

# **Simplified Aquaponics Manual**

**Text & Photos By  
Drs. Paul & Bonnie Range  
Unless otherwise noted**

**With research, help & advice from:  
Travis Hughey and Ed & Gloria Haswell**



Paul & Bonnie:  
2449 FM 3509 Burnet, Texas 78611 512/755-3098 [mail@oneseedling.com](mailto:mail@oneseedling.com)

## Simplified Aquaponics Manual

Water is becoming a commodity that will be worth more than oil. 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.

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.



Fox Spring



Figure 1

Aquaponics solves all of those problems and there are no chemicals or runoff to contend with. 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. Fish and plants alike qualify under current guidelines for "Organic" and thus fetch a higher price at market.

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 will result in production up to 10 times that of a square foot of garden space.

Pictured to the left, **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 car and will fit in most kitchens and uses 55 gallon barrels which are available almost anywhere. 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, CO<sub>2</sub> 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. Our 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, 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 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 gardening where losses of 85-95% are common. Water added to the system should not be from city water sources that are chlorinated as this can adversely affect both fish and plants. City water should be allowed to sit in an open container for 24 hours prior to adding. Most well water is acceptable and we 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 most systems you had to have a fish tank, two pumps, grow beds, drain lines for each bed and a sump tank. Ours 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. We have used square, rectangular and round tanks, made from everything from plastic to metal. Polyurethane tanks seem to work the best with the least problems. 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. This will facilitate in allowing the pump to remove solids.

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

### Pump

In the simplified system you only need one 500 GPH 12 volt bilge pump that is currently selling for about \$9.95 at Wal-Mart. For those who wish to use 110V, we recommend a pump like the M350 Fountain pump by Beckett, available at Home Depot stores.

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 will actually supply another 55 gallon barrel and another complete system. Cap this system also and drill 3/8 inch hole. Do not exceed 6 feet in pumping height.



Figure 3

### Dump Tank

Using the 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 siphon is about an inch off the bottom of the 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 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

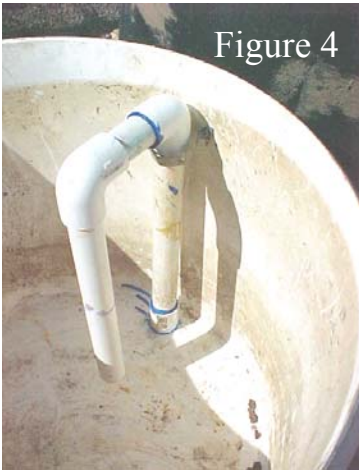


Figure 4

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.

When the sealant is dry to the touch, construct the rest of the siphon and glue all the joints. We purposely did not give measurements for the siphon 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. **Figure 5** is of a horizontal barrel dump.



Figure 5

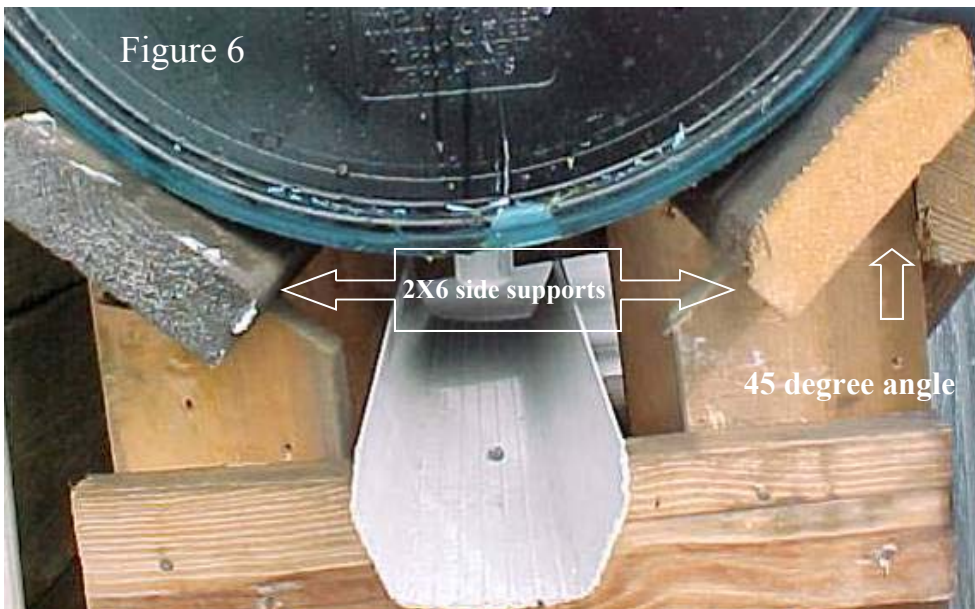
## Grow Beds

One vertical plastic 55 gallon dump barrel will supply eight 55 gallon barrel halves. Eight grow beds seems to be the absolute upper limit for a 55 gallon vertical dump system. Six 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 THOROUGHLY 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 3 inches from either end. 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. We 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. We build our racks from scrounged lumber but can be built from any material that will support the 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

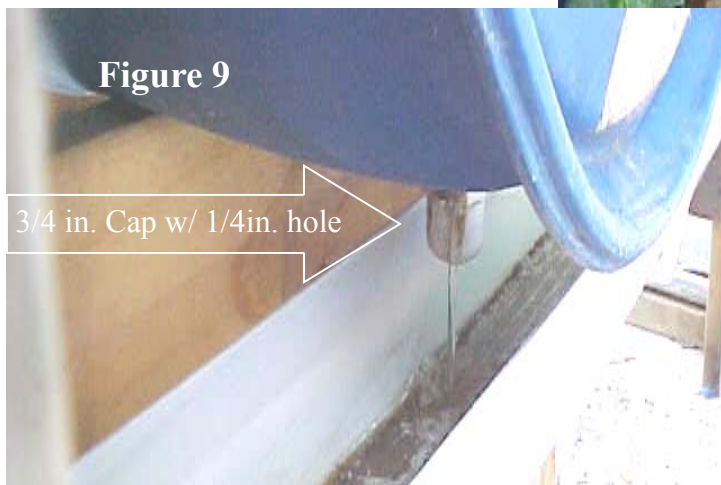


use the support system in **Figure 7**, photo by Travis Hughey. Placing the barrels side by side uses slightly more lumber when compared to end to end but takes up less linear space.

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 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 1 inch 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 3/4 inch PVC pipe so 1/2 inch protrudes on each side

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 3/4 slip to 3/4 male thread to drain to the gutter. The drain will also 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 3/4 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

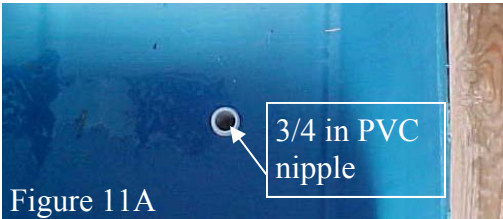


Figure 11A

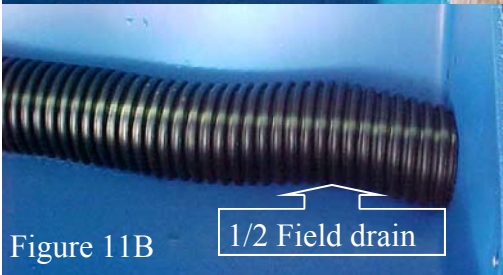


Figure 11B

### 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 con-



Figure 13

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.

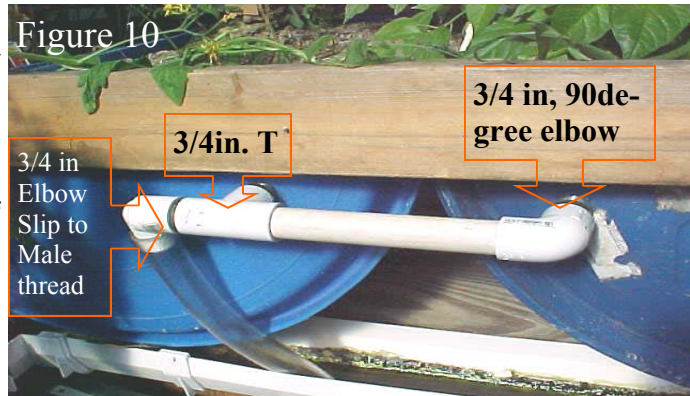


Figure 10

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**.

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 is 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

nected to the "T" and a cap with 1/2 inch hole on the end. The idea is for water to enter the pipe and flow out a 1/2 inch hole, fill the grow bed to about 2 inches from the top of the grow bed and drain slowly out the 1/4 inch hole.

Nitrogen rich water is pouring from the outlet in this picture. See **Figure 14**. The pipe is laying on the edge of the barrels. All lines should run slightly downhill for



Figure 14

## Operation

Fill the fish tank with non-chlorinated water. Start the pump. When the dump barrel initiates check for leaks. Ideally each grow bed should drain out before the next load of water comes in from the dump tank. Using a 500 GPH pump and the dump barrel insures this cycle will be 30-40 minutes long. This is enough time for the grow beds to empty. There should always be a small steady drip from the grow bed drain cap at the end of the cycle. 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.

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. We 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 400 gallon tank daily. For those who object to raising or eating animals this is a viable alternative.

## Fish

Fish are an interregnal part of our 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 our 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.

We have found that 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

1/2 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 Chinese restaurants. In Texas, raising tilapia requires special licensing and permits so we raise carp and goldfish in our system.

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

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. We have found that 6-8 grow beds per 400 gallon tank is a good operating number. 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  
 Black Seeded Simpson  
 Swiss chard  
 Watercress  
 Watermelon  
 Redina lettuce  
 Amaranth  
 Tatsoi  
 Garlic chives  
 Cilantro  
 Zucchini  
 Common chives  
 Most common household plants

Impatiens  
 Beets  
 Peas  
 Chives  
 Cabbage  
 Endive  
 Celery  
 Collard  
 Okra  
 Recao  
 Cantaloupe  
 Endive

Mints  
 Mustard  
 Arugula  
 Beans  
 Taro  
 Spinach  
 Parsley  
 Kale  
 Dill  
 Rice



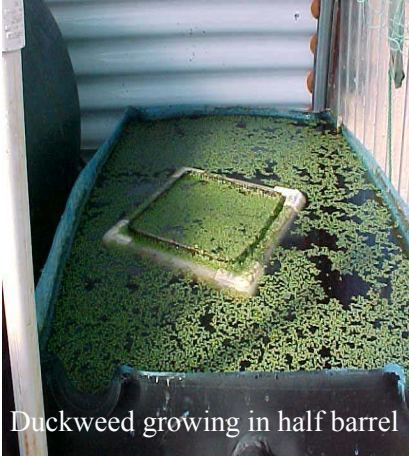
### Fish Food

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



**Duckweed** will double itself each 24 hours under the correct conditions. The water temperature needs to be 60-70 degrees F. and rich in nutrients. We get these nutrients from manure tea made from donkey dung. Fish eat duckweed slower than commercial feeds so we feed at the first of the day and if all is eaten by dark then we add a little more. If there is duckweed left over from the night before then we 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.

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. We will cover the addition of evaporated sea salt to the system later.



Floating container for manure

## 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 Gloria 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:



Figure 16

Large plastic container ( wood can be used also)  
 Foam scraps that will absorb and hold liquids,  
 Hardware cloth, **Figure 16** photo by Gloria Haswell  
 Screen or ground cloth, cut to size to fit on top of wire mesh  
 Paper, computer paper, newspaper or corrugated card board works fine. Do not use the colored glossy pages.



**Figure 17**

Drill 1/2 inch holes about every 2 inches around bottom of container to allow air flow. **Figure 17** photo by Gloria 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 bag and filters included, crushed eggshells, breads and pastas. Basically you can add any thing 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



**Figure 18**

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 too dry, the worms will try to crawl out. Some people place a light above the

bin to keep the worms in. I have found this not 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 Gloria Haswell. Fill the screen with new bedding and start feeding in the top layer. The worms will crawl through the screen to the



**Figure 19**

area where the new food is. **Figure 19** photo by Gloria 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.

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

### Sea salt



**Regular White Sea Salt**

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.

If you ingest 4 teaspoons of common table salt, within 20 minutes you will die. Ingesting the same amount of sea salt you will not. What it **will** do is decrease the diastolic reading of your blood pressure to an level that may be unacceptable. **So do not try this!**

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. We add 1 gallon of seawater (reconstituted from evaporated sea salt at point 0.4 pounds per gallon) twice per month and we notice increased blooms and fruiting without any ill effect at all. Both fish and plants seem extra healthy. [http://www.bonniesplants.com/how\\_to/salt\\_vs.htm](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 pores such as gravel is that the condensation of water vapor from salt water might



**Red Hawaiian Sea Salt**

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 our 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>. We 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 we reference “evaporated” sea salt, please inquire of your source if it was heat evaporated or sun dried. The heat evaporation changes some of the properties of the salt. **We are 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](http://www.acresusa.com)

## Parts Needed

To build a 6-half barrel aquaponics system you need the following:

### Barrels end to end system

1-400 gal. fish or stock tank  
4 - 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 – 350gph fountain pump  
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 from your local cement plant or gravel pit to fill the barrel halves  
1 – 5 gal. bucket of local pond or stream water  
400 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**)