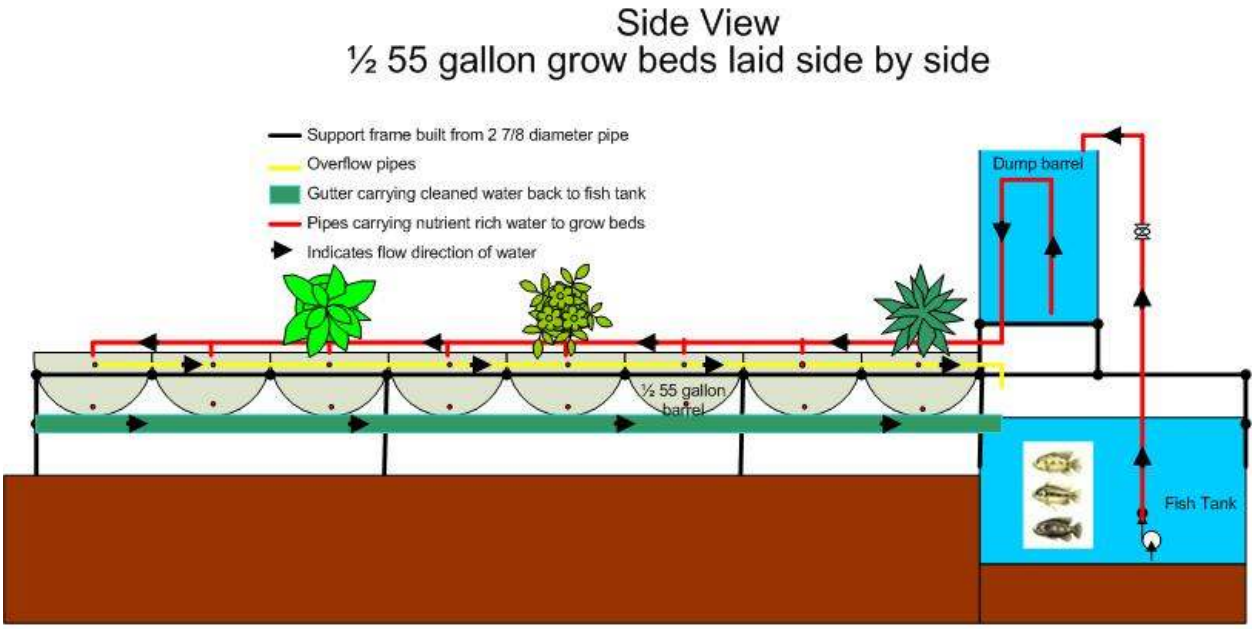
1 - 250 gal. fish or stock tank
5 - 55 gal. plastic barrels
20 ft. - 1 in. PVC pipe
20 ft. - 3/4 in. PVC pipe
1 – 1 in. slip to male thread adapter
1 – 1 in. slip to female thread adapter
10 – 1 in. PVC "T"
3 – 1 in. PVC 90deg. elbow
6 – 1 in. PVC caps
16 – 3/4 in. PVC 90 deg. Elbow
2 – 3/4 in. PVC 90 deg. elbow, slip to 3/4 in. male thread
4 ft. of clear 1 in. hose
20 ft. PVC rain gutter
2 – 20 ft. 2X6 pine (do not cut)
1 - 2X6 pine 12 ft. long (cut in half) (join to 20 ft. piece to make side rails)
(see **fig.1& 7**)
1 - 2X4 pine 18 ft. long cut in 3 ft. pieces with 45 deg. to accommodate side rails
2 - 2X4 pine 12 ft. long cut into 2ft. lengths for cross bracing and gutter support.
(see **fig. 6**)
1 lb. – 16d nails or 3 in. coated deck screws
1 – small can of "rain or shine" PVC glue
1 – small can of PVC cleaner
1 – small tube of good grade silicone cement
1 – small variable flow fountain/bilge pump w/ a 6 ft head height
Hacksaw
Power Drill
Jigsaw w/wood blade
Skillsaw w/wood blade
Drill bits; spade, 1 1/4 in., 7/8 in.
Drill bits; high speed, twist, 1/4 in., 3/8 in., 1/2 in.
Enough 1/4 in. pea gravel to fill the barrel halves
(from your local cement plant or gravel pit)
1 – 5 gal. bucket of local pond or stream water
250 gals. Non-chlorinated water

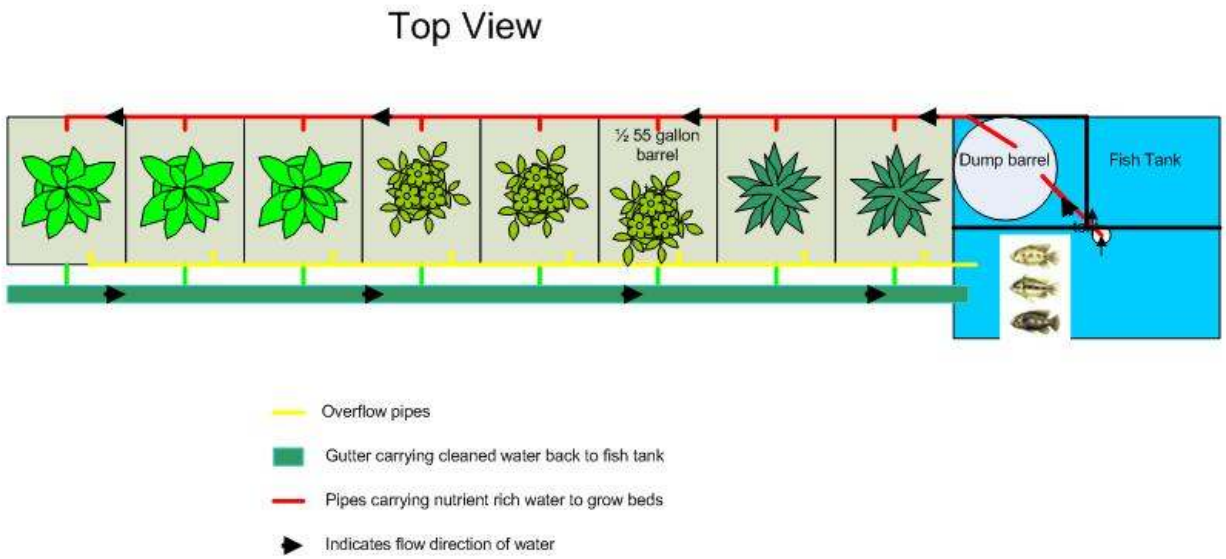
Barrels side by side system

List is the same except;
10 – 1 in. PVC "T"
3 – 1 in. PVC 90 deg. elbow
6 – 1 in. PVC caps
16 – 3/4 in. PVC 90 deg. elbow
2 – 3/4 in. PVC 90deg. elbow, slip to 3/4 in. male thread
4 ft. of clear 1 in. hose
20 ft. PVC rain gutter
2 – 20 ft. 2X6 pine (do not cut)
54 ft. - 2X6 pine (multiples of 3 ft. lengths for side supports, see **fig. 1 & 7**)
60 ft. - 2X4 pine (12-3 ft. lengths, 12-2 ft. lengths for cross braces and gutter support. See **fig. 6**)

PHOTO GALLERY

Here are some pictures & drawings showing other points of need and interest and of some other systems.





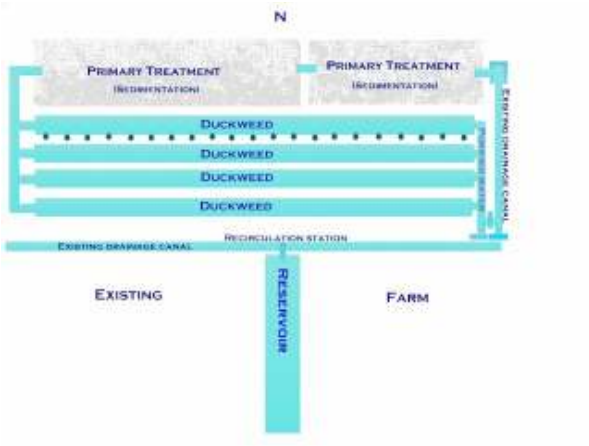
This is a typical layout for a one node system. But remember that it can just as easily be flipped with the fish tank on top. Also, for the easy of illustration the lines are shown on different sides. They can all be on the same side. It can also be "U" shaped to fit into a greenhouse if need be.

Here are a series of nodes under construction which are part of a large, commercial sized system of mine. Note the elevated dump barrels in the back right.

This is the same system as in the picture above. It has the fish tank on the top of the system. Each of the dump barrels feed two or more nodes. The water coming back into the system is from a small sump tank that is the low end of the system.

When you are starting with seeds or very small seedlings they will get a great start if you use an assembly like this. The grid style outlet has multiple holes along the bottom all of the way around. Once their root systems get developed then these grid outlets can be replaced with the regular single point outlet.

This water coming into a dump barrel with siphon is coming in faster than what you would do for a small system but each of these dump barrels are dumping for several nodes so I have the timing of the dumps running a little faster.

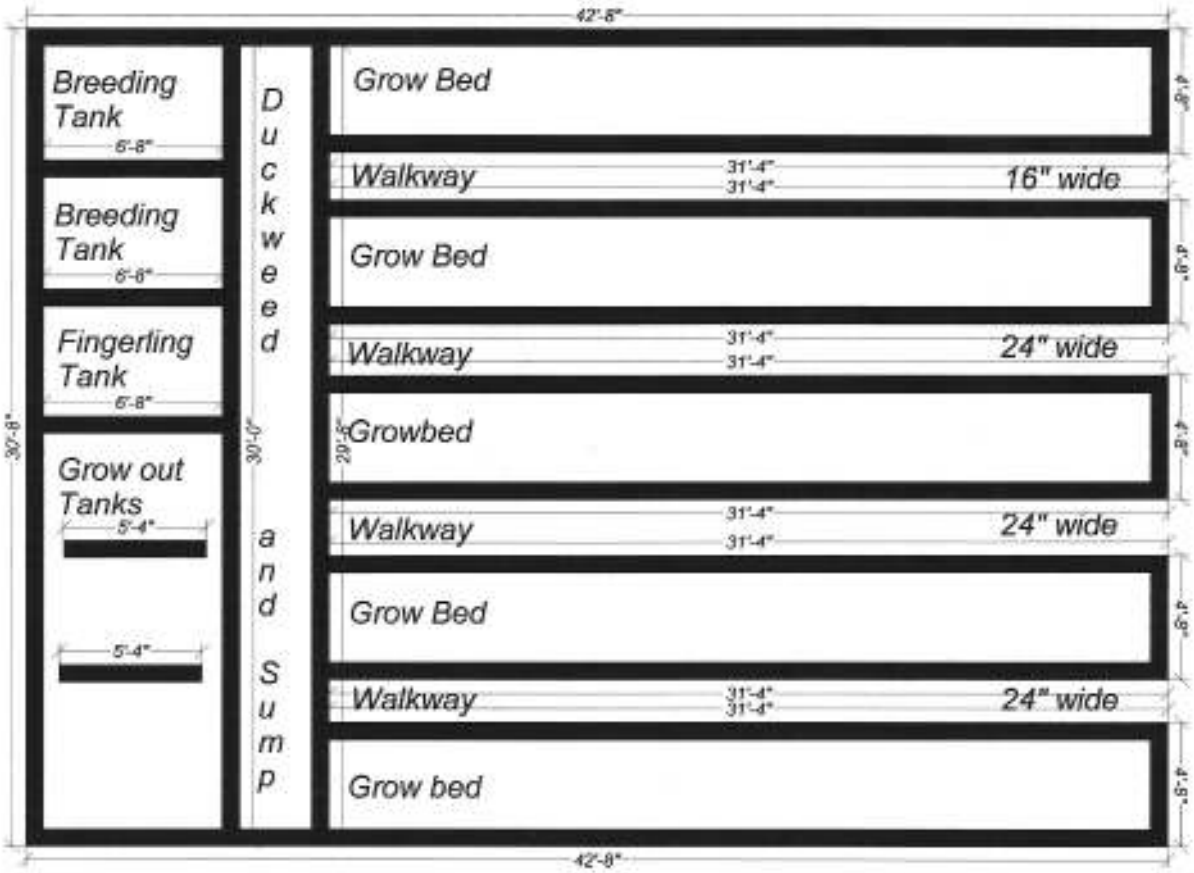


There is awesome potential in duckweed to clean up water! Not only can it be grown to feed your livestock but it can improve water quality even to the point of removing heavy metals!!!! Let's grow some duckweed!

Duckweed growing in a dump barrel & anywhere you can grow it!

My buddy, Floyd's system is a very neat straight line single node. Note that the IBC container being used for the fish tank is buried about 2 feet in the ground and that he has put a nice homemade greenhouse around it.

Now, understand this system works fine but let me point out a few things that could be done a little differently: 1. The gravel is a little too high. 2. The overflow drains are too low. 3. The flow needs to be adjusted ~ you can tell because you can see water over the gravel. The fix would be to alter the size of the nozzles on the feed lines &/or the drain lines; without actually seeing run it but my guess would be to decrease the size of the feed nozzles.



4,734 gallons total

Each grow bed 81.38 sq.ft.

406.9 sq. ft. grow area

System will produce 6,000 fish per year

16 oz. for 60 persons per week.

5.3 oz. fish three times a week.

Another complete system of grow beds can be added to bottom later without additional fish tanks.

This is a system I designed for an orphanage in Honduras several years ago. It is large enough to feed about a 100 people and as noted is designed with the idea to expand so they can sell/share the excess. They had an outreach ministry to widows in the surrounding mountains that they were hoping to increase with the expansion. Over the years I have used this basic layout in many larger projects. The drawing doesn't show the dump system but the easiest way is to place them over the duckweed/sump at the end of each grow bed.

Catnip gone wild and got cropped!

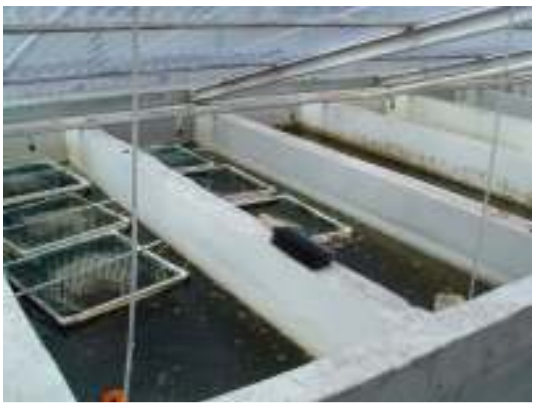
These next several pictures are from the Rio Bravo Orphanage in Reynosa, Mexico with my friend Spenser Hansen (different spelling ~ no relation, though I would claim him & his sweet family in a minute!).

I am encouraging Spence as he is grading the fish. The all got A's ~ all 5K in that one tank!

Two of 4 beds we converted over from people food to fish food. Plus we added another huge bed of same in the back greenhouse. But, hey, he has 10 – 15K fish at any given time and the chickens loved it, too.

Gee, I'm must be getting a little rusty on my fish identification! Can somebody give me some help?

This is one of the cages for propagating fish.



Here are some of the propagation tanks with the cages.

Spencer's system is so big and complex, running through several rooms of a huge greenhouse and outside and back again that I brought him down this little system so that he could show people in terms that they could understand what aquaponics is all about. It goes from top to bottom: duckweed growing tank over the dump tank, to the 2 grow beds and then the fish.

AND the best was saved for last! My dear friends, Travis and Lori Hughey, know how to do things right! Many of my projects are done with what can be had but here are some pictures of what a wonderful addition one of these systems can be when excellence is the measure! Oh, and pray for them! They are missionaries in Kenya!

Hey, here is a picture that you can see a bit of the drain guard/water level viewer in these front right beds that are not planted! Not the shot I was looking for but better than nothing.

Now this is a propagation room! WOW!

This is a picture of a worm bin under construction next to a stack of seed sprouters. I have manuals on those things as well methane production and a few others.