1 Design Considerations
Garland Aquaponic Farm

Hub for the Urban Food-Based Economy

- Introduction
- Aquaponic Farms
- Site Designation Considerations
- Interior Design Considerations
- Lighting Requirements
- Rooftop Garden Considerations
- Energy Supply Requirements
- Core Volunteer Team
- Plan of Action
INTRODUCTION
The Aquaponic Farm (defined and described in this section) is the hub for Garland’s new urban food-based economy and its Urban Agriculture Center. With the possible exception of the Garland Farmers’ Market, it occupies the largest square footage of all the other business modules of the Urban Agriculture center and consists of three areas: Garland Aquaponic Farm, Garland Aquaponic Café, and Garland Aquaponic Grocery. The Garland Aquaponic Farm is the section of the Aquaponics building that will house the plant and fish tanks. The other one-third of the aquaponics building is reserved for the Aquaponics Café and Aquaponics grocery store where produce and fish from the farm are sold. The aquaponics building also contains the rooftop garden that will feature a hydroponic vegetable and flower garden, a greenhouse, and a solar panel array to supply energy to the Aquaponics operation (or at least supplement by at least 50%).

Details regarding the café, grocery and rooftop garden are provided in the related design considerations module.

The proposed Garland Aquaponic Farm will occupy a little more than two acres including its rooftop. While this is not a lot of space in terms of a traditional farm, it is an enormous space for an aquaponic facility. The two-acre Growing Power farm and community center in Milwaukee in 2011 was producing fresh food for 10,000 of the area and generating $250,000 in sales. Since we will expand our rooftop gardens to include the entire shopping center, we could have approximately 6 acres of space and anticipate revenues in the neighborhood of $750,000 from the Aquaponic Garden. In addition, the Aquaponic Café, Aquaponic Grocery, and Aquaponic Tours will generate additional income.

The Aquaponic Farm could also offer training and certificates in Aquaponic and hydroponic gardening in addition to daily public tours.

The Garland Aquaponic Farm is the heart of this entire plan. It is the magnet that attracts people and promotes the surrounding businesses in the Garland Urban Agriculture Center. How many people have seen a large commercial aquaponic farm in operation? Seeing aquaponics in action will raise enthusiasm in our community for this method of urban farming. It will also create retail stickiness for the other business modules. Once people see the beautiful vegetables produced hydroponically, many of them will want to try it themselves.

Next door to the Aquaponic farm is the Hydroponic Supply store. Smaller, affordable hydroponic units and needed supplies are sold in this store. Another business module located in the Garland Urban Agriculture Center is the Commercial Kitchen to Rent. Citizens who want to make their recipes and sell them commercially can create them in this kitchen that is designed to meet all the local and state requirements for a commercial kitchen. Although this business is not directly related to growing or selling live food as most of the other businesses in this center are, it is still food-connected and designed to stimulate entrepreneurs in our community. It is just one more way to provide jobs for our community. Another interrelated business that could prosper in this center might be a solar panel business—especially if the Aquaponic Farm uses solar power as the source for is energy.
**Job Creation and Strengthening Local Economy**  
The primary goal in creating the Urban Agriculture Center is to stimulate jobs with businesses that are locally held and pay a living wage for their employees. This closely related group of locally owned businesses imitates the symbiotic and mutually beneficial relationship of the fish and the vegetables. They exist in collaborative harmony as opposed to dissonant competition. Also, because these business are locally held, they anchor and secure the local economy for the people.

**Aquaponic Farms**

An aquaponic system is based on a closed-loop nutrient cycle. Fish such as tilapia and perch create fertilizer for food plants that then filter and clean the water for the fish tanks. It follows the permaculture principles as it produces no waste, integrates rather than segregates, obtains a yield, etc. Once an aquaponic system is set in place, it uses very little water—only the little bit lost through evaporation.

In other words, aquaponics creates a symbiotic environment for the plants and fish. In aquaculture, effluents accumulate in the water, increasing toxicity for the fish. This water is led to a hydroponic system where the by-products from the aquaculture are filtered out by the plants as vital nutrients, after which the cleansed water is recirculated back to the fish. The term *aquaponics* is a portmanteau of the terms *aquaculture* and *hydroponic*.

Aquaponic systems vary in size from small indoor or outdoor units to large commercial units, using the same technology. Aquaponic science may still be considered to be at an early stage, relative to other sciences. However, hydroponics is a well-established science that has successfully been applied since the 18th century.

Because of the efficient recirculating/recycling of water within the closed-loop system and the shortened growing cycle of the produce, Aquaponic farming is far more efficient than traditional farming methods. Lettuce, for example, only needs 26 to 30 days to mature, compared to the 45 to 48 days it takes in a traditional garden or farm. With aquaponics, everything is faster and larger. Reduced amount of water for its operations is also a huge benefit. Some estimates are as high as 90% less water than traditional farming methods. However, most of the literature puts that estimate at 70% less.

**Aquaponic Farm Basic Design Parameter Considerations for the Build**

The basic design parameter considerations for the build include the following:

- Fish Tank Shape and Design
- Media Beds and Sizing
- Fish to Plant Ratios
- Solids Filtration Treatment and Re-Use
• Basic Water System Chemistry

**FISH TANK SHAPE AND DESIGN**

All aquaponic systems contain three key components: 1) fish, 2) plants and 3) water that is effectively filtered and recycled through a carefully designed system of fluid dynamics to optimize plant and fish growth and minimize exposure of the fish to potential toxicity. The space in which the fish are held may be a single or a multi-tank configuration. Single tank configurations are usually applicable for home systems whereas multiple tank configurations better suit commercial applications.

As Dr. Wilson Lennard emphasizes, fish health is critical to the optimized performance of the aquaponic farm, and water quality control is paramount to both the fish and the plant health.

*Fish Tank Construction Materials*

Fiberglass and polyethylene molded tanks are the ones most commonly used although other materials such as stainless steel may be used. In keeping with the permaculture principles that are put forth as basic guidelines for this Garland project, we want to be particularly keen on re-use of any existing materials in our community for building these fish tanks. For example, there may be industrial tanks or vats from a factory that has been closed down. Perhaps the interior of these, if needed, could be coated or lined with a non-toxic substance and used for the fish tanks.

Judging from the photo below, some plant tanks such as the one from Sweet Water in Milwaukee appear to have been constructed by building a frame using wooden 2x4’s and stapling heavy industrial grade plastic liners to these. One obvious drawback to this construction is the danger of puncturing the liner when harvesting the fish.
Photo from Sweet Water Aquaponic Farm in Milwaukee. This farm was constructed on the site of a factory that had been shut down. The example shown is one of the plant tanks.

**Fish stocking density**

The number of fish to be kept in a tank of course determines the size of the tank. Fish stocking density is the weight of the fish held relative to the holding volume of water. Specifics for optimal fish stocking density may be found by referencing a paper written by Dr. Wilson Lennard: *Aquaponic System Design Parameters: Fish Tank Shape and Design*


**Flow dynamics for fish tanks: ROUND TANKS!**

Round fish tanks provide the best fluid dynamics. Corners in fish tanks will slow or quicken water flows in certain regions of the tank. They also create areas of low or even no water exchange. This is obviously not good because such a design does not ensure the timely fish waste solids removal and thus timely bio-filtration of the dissolved fish wastes and their conversion by the plants to non-toxic nitrate.

**Water flow rate and Fish stocking density**

The water flow rate through a fish tank should be as fast as is practically achievable. Dr. Lennard points out that if the water velocity is too fast, then the fish must constantly swim against the flow and this may negatively affect fish health. The water exchange rate must be adequate to ensure healthy water for the fish. [Again, more detail may be found in *Aquaponic System Design Parameters: Fish Tank Shape and Design* referenced above.]

**Water flow and solids removal**

Round fish tanks that allow for predictability of water flows also make it easy to predict where the solids of waste will settle—at the bottom and near the middle of the tank will be the highest concentration. Where a bottom center outlet is used in a round tank, an internal submerged water pump placed at the center of the tank will allow for solids to be quickly removed from the fish tank.

**Fish Tank Surface Area to Volume Ratio**

The fish tank surface area to volume ratio is important because this ratio affects the gas exchange abilities of the tank water body. If the surface area of the tank is too small compared to the water volume, then the gas exchange rate may restrict the potential for oxygen to enter the water and not enough carbon dioxide will be released. Dr. Lennard recommends that fish tank surface area to volume ratios should be as high as practical with a minimum ration of 1.0. Thus we should not be seeing any tall cylindrical shapes for our fish tanks. For the most part, they will resemble a construction shown in the illustration on the next page—more or less like that of a child’s swimming pool in terms of surface are to volume ratio, only of course the total size will be much larger for commercial fish tanks.
MEDIA BEDS AND SIZING

Note: Detail supporting this sub-section of the Garland Aquaponic Farm section may be found in a fact sheet created by Wilson Lennard PhD titled: Aquaponic System Design Parameters: Media Beds and Sizing http://www.aquaponic.com.au/Media%20beds%20and%20design.pdf

The media bed is the area used to grow the plants and perform the bio-filtration, solids filtration, and mineralization. As Dr. Lennard points out, media beds have been used to perform all these processes for over 100 years. Thus there is much scientific and engineering data available regarding the performance and design of media beds.

**Note:** the “media” in which the plants are grown is not soil. It is an inert PH neutral substance such as gravel or hydroton that is used to provide support for the plant and also the surface on which the bacteria live that will perform the water purification functions of the system.

Below is a photograph of Hydroton and a commercial bag of it (other brands are also available). Hydroton (a brand name) are expanded clay pebbles of various sizes and irregular shape. They are available in some garden supply stores and all hydroponic supply stores. At retail prices they are somewhat expensive. However, it lasts forever and does not need to be replaced or replenished as soil does. (A package I recently bought is in a bag 18x12x5 inches cost about $25. The brand I purchased is different from the one illustrated below and is imported from Germany—which brings another point up to the development of this project as a job creation plan for our community. We might explore the possibility of building our own plant to make and sell these pellets—We have more than enough clay here in Dallas County, don’t we?)
The plant beds are filled with media that performs four functions described in detail in this sub-section “Media Beds and Sizing”:

• Media beds are the site where the plants are grown
• The media in the media beds provides the surface area for the colonization of the bacteria that perform the conversion of ammonia (from the fish waste) to nitrate—a process known as bio-filtration.
• The media in the media beds filters out solid fish waste particles—a process known as Solids Filtration. [*Some aquaponic systems use separation filters to screen and thus remove these solids from the fish tank. The waste solids are diverted to a separate, isolated mineralization tank instead of passing through the media in the plant bed.*]
• In other aquaponic systems the media beds act as a site for breaking down solids and dissolving the constituent elements back into the water column—a process known as Solids Mineralization.

**Media beds are the site where the plants are grown**

The media bed is the site where the plants grow and the water from the fish is purified. Many of the same principles of hydroponic gardening apply to the media beds of an aquaponic system. The primary difference between the two systems is that the media beds of an aquaponic system are part of a closed loop eco-system whereby fish and plants thrive in a symbiotic relationship. The fish provide the nutrients to grow the plants and the plants clean the water for the fish. By contrast, in a hydroponic-only system, organic nutrients are added as needed by the human gardeners to the water in which plant roots dangle.

The media bed is a reservoir (or tank) that holds the media (an inert substance such as hydroton). The media holds the plant upright while its roots dangle in the nutrient-rich water below.

The simple system pictured in the next illustration is made from one IBC (Intermediate Bulk Container). The top was cut off and turned upside down to become a grow bed for the plants. Water is pumped up from the fish tank into the grow bed. The water trickles down through the media, past the roots of the plants before draining back into the fish tank.
Bio-Filtration Performed by Media Beds

In aerobic aquatic systems such as the Aquaponic Farm, bio-filtration is the name given to the biologically assisted conversion of the organic fish waste to an oxygen-rich state. More specifically, it is the nitrification process where ammonia from the fish waste is converted to nitrate.

Ammonia from the fish waste is a gas that dissolves in the water and can be deadly to fish. High ammonia concentrations will kill fish. However, fish have the ability to accept and live in relatively high concentrations of nitrate without any toxic effects (Ibid).

The conversion of ammonia to nitrate is performed by several bacterial species. The media in the aquaponic media bed provides this surface area for the bacterial colonization.

Bio-filtration works like this:
- The media is several inches deep as illustrated below. As you can see, there are spaces between the media.
• It is through these spaces that the dirty water from the fish flows. Bacteria grows on the top surface as well as the surfaces of these in between spaces and forms a biofilm that covers most of the surface of the media.
• The biofilm occupies some of the free spaces, thus making them smaller and trapping the solid fish waste and particles.
• Biofilm occupied and unoccupied spaces between the media particles act as a filtration zone that traps solid fish waste, thus screening and removing solid fish waste particles from the overall water column.
• The media bed also contains colonies of bacteria that break down (mineralize) the solid fish waste and dissolve it safely back into the water column.

The balance of the build-up of the solid fish waste particles with the breakdown of them through the process of mineralization is important to achieve efficient continuance of waste filtering without clogging the system.

**Solids Mineralization Rate and Bed Sizing**
It takes time for bacteria to fully mineralize the solid fish wastes and this must be taken into account when determining the size of the media bed. Ideally, the rate at which the solids enter the bed is equal to the rate at which the bacteria can mineralize the solids. The media beds must be sized for solids treatment so it doesn’t clog the system (unless as previously mentioned, you screen and divert the fish solids from the fish tank to a different tank for the mineralization process). This consideration is a function of the input rate of the fish waste solids and the mineralization rate of the bacteria present in the bed. Keeping these factors balanced will keep the system operating efficiently.

According to Dr. Lennard (Ibid), fish produce solid fish waste at a predictable rate based on the amount of food they are fed on a daily basis. Also, the fish waste solids mineralization rate of the bacteria occurs at a predictable rate based on the amount and concentration of fish waste solids present and the area available for mineralization bacteria to colonize.

Thus, it is possible to size the media bed so it treats and removes the solid fish waste at a rate equal to or faster than the rate at which fish produce the solid waste. Thus, the media bed has a low chance of ever clogging.

**Two kinds of Bacteria: Aerobic Bacteria and Anaerobic Bacteria**
We want to avoid anaerobic bacteria in aquaponic systems because they have a potential to release toxic compounds that are detrimental to the plants and fish. We want to encourage aerobic bacteria. However, because aerobic bacteria also use oxygen, the oxygen usage rate of the bacteria is also a factor in the sizing of the media bed. However, as Dr. Lennard points out, a precedent has been set with respect to sizing media beds for solids mineralization capacity. Scientists and engineers
have worked for many years in the field of constructed, media-based wetlands for the treatment of an array of organic solids. We have a huge knowledge base in this field of study.

**Aquaponic Media Bed Sizing Calculators**

There are currently a number of ways to size a media bed. However, many of them do not take into consideration the ability of the media bed to break down and mineralize the solid fish waste.

Dr. Lennard, at Aquaponics Solutions, has designed a spreadsheet model/calculator for aquaponic systems that does this. The calculator is available free to anyone who wishes to use it. See [www.aquaponic.com.au](http://www.aquaponic.com.au)

**Nutrient balancing ratios and effects**

According to Dr. Lennard and others, aquaponic design ratios are a hotly contested area of aquaponic system design. The only scientifically tested and confirmed fish feed to plant grow bed ratios freely available are those Dr. James Rakocy and his team from the University of the Virgin Islands produced.

**However, these ratios are for aquaponic systems that employ almost complete fish waste solids removal**

Dr. Lennard has experimented with these ratios at Aquaponics Solutions. Details are available at his website and also in the fact sheet referenced in the beginning of this section.

**NOTE:** Dr. Lennard uses a separated treatment approach to mineralize fish waste solids. The fish waste solids are quickly removed from the main aquaponic system using standard, established aquaculture solids separation filters (sedimentation screening) and these solids are placed in a separate, isolated mineralization tank. The tank is highly aerated. The fish waste solids break down, mineralize and dissolve into the water column in this tank.

Every day more solids are added to the mineralization tank and so every day, the aeration is turned off for a period of time and a portion of the clarified liquid at the top of the mineralization tank is added back into the main aquaponic system for plant use. This approach avoids any issues associated with directing solids through the media. It also removes any worries regarding whether the media bed is sized correctly for complete and efficient mineralization of the solids.

Dr. Lennard states that he has used this method for six years with success. Furthermore, as previously mentioned it has been used extensively in the media-based wetlands industry.
FISH TO PLANT RATIOS
Aquaponic System Design Parameters: Fish to Plant Ratios (Feeding Rate Ratios)

As mentioned in the previous sub-section, aquaponic feeding rate ratios are an area of debate.

The two major components of any aquaponic system are the fish and the plants. Some recommend a ratio between the volume of water for the fish and the volume of water for the plants. Others recommend a ratio between the volume of water for the fish and the volume of media in the bed. Still others recommend a ratio between the number of fish and the volume of media in a media bed.

However, if any balance is to be met, Dr. Lennard suggests it is a balance between the amount of fish waste produced and the amount of that waste the plants will use or uptake as their nutrient source.

The amount of fish waste produced is, of course, directly related to the amount of food the fish eat.

Lennard suggests a few simple steps to determine feeding rate ratios:
1. Determine how many plans and of what species you wish to grow.
2. Determine the area those plants need to grow.
3. Determine how much fish feed the fish need to eat to meet the nutrient requirements of the plants.
4. Determine what weight of fish we require to eat that amount of food
5. Determine what volume of water that weight of fish needs to happily live in.

For more detail regarding feeding rate ratios please reference the paper cited above for this sub-section.

SOLIDS FILTRATION TREATMENT AND RE-USE
Aquaponic System Design Parameters: Solids Filtration Treatment and Re-Use

Solid filtration, treatment and re-use may be configured two main ways:

1. Use standard, established aquaculture filtration methods to quickly remove and separate the solids from the fish tank mineralizing those separated solids away from the main aquaponic system and then returning the mineralized supernatant to the main aquaponic system. [‘This is what I recommend from my research.’]
2. Use media beds to perform filtration that keeps the solids within the main aquaponics system and rely on the media beds to mineralize the solids of the resulting nutrients are available in the main system.

The golden rule for Recirculating aquaculture systems (RAS) in terms of solids treatment and processing is to remove as many solids as quickly as possible. Many of these solids removal approaches have been adopted and evolved from the sewage wastewater treatment industry.

The two most common methods to physically remove solids from water bodies are:

1. **Sedimentation techniques** in which the solids are separated from the water column by using gravity to settle them out.
2. **Mechanical techniques** in which the solids are mechanically removed from the water column using screening.

Sedimentation uses the force of gravity upon the solid particles to settle them out of the water column. Once at the bottom of the tank, an ancillary approach such as suction may be used to remove the collected solids.

**Mechanical filtration** uses some sort of material to screen the water so that the water will pass through but the solids will not. The smaller the pore of the screen the more solids may be separated.

Screen filters come in two types:
1. Static—the screen does not move and the water passes through it.
2. Moving—the screen moves so that its entire surface may be exposed to the water to be filtered.

Static screen filters need active management as screens need to be regularly removed, washed and re-inserted. If the requirement to wash the screens rises above 2 to 3 times a day because they clog too often, this is impractical.

The most popular type of screen filter is the drum screen filter. The screen is attached to a drum. The drum is a an automatic, self-cleaning filter that makes sense for large aquaponic systems with many fish.

**NOTE:** From all I’ve read, I do not recommend using the media beds to filter the solid fish waste. It’s just too tricky to size media beds so there is a level of predictability. Too many examples are cited in the literature where the amount of solid fish wastes entering the media bed are greater than the media bed can handle in terms of solids mineralization. Thus solids begin to accumulate and clog the system.
Bacteria
Aquaponic systems have three biological inhabitants: plants, fish and bacteria. Bacteria is critical to the operation and ecology of the aquaponic system. It performs critical processes that assist and drive the biological balance of the system and make the water livable for the fish and plants.

Because they are biological beings, they do use some of the nutrients in the aquaponic system such as carbon, oxygen, nitrogen, phosphorous, potassium, calcium and others just like the fish and plants do.

Nitrification, a critical process in the aquaponic system, converts ammonia to nitrate. It is performed by several species of nitrification bacteria.

Fish
Fish also are dependent on the water to deliver a living condition that is right for them. Fish gills do not just act as a site for oxygen and carbon dioxide exchange. Fish also expel the products of some of the metabolic processes through their gills. For example, they expel ammonia through their gills as a gas that immediately dissolves in the water. Nitrate levels that are too high in the water are harmful to fish.

Plants
The nutrients that the plant roots are taking up from the water can be affected by the chemistry. Hydroponic farmers know that if the PH of their water is incorrect this can stop their plant from gaining access to the nutrients.

Water
Water is in a constant chemical flux. It is a highly reactive element than can be affected by many chemical forces. The pH of water is often referred to as “the Power of Hydrogen. The scale of pH is between 0 and 14. pH 7 is known as “neutral pH.” When pH drops below neutral 7, this state is known as “acid”. When pH is above neutral 7, it is said to be “alkaline. Fish have an internal pH of about 7.4 and they like the water they swim in at approximately the same level. If the pH of the water is too low or too high, it can kill the fish. The pH level of an aquaponic system should be checked daily/

The most important water chemistry to test is pH as this allows us to manage and manipulate the water chemistry to our own requirements. However dissolved oxygen, water temperature and electrical conductivity are also important parameters that can be used as indicators.
of how our aquaponic system is operating. An understanding of water chemistry is important to controlled aquaponic system operation and management.
SITE DESIGNATION FOR GARLAND AQUAPONIC FARM

Before the details of the design can be drawn up, a site must be selected and either purchased or leased.

*Permaculture Principle 5—Use and value renewable resources and services:* Make the best use of nature's abundance to reduce our consumptive behavior and dependence on non-renewable resources.

The proposed site for the Garland Aquaponic Farm is a location within the cluster of businesses to be known as *The Garland Urban Agriculture Center.* The proposed site is a suitable location for a number of reasons: it is on a main thoroughfare (Lavon); it is very near to the George Bush; and it is about two miles from the Firewheel Center. Another possibility for the location of the Garland Urban Agriculture Center might be an area closer to, or possibly even on the downtown square of Garland. Ideally, the site will be one that can house the Aquaponic Farm, Café, and Grocery in one space. Additionally it should have at least five other empty space adjoining or within walking distance as well as a place for a farmers market and parking.

The site found that appears to offer the most potential was once an Albertson’s store located near the intersection of Lavon and Naaman School Road. Area traffic generators include Firewheel Mall, Home Depot, Lowes, Kohl’s, Hobby Lobby, Tuesday Morning, Big Lots, and Wells Fargo branch.

However before any determination is made to purchase the property, an architect a structural engineer, electrician and plumber who have an understanding of the basic parameters of this proposed build should inspect and provide approval. Of course all zoning requirements would need to be cleared as well.
Potential Site Advantages:

- Storefront has high visibility from Lavon
- Located conveniently off the George Bush and about 1.5 miles from the Fire wheel Shopping center
- The building is for sale.
- The interior is over an acre (66,817 square feet)
- The roof is flat and over an acre—perfect for a rooftop garden and an array of solar panels
### Property Information

**Location**
Store #4118  
3046 Lavon Drive, Suite 129  
Garland, Texas

<table>
<thead>
<tr>
<th>SIZE</th>
<th>NNN</th>
</tr>
</thead>
<tbody>
<tr>
<td>66,817 SF</td>
<td>Tax</td>
</tr>
<tr>
<td>6.16 Acres</td>
<td>CAM</td>
</tr>
</tbody>
</table>

- NNN:
  - Tax: $1.85
  - CAM: $0.07
  - Ins.: $0.07
  - Total: $1.99

**Traffic Counts**
- Lavon (SH 78): 40,000 VPD (TxDOT 2010)
- SH 190: 27,000 VPD (TxDOT 2010)

### Demographics

<table>
<thead>
<tr>
<th>Year</th>
<th>1 Mile</th>
<th>3 Mile</th>
<th>5 Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population 2012</td>
<td>13,772</td>
<td>96,334</td>
<td>257,040</td>
</tr>
<tr>
<td>Avg. HH Income 2012</td>
<td>$75,103</td>
<td>$72,803</td>
<td>$77,289</td>
</tr>
</tbody>
</table>

---

**Store Front Visible from Lavon.** (Albertsons signage has been removed)
INTERIOR OF AQUAPONIC FARM WITH CAFÉ AND GROCERY IN FRONT

The roof will also feature a vegetable garden—perhaps vertical hydroponic only. Also part of the roof will be home to a solar panel array.
INTERIOR DECORATION CONSIDERATIONS
It is suggested that a professional interior design consultant be part of the build for the Aquaponic Farm, Café, and Grocery. This is to ensure that, in addition to being functional and safe, the Farm, Café and Grocery [known collectively as The Garland Urban Agriculture Center] will have a design that is cohesive among the three elements of the Urban Agriculture Center. We don’t want to end up with a center that looks hodge-podge and mismatched. We want a modern clean look that speaks of the 21st century as opposed to a throwback to 1960.

INTERIOR LIGHTING REQUIREMENTS
The primary requirement here is that the lighting will be sufficient to sustain the health and growth of the plants and fish. The Build Team will determine the placement as well as all the other details regarding the interior lighting requirements. Possibilities also include installing roof top skylights.

Design Considerations for Lighting:
- **Canopy Penetration** – The light should penetrate deep enough into the plant’s canopy to effectively light the lower leaves. A tomato plant has a very different canopy depth than a lettuce plant.
- **Heat** – Some light sources produce a lot of heat. This can be a good thing when you are heating a greenhouse in the winter but not so good if you are growing in an enclosed space in Texas in the summer.
- **Duration** – how long you run your lights depends on day-length requirements of the plants. And whether they are fruiting plants such as tomatoes or foliage such as lettuce.
- **Spectrum** – Make sure you are covering the blue and red spectrums that are absorbed by plants.
- **Energy input for light output** – Some fixtures require a lot of power and others are energy efficient.

Currently there are three types of lighting sources, in addition to natural lighting:

1. **Florescent Lighting using T5 bulbs**
As the number next to the “T” goes down, so does the diameter of the bulb. (T8’s are bigger than T5’s and T 12’s are bigger than either T8’s or T5’s.)

T5’s have a broad plant lighting spectrum so they work for both fruiting and foliage plants. They are also low power use and don’t throw off a lot of heat. However, they will only reach through 18” of plant canopy. For taller plants such as tomatoes you can put them up sideways. Their performance drops off significantly after 6 months, even
though they still look just as bright as the day you got them. You must replace the bulbs every 6 months of use.

2. High Intensity Discharge (HID) Lighting

Both Metal Halide (MH) and High Pressure Sodium (HPS) bulbs fit into the HID category. Their general characteristics:

Bulbs usually last a year but they are more expensive and throw off serious heat. They provide much more intense light that goes through almost any plant canopy. If you get a switchable ballast you can easily move from a high-pressure sodium bulb (red spectrum for fruiting) to a metal halide bulb (blue spectrum for vegetative growth) for an even more precise plant spectrum. Bulbs last at least a year. However, the bulbs are expensive, they draw more power than fluorescents, and they throw off some serious heat.

- **Metal Halide bulbs** – These bulbs produce an intense light of blue-white spectrum – excellent for vegetative plant growth. A plant grown under a metal halide light will often exhibit increased leaf growth and strong stem and branch development. They are less suited for the flowering and fruiting stages of most plants.

- **High Pressure Sodium** – These lamps produce an orange light, which simulates the autumn sun. This light is best for fruiting and flowering – flowers and fruit will be larger and more prolific when these lights are used. Flowers and vegetables finished off under high-pressure sodium will show tighter, stouter blossoms with increased yields. High-pressure sodium lights are often used in commercial greenhouses. If there is to be only one light source for the entire life of a flowering plant, HPS is the best economical choice. Many indoor and hydroponics gardeners switch between MH and HPS bulbs, depending on the growth cycle.
**LED lighting** – one of the newest of the lighting technologies on the market. The pros of LED are their very low power consumption, they produce no heat and you never replace the bulbs. But because they are still new there is not much data regarding how well they supply plants with needed light. They also cast an odd light over the plants that gives a red glow to the room. [Ibid.]

Early versions of these lights had insufficient power to be effective for most growers. Recently, however, Kessil has introduced a new high-density LED array technology, which packs more LEDs and offers more power than previous LED Grow Lights. Interior Gardens now carries the Kessil H150 line of 32W LED Grow Lights.
ROOFTOP GARDEN CONSIDERATIONS
This proposal recommends the inclusion of a rooftop garden to the Garland Aquaponic Farm. The rooftop garden can feature hydroponic farming as well as other traditional urban farming methods that use soil. Special considerations need to be given that take into account wind and heat factors. In addition to the plants, part of the roof will likely house solar panels. It could also house two or three beehives.

Factors for consideration:

- **Wind**
- Garland summer heat – probably best to consider the rooftop garden as a seasonal part of the aquaponic farm unless we are able to create a small hoop house on the roof that is air-conditioned via solar. Otherwise, the garden would be closed Mid June through October 1.
- Weight bearing capability of the selected structure as determined by the structural engineer is another factor.
- Accessibility – might need to build stairs
- Safety issues for visitors. Questions such as railings and whether to limit roof access to adults only.
- Part of the rooftop might be reserved for skylights for the aquaponic garden below.

ENERGY SUPPLY REQUIREMENTS
Some researchers have found that a solar water-heating system can dramatically cut energy costs. Another synergistic benefit can be gained by using heat pumps and exchangers, package refrigeration and condensation units to complement each other in
controlling humidity and warming the atmosphere in an operation that is water-vapor intensive. Even small changes such as locating supply air ducts to the ceiling to allow air to move over interior walls helps to prevent moisture accumulation and mitigate high humidity. (Source: http://organicconnectmag.com/wp/new-ideas-for-sustainable-local-fish-farming/#more-10983 (accessed January 21, 2013)

Temperature regulation in a fish tank is of high importance. Water that is at the right temperature can contribute to the healthy growth of your fish crop. You can use solar power to heat up the water to the desired temperature. You can also use solar powered heaters or air conditioners to maintain the desired temperature in your greenhouse. The pumps that supply water to the hydroponic bed and the fish tank can also be powered with solar energy.

Read more: http://www.doityourself.com/stry/using-solar-power-for-aquaponics#b#ixzz2Ip34Gg8r

CORE VOLUNTEER TEAM

Ideally all members of this team are from within 20 miles of the Garland city limits. All members of this team must read at least the Introduction and this Section 1 of the proposal. They understand that the creation of the Aquaponic Farm is but one piece of the larger construction of the Garland Agriculture Center that will eventually feature several food-based businesses. They understand the mission of the Garland Agriculture Center is to help stabilize our local economy by creating locally held businesses that pay employees a living wage. All members of this team understand the principles of Permaculture and agree to follow these principles in their work. This is a volunteer team. At the conclusion of the build they will also train the full-time employees who will take over the operations management of the Garland Aquaponic Farm. What citizen does not want to participate in a huge job creation project for their community?

[Note: Team members are numbered in the table below to provide an overview for the people needed—not to indicate descending order of importance. Also this is not necessarily an all-inclusive list. There may be other volunteer members who are needed. ]

<table>
<thead>
<tr>
<th>Title</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Structural Engineer</td>
<td>Assists in the selection of the building where the Garland Aquaponic Farm is located. Ascertain initial weight-bearing loads for building to determine appropriateness of structure for build and then participates as a member of the team who creates the support structure to hold the plant and fish tanks.</td>
</tr>
<tr>
<td>2. Garland City Council</td>
<td>Assist in the selection of the building where the Garland Aquaponic Farm is located and in adjusting city code requirements when needed.</td>
</tr>
<tr>
<td>3. Architect</td>
<td>Assists in the design of the build of the structure that will house the aquaponic tanks.</td>
</tr>
<tr>
<td>4. Electrician</td>
<td>Assists in selection of pumps and other necessary electrical equipment and is in charge of wiring the building. Also this</td>
</tr>
<tr>
<td>Title</td>
<td>Responsibilities</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>5. Financial Expert</td>
<td>In the initial stages of this project this person may oversee activities associated with obtaining funding for this project. Also responsible for managing the budget for this build and keeping expenses under control.</td>
</tr>
<tr>
<td>6. Documentation Experts</td>
<td>From the day the search begins for a site for the Garland Agriculture center a team of three to five people are in charge of recording the events that transpire. Included on the volunteer team will be writers and video experts. The outcome of their work will be documentation that will be sold to help the ongoing support of the Garland Aquaponics Farm. [Note: Since this is a job creation project, these people will be paid royalties of 10% on the sale of their work.]</td>
</tr>
<tr>
<td>7. Legal Counsel</td>
<td>Every project needs one.</td>
</tr>
<tr>
<td>8. Solid Waste Engineer</td>
<td>Responsible for making determinations in the final design for the way the Aquaponic system manages the solid waste produced by the fish.</td>
</tr>
<tr>
<td>9. Interior Designer</td>
<td>Works with the architect, structural engineer and the marketing/advertising team to create a design for the interior that is not only functional, follows the principles of permaculture, but is also aesthetically appealing. We want the final design of the Aquaponic Farm to look like it was born in the 21st century as opposed to a mismatched affair that looks like your Uncle Ralph designed it in 1965. The interior of the Aquaponic Farm should also be designed to facilitate and enhance safety for the visitors who will tour the facility (another of the income-producing sources for this facility).</td>
</tr>
<tr>
<td>10. Citizens Steering Committee</td>
<td>I would love to be a member of this team.</td>
</tr>
<tr>
<td>11.</td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td></td>
</tr>
</tbody>
</table>
### Additional Notes:

The two largest expenses involved in the set up of the proposed Aquaponic Farm, Café and Grocery will be labor provided by professional experts listed in this table. However, if that labor is free there is one big expense gone. The other large expense is the building. However, if we can purchase this building though grant money, or even perhaps a bond issue, that will take care of that expense. The materials for the interior are estimated at $150,000 - $200,000. (Not including the solar system setup).

The operations of the Aquaponics farm, café and grocery will be self-sustaining. It should easily support at least 6 to 10 employees.

Another potential for obtaining funding for the Garland Urban Agricultural Center might be to solicit funds from local entrepreneurs who would profit from being located in such a center. I prefer that at least 60% of these businesses be locally held as opposed to Wall Street chains as one of our goals here is to strengthen and anchor our local economy and we are not going to do that with Wall Street chains. As mentioned previously this is the #1 location for a hydroponics supply store. Another business might be commercial kitchens for rent. Yet another might be gardening tools and information for traditional gardeners. One of the goals of the Garland Urban Agriculture center is to strengthen the local economy by encouraging all citizens to grow some of their own food. This enhances our local economy in two ways: 1) if citizens grow part of their food, then they have more spendable income 2) some citizens will even sell some of their produce, thus stimulating the economy even more.
PLAN OF ACTION

The most difficult and important part of any project is planning. The same may be said for this project as well. However, although all the various details mentioned in this Section 1 Design Considerations for the Garland Aquaponic Farm may sound like a lot, once all these many decisions are made: 1) It will be easy to build ("It is not rocket science.") and 2) the Garland Aquaponic Farm will even be easier to maintain. Here are a few of the very best things about an aquaponic or hydroponic garden as compared to traditional gardening: 1) it uses 70% less water than traditional farming/gardening 2) crop yields are 2 to 4 times that of traditional farming/gardening 3) no pesticides are needed 4) no back-breaking work hoeing weeds 5) no back-breaking work harvesting as plants are at waist-level. Once the aquaponic farm is up and running all that needs to be done is to daily check to make sure pumps are running, check the pH of the water once a day, check the filter system twice a day to ensure it is not clogging, feed the fish and harvest the plants.

STEP ONE:
Make a determination to move forward with the project to build the Garland Urban Agriculture Center and select a steering committee. Perhaps it is at this point the steering committee must form a non-profit corporation. (I’m not sure how this works.)

STEP TWO
Steering committee selects a site. (Ideally an architect and a structural engineer will be on the steering committee.) In making this selection, they choose a site that is large enough to house the aquaponic farm, stable enough for a rooftop garden, and with room for a small café and a small grocery in front. Additionally space nearby should be considered for a weekly Garland Farmer’s Market. Although the other proposed supporting business modules described in this proposal are not directly part of the Garland Aquaponic Farm, Café, Grocery and Farmer’s Market build; they are part of the overall plan for the Garland Urban Agriculture Center. Among these businesses include a hydroponics supply store, and a Commercial kitchen to rent. These would come soon after the build is complete and would be privately funded. (This is the new business we are encouraging for our local economy.) (Estimate: one month)

STEP THREE
At this point the steering committee rounds up the complete Build Team. Some of the members of the Build Team should already be on Steering Committee, but likely more are needed. The volunteer build team creates the plans for the Garland Aquaponic Farm and submits to steering committee for final approval. (Estimate: Two months)

STEP THREE
Determine how much money will be needed to fund the project. At this point the steering committee rounds up the complete Build Team. Some of the members of the Build Team may already be on Steering Committee, but likely more are needed. The amount of money to fund the project of course includes purchase of the property to house the Farm, Café, Grocery and space for Farmer’s Market. It includes the total cost for the build (all fixtures, heating/cooling, stock with plants and fish. Estimate monthly operation costs (plan for 4 full-time employees to start). Note: The café could be just a
juice bar at least initially. It would not open until three months after the farm is operational. The same is said for the grocery. After all, it will take 3 to 4 months before we are harvesting plants from our farm. Estimate total annual cost for operations. (Estimate: One week)

**STEP FOUR**

*Work out a plan to obtain funding.* If we operate the Aquaponic Farm, Café, Rooftop Garden and Farmer’s Market as nonprofit, we can apply for a grant from folks such as the USDA; the Clinton Foundation and others. **This is a job creation plan** and we need to market it thusly. Not only is this a job creation plan for our community, it is one that every single municipality in the USA could put into action. It will create jobs and it will stimulate our economy. (Not certain, but I hope not more than a month)

**STEP FIVE**

*Volunteer Build Team completes build.* This could happen within two months.

FROM START TO COMPLETED BUILD, I BELIEVE IT IS POSSIBLE TO HAVE A FULLY COMPLETED AND STOCKED WITH FISH AND PLANTS AQUAPONIC FARM HERE IN GARLAND WITHIN 6 MONTHS.

If we started in March, we could open the Aquaponic Farm for tours just in time for our Labor Day Celebration—very appropriate for a job creation plan.
1. Dr. Wilson Lennard. An Australian, Dr. Lennard earned one of the few PhDs in aquaponics in the world in 2006. He designed, constructed and managed Minnamura Aquaponics, Australia’s first commercial scale aquaponic system. He writes extensively on the topic of Aquaponics and consults worldwide through his company, Aquaponic Solutions.

Note: the following Aquaponic Fact Sheets are available for free download. They are valuable source material for those involved in the design and build of the Garland Aquaponic Farm as they provide the basics for all the central features of an Aquaponic Farm design. These fact sheets are also valuable for the planners and members of the steering committee who will be making business decisions regarding this design.

Aquaponic System Design Parameters: Fish Tank Shape and Design

Aquaponic System Design Parameters: Media Beds and Sizing

Aquaponic System Design Parameters: Fish to Plant Ratios (Feeding Rate Ratios)

Aquaponic System Design Parameters: Solids Filtration Treatment and Re-Use

Aquaponic System Design Parameters: Basic System Water Chemistry