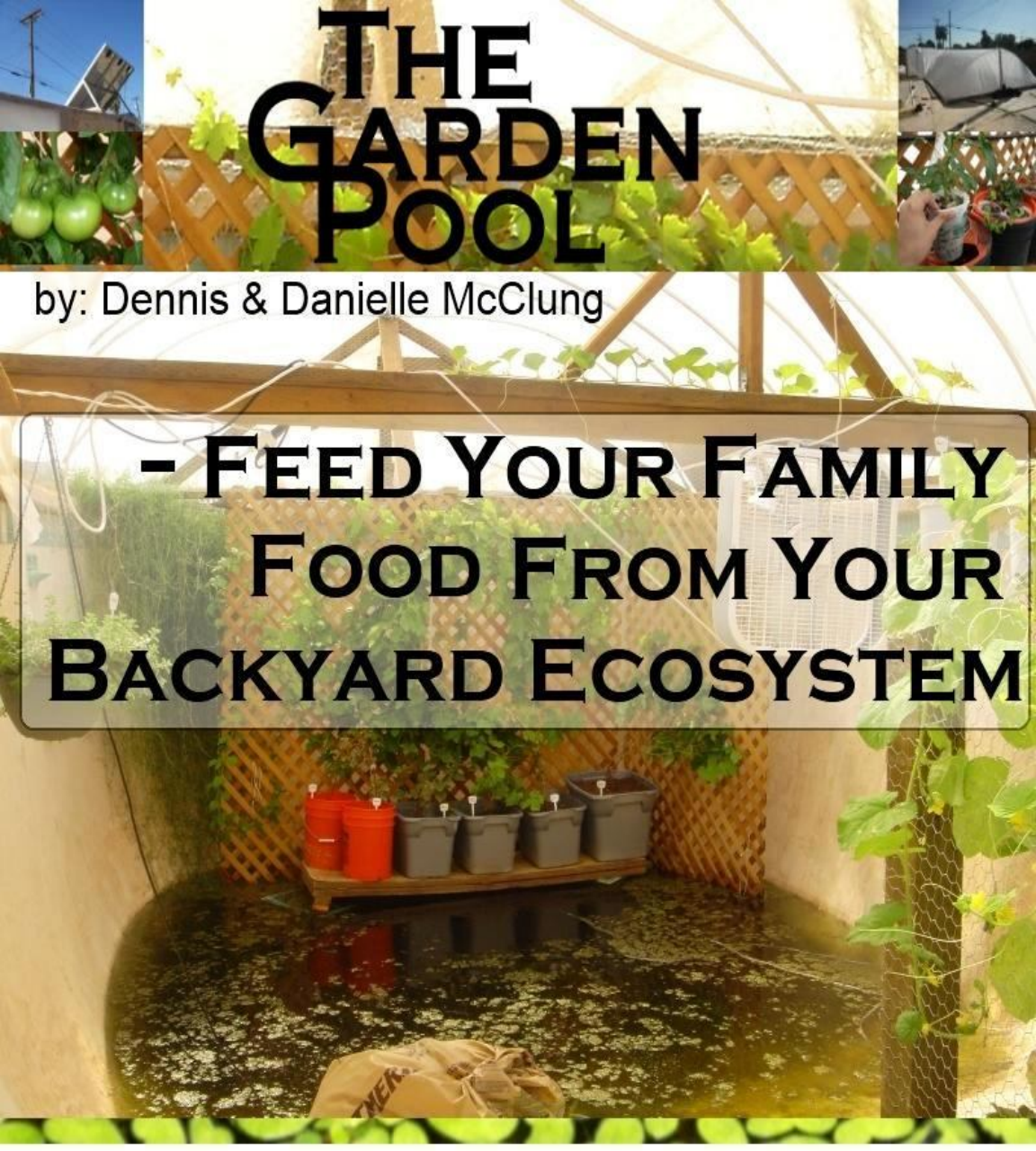
The Garden Pool

by: Dennis & Danielle McClung



- Feed Your Family Food From Your Backyard Ecosystem

- Design, Build, and Operate your own Garden Pool.
- A close-loop food production method using 90% less water than conventional farming methods.
- Aquaponics, Solar Power, Biofiltration, and more!
- Turn any backyard in to a constant food source using techniques developed at the Garden Pool.
- 10 Chapters teach you everything you need to know!

The Garden Pool

Feed your family from your backyard ecosystem.

By: Dennis and Danielle McClung

How to design, build, and operate your own Garden Pool system of self-sustaining food production in your backyard.

Published by
Garden Pool, LLP
Mesa, AZ 85201

Visit our website: GardenPool.org

First Edition: June 2012

Acknowledgments

We would like to thank the people who sent the many emails of encouragement and the wonderful folks we have met on our family's journey. We really appreciate the support and encouragement and we feel that this has inspired us to continue our journey and has helped our old pool become the Garden Pool it is today.

We would like to thank our children, parents, family, and friends for being so supportive of us in our experiment. We would really like to thank our early Garden Pool supporters including: Don Morecraft, Hilda Soto, our local Garden Pool meetup members and volunteers, JK Scott, Home Grown Hydroponics, Rosebud Magazine, Treehugger.com, MAKE Magazine, Dave “The Garden Guy” Owens, and Alex Peña.

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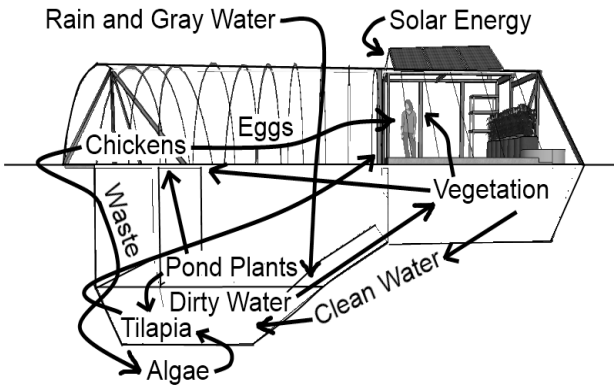
1. Introduction

1.1 Every generation has their challenges. 68 years ago humanity was overcoming the challenges of the Great Depression and World War 2. They did so and helped spur an historic population boom and a new way of living. The Industrial Age became the Space Age. Factory-made TV dinners soon replaced meals made from food grown by local farmers. If a family was doing well, there was a car or two in the garage and a swimming pool in the backyard of their suburban home.

The Phoenix Metropolitan Area has over 10,000 empty unused pools. We purchased a foreclosed home in the largest suburb in America, Mesa, Arizona. Here is the corner of our backyard and our empty pool.

Today, the solutions of yesterday have become a part of some of the challenges we face. Many suburbs are now littered with foreclosed homes with energy demanding empty pools that are breeding pits for disease carrying mosquitoes.



How the Garden Pool closed-loop food-production system works.

There are almost 8 billion mouths to feed and modern food production relies on increasingly patented hybrid plants, petrochemical fertilizers, hormone-injected animals, and other non-sustainable practices. Simply put, our generation has unparalleled challenges and we need several solutions for

our times. This e-Book will explore the solution we have created from our old backyard swimming pool.

The Garden Pool is a closed-loop food-producing system that we developed using our old swimming pool. We partially fill the pool with rain water harvested from our roof. We raise both fish and chickens and also the food to feed them in the deep end of our pool. The nutrient rich pond water is distributed using solar energy to grow fruit, veggies, and herbs using our own method of aquaponics. It is like a miniature biosphere in our backyard that provides fresh organic food for our family everyday. Being close-looped, we have had international interest in our sustainable agriculture system that we call the Garden Pool.

The McClung Family in 2011

What started as an empty swimming pool has truly improved our overall quality of life beginning with our mind, body, and soul. We have filled our minds with the knowledge of the lost art of growing food for your family. Both the healthy and fresh food we have grown and our daily garden exercise has left us our bodies in healthier shape. We feel that working in gardens and with animals is good for the soul.

Another personal benefit is the economic savings we have enjoyed. As food prices continue to raise, we estimate that we save anywhere between 50-70% off of our monthly food bill while eating better food than before. Our family collects a half dozen eggs, nearly 2 quarts of milk, fresh veggies, fruit, & herbs, and all the fish we want to eat every day!

We noticed that our family has grown closer. We spend a lot of time together outside in the fresh air. We work, play, and enjoy each others company. There is nothing greater than spending the afternoon with the kids chasing baby goats around the lawn or picking fresh strawberries. Our family has also grown a greater sense of appreciation for both hard work and fresh food. Overall, we feel that the Garden Pool has helped strengthen and improve our family life.

Besides our family life, we feel that the Garden Pool has strengthened our participation in our local community by providing a platform to meet our neighbors and others in our area that are interested in growing food. Our local meetup group has introduced us to hundreds of amazing folks from our community!

A public volunteer project, building raised aquaponic garden beds at the Garden Pool.

The benefits of the Garden Pool can be applied to a greater context than just our person, family, and local community. If applied on a larger scale then the benefits are just as proportionate. The Garden Pool is a self-sufficient, all organic, and closed-loop backyard food production method. Most nations are concerned with water and energy usage, food security, and sustainability as we approach a post-petrol world. By 2050, it is projected that there will be over 1 billion people on the planet without access to adequate potable water. Water is the maker of all life on Earth. Every living cell on the planet requires water to live as does all of our Earth's ecosystems and civilizations. Many areas on Earth rely on ancient aquifer reservoirs that have taken ages to fill making potable water a non-sustainable resource. A method of agriculture that can harvest, recycle, and store water and energy could help countless people.

Filming for a cable survival reality show in the Garden Pool. The GP method of growing food could prove invaluable for food security.

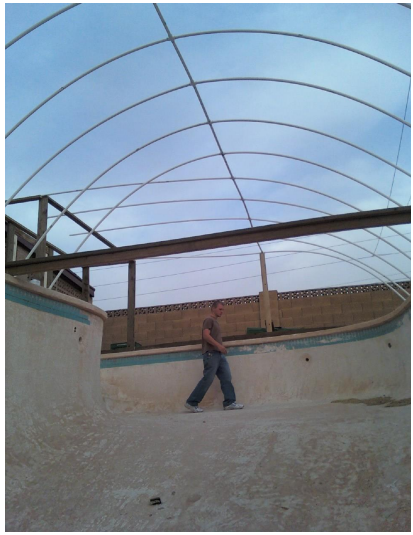
In industrialized nations, the majority of food is shipped hundreds or thousands of miles before it reaches the family dinner table. In times of war or natural disaster the

system to deliver food may be destroyed. The ability to grow food locally provides greater food security. With rising food costs and global economic turmoil, the issue of food security has become a viable issue for those who may have never considered home based food production before. Families are growing gardens again as we did 68 years ago in victory gardens.

Dennis talking with Janet Shamilan on NBC's Today Show about preparedness.

The Garden Pool system can be adapted for most climates. It uses low-tech and natural solutions in innovative ways. We openly share what we have learned with the public in an attempt to create an open source model for others to follow and modify to suit their needs. We have written this e-Book in order to further expand the ability to share what we have created and to help support our future research.

1.2 Many folks have asked us what inspired us to make the Garden Pool in the first place. In March of 2007, Dennis created the world's first 2012 survival supply website, 2012Supplies. Dennis doesn't believe in doomsday, but he was fascinated with the continuity of our civilization in the event of a societal collapse. Dennis talked to Danielle about what they could do to live a more prepared and self-sufficient life. We both felt that this could be a positive change in the way we live. We decided to use the end of 2012 as our 5 year target date. We felt that if we seriously wanted to change our lives, then we would be more likely to succeed with the pressure of a deadline. We spent the next two years gearing up to buy our first home.


Danielle's brother, Travis, helped Dennis build the Garden Pool.

In October of 2009, we experienced our busiest time in our lives as a young family. We found our first home and we were ready to close at the end of the month. The home that we were purchasing came with a huge run-down pool that would have have been very costly to fix. Dennis had designed a paper model of a greenhouse to cover the pool and Danielle agreed to the experiment. We had an empty Garden Pool constructed two days after we closed on our first home.

A view of the deep end of our pool.

Our creation was still in its early stages, but we felt that the Garden Pool had huge potential. We worked intensely on refining the design over the next year. We reached a point where we had many of our friends and family wanting to see what we had made, so we began organizing tours. We made a website and a YouTube video for those attending tours to use as reference and to share. To our surprise, our first video went viral.

Suddenly, there was a new eco-friendly way to use pools and a new way to grow your own food very efficiently using simple DIY technology. The Garden Pool became our primary focus as we began to realize what the concept could do for others as our efficiency and productivity increased.

The deep end of our pool after the Garden Pool was built.

So here we are today, humbled and thankful to have this chance to share what we have created. We hope that you succeed in creating your own Garden Pool and hope that you improve upon what we have created.

2. Coming up with a Great Plan

2.1 The first thing you should know is that you don't need an empty swimming pool to use the Garden Pool system. What you do need is an area to grow using water. We have seen folks use old spas, IBC containers, ponds, 55 gallon barrels, fish tanks, and more.

The reason why we used an empty pool is because our dream home happened to come with a large run down pool. We did not purchase our property with the intention of inventing a Garden Pool. It just happened to be the right pool at the right time. If we happened to have no present water feature, we might have dug a pond and called it our Garden Pond.

This is our backyard when we began planning the Garden Pool. Half of the backyard was an old empty pool and concrete slabs.

What is your dream food-producing setup? Do you wish to have everything the Garden Pool offers? Do you wish to scale the model up or down? You need to ask yourself these questions to define your dream before you can make it a reality. Answering the following questions is a great way to determine what path you should take:

- How much food are you looking to produce?
- What kind of food do you enjoy eating and you desire to grow.

Print a satellite image of your property to use for reference as you begin your assessment and design.

- How much time are you willing to devote to keeping the size system working?

This e-Book will teach you how to replicate the Garden Pool system, but we encourage you to make your system your own and what you are comfortable living with.

One tool that we like to be armed with before you step outside is a good satellite image of the property that has been printed off and on a clipboard. It is a great method to accurately recall every detail of your property for later use with your computer. Satellite images also gives a good picture of shadows and the orientation of the property.

To get your own free satellite image, go to http://maps.google.com and find your property by entering your address. Take a screen grab and save it as an image file. **For Windows**: press the *Print Screen* key and then open up an image program such as MS Paint. Press *Ctrl+V* to paste the image in the program. Save image in the program. **For Mac it is much easier**: just press *Cmd+Shift+4* and you will be able to crop the area to capture and it will be saved to your desktop. You can now clean up and print your own satellite image of your property to serve as a design note guide.

Satellite image that was cleaned up using an image program. The backyard is more than half full of an empty pool and concrete. The rest of the yard is sandy dirt.

Now that you have decided what you wish to feature in your design and have printed a satellite map, it is time to go outside and

walk your property. The first thing we look for are the obvious challenges. As you can see, our backyard had a limited amount of soil, lots of concrete, and a empty large pool. We were fortunate to be on a corner lot with a South Facing backyard, a flat yard, and a great place for a pond!

Every backyard will be as unique as the gardeners tending to them. Let's look at a few scenarios and suggestions to overcome the challenges they have:

- **No Pool** – There are many alternatives to keeping fish and storing water. The larger the container, the better. We have seen folks use IBC, old spas, ponds, and even inflatable pools.
- **Small Area** – Vertical aquaponics, such as Shelfponics, will help maximize the area you have to grow.
- **Roofs** – Look for runoff of rain water, gutters, and a place for a possible rooftop garden.
- **Hills** – Use hills to collect water, create flat steps, and use the benefits of gravity.
- **Shaded Area** – Grow crops more adapted for shade or use supplemental lighting.
- **Concrete Area** – Use as support for heavier grow solutions such as raised aquaponic beds.
- **Large Area** – Use large strips of land for the raft method of growing.
- **Extreme Heat** – Use shade cloth in the hottest months in your greenhouse areas and take proper precautions for areas exposed to extreme sun.
- **Extreme Cold** – Make a double layer greenhouse, use heaters, and grow cold weather food.
- **Windy Areas** – Sturdy walls, raised aquaponic beds, or staked fruit trees can help stop the force of the wind.
- **Neighbors** – It is easier to make friends with your neighbors and a quick way to friendship is by sharing food. Ultimately, you have rights and so do your neighbors. It is best to know what those rights are before altercations.
- **Pests** – The easiest way is to deal with pests is to design a physical barrier or to use a natural solution.

Everyone will have their challenges and limitations. Nothing can limit your success greater than your own lack of desire and effort to succeed in

your creation. We are our worst enemies, however, we can do anything we work hard enough at. When we first moved in to our home we had many obstacles that many would have backed away from. If we can do it, then anyone can! Take note of your challenge areas, keep your head high, and keep going.

A view of our ideal design using the Garden Pool system of food production.

As you are walking your property, take note on your clipboard of where you will place the following:

- **Pond Area** – Sunny and Low - Should be exposed to as much sunlight as possible in the lowest area in elevation in the yard to maximize solar and gravitational energy.
- **Aquaponic Greenhouse** – Sunny and Protected – Should be placed in a sunny area that is above the pond in elevation and placed near walls to protect from high winds.
- **Aquaponic Grow Areas** – Sunny and Watered – Can be placed in a variety of places from small to large. Plants require sunshine and a water source.
- **Dwarf Fruit Trees** – Sunny, Watered and Spaced – Dwarf fruit trees can be container grown or planted fairly close together, but require a significant water source such as gray water or aquaponics.
- **Chicken Area** – Coop, Food, & Water – We placed our hens in a coop above our pond so that the waste falls in to the pond. Chickens will need regular care and plenty of food, water, and space to run.
- **Goat Area** – Secure Home, Food, & Water – Goats are intelligent animals that can escape the weaker pens. We have a very sturdy

pen with a roof that has plenty of fresh air, bedding, water, and food. We took advantage of the corner of our property to use two high fences.

- **Gray Water –** Wash Water – Gray water accounts for 80% of the water a family uses. It is great for growing. Where are your clothes washing machine, bathing areas, and utility sinks? These water sources can be routed to grow fruit trees or raised beds (and then to the pond).
- **Water Harvesting** – Rooftop Area – Your roof can gather thousands of gallons of micro-nutrient rich water for growing. Think about where your gutters can flow in to your pond area.

2.2 Now that you have laid out your general 2D plan on paper, it is time to build your 3D design on the computer. We do all of our design on the free program marketed by Google called SketchUp. This free download enables you to build a scale model design of your homestead that incorporates Google Earth images. In other words, you can build a free 3D model with real satellite images of your property. There are many models you can download that others have made available to the public via Google 3D Warehouse. You can find anything from virtual PVC fittings to chickens in SketchUp. There are also many video tutorials available on Google's YouTube to learn how to use SketchUp.

Using SketchUp geo-location to import and crop satellite images from Google.

Once you have downloaded, installed, and opened SketchUp it is time for you to find your home with Google's Geo-location. After you enter your address, you will crop to fit. You are ready to begin designing in 3D.

The Garden Pool designed in Google SketchUp. The pond area is the lowest place in our backyard.

Pond Placement - The first part of the 3D design process is the pond area. The best place to place the pond is on the lowest place on the property to take advantage of gravity. If you have a pool, then this is the place for you. If you don't have a pool, you can place a pond anywhere.

Your pond must be the right size for your growing needs. Our pool was pretty large, measuring 16' wide by 30' long. We chose to use just the deep end of our pool as our pond. It is roughly 16' wide and long. The depth of the water is between 3'-3.5'. We have roughly 5,000 gallons of water. Keep in mind that you must have an equal amount of water to grow medium to twice as much grow medium than water. If we would have filled our entire pool to around 20,000 gallons, then we would have enough nutrient water for 125 raised aquaponic garden beds. This would easily be an acre farm! By using just the deep end, we can have a large, but manageable backyard garden.

The pond should get as much sun as possible as this will help with heating and growing algae. If you are using a container for your pond, it I best to bury the container. When the pond is below grade it is kept a more constant temperature by the thermal mass and you can use gravity. Also, the larger your pond is, the more stable and productive it will be.

Grow Area - After you have decided the size and placement of your pond it is time to add the aquaponic growing area. We place one pump in the pond and distribute that water to all of our grow sites. The water from the grow areas are plumbed so that the outflow goes back in to the pond. The fact that the pond is lower than the grow areas saves us energy in returning the water to the pond by using gravity. Place your grow areas closely surrounding your pond with the future plumbing in mind.

We use common items such as kiddie pools, rain gutter, and 5 gallon buckets to grow. We also use shelfponics, 55 gallon barrels, and raised aquaponic garden beds. Every type of grow areas we use are productive, however some types are better suited for specific growing applications:

A view of an inside corner of the Garden Pool growing with Shelfponics, 5 gallon buckets, and rain gutter.

- Kiddie Pool – Great for growing any type of vegetation, even trees. Must be for slab or ground due to extreme weight. The pools do great on a slight slope or an even surface.
- Rain Gutter – A very productive way that is perfect for vertical gardening any small to medium sized plants. We have over 180 linear feet of rain gutter through out the edges of our Garden Pool.
- 5 Gallon Buckets – Great for tall plants with larger root structures such as large tomato plants, and eggplant. It is also good for vine plants such as cucumber. We placed our on the inside edge of the Garden Pool.
- Shelfponics – Perfect for lettuce, basil, and even tomatoes. A great place to start plants too that can be placed in areas with a small footprint such as a corner or narrow areas.
- 55 Gallon Barrels – Great for plants of almost any kind, but they are heavy and should be placed on a level surface that can support the weight.
- Raised Aquaponic Garden Beds – For slab or ground only due to extreme weight. Great for floating plants, raft style, or filled with grow medium like gravel. Great for any vegetation.

Greenhouse - The next step is placing the greenhouse to protect the grow areas. We placed our greenhouse over our pool. We used a simple PVC hoop-house concept in our design. It is a very stable and inexpensive

option. The greenhouse should leave room on the sides to allow for vegetative growing areas. We allowed a 2' perimeter on the inside of the greenhouse that is on the ground level. It makes a great place to grow.

Once your design is complete, take a second look at the finished results. Make sure that what you have created on the program will be easy and comfortable to live with. Remember, the more you will grow, the more you will have to work on it. Make sure that your expectations are realistic with the time and energy you are willing to devout to your project. Do not set yourself up for failure. You want a design that suits your needs and lifestyle best. If you are a busy person and cannot make more time, scale your design back a bit. This voyage you are about to begin will take patience. In growing food, there are no immediate results.

The completed Garden Pool 3D SketchUp design.

Now it is time to decide what stages you will build your creation. We started by building the greenhouse structure first. This gave us a great place to work. We then added the pond to the deep end of our pool. After that, we built the vegetation portion. Create a game plan and decide how many days it will take you to accomplish this. We physically built the greenhouse structure in only two days, but everything else was built in steps. Take a look at your steps and make sure that your projects will be affordable to build and able to be completed in the time allotted. Make sure that your expectations are realistic. Building is very physical work and you don't want to get burnt out.

Now that you have a solid design and plan, it is time to break ground. Don't just sit there in research mode forever. It is time that you made a

goal for yourself for the completion date of your Garden Pool. Share what you are doing with others. You might be surprised how many people are interested in what you are doing. You may get a few volunteers to help. Once we got started, we worked at our Garden Pool every weekend until our ecosystem was self-sufficient. It took us over a year until we reached that point, but being a weekend warrior for a year was a small price to pay.

3. Building a Garden Pool

3.1 You now have a solid design and a great plan. The time has come to build your Garden Pool. We built our GP in manageable steps.

We framed the base of the GP with 2" x 6" pressure treated lumber. We also installed bridges spanning the width of the empty pool. When framing the support, use exterior grade deck screws. We used 2.5" & 3.5" screws. Deck screws will hold up with the expansion and contraction of the wood.

We begin with **Framing the Garden Pool.** We framed the perimeter of the pool with 2" x 6" x 16' pressure treated wood. As you can see in the picture to the left, we have an area surrounding the inside perimeter of the pool that is about 2 feet wide on ground level. This area will be used as grow areas when the project is complete. If you have a kidney-shaped pool, make the frame rectangular.

Once your pond is framed, you should add support bridges to keep the rectangle from expanding and adding added support. It is also a great place to hang vertical grow areas from. The picture below on the right is a closeup of the bridge support meeting the frame. We have two bridges spanning the width of our Garden Pool that you can see below to the left.

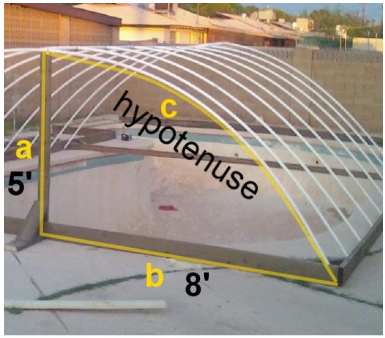
The structural bridge is made of a 2" x 4" capped with a 2" x 6" forming a "T". This meets the 2"x6" frame and is supported with diagonal cut 2"x4".

After you have the perimeter and bridges framed it is time to make the door. We placed our door in front of our pool's steps. We used 2" x 4"s to make the structure and added a door framed with 1" x 2" wood. Be sure to make sure that your entry area is plumb and square. Below to the left you will see how the entry framed in our Garden Pool.

Now that framing is complete, it is time to add **Structural Support.**

Here are the materials needed:

- 10' x 3/4" PVC – Used to construct the hoop house. You will also need the appropriate primer, glue, & fittings.
- 1/2" Steel Conduit – An alternative to PVC. It is really a matter of preference. We opted to go with PVC as it is easier to work with.
- 1/2" x 4" Concrete Expansion Anchors – Used in areas prone to high winds to prevent the Garden Pool from lifting off of the concrete and flying away. It anchors the frame to the concrete.



$$c = \sqrt{a^2+b^2}$$
$$c = \sqrt{5^2+8^2}$$
$$c = \sqrt{25+64}$$
$$c = \sqrt{89}$$
$$c = 9.44'$$

We opted for a hoop-house design because it is simple to build and is aerodynamic. Wind is the greatest foe of a greenhouse. The hoop structure is only 5' tall when standing on ground level. The shorter your structure is, the more wind resistant it is going to be.

The entry to the Garden Pool uses the existing pool steps. The PVC was mounted on the top of the door frame.

We used 10' schedule 40 PVC to serve as the ribs of the hoop-house. In order to determine the length of the PVC ribs (side "c" in the image to the right) we use the Pythagorean theorem as it is the hypotenuse of a right triangle. We know the desired height is 5' (side "a") and we know that side "b" is 8' long. Follow the formula as we did. We rounded up to 10' to account for the curved hypotenuse.

We used PVC primer and glue to connect two 10' PVC ribs that will be spaced 2' the entire length of the hoop-house. On the two ends of the hoop-house we used two PVC "T"s and

for the rest we used PVC “crosses”. We had to connect 40 10' pieces of PVC for our pool that was framed 32' long. Once the now 20' ribs are primed and glued together and have dried, it is time to connect them using 2' pieces of PVC to serve as the spine of the hoop-house.

The first half has been installed.

Do not try to glue the entire hoop-house structure at once. We connected half of the structure first. On the picture to the left you can see the first half of the hoop-house connected and installed. We used 3/4” electrical conduit anchors to connect the PVC to the wooden framed base as seen in the picture to the right. We added a vertical 2” x 6” from the framed base to stabilize the half hoop-house structure. This part of the project is much easier with more than two people to safely lift, carry, and anchor the PVC structure to the frame. When we connected the second half that met the door frame, we placed the PVC on top of the door frame as seen in the previous page of the door frame.

We anchored the completed wooden frame to the concrete with 1/2” x 4” Concrete Expansion Anchors and sturdy steel “L” brackets as seen in the picture to the left. We used a powerful 1/2” drill and concrete drill bit to make a hole in the concrete for the anchor. We anchored the frame in 4 spots of the frame that we recognized as potential areas that could lift if the wind was extreme. We anchored on each narrow end on center, where the PVC meets the vertical support 2” x 4” and the wooden base. If we wanted to, we could unbolt the Garden Pool and move it. It is not a permanent structure.

The frame of the GP is anchored to the concrete to prevent lifting in the wind.

3.2 The last thing to do is to add the greenhouse covering. The covering serves as the C**limate Control**. We use two types of coverings for the Garden Pool depending on the weather.

In the cooler months, when the temperatures are in the 50°F's and below we use a 12-14 mil UV Treated, reinforced, clear tarp with grommets. This material we have found to be the strongest clear greenhouse covering that can withstand most sever storms. We have survived the biggest storms the Sonoran desert has given us and this covering has held up hail, micro-bursts, dust devils, 60 mph winds, and a huge haboob that devoured the city. We needed a piece that was 40' x 20'. Your clear tarp should last many years. In the warmer months we use 40% White Shade Cloth that is the same size as our clear tarp and should last many years as well. The white color of the shade cloth reflects the sun and also shades. The picture above to the right shows samples of the two coverings we use and their shadows.

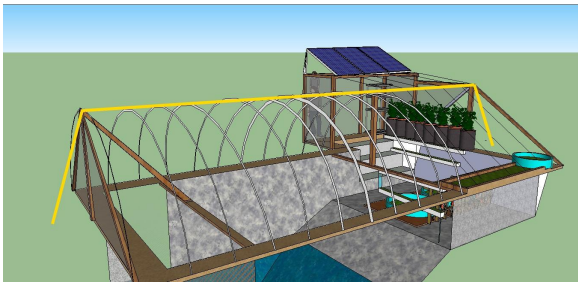
The top covering is a piece of the clear reinforced tarp and the bottom piece is the white shade-cloth we use.

The loose shade-cloth has been secured with 1/8" braided nylon strings. This web prevents the looser areas of covering from moving too much in more extreme winds.

Now that you have the cover, it is starting to look like a Garden Pool! There is still work to do. The next thing we do is secure the loose areas of the cover to the wooden base. You do not want

any areas of the cover to flap or get carried in the wind. We use 1/8” braided nylon string nailed to the wooden base to serve as a protective web over the cover. During high winds the weakest area is the cover. If wind gets under the cover, the cover may come flying off or damage your structure! In the picture to the left you can see three string that prevent the cloth from moving much during stronger winds.

Now that the cover is secure, it is time to provide the spine of the hoop-house with some extra protection. In a bad storm, the hoop-house may rock to and fro. This movement could snap the spine and could potentially collapse. As a precaution, we installed a braided 1/4” steel cable through the spine of the hoop-house and anchored it to the concrete with a heavy-duty concrete screw.



The yellow line shows where we place the braided steel cable for support.

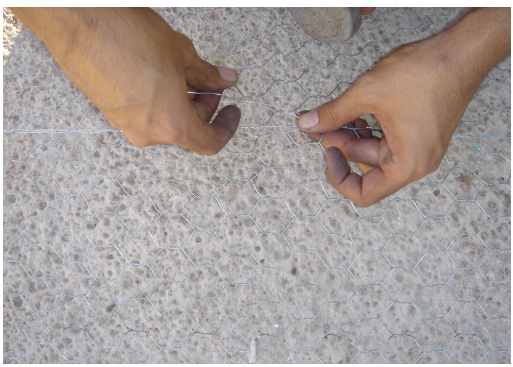
We decided to reinforce the bridges inside the Garden Pool and to add lattice to hang down in to the deep end of the pond for our grapes. We used dimensional lumber and metal brackets to add stability. The two pictures below are the before and after.

The GP has the reinforcement and lattice added.

The GP before the bridges were reinforced.

The water in the pond flows to the 3-way valve made from 1/2" irrigation tubing.

3.3 Now that the GP is built and reinforced we begin building the aquaponic grow areas. We will install one main pump that will feed all the grow areas with aquaponic water. Using one pump saves a ton of energy. We can use one pump by distributing the water flow to every area using simple our 3-way valve constructed from black ½" irrigation tubing, shutoff valves, and the appropriate shaped fittings. The shutoff valves enables correct flow to all areas. It provides back pressure to ensure a more even distribution of water. If you did not add the shutoff valves tot he tubing, the water would likely flow to the closest grow area as water follows the path of least resistance. The pump water flows from a garden hose to the 3-way valve, to the grow areas. All grow areas eventually flow back in to the pond. Since the pond is below grade, it makes it easy for gravity to carry the water back down. Here is a great video that gives a tour of how the water is distributed in our Garden Pool and how it eventually goes back in to the pond area. You should try to add as much volume of grow area as you have in your pond. You can even have twice the volume of grow area to the amount of pond water.



We braided the chicken wire together with 16 gauge wire.

3.4 Now that the structure of the Garden Pool is built and the grow areas are in place, it is time to add chickens! As you can see from the picture above to the right, we added the chicken coop above the deep end of our pond using chicken wire. We braided chicken wire together to serve as a floor to cover an area that measures 16' x 4'. We used a structural bridge and the inside edges of the framing to mount the chicken wire floor with a staple gun. We formed walls with more braided chicken wire to serve as walls until the entire

coop was enclosed.

We added an old bookshelf to serve as a place to lay the eggs. We removed the back of the book shelf and added hinges to make collecting eggs easy.

We introduced the chickens in to the coop when they were young so that they would grow accustomed to the environment and they love their unique coop. We provide shelter from the elements that does not build up with waste. Most of the chicken waste falls into the deep end of the pool that will be the pond.

A view of the chickens over the pond.

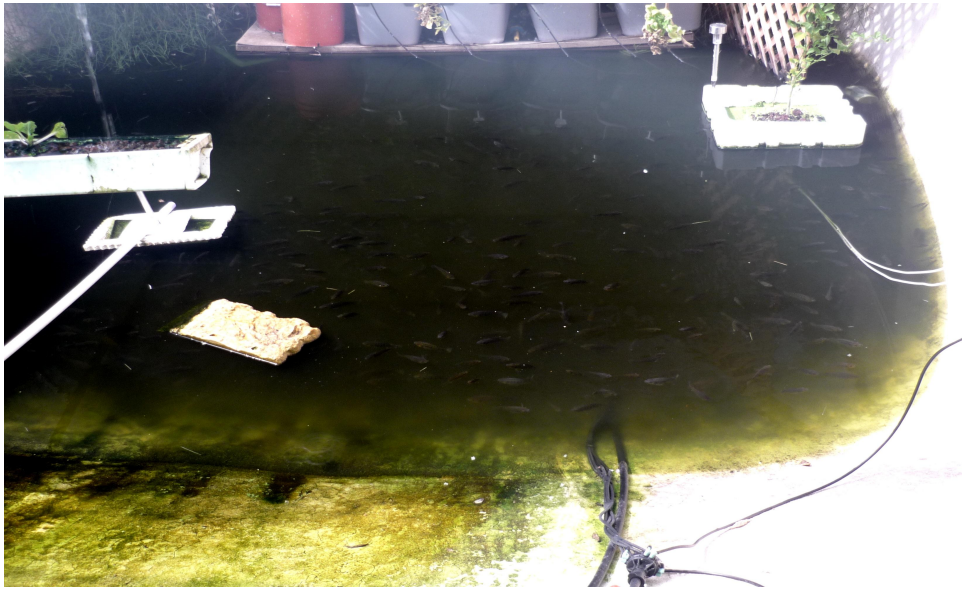
3.5 Now that chicken waste has begun falling in to the deep end of the pool, it is time to fill the pond! We originally filled the pond with city water and waited This part of the construction process really adds life to what you have created. We have decided to use the deep end of the pool as a pond for our GP system.

If you don't have an empty pool, build a pond! A simple and inexpensive way to do so is to dig a hole 3.5 feet deep and as large as you wish. Always call your utility company before you dig. Line your pond with 45 mil EPDM fish-safe pond liner. Bury the side of the pond so that the liner will not be exposed to direct sunlight when filled with water.

We originally filled our pond to about 3 ½' deep with city water from the garden hose. We filled our grow areas with grow medium and began cycling the pond. Running the pump without fish or vegetation allows you to check for leaks, it lets the chlorine evaporate, and it makes sure there are no flaws in your design. We cycled until we noticed algae forming.

Once there was algae growing we introduced our fish. We started with 5 mature tilapia (4 females and 1 male) to breed and stock our pond. About six months later, we had hundreds of fish! You will have to feed the fish with commercial fish food until you begin growing your own fish feed. The fish will love the free space and grow rapidly.

Our original 5 brooders that are swimming on the shore.



A polarized lens filters the water's reflection. There are hundreds of tilapia fish 6 months after the pond was stocked.

4. Harvest and Recycle Water

4.1 Now that you have a pond, fish, and plants that depend on the water, you must maintain the water level. One of the ways that the GP system is unique is where the water we use to maintain the pond comes from. Most of the water we use in the pond area comes from rainfall. We installed a rain-catchment system on our home that provides, on average, over 10,000 gallons of water a year in the middle of the desert! That is more than enough water to completely fill the pond twice a year. Our rain-catchment system was built as a part of a public volunteer project. We added rain gutter to our home and a 300 gallon reservoir as seen to the right. For small rains, it can store most of the rain that falls. When we have large storms, we open the bottom of the reservoir and feed it to the GP with a garden hose using gravity. As any gardener knows, rain water contains micro-nutrients that help plant growth. These micro-nutrients are often lacking in conventional aquaponic setups. The more nutrient rich the water is, the more you can grow.

Dennis and Bob carrying the final component of the rain catchment project, the 300 gallon reservoir. This public volunteer project appeared on The Learning Channel.

Dennis and a team of volunteers installing the peal and stick rolled aluminum roofing. Notice how reflective the surface is.

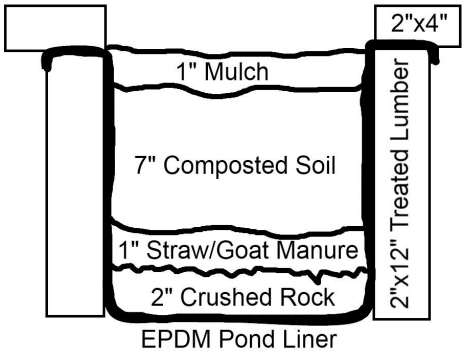
In order to get the cleanest water from the rooftop, we removed our asphalt shingles and replaced it with a unique rolled aluminum product that also keeps our home much cooler in the summer. It also cuts our electrical usage by 15% in the summer as our home does not get as hot. You

can see the installation of this roofing in the picture. This product is better suited on our low pitch roof than the shingles that we removed. Shingles should not be used on roofs with a pitch of 2:12 like our roof had. This new roof is not only better for collecting drinking water, it also keeps our home cooler in the summer, and is very durable. A white or reflective roofs are called “cool roofs” and may be eligible for tax rebates.

A view of our raised shower bed. We are growing taro, sunflower, corn, and red-leaf amaranth, and 7 dwarf fruit trees with our recycled shower water.

4.2 Another way that we add water to our system is by using our gray water, which is the water we use to wash ourselves and our clothes. This water may be up to 80% of a family's water use. We recycle our shower water and our clothes wash water to grow. Growing with gray water is easier than it sounds. The main rule with gray water growing is that you want to use bio-degradable “green” soaps and never store gray water. You must immediately use untreated gray water to avoid the possibility of growing unwanted bacteria.

We added a solar powered bilge pump to the lowest part in our shower pan, right above the drain. We piped the water through the wall with 3/4” PVC to a raised shower grow bed we designed to also filter the soapy gray water.



A cross section of a Raised Shower Bed showing the layers used in construction.

The grow bed, as seen to the right, is about 12” tall and 12” wide and 10' long and lined with EPDM pond liner.

The diagram to the left shows how we filled the raised shower bed. The bottom 2” of the grow bed is filled with crushed 1” rock. The next layer is an inch of goat manure and straw. The straw helps promote the bacteria that help bio-degrade the soaps in the gray water and the goat manure adds nutrients to the soil. We then add 7” of rich composted soil. We add earth worms to help break up the soil. On top of this layer top it off with mulch. The mulch helps retain water, covers the pond liner from the sun, and slowly adds nutrients to the soil.

We then plant in the grow bed. We avoid growing root veggies or any other plant part we eat that may come in direct contact with the gray water. This is 10 cubic feet of soil that both grows food and purifies the water. At the end of the grow bed, it is plumbed with a garden hose. Once the water leaves the grow bed, we can either add it to water the dwarf fruit trees or in to the pond area of the Garden Pool.

With our shower water, we provide water to grow 7 dwarf fruit trees, a lawn for the chickens and goats, the food we raise in the raised shower grow bed and supplement the water level of the Garden Pool. Here is a great video that shows the basics of the shower water system we use.

Here are 3 types of bananas and yucca that we grow with our laundry water.

The other form of gray water we grow with is our laundry water. With the

system we use, the clothes washing machine waste water exits in to a utility sink tub. The drain takes the water to our side yard with gravity. Here we grow 3 types of bananas, a dwarf almond tree, and a mission fig tree. The trees are planted with a moat that is plumbed to exit to the next tree and they are topped off with mulch. Here is a video to show you how that works.

The yellow line shows where our PVC is buried to connect the gravity-fed gray water system.

5. Create, Use, and Store Electrical Energy

We have 9 Solar Panels that are mounted, facing south, on top of our entry area. The electricity generated is wired to go inside the Garden Pool to the Charger Controller.

5.1 Besides water, our system needs electricity to run the pumps and the timers. The easiest ways to generate sufficient electricity for your needs is by either solar, wind, or hydro power. For us, solar was the solution. We live in the area of the US that gets the most sunshine.

We installed a small solar setup and expanded it as our electrical needs increased. That is one of the benefits of solar, you can start small and easily add on to the system you have built. It is also 12 volt DC, which is a little less dangerous to work with than 120 volt AC.

The electricity needs of the Garden Pool are not enormous. In our Garden Pool, there is one main water pump that is on a timer. We set our pump on a timed cycle to turn on for 30 minutes and turn of for 2 hours. This timing saves us a ton of energy. The demands of the pump dictate the size of your solar setup. We have a 150 watt pump. We have roughly the same amount watts in solar panels. Because we only use electricity for one fifth of the time, we store the excess electricity in three marine deep cycle batteries that

Our Charge Controller (on top right) prevents our panels from over charging the deep cycle batteries.

provide 375 amp hours of storage.

The components of a solar setup is pretty basic. You have the solar panels (seen on the previous page above to the left) which generate electricity that flows to the charge controller . Next, the electricity travels to the batteries as seen to the right. When the batteries are full, and there is no electricity being used, the controller stops the electricity flowing in to the batteries to prevent over charging and destroying the batteries. 12 volt items, such as our shower bilge pump, are wired directly in to the batteries. The items that use standard 120 volt AC must use a power inverter to convert 12 volt DC to 120 volt AC.

It is very important to make sure that all of your wiring is rated for outdoor use and that any electrical items that are not made to get wet are covered in case of rain or system leaks. Water and electricity do not mix and can be fatal. We store our electrical items in marine battery covers or 5 gallon buckets with lids. We always use indoor/outdoor electrical timers and fully submersible pumps and/or electrical heaters for fish tanks. You should feel comfortable with the thought of a rainstorm making it's way in to your Garden Pool. Your electrical components must be ready to withstand the storms. When we know a storm is coming, we make our way to the GP to batten the hatches. We make sure that the doors are closed and all electrical items are covered. If you are in doubt, cut the power.

A 2 watt LED light provides supplemental lighting to a young moringa tree.

Now that there is electricity, you can power not only your pump, but also any supplemental grow lights you may wish to add. We use LED grow light bulbs that only consume 2 watts of electricity each on simple clamp lights. They are the coolest form of lighting so you can place extremely close to your plants. We use LED lighting for our early plants that are still in vegetative mode of growing. When purchasing LED grow lights, make sure that they are in the correct color

spectrum for vegetative growth and they are made for plants. We turn our lights on at dusk and we let them run through the night. It gives our young plants a jump start in growth by doubling the hours of light the plants receive.

5.2 Solar is the way we chose to generate electricity, but it is not for everyone. There is also wind and hydro power. If you live in a windy area, then wind power is a great option. If you live near a running source of water, such as a stream or river, then hydro power would be a great solution. Both hydro and wind charge the marine batteries in the same basic way, by turning an electric DC motor. Wind power uses wind blades and wind to spin the DC motor. Hydro power uses a paddle wheel to turn the DC motor. Both hydro and wind generate electricity quicker than solar. Besides the DC motor, the rest of the system is similar to the solar setup. The electricity generated from wind or water also goes to a charger controller and then to the battery bank, just like our solar setup. You can use a hybrid system of wind, hydro, and/or solar. We will probably add a wind mill to our system. On the days when it is overcast and bad conditions for solar, it is usually windy at our Garden Pool.

5.3 We save electricity at the Garden Pool by using timers on our pumps. The timers that we use are inexpensive 3-prong indoor/outdoor mechanical timers with 30 minute increments. We have found that these timers last a long time because they are covered to prevent moisture from destroying the timing mechanism. Here is the timing we use for the various ways we grow:

- Garden Pool – 30 minutes on and 2 hours off
- Raised Aquaponic Beds – 30 minutes on and 2 hours off
- Shelfponics – 30 minutes on and 30 minutes off
- 55 Gallon Barrels – 30 minutes on and 30 minutes off
- Aeroponics – 30 minutes on and 30 minutes off

The indoor/outdoor mechanical electrical timer set to 30 on and 30 off for our aeroponic setup.

6. Bring Your Creation to Life

6.1 Your Garden Pool is almost completed. At this point, however it is not an ecosystem. What you do now is introduce a bit of mother nature to make sure your GP system maintains the biological advantage that keeps the GP from crashing. We have found that the more alive the GP is, the more reliable and worry-free the system runs. We have tried to replicate nature as much as possible, much like a biosphere. Everything we add has a reason, or maybe several reasons.

Growing duckweed during the winter in Raised Aquaponic Grow Beds.

The first thing we add are plants for the pond. The most important pond plant is **duckweed**. We use the *lemna minor* variety of duckweed.

Duckweed purifies our water, feeds both our chickens and fish, prevents toxic algae blooms, and minimizes evaporation. Go here for a starter kit. We started with a ¼ cup and now have over 50 square feet of surface area dedicated to growing duckweed.

Here are our 12 original tips for growing duckweed:

1. Duckweed prefers slow moving water, but you will notice fastest growth with areas of agitation. Slight agitation, such as where an outlet flows, seems to increase the asexual reproductive process. The duckweed divide quicker.
2. Grow in several places. You will find the best micro-climate for production this way. Also, if one spot fails, you have several others producing.
3. Do not grow in the same area as you are raising your fish. They'll eat your crop.
4. Surface Area! The more you have the more you will get. Duckweed needs only a few inches of water, but takes as much space to spread as possible.
5. Duckweed grows faster in warmer weather. If you want faster

yields, make sure your water temperature is over 70°F.

6. If your duckweed is turning white, something is wrong. The duckweed is dying.
7. Don't forget nutrients! Duckweed needs more than water and sunlight to grow. We use the tilapia waste water to grow our duckweed, but you can use other nutrients. Compost teas or organic hydroponic nutrients also do well.
8. Not all duckweeds are equal. We have experimented with several different species of lemna and have found that *lemna minor* is our favorite duckweed for production.
9. Duckweed has the smallest flower in the world, but we have never seen it. Don't worry about pollination as means of reproduction. The plant grows and divides asexually, much like a single-celled organism does. Don't worry about finding tiny bees.
10. Duckweed can grow thick! When production is highest, duckweed can grow several inches thick. We have had our pond area full before and it looked like a lawn.
11. Don't forget to add oxygen. If you place duckweed in a pool without aeration the water will eventually go anaerobic. Without oxygen, nothing will grow.
12. If you grow in an aquarium you may grow more algae than duckweed. It limits the growth of algae because it floats and gets the light before the algae, but not in clear aquariums.

The next plant we added to the pond was **water hyacinth**. Water hyacinth is another invasive pond plant and is edible, like duckweed. We grow our hyacinth in the pond with the tilapia and feed the plants to the chickens. They love eating it as much as they love duckweed. The fish will only eat the roots if they do not have any algae or duckweed. The plant grows rapidly, so make sure that you keep it in control. You never want your pond to be more than ¾ full of pond

A beautiful water hyacinth in full bloom in a raised aquaponic garden bed with duckweed.

plants. While pond plants generate oxygen for the pond in the day, it can suffocate the fish at night.

Water hyacinth's violet flower is a beautiful addition to the pond area and helps to attract pollinators for the vegetation. Our water hyacinth first blooms for us in May and continues to bloom all summer.

The roots of the water hyacinth look like feathers and is a part of the water purification process.

Water hyacinth, once again like duckweed, is great for filtering the water. Fish waste and other solids are captured by the feather-like roots of the floating pond plant. Once the solids are on the roots the snails can help remove the sludge. The fast growing plant is used by many countries to clean water from factory runoff because of the plant's ability to absorb heavy metals and chemicals such as cyanide, sulfur, phosphates, ammonia, and even chlorine.

Taro growing in the Garden Pool near the pond area.

Besides floating pond plants, we also use plants that grow on the edge of the pond. One of the fastest growing edge water plants we grow is also edible and is consumed by people all over the globe. **Taro**, also known as elephant ear, is an easy edible plant to grow on the ponds edge or kiddie pools. Taro gives a great tropical feel to your Garden Pool. We plant taro in gallon sized pots filled with a 50-50 blend of perlite and vermiculite. We place these pots half way submerged in slightly flowing water. This method of growing makes it easy to harvest the roots to eat. The taro has many culinary uses and will spread rapidly in your system through runners. We started with one plant that multiplied in to dozens of taro plants. This plant can be cooked like a potato and can even be made in to taro flour.

Marigold growing in rain gutter using NFT. Marigolds attract pollinators, repel pests, and we feed the flowers to the chickens to produce a richer colored yolk in the eggs.

6.2 As we have mentioned, we like to attract bees to the Garden Pool to pollinate. The water helps keep the bees, but the **pollinator-attracting flowers** are what brings them here. We grow marigolds, nasturtium, purslane, and hibiscus. The bees can see the flower's UV signature through the greenhouse covering. They make there way in small crevices and pollinate everything. We do not have to hand pollinate. Once the bees are in the Garden Pool, it is difficult for them to find a way out, so we always have pollination occurring.

We also let around 10% of our herbs and veggies go to the flower stage to both attract pollinators and to also produce seeds. We try to stick with heirloom varieties of vegetables because the plants are very genetically stable and they are easy to open air pollinate.

Two types of basil that are flowering.

We have found that marigolds are a great flower to attract pollinators, and they also repel pests. We try to deter the pest with the help from a few plants. There are many great pest repellant plants that you can grow.

The following plants are naturally **pest repellant plants**:

Ants Pennyroyal Spearmint Southernwood Tansy	**Asparagus beetle** Tomato Cabbage maggot Hemp Mint Tomato Rosemary Sage	**Carrot fly** Black salsify Coriander Rosemary Sage Salsify Wormwood
Mexican bean beetle Marigold Petunia Potato Rosemary Summer Savory	**Aphids** Anise Chives Coriander Garlic Nasturtium	**Cabbage Moth** Catnip Celery Hemp Hyssop Nasturtium
Garlic Onion Petunia Squash bug Nasturtium Petunia	Pennyroyal Petunia Spearmint Southernwood Tansy	Rosemary Sage Southernwood Thyme Wormwood
Japanese beetle Garlic Pelargonium geraniums Larkspur, Rue Tansy	**Colorado potato beetle** Dead nettle Flax Green beans Horseradish	**Whitefly** Marigold Nasturtium Nicandra (Peruvian Ground Cherry.)

Besides keeping the insects in check, plants can also help their neighboring plants thrive. Here is a list of **companion plants** to help your Garden Pool perform it's best:

- **Asparagus** – tomatoes and parsley.
- **Beans** – cabbage, carrots, cauliflower, cucumbers, and beets.
- **Beets** – bush beans, onions, and kohlrabi, and lettuce.
- **Cabbage** – broccoli, cabbage, collard, kale, kohlrabi, rutabagas and turnips.
- **Carrots** – onions, leeks and herbs such as rosemary, wormwood,

and sage.

- **Corn** – potatoes, peas, beans, cucumbers, pumpkin, and squash.
- **Lettuce** – strawberries, cucumbers and carrots.
- **Onion** – beets, cabbage, strawberries, tomatoes, and lettuce.
- **Tomato** – basil, chives, garlic, onion, parsley, marigold, nasturtium and carrot.

6.3 Plants are great to add to the ecosystem we have created, but now it is time to balance the system by adding some critters. The first thing we add are **earthworms**. The earthworm has proven surprisingly useful despite the fact that we do not use much soil to grow. We introduce the worms to every aquaponic grow area in the Garden Pool. Believe it or not, the oxygen rich aquaponic water does not drown the worms. They thrive in the aquaponic environment. The worms are responsible for breaking up all of the solids that are pumped in to the aquaponic grow areas from the pond. The worms convert the sludge into worm castings which provide the system with rich nutrients, including potash and potassium, that traditional aquaponic setups lack. Traditional aquaponic setups use additional equipment to separate the floating solids from the pond water before sending to the grow areas. We do not as we find it is easier and more sustainable to let the worms handle the solids from the pond water. The worms keep the roots of the vegetation clean and enables the plant to absorb nutrients more effectively.

Common pond snails eating algae in the Garden Pool.

Another crawling creature that eats sludge for us is the **common pond snail**, *lymnaea peregra*. The snails are found on areas of the pond that have large amounts of algae and on the roots of the floating pond plants. These workhorses eat algae that builds up in the pond, keeping it clean. The snails also eat the muck the settles on the pond floor. This muck is a combination of dead plant matter and animal waste. If left unchecked, this muck can contribute large amounts of ammonia in the system. The snails also provide the fish and chickens with a healthy snack of protein and calcium. In plants growing in DWC, the snails keep the roots clean, enabling the plant to

absorb more nutrients. We consider the snail to be the earthworm of the pond water.

A Black Soldier Fly rests on an aquarium in the Garden Pool.

Black Soldier Flies, or BSF, are a huge part of the Garden Pool system. The wasp-looking fly does not pester us like the common house fly does. The BSF accomplishes 3 main things:

1. Feeds our fish and hens – The BSF larvae is sold commercially as a calcium-rich and nutritious protein source. The BSF larvae are self harvesting.
2. Composts GP waste – Fish fillet scraps and left over vegetation is converted in to a great compost in no time.
3. Repels house flies – The annoying house fly is no longer a problem in the Garden Pool since we have the BSF. The house fly stays away from the pheromones of the BSF.

Once you have a well-established colony of BSF larvae going, you will have a very productive and self-harvesting feed system going. Here is our BSF Composter / Automatic Chicken Feeder. Our 8 hens can eat at the same time with this unit and it can easily be modified to feed the fish. The portability makes it easy to go between the chicken coup and the compost pile.

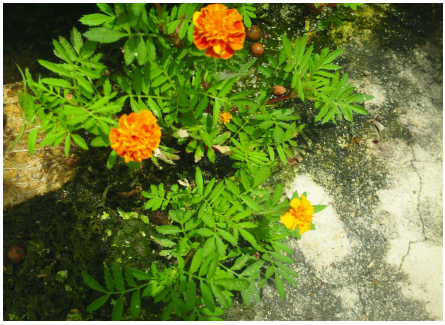
Our hens eating from our DIY BSF Composter / Automatic Chicken Feeder.

We also use **frogs and lizards** to help keep the pest population down. We have an assortment of desert lizards that love the cool and wet environment that the GP offers. Not a week goes by without spotting any lizards in the Garden Pool. We also have frogs in our pond area. They help keep the flying insects under control and also serve as a canary in the coal

mine. Frogs are very sensitive to chemicals and their disappearance would be a good indicator that there is something wrong with the eco-system.

There is also another type of fish we raise besides tilapia and that fish is called the **mosquito fish**, or gambusia. We grow these fish in our duckweed grow areas to eat mosquitoes. We cannot raise tilapia where we grow the duckweed or they would consume it all so the mosquito fish is a great addition to our ecosystem because they only eat mosquitoes. Without the proper elements, the Garden Pool could become a breeding ground for mosquitoes. These small fish eliminate that threat. Gambusia are tough to kill and take very poor water quality.

If we find that the fish are overpopulating the pond we will add **predators** to thin the small fish out. We have used a channel catfish for this purpose. We don't want to breed catfish so we only placed one fish in the pond that was about 8” in length. We will fish for the catfish once the population levels are manageable. You will know this by the ammonia levels in your system. The pond will eventually have too many small fish so a predator will balance this out.



Marigolds growing in string algae.

6.4 We grow **algae** to feed to our fish and we are even experimenting with using it as a grow medium. While too much algae is bad, such as toxic algae blooms, it is the favorite food of the tilapia. They will eat algae before they eat duckweed.

We purposefully grow string algae to feed the fish we raise. We also let algae grow on the side of the pond that are not covered in pond plants for the fish to eat. Where you have nutrient rich water and sunlight you will grow algae. It is that simple. The challenge is not growing too much that it turns toxic or takes all of the nutrients from the grow area. The way we do this is by limiting the amount of sunlight that reaches the pond. The most effective way to do this is by the floating pond plants that we have introduced.

Nitrifying Bacteria was purposefully added in to our system to jump start the biological process of converting the fish and chicken waste from ammonia to nitrite and then finally to nitrate. Nitrate is basically plant food and is much safer for the fish. We use nitrifying bacteria to do this. This bacteria grows in all of the grow medium in the aquaponic grow areas. We also added sand and rock on the bottom of the pond for the bacteria to help reduce the sludge that builds up. You can purchase powdered nitrifying bacteria at most pet stores in the fish or pond areas. It isn't necessary as the bacteria will eventually naturally occur, but it does make the process faster. Nitrifying bacteria is the most important part of the ecosystem. Without the bacteria, the entire system would eventually become toxic, killing most of the plants and animals in the ecosystem. It is one of natures miracles and a vital part of the Garden Pool.

7. Grow Plants

Lettuce and chard growing in rain gutter filled with hydroton using NFT.

7.1 Your GP is built, the water is flowing, and the chickens are clucking. It is finally time to grow food! We will now discuss aquaponics. Aquaponics is the symbiotic cultivation of fish and vegetation in a recirculating environment. To put it simply, the fish water feed the plants which filters the water. This water then goes back to the fish. Aquaponics uses more than 90% less water than traditional farming methods because the water is recycled.

We often start the plants in soil cubes or starter trays and rinse the roots free of dirt to plant when they are about 6 inches tall. For plants with small seeds like basil or lettuce, you can sprinkle seeds directly in to the grow medium and they will usually sprout. We prefer to grow in hydroton because it is very light, can be used over many times, and it makes transplanting plants easy.

We recognize 4 primary techniques of growing in aquaponics. The first method is called **Ebb and Flow**, or flood and drain. Ebb and flow floods the grow area with fish water and then the water drains back in to the fish area. We use ebb and flow in our 55 gallon barrel setup. The benefit of using ebb and flow is it uses less electricity than constant flow and the roots are ensured plenty of oxygen by allowing to dry out a little.

Deep Water Culture, or DWC, is the next method. DWC allows the plant's roots to be submerged in water at all times. We use DWC in 5 gallon buckets and also when we grow lettuce on floating styrofoam rafts. DWC must use oxygenated water to prevent the plants from getting too much water. Floating pond plants grow in a similar fashion as DWC.

The final method of aquaponic growing we use is called the **Nutrient Film Technique**, or NFT. We use NFT in our rain gutter grow method and

also with shelfponics. NFT uses a small film of water to feed the roots. We prefer to use hydroton in all of our NFT systems because it holds moisture. The one drawback to NFT is the fact that the plants can die quickly if the pump fails and you do not have grow medium to maintain moisture. NFT can grow most types of vegetation that do not have a very large root structure.

We have developed our own method of growing in aquaponics that we call the **Gravel Method**. The grow areas are full of gravel or other grow medium and the water is constantly full, but has water flowing through it. We experimented with this using kiddie pools and have found it to be the most reliable, versatile, and productive method of growing. This method is very heavy and should be on a the ground or concrete slab.

Eggplant and squash growing in a kiddie pool using the gravel method.

Now that you are familiar with the 4 methods of aquaponic growing, we will talk about example aquaponic setups that we designed and you can build. Here is a comparison chart that shows which aquaponic method of growing each different type of system uses:

	Ebb & Flow	DWC	NFT	Gravel
Shelfponics	X		X	
55 Gallon Barrel	X		X	X
Raised Aquaponic Garden Beds		X	X	X
Rain Gutter			X	
Kiddie Pools		X		X
Floating Rafts		X		

We have found that not all methods are created equal, but each has it's advantages. We find that anything can be grown in our 55 gallon barrel design, raised aquaponic garden beds, and kiddie pools. Rain gutters and shelfponics should be used for small and medium sized vegetation as well as clones, but they both are great uses of vertical space. Floating rafts should only be used for growing lettuce or other leafy greens.

Here is a chart that shows what type of plant is suited for the different methods of aquaponic growing:

	Ebb & Flow	DWC	NFT	Gravel
Asparagus	X	X	X	X
Beans	X	X	X	X
Beets	X			X
Cabbage	X	X	X	X
Carrots	X			X
Corn	X			X
Lettuce	X	X	X	X
Onion	X			X
Tomato	X	X	X	X
Squash	X	X	X	X

Lettuce in Shelfponics.

Shelfponics is a vertical aquaponic gardening system that we developed at the Garden Pool. This system uses a 10 gallon fish tank, but it can be plumbed to your pond area as we have done. It is a great use us a small space that is perfect for growing small to medium veggies and herbs. We recommend using hydroton as the grow medium because it is incredibly lightweight and provides superior drainage. We have also grown duckweed in this system. A small stream of water travels through the shelves, working it's

way down to the reservoir of fish water.

Growing in 55 gallon barrels.

Our simple 55 Gallon Barrel design has proven to be an incredibly easy way to grow just about everything that can be grown in aquaponics. Depending on how you open the valves, you can grow with Ebb & Flow, NFT, or our Gravel method. If you leave the exit valve slightly open, it will act as an Ebb & Flow system. If you open the exit valve completely open, then it will act as an NFT system. If you close the exit valves completely, then the grow area will be full of medium and water and act as the Gravel method. We prefer the gravel method as we have more time to find a new pump in case of a pump failure or clog in the system.

We grow using a variety of methods using raised aquaponic garden beds.

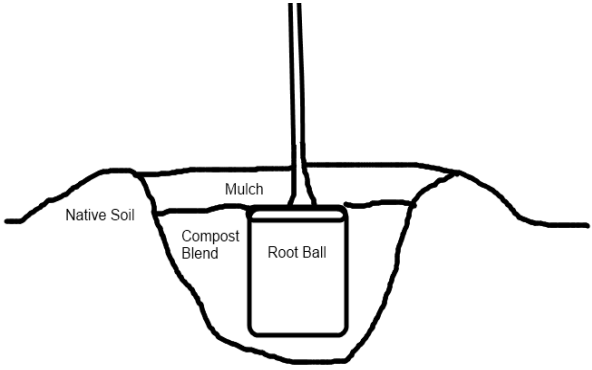
The raised aquaponic garden beds can be setup to grow with every method except Ebb and Flow. The raised beds can also serve as mini-greenhouses in the winter or they can be covered in a shade-cloth during the summer. You can float styrofoam rafts to grow lettuce, floating plants, or you can fill it with gravel and use the gravel method to grow most types of vegetation. We have our raised aquaponic garden beds plumbed to our pond in the Garden Pool.

You can be creative and come up with your own systems of growing that use the 4 methods of growing. Every system should go through the process of cycling. If you do not have fish and the water is from the city supply, then it is a way of making sure the chlorine evaporates. For us it is a great way to make sure that there are no leaks or weak areas in design. If

you see problems now, they will only be harder to take care of with vegetation growing. Let your system run long enough for a day or two. This is plenty of time to see the system work, the chlorine to evaporate, and to find areas the need fixed.

7.2 If you live in a city lot with limited space, then it is a good idea to plant **dwarf fruit trees**. These fruit trees produce fruit like non-dwarf varieties, but are usually grafted on a dwarf root stock to limit the size of the tree. Typical fruit trees may need planted 20 feet apart or more or most can be grown in containers. We space our dwarf fruit trees between 7-10 feet apart, depending on the mature size of the dwarf tree, and we water them with gray water. We currently have planted many fruit trees including avocado, fig, pomegranate, bananas, guava, orange, lemon, persian mulberry, grapefruit, lemons, peach, nectarine, almond, and more. If you are looking for a great selection of fruit trees, check out the selection of fruit trees on our website.

When we plant our fruit trees we do the following:



We plant dwarf fruit trees using a moat.

1. Always call your local utility company before you dig to make sure there are not any hidden utility lines where you are planning to place your tree.
2. Soak the area that we are going to dig in the ground with a garden hose and wait for the earth to soften.
3. Dig a hole that is three times wider and deeper than the pot that the tree is in.
4. Mix half of the dirt that you removed 1 to 1 with good quality and easy draining composted soil.

5. Put enough of your mixed soil in to the bottom of the hole so that the potted tree is level with the surrounding ground.
6. Carefully cut the bottom of the pot out and place the tree where it is going to be planted.
7. Once the tree is in place, cut a horizontal cut up the pot to remove the pot from the tree.

The yellow line shows where the 3/4" PVC is buried.

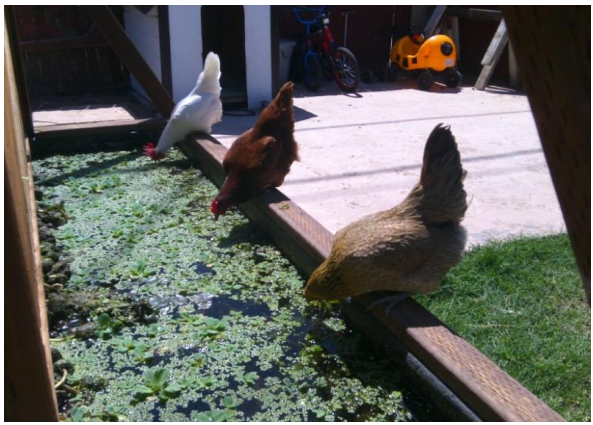
8. Fill in the rest of the mixed soil in the hole.
9. With the rest of the unmixed native soil, create a moat around the hole you dug that is about 5 inches tall and wide. This creates a water reservoir for your tree.
10. Fill the hole with compost to the top of the moat. This will retain moisture for the plant.
11. Stake your fruit tree, allowing the top of the tree to move about one foot in the wind.
12. We will connect trees together using buried 3/4" PVC. When we water one tree, the overflow waters the next tree and so on. This is very handy for gravity-fed gray water systems.

A dwarf mandarin orange tree using the gravel method.

You don't have to plant your trees in the dirt. Trees can be grown in the Garden Pool system using aquaponics because the water is incredibly rich in nutrients. We have been growing a dwarf mandarin orange tree in aquaponics for several years. We know many folks that have been growing aquaponic fruit trees all around the world.

8. Raise Animals

8.1 The Garden Pool has created a unique method of aquaponics, partly because of the introduction of **chickens** in to the system. We have found that the chickens are healthy and happy in our ecosystem. We purchase the chickens when they are chicks and raise them together in their Garden Pool coop. When the chickens are old enough to wander about, we let them free range. They naturally go back to the GP coop once dusk sets in. When the chickens begin laying eggs. We keep them cooped up until we collect eggs and then we free them to roam the yard. They help keep the bug population down, add nutrients to the pond, and provide us with eggs!



The chickens eat pond plants in the raised aquaponic garden bed.

We grow 100% of the chicken's diet in our closed-loop GP system. Here is what we feed our chickens in order of importance:

- water hyacinth
- duckweed
- snails
- bsf larvae
- worms
- veggie scraps
- sunflowers
- sorghum grain
- grass

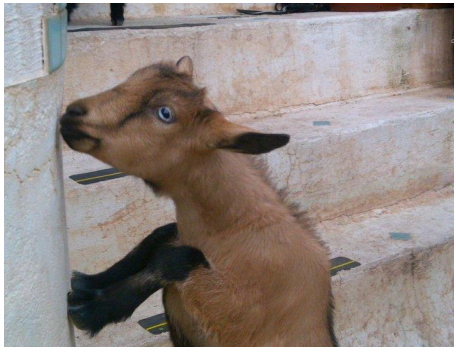
Chickens roosting over the deep end of the pool.

We let the chickens feed themselves in our raised aquaponic garden beds. Their favorite plants are duckweed and water hyacinth. They also find many bugs in our backyard as they roam the yard after laying their eggs for the day. We provide

calcium to the chickens by snails and bsf larvae. Calcium supplements are necessary for egg laying hens.

The Garden Pool chicken coop stays pretty clean. This is not usually the case with chicken coops. A clean environment is a healthy environment for the chickens and those who eat the eggs. Salmonella outbreaks occur, usually in commercial chicken factories, when the chicken eggs sit in piles of chicken waste that eventually can harbor salmonella. Since the chicken waste falls to the pond, the chicken coop is relatively free of waste. We have noticed that the chickens will waste over the pond and keep the sides clean for growing edible grass.

8.2 We raise **Nigerian Dwarf Goats**. The goats are not currently a part of the closed-loop system as we are not raising 100% of their feed, but we are working on it. The breed originated from West Africa and the goats don't seem to mind the hot summers here. The Nigerian Dwarfs are easy to handle and care for living in a city. Nigerian dwarfs only require 1/3 to 1/4 the amount of space and feed as the standard size dairy goats. The average weight is around 75 pounds. The Nigerian Dwarfs can produce up to a half a gallon of milk per day. Also the Nigerian goats have a higher percent butterfat than full sized goats, which is desirable for making cheese and makes the shelf life of the milk last longer.



Our young goat on her first day at the Garden Pool.

Dairy goats are herd animals, it is best to at least have two. One goat on it's own is not healthy for the goat, even if you have other animals, such as dogs, cats or chickens. You will have a much happier goat if you get two of them and have fewer behavior issues. It doesn't matter if the two you get are two females, a male and female, but two males may or may not get along. As for exercising your goats, it is also important for your goats health. If you have a pen that doesn't have a field or lots of room for them to roam, what you can do is buy a dog leash and take your goats for walks. The first few times you do this the goats might get confused, they are

smart animals and will catch on quickly. Goats do well with routine, just like dogs. By walking your goats it is good exercise for you and the goats.

The gestation period for our goats was just five months. The Nigerian Dwarf goats are great goats for birthing their kids, 99% of the time do it on their own with no human assistance. Honey, our doe had two kids in January and she did the birthing her self with no help from us. After delivering her two babies and eating the vitamin filled afterbirth, she was up and ready to nurse. We cleaned off the kids for her and she was a great natural mother. You won't always find that is the case. If you see the mother abusing the babies, you can take the babies away and bottle feed. Some goats do need help birthing, so be prepared to help if the time comes. The babies are fun to watch jump around. At about 6-8 weeks they should be weaned from the mother. This enables you to either sell the kids or keep them for breeding. Young bucking can breed as early as 8 weeks of age. Doelings can be breed as early as two months, it is better for the doeling to wait until 7-8 months to breed.

Our milking goat, Honey, on her milking stand.

Using your goats milk once the babies are weaned is great. You can make yogurt, cheese, butter and drink the milk as is. There are a few ways to milk your goats, either by hand or a hand vacuum pump. There are portable commercial milking units as well. Being as we only have one goat to milk, the hand vacuum pump and milking by hand is just fine for us. We milk our doe Honey, twice a day. We use our goat milking stand to make the process easier. Now that we have been milking her for a while she knows the routine and climbs right up the milking stand. You must always clean the teats before and after milking. Once you get into the swing of things milking doesn't take long at all. Our goat produces one half gallon a day, which is more than plenty for our family of five. Goats milk has so many benefits. It has more calcium than cows milk, less sodium and goats milk is easier to digest.

A Nile Tilapia we caught to filet.

8.3 We raise Nile Tilapia in the Garden Pool system because they are suitable for our environment. If you live in a colder climate then you can use yellow perch. The tilapia are a part of our closed-loop system. This is what they eat in order of importance:

1. Algae – The favorite food of our fish. Algae naturally grows anywhere that the nutrient water touches light. Our pond is dark colored because we encourage algae growth.
2. Duckweed – The floating pond plant is high in protein and the fish love it. We have to raise the plant separate from the fish or they will eat all of it. It is easy to raise and grows incredibly fast.
3. Pond Plants – The tilapia will eat the tender roots of floating plants. When the algae and duckweed is low, the fish will start to go after the pond plants such as water hyacinth.
4. Pond Snails – Tilapia eat young snails that naturally grow in the system. This adds calcium and protein for the fish.
5. Black Soldier Fly Larvae – The youngest grubs can be easily eaten by the fish. The larger grubs are eaten only by large fish. This serves as both a calcium and protein supplement.
6. Worms – We feed the earthworms that we raise to the fish as a protein snack.

The Nile Tilapia grow and reproduce very quickly. They can grow from an egg to a harvest-sized fish in 9 months. One mother fish can have more than 1,500 babies in her mouth at a time. This exponential growth is great for the GP system. We separate small fish to prevent the adults from eating them. We place the small fish in barrels and tanks until they are large enough to place in the pond with the adult fish. This method enables us to eat several fish per week as long as we keep stocking the pond with replacements.

9. Maintenance

9.1 The Garden Pool requires daily maintenance, but it does not takes more than one hour a day. Here is what a typical day looks like for us:

6:00 AM	Milk the goat and make sure they are taken care of.
6:12 AM	Inspect the chickens and fish to make sure they have plenty of food and water.
6:19 AM	Walk the Garden Pool to make sure the pumps are functioning and that the water flow is not clogged.
6:25 AM	Make sure that the fruit trees are getting water, plant seeds, tend to any plants needing attention.
6:00 PM	Milk the goat and make sure they are taken care of.
6:12 PM	Lock the chickens in the coop for the night.
6:15 PM	Walk the Garden Pool to make sure the pumps are functioning and that the water flow is not clogged.
6:21 PM	Tend to sprouts and plants that may require care.
6:25 PM	Make sure the fish are fed and happy.

9.2 Every month we perform the same routine:

- Walk the Garden Pool to inspect the structural support and greenhouse cover for signs of wear and damage.
- Clean and inspect the solar panels.
- Check the wiring for damage and areas that are exposed to water.
- Harvest larger crops and clean the hydroton.
- Inspect the chicken coop for any problems.
- Make sure that the aquaponic outlets are not clogged and free of root buildup.
- Catch small fish and separate in to tanks and barrels.
- Trim the goats hooves and clip the chicken wings.
- Check the gray water system for clogs or damage.

9.3 When the seasons change, you must prepare the Garden Pool for the coming change. Here is what you do in the winter:

- Install the plastic tarp cover when the nightly lows begin to reach the mid 50's.

- Paint the young dwarf fruit tree trunks white.
- Check the rain-catchment system for debris in the gutters.
- Check the battery bank for defects and malfunctions.
- Remove pond plants so that no more than 1/4 of the pond area is covered to help heat the water via sunlight.
- Insulate any pipes or tubing that you may worry about being exposed to freezing temperatures.

Here is what you do in warmer weather:

- Install the shade-cloth once the nightly low temperatures are out of the 50's.
- Paint the young dwarf fruit tree trunks white.
- Check the rain-catchment system for debris in the gutters.
- Check the battery bank for defects and malfunctions.
- Let the pond plants grow so that no more than 3/4's of the pond area is covered to help reduce algae blooms in the water.

10. Resources

10.1 There are many places to go from here for further education in the methods we use at the Garden Pool. The best place to learn is at the Garden Pool itself. We offer both public and private tours, free classes, and public events at our home in Mesa, Arizona. If you live near the Garden Pool, we even offer consultations, system design, and even project management. To get a hands on experience in building Garden Pool systems, join our local meetup group where we schedule public volunteer projects. It is a great way to meet other folks interested in growing food.

The next best place for information is our website, GardenPool.org. We created GardenPool.org to document our family's journey and also to serve as a source of information for the GP concepts. When we began researching online, there wasn't a single website that contained the assortment of information we needed. Here are some useful GP links:

- Online Classes: http://gardenpool.org/category/online-classes
- DIY Projects: http://gardenpool.org/category/diy-projects
- Goats: http://gardenpool.org/category/goats
- Chickens: http://gardenpool.org/category/chickens
- Recipes: http://gardenpool.org/category/recipes
- Gardening Tips: http://gardenpool.org/category/gardening-tips

10.2 There are many local places to learn about the aspects of the Garden Pool system. We believe in using local resources as they have the best information for your particular location. Here is a list of local places to learn more:

- Locally Owned Nurseries – These establishments often are the most knowledgeable of the varieties of vegetation that do best in your local area.
- Pond Clubs – There are pond clubs in most areas and it is a great resource to see other ponds, meet pond enthusiasts, and trade pond plants.
- Permaculture Guilds – These groups can be found in many locations and you will find many like-minded folks exploring relevant subjects.
- Gardening Clubs – A great place to connect with local gardeners.

- Fruit Growers Clubs – If you are looking for those who know how to grow fruit trees in your area, connect with the locals.
- Local Gurus – Every community has local leaders in various food production fields. Folks listen to them for a good reason, they are used to growing in your community.
- Extension Office – Every state in the US has an extension office that is handled by specified university. The extension office program is responsible for both the Master Gardener program and also 4-H.