NAU NORTHERN ARIZONA UNIVERSITY

Mechanical Engineering

To: Professor David Trevas

From: Vertical Farming Team

Date: 9/25/2020

Subject: Implementation Memo

The Vertical Farming project came from years of interest in a method of farming that can be self-sustaining and be user friendly. People should not need to be farmers with all their time invested into their food source to have enough food growing to feed their family. The project should be easy for clients to use as well as being visually appealing. With those two aspects thought of, what is visually appealing that can create nutrients? The normal composting method can be used since it is the best method for nutrients... the downside is that you need to build up your compost with many types of decomposing natural materials. Decomposition comes with many negatives. Some of these are, the time needed to decompose, the smell, and of course the need to move said material from a pile or bucket to a planting site. Now with this information people usually have an interest in aquariums and fish waste is all in the water column and depending on the tank and fish type the plants would have nutrients readily available to use and the user would have little maintenance. As well as the added benefit of freshening the air inside of the home creating a nicer smell depending on the plants.

The project will be made as user friendly as possible and has the option of a DIY build or a semi assembled option that comes with everything the user would need to assemble his or her system. The team is leaning towards a semi assembled product since there can be user error in DIY systems which will have customers unhappy and needing customer service. The plan that the team has made is that we will have a wooden base to keep cost down while using Unistrut for the above tank scaffolding that will hold the rain gutters. The rain gutters will use a capped method covering the top with 2-inch diameter holes drilled into it to house mesh nets that will hold onto the plant's roots.

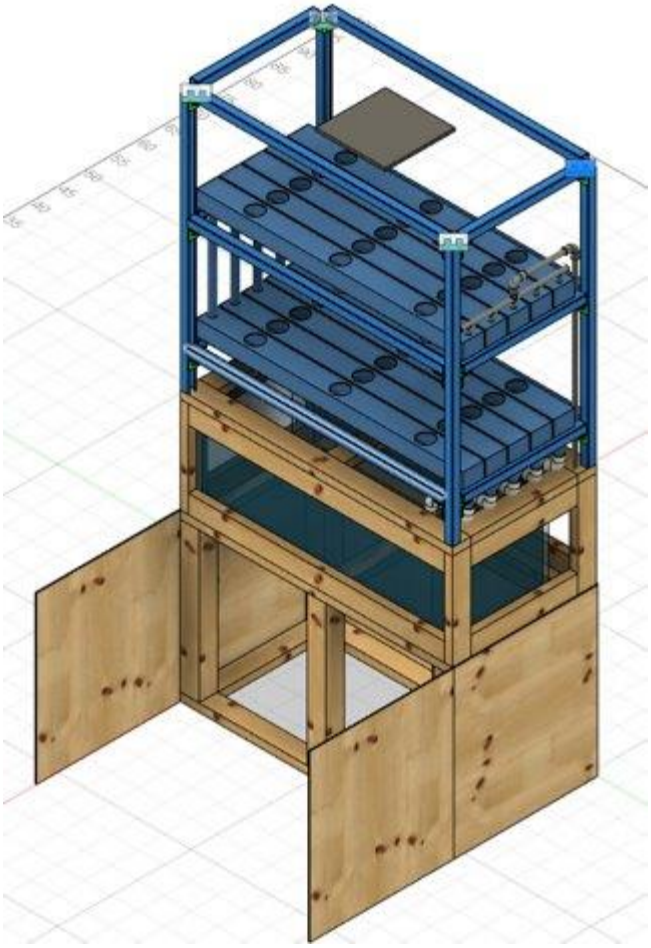

Figure 1 – Complete system with wood base

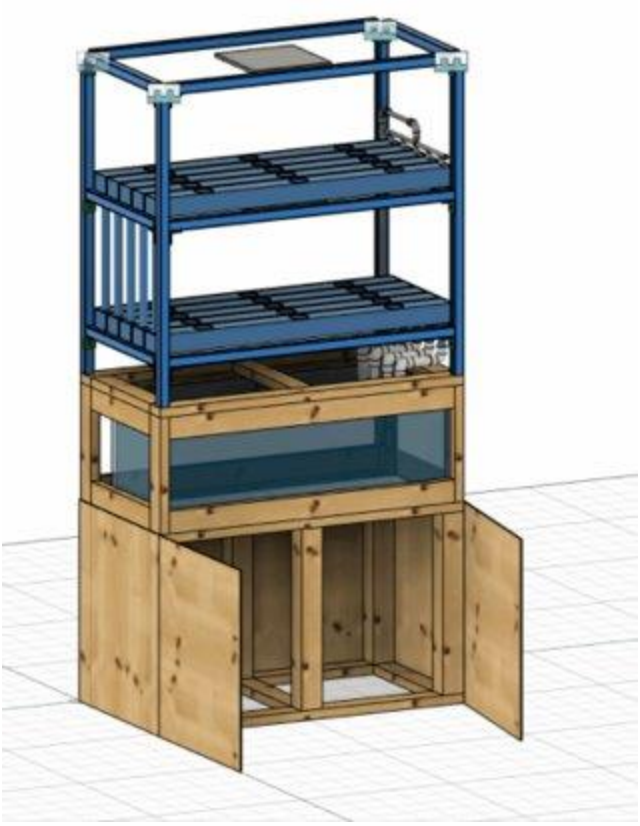

Figure 2 – View two of final CAD

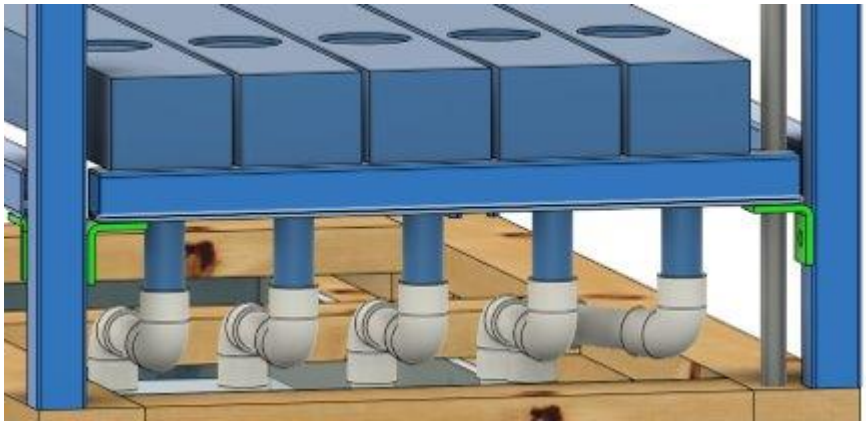

Figure 3 – Drainpipe side view

The ordering of parts and building is just now underway, the Bill of Materials is needing updating and the team needs to decide who the companies will be that are filling our orders depending on cost and availability.

1 Implementation

The project will need to be started as soon as materials come in in order to have time for testing and be able to run successfully for the final presentation.

1.1 Manufacturing

As a major goal of this project is for parts and materials to be easily accessible, there are no specific manufacturing operations or pieces that need to be created. The main components of the project can be put together using simple and easy to obtain fasteners, adhesive, and materials. The wood base is held together with wood screws as well as wood glue. The Unistrut and Unistrut components is held together by bolts and screws into the wood and other Unistrut pieces. The tank simply sits in the cradle created by the wooden based. The troughs and PVC piping are the hardest pieces to create. The troughs need to be sealed on either end with a cap and the PVC tubing needs to be mounted into the troughs using a waterproof adhesive. Other than these large pieces, the powering and monitoring of the system requires basic soldering and wire running.

A list of equipment the team will need for manufacturing would be a wood saw, adhesive for wood as well as PVC, wood screws, Unistrut bolts and screws, a soldering iron, and a way to add caps to the troughs, possibly using a welder.

-sealant

-c-clamps

1.2 Design Changes

1.2.1 Design Iteration 1: Change in base material

The plan was to use Unistrut for the whole structure of the stand, but the team figured out that we could cut cost almost in half on structural materials just by making the base material be wood instead of Unistrut. So, depending on funding the team thinks that this will be the final change in material changes for the base. The wooden base will be slightly thicker and heavier compared to a Unistrut base but will still meet the engineering requirements of strength required to carry the design load.

1.2.2 Design Iteration 2: Change in pumps discussion

The original plan was to build the prototype with 14 grow troughs. Ten troughs were to be installed above the fish tank and four smaller ones installed under the fish tank. The goal now is to build a proof of concept to show that our grow trough idea is feasible. The proof of concept will be comprised of two tiers of grow troughs placed above the fish tank requiring a flow rate of 2.8 gallons per hour. This is a reduction from the original 28.044 gallons per hour needed for ten grow troughs. The updated target operating point is labeled with an x in the figure below. The Ponics pump model PP-291xx will still be used to provide the flow rate necessary. The pumps performance curve is shown in red. The 2 pumps selected to circulate water to the lower grow troughs will no longer be needed.

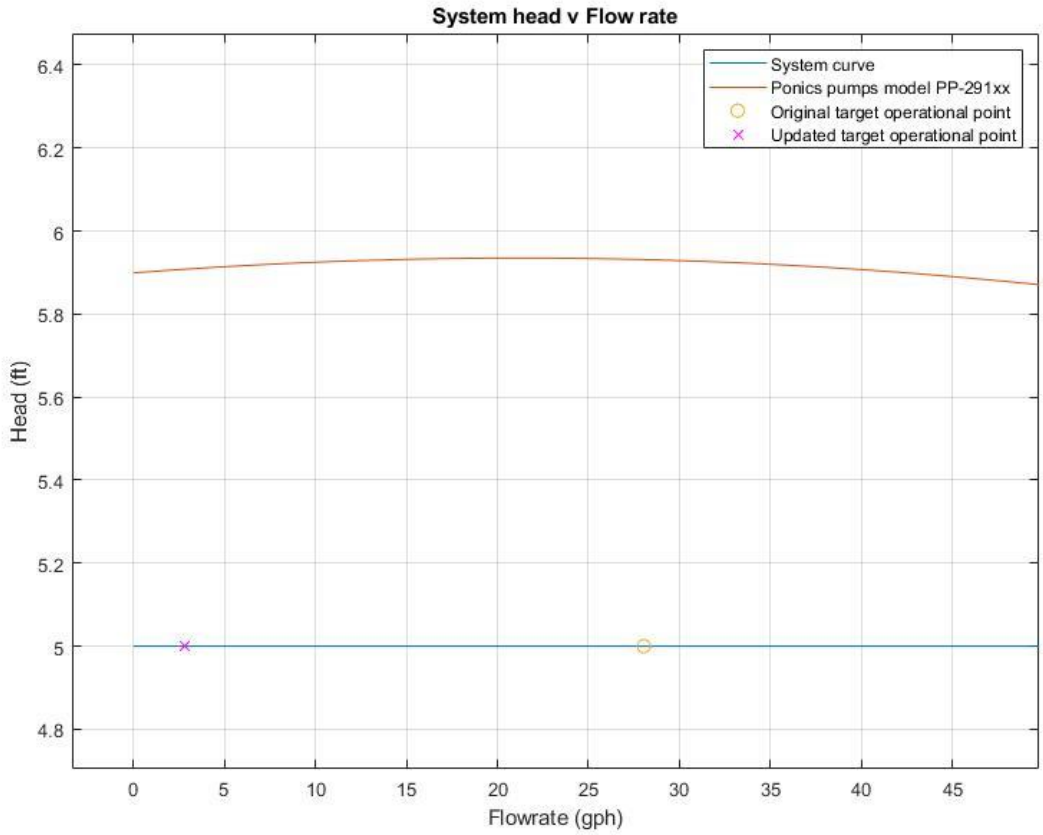

Figure 4 - Updated target operation point for 2 upper grow troughs.

2 Future Implementation

Moving forward, the team is expecting to begin construction within the next couple of weeks. The next week will consist of ordering and gathering materials. The current design has been approved across the team and is the expected design to be seen at the end of the capstone project. Table 2: Bill of Materials, shows the materials list the design requires. With the budget and purchasing process recently approved and clarified, no materials have been purchased making the next seven days crucial for the construction phase of the project.

2.1 Further Manufacturing and Design

Currently, all parts and assemblies for the design will not require any manufacturing. All components are easily accessible in the public market allowing for any consumer to add or customize the vertical farming system using parts from the local hardware store.

2.2 Fish food choice (Yanchu)

Fish can be divided into meat eating fish (carnivores) and plant eaters (herbivores) according to the type of food they eat. There is a big difference in the nutrients required by the two kinds of fish. For example, plant eaters need more fiber and meat eating requires more protein, so the food of the two species is also different. The fish we chose in this project is Amphilophus citrinellus, which is a kind of omnivorous fish. AquaNourish's food was chosen because AquaNourish provides special food for omnivorous fish at different growth stages, and the fish food can satisfy most kinds of omnivorous fish. The most important thing is that its price is relatively low, which can effectively reduce the cost of customers.

2.3 Schedule Breakdown

Table 1 – Project Schedule

		Name	Duration	Start	Finish
1		Receive budget	1day?	09/14/2020	09/14/2020
2		Final decisions on Materials	4days?	09/15/2020	09/18/2020
3		Start ordering stand materials	1day?	09/16/2020	09/16/2020
4		Order and pick up uni-strut in Phoenix	1day?	09/21/2020	09/21/2020
5		Start cutting uni-strut to length	1day?	09/23/2020	09/23/2020
6		Stand made and assembled	1day?	09/28/2020	09/28/2020
7		Rack assembled	1day?	10/02/2020	10/02/2020
8		Buy gutters and pumps	1day?	10/02/2020	10/02/2020
9		Test fit tank	1day?	10/05/2020	10/05/2020
10		Cut and fit gutters	1day?	10/09/2020	10/09/2020
11		Plumb the whole project	5days?	10/12/2020	10/16/2020
12		Test run full for 5 days	5days?	10/19/2020	10/23/2020
13		Buy lights	1day?	10/19/2020	10/19/2020
14		Wire up lights and sensors	2days?	10/23/2020	10/26/2020
15		Test electrical system	1day?	10/26/2020	10/26/2020
16		Run full system for 5 days	5days?	10/26/2020	10/30/2020

The schedule is slightly off since the team is already at 9/25 with no materials even though it says this weekend, we would have the stand built. The team is starting to get moving along on filling orders now so we can hopefully catch up and stay on schedule.

2.4 Budget breakdown

Shown in Table 2, the current anticipated budget for the full-scale design is ~$1300.00. The design budget could be decreased if the team decides to scale down the project design, but that choice will be based off the approved funding. Although currently the project is over budget by $300.00, the team has decided to move forward with purchasing as much as possible with the current budget in place in order to get some forward momentum with the design. Researching the material costs has led to the construction of the table below. All materials have been weighed between quality and affordability with certain items being manipulated to avoid high shipping charges like the Unistrut. The Unistrut will be picked up in-store, or otherwise the shipping charges would further place the design over budget. Overall, the team is confident the materials in Table 2 will be all that is required for the completion of this project.

Table 2: Bill of Materials

Material	Amount	Units	Pricing	Cost/Unit	Total Cost	Supplier
Unistrut p1000	51.5	ft	35.75	USD/10ft	$196.625	Gainger
Unistrut p2223	16	pieces	9.62	piece	$153.92	
Led Panel	2	Pieces	160	USD	$320	Amazon
Downpour spouts	42	ft	27	USD/10ft	$135	HomeDepot
0.5 in PVC tubing	20	ft	2.15	USD/10ft	$4.30	HomeDepot
0.5 in PVC Elbow	15	pieces	0.4	USD/Each	$6	HomeDepot
Wood	62.5	ft.	6	USD/8ft	$46.80	HomeDepot
PlyWood	2	Sheets	22	USD/Sheet	$44	HomeDepot
4x4 Wood	14	ft	14.5	USD/8ft	$29	HomeDepot
Electronics, Pump, Arduino, Sensors	[redacted]				$150	Various
Building Materials, PVC pipe glue, screws					$150	Various
Automatic Fish feeder	1	N/A	16	USD/Each	$16	Amazon