Project Deliverable D: **Conceptual Design**

GNG 1103 – Engineering Design

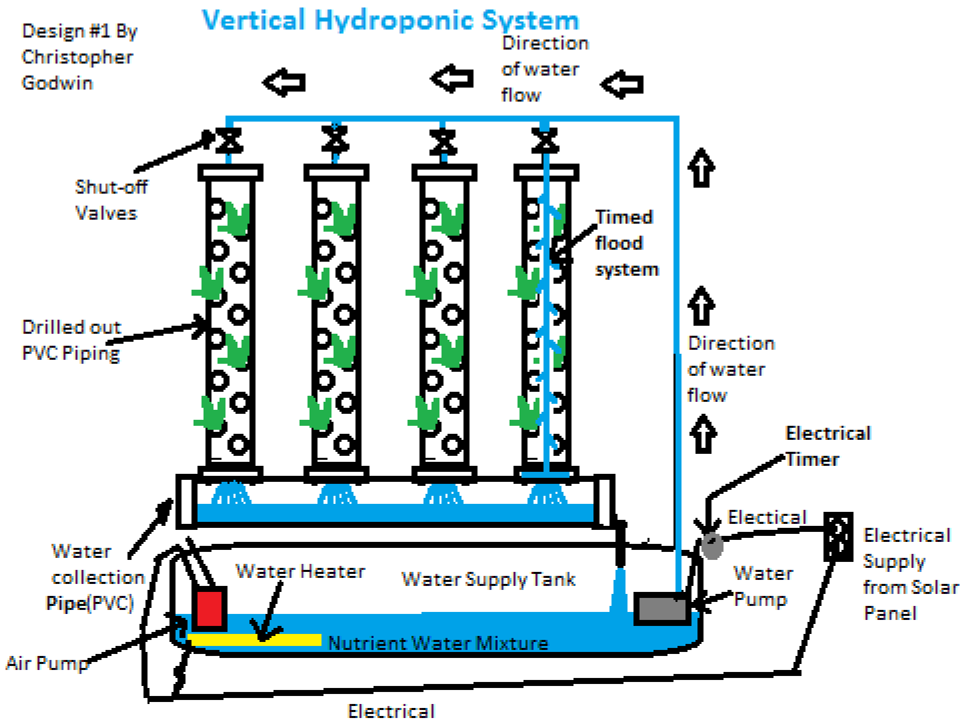
Faculty of Engineering – University of Ottawa

To solve the problem explained by the client and to address the needs that their problem presents, many candidate designs must be presented that can then be synthesised into one global concept. This document showcases designs from each team member and aims to conclude with a combined design that will best serve the needs of the client, best meet the criteria defined, and be used moving forward for testing and prototyping.

We decided on using a vertical system instead of a horizontal system in order to maximize the space we have in the greenhouse. The system we chose was based on the first design submitted by Chris, which involves a series of vertical, slanted PVC pipes with either y-joints or drilled holes to insert plants into. The idea was altered to become a horseshoe shape that fits optimally inside the construction team's proposed structure. This further increases total surface area so that our concept meets the benchmarking criteria we were aiming for. Using the selection matrix processed described in lecture and practiced in deliverable C, the team ranked the global design versus the three benchmarks and concluded that if executed correctly, it can outperform it's competition.

Chris Godwin's 3 Design Drawings

Chris' Design #1



Design #1:

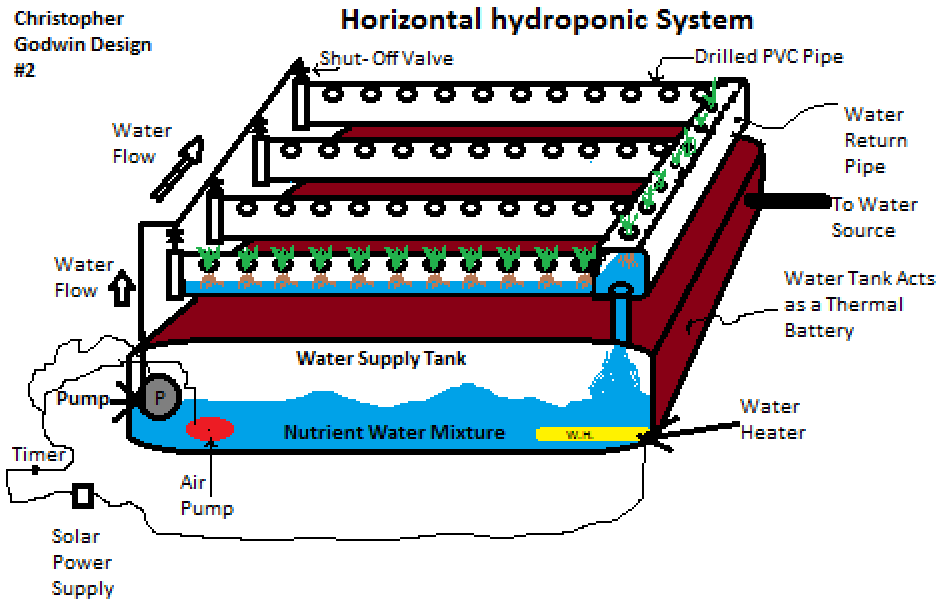
For this design a nutrient water mixture is pumped from a water supply tank. Preferably painted dark red or dark blue to absorb the most about of heat from the sun and act as a thermal battery to both absorb heat and give off heat to the atmosphere. Water is also heated when the temperature drops below 10 deg. C. This could be monitored using a temperature probe if an automatic system is chosen.

Water is injected with air using and an air pump and then a water pump would supply the water to the top of the towers. The water supply can be turned on or of manually to each tower using a gate valve. Water then flows down the tower and provides a drip of water to the roots. This supplies the roots with nutrient filled water. Any excess water flows down the tower back into the nutrient supply tank to be reused when needed. The water flow would be controlled by cycling the water pump on and off using either a manual or electric timer. Power would be supplied to the pumps, heater and timer by use of a solar panel system using DC direct power to save cost and avoiding an inverter to convert power from DC to AC.

<u>The advantages</u> for this design are that it uses the vertical space so that you can grow more per square foot of floor space, less water due to a drip system.

<u>The disadvantage</u> is that you have to use a pump to supply water to the top of the system.

<u>Chris's Design #2</u>



<u>Design #2</u>

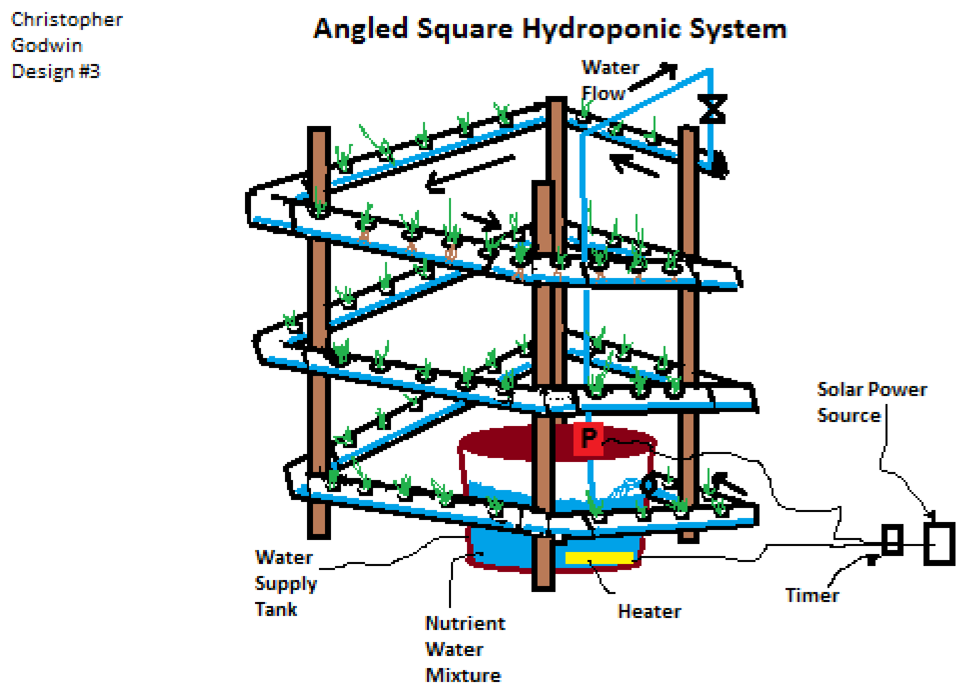
For this design, it uses a horizontal system and could be stacked one on top of another to add more layers. The water tank acts again as a thermal battery along with heater element in tank to heat water as needed using a temperature probe to measure the temperature and turn on when needed.

Water is again injected by use of an air pump. Water then is pumped to the main piping header to supply nutrient water mixture to each horizontal hydroponic PVC pipe. The water can be controlled by cycling the pump on and off at a set increment by use of a timer. Manual valves are used to isolate each individual PVC supply pipe that hold the plants. The PVC pipes are angled slightly to use gravity to flow through the pipe. Water floods the root system supplying the plants with nutrients. The water then goes into a PVC return pipe and back into the main supply tank to be reused.

<u>The advantage</u> is that it provides easy access to grown food because it can be a waist height.

<u>Disadvantage</u> is that is uses more water and takes up more floor space so less plants per square foot.

Chris' Design #3



Design #3

For this design, a water supply tank is located in the middle of the hydroponic system. The barrel or water supply tank is filled with nutrients, acts as a thermal battery, and can be heated when needed using a water heater controlled with a temperature probe. The water pump is located on top of the supply tank and sucks water up out of the tank to the top of system. The pump is controlled using a timer to cycle on and off the pump. The entire system has a manual shut off valve to cut the supply or manually throttle the supply of nutrient water to the system.

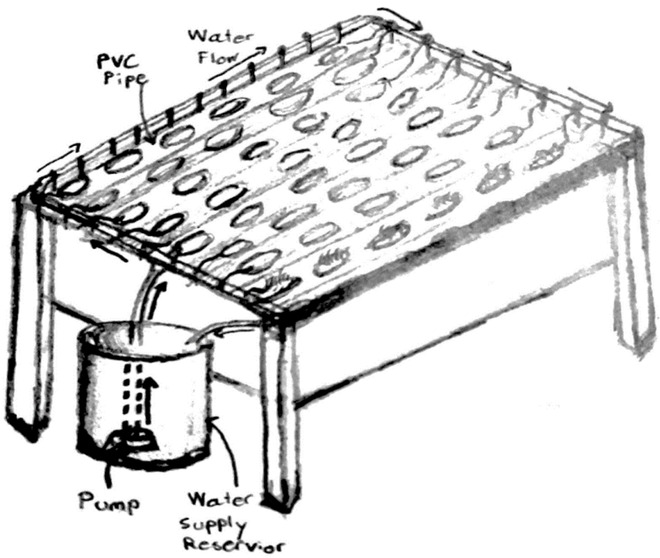
The water flows down the PVC piping that is angled around every corner from top to bottom. This allows the water to flow back into the supply tank to be reused.

Advantage is that it you only have to supply water to the top and it uses gravity to flow back to the tank.

Disadvantage is that it takes up a lot of space and water due to a flood type system.

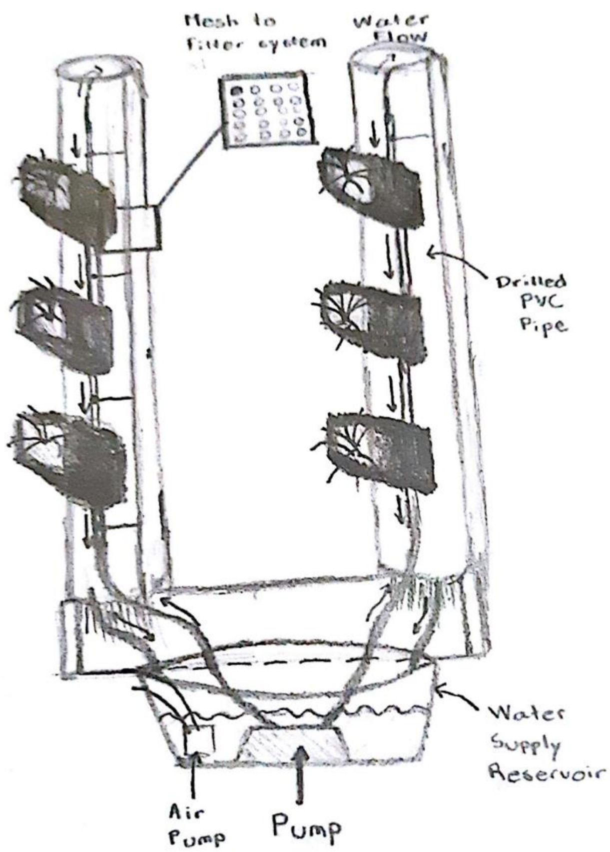
Rohit's Design Drawings

Design #1: Horizontal Hydroponic System



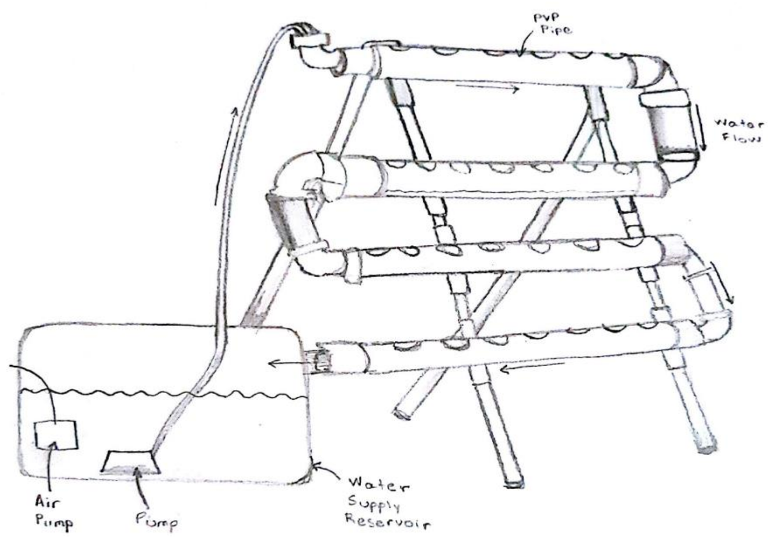
This design implements a horizontal hydroponic system with drilled PVC pipe laid side by side. There is tubing all around the border of the system that supplies water to each individual pipe. The water flows in a constant cycle returning back to the central water supply reservoir, where it gets reused. The reservoir includes an air pump that injects water into the tank. Then, water is pumped up the central piping, again supplying water to each PVC pipe. Inside the water, there is a nutrient mixture, which supplies nutrients to the roots of the plants when water enters the system. Some disadvantages include the use of space, as the design does not maximize the space of the greenhouse. Another issue would be weight and modularity as it would be hard to transport this system.

<u>Design #2:</u> Vertical Hydroponic System



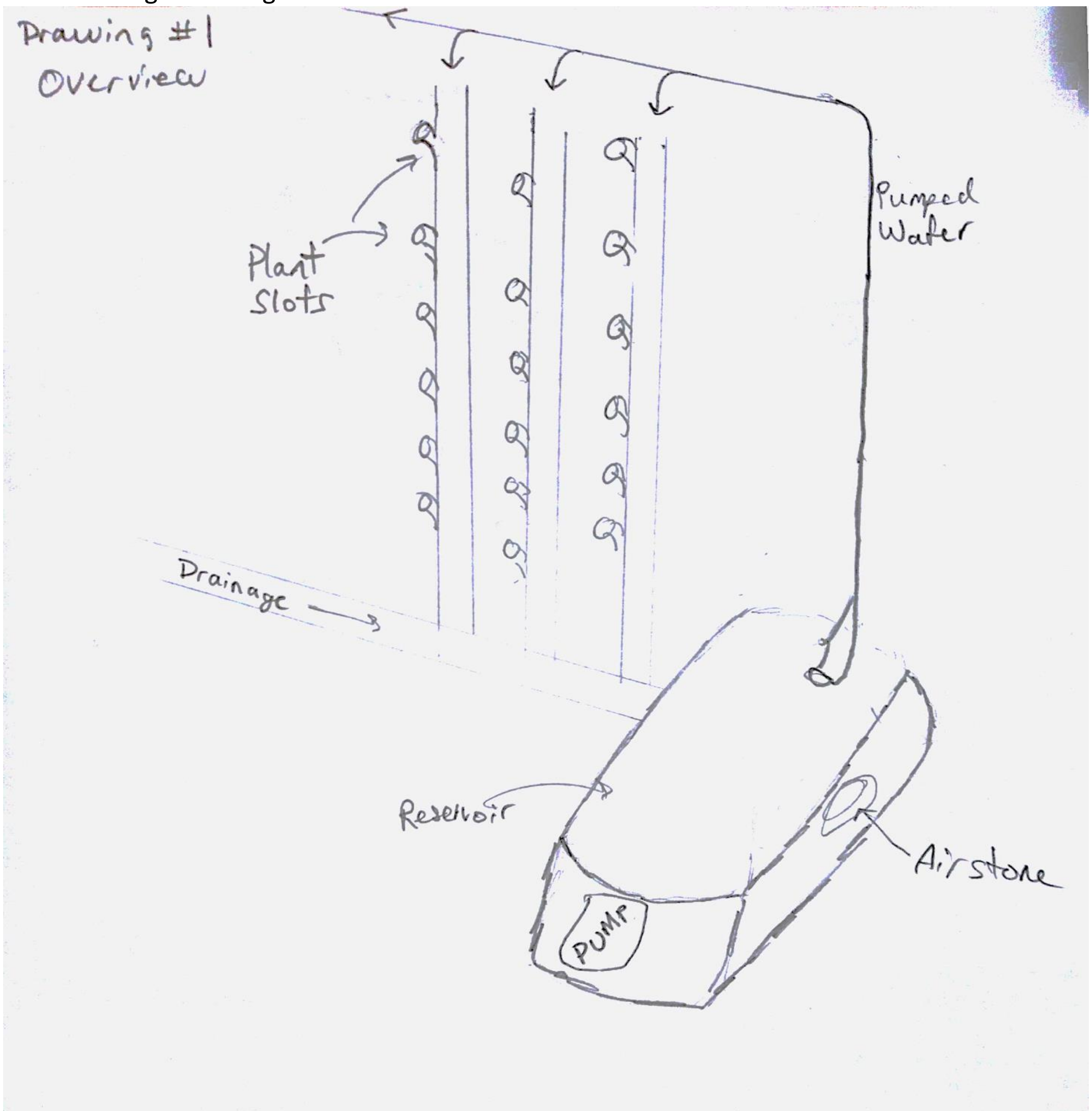
This design implements a vertical hydroponic system, which uses gravity to flow water through the system. Each pipe has multiple cutouts, each attached to a joint. Again, a nutrient water mixture is pumped from the water supply reservoir to each pipe. At each joint there is a mesh filter system, which prevents bacteria to enter the water tank. This prevents any contamination when the water is reused and supplied back. The water supply cycle will be controlled manually or automatically using a timer. As this system is vertical, I believe it less space will be taken up inside as it can be easily hung on the walls of the greenhouse. A huge advantage with this design in the ability to maximize the space in the greenhouse. The PVC pipes can be easily hung on the walls, so allow for space to walk. One disadvantage is the need for multiple pumps to supply water to each PVC pipe, highlighting cost as a huge constraint.

Design #3:

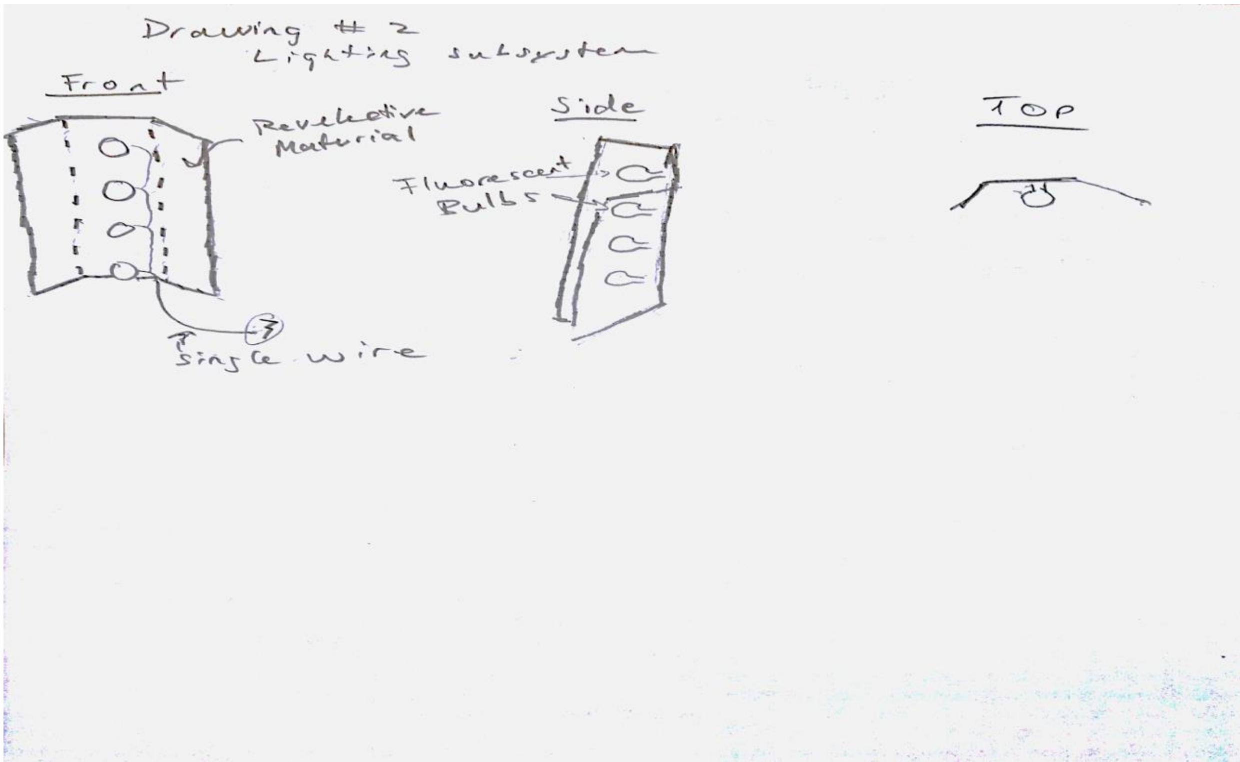


This sketch implements an angled hydroponic system, where water is supplied through the main piping and then flows down the piping by gravity. When the water reaches the bottom of the system it will return to the main water supply reservoir, where the water will be reused. Each pipe contains multiple cut-outs where water floods the root system supplying the plants with nutrients. All power is supplied from the solar power source, powering the heater (to control the temperature inside the water tank), air pump and the water pump. The advantage of this design is the foldability feature which makes it very easy to transport. A disadvantage though is the ability to provide sunlight to the plants as they are going to be faced directly upwards, restricting the amount of sunlight they receive.

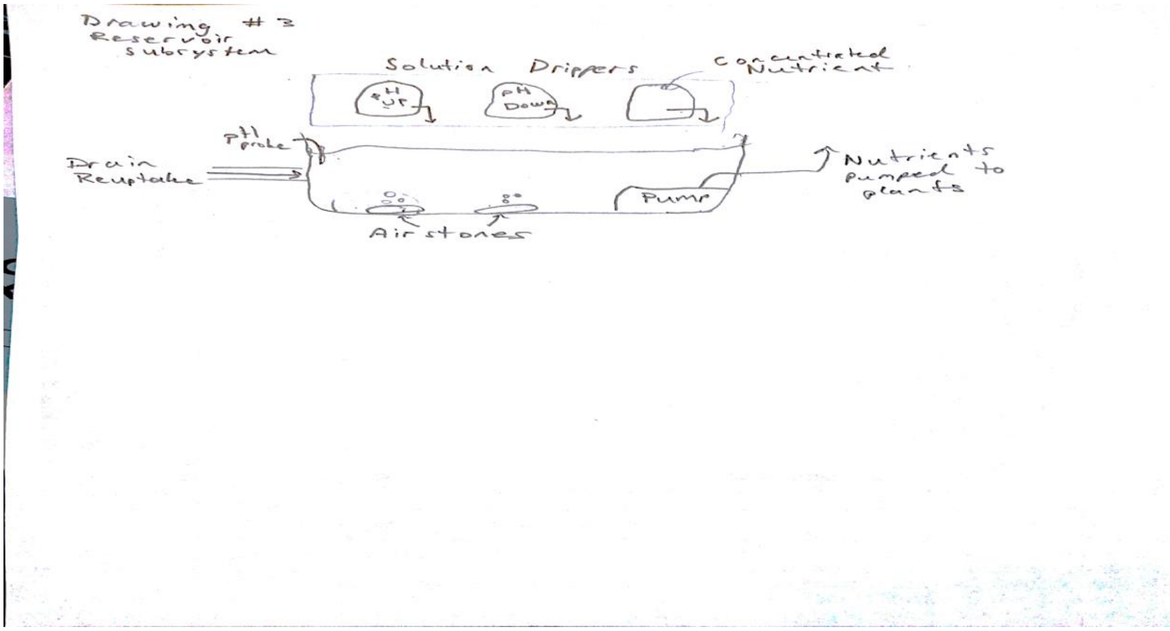
Aidan's Design Drawings



This design describes an overview of the main components of a hydroponic system. It includes reservoir, plumbing and planting subsystems. Water is pumped from the reservoir, passes through and array of vertical PVC pipes and return to the reservoir via the drain pipe. Although the sketch suggests three vertical pipes this quantity can be expanded to any quantity that fits the greenhouse enclosure. Plants are inserted into PVC Y-joints in a lattice formation to maximize surface area. This surface area maximization is its greatest advantage. It may be disadvantageous to have to pump against gravity as it will increase energy demand.

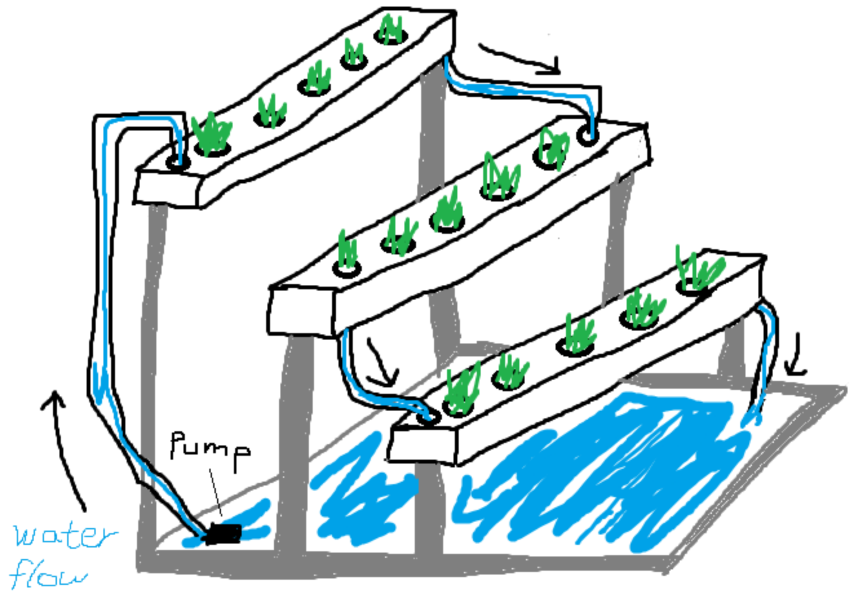


This sketch gives three views for a lighting subsystem that will be installed alongside the hydroponic system. The goal for this subsystem is maximum modularity and minimum cost. The subsystem consists of fluorescent bulbs, a reflective container and power going to each bulb. The bulbs are installed in a vertical array similar to the plants. Reflective material, preferably recycled aims to cut down on cost and maximize the efficiency lighting system. For each lighting unit, all power runs to a single plug. This fact increases modularity as the only thing require to alter the setup is an extension cord. The disadvantages of using artificial light is that it will be more expensive and demand more energy. This is more than offset by the gains made in plant growth.

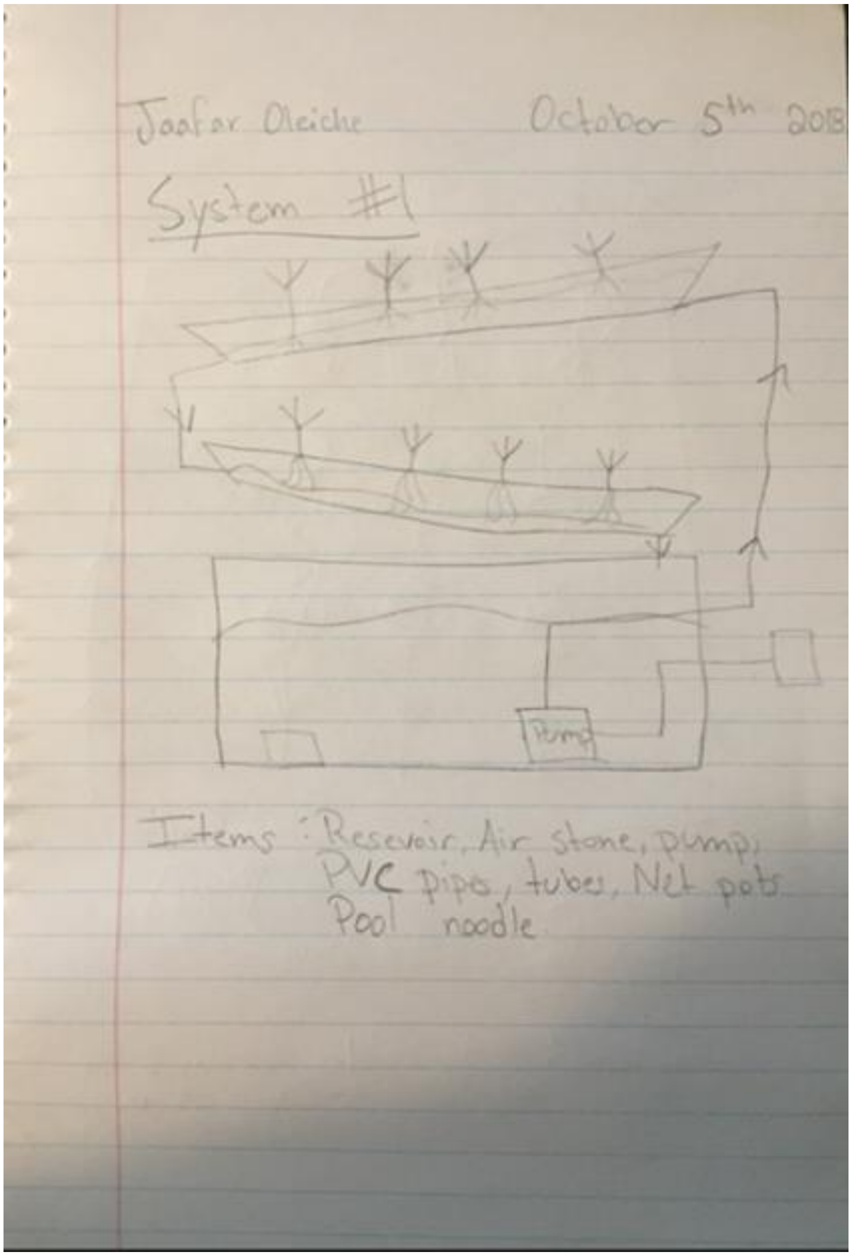


This conceptual design describes an ideal reservoir subsystem. The system aims to be entirely autonomous through the use of sensors and drippers. The only input that will be required from the user of the greenhouse is occasional addition of water to the system as the plants will slowly remove water from the system. The pH probe will give information to the various drippers so that an ideal nutrient solution can be maintained. Airstones oxygenate the water and ensure that the solution uniformly mixed. Water enters the reservoir via the drain pipe and is pumped out to the plants on the opposite side. While this system adds a great deal to the autonomy of the global concept its relative difficulty to develop and install is high. It also makes general upkeep of the greenhouse potentially require a technician that understands the automated systems, increasing the quantity of support the final product will need.

Hui's design #1



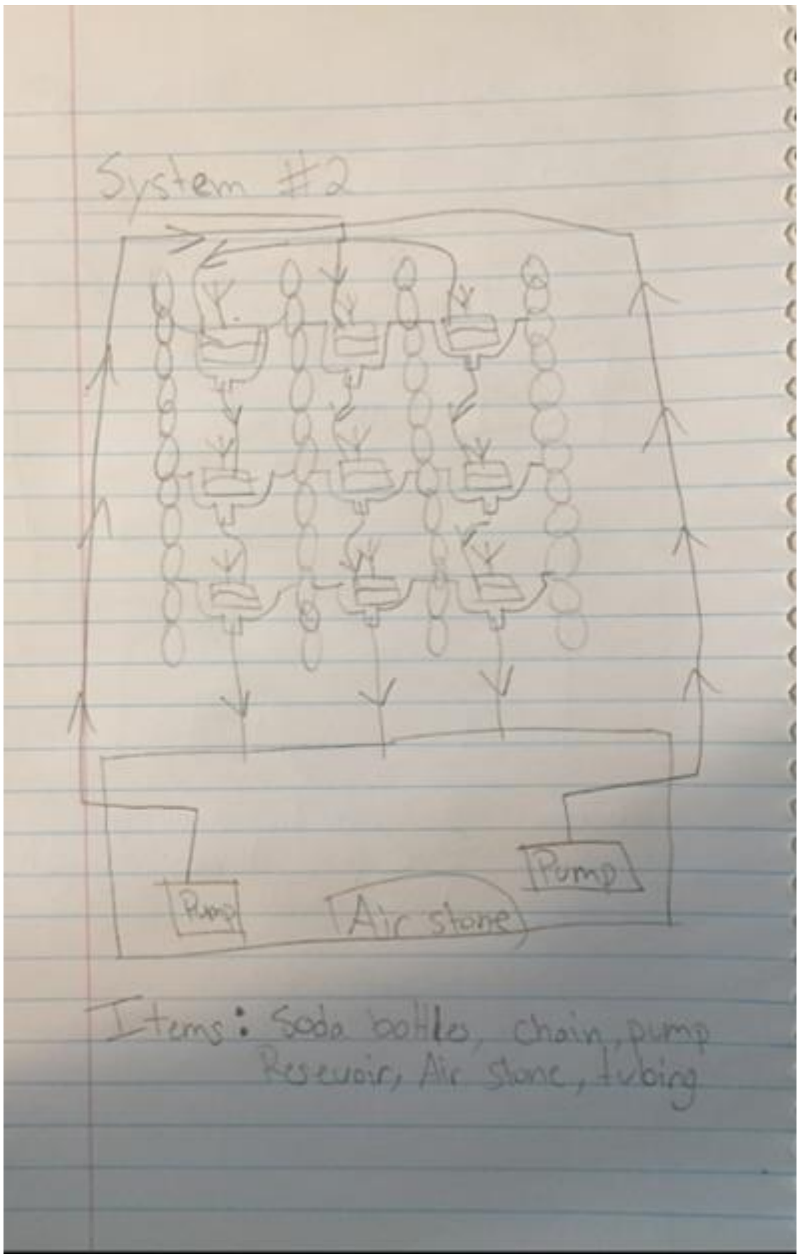
In this design, it uses horizontal hydroponic system. There is a water tank at the bottom of system. In this tank, a pump is used to transport water to the highest level of the system. Water goes from the highest level to the lowest level, which allows the water can be fully absorbed by plants.



Design 1:

A reservoir is filled with water and nutrients, it also contains an air stone and air pump in order to allow the intake of oxygen; located at the bottom of the system, a pump sends water through the tubes/pipes that leads to the first PVC pipe. It is slightly inclined in order to allow gravity to bring the water back down, and contains a holes that house a certain amount of plants using pool noodles cut in a way to keep them secure. When the water is pumped up it will follow the tubes while passing by the roots of the plants and going back down to the reservoir using gravity. The amount of floors can be changed, that is to say instead of simply having two we can increase the number to 4 or 5 depending on the vertical space allocated and on the needs.

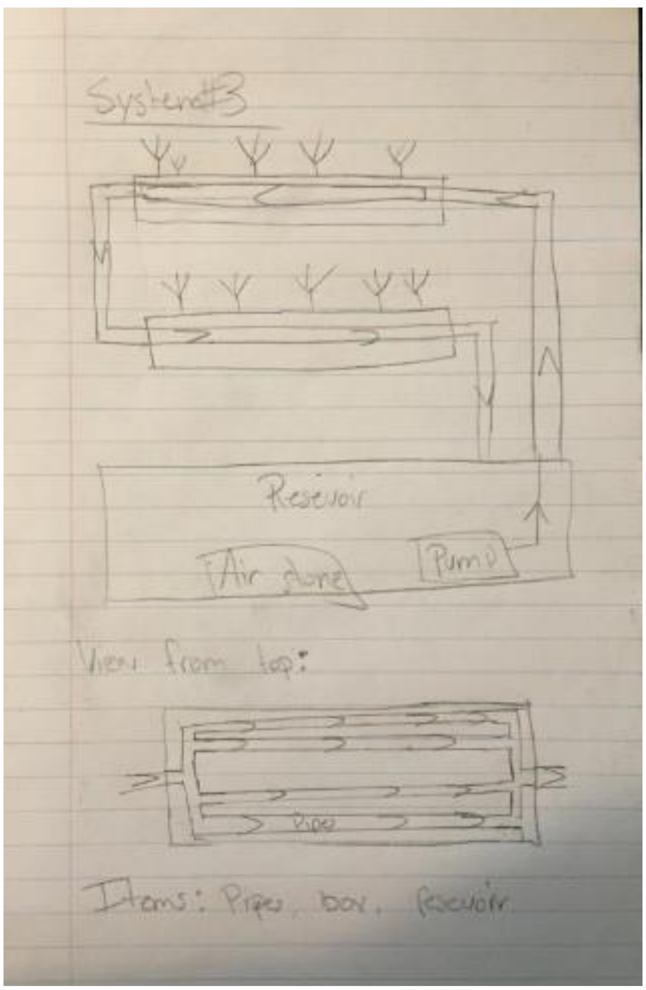
Advantages :
-Saves space as it will be vertical
-Can house different plant sizes depending on PVC pipe size
Disadvantages:
-Flow system means it will need a lot of water
-Pump needs to work against gravity



Design 2:
This system uses chains in order to create a vertical flow. It starts with a reservoir that contains water and nutrients, it also contains an air stone and air pump in order to allow the intake of

oxygen; located at the bottom of the system. A pump or two (depending on the size) is used to send the nutrient filled water to a central pipe system at the top which splits off depending on the amount of columns, from there it enters the plants pot which is housed in the bottle cap half of a soda bottle pipes leading from the cap to the next plant allow for gravity to move the water down and back to the reservoir. The number of columns and the amount of plants per column can be changed.

Advantages :
-Saves space as it will be vertical and flat on the wall
Disadvantages:
-Flow system means it will need a lot of water
-Pump needs to work against gravity
-Can only house small plants

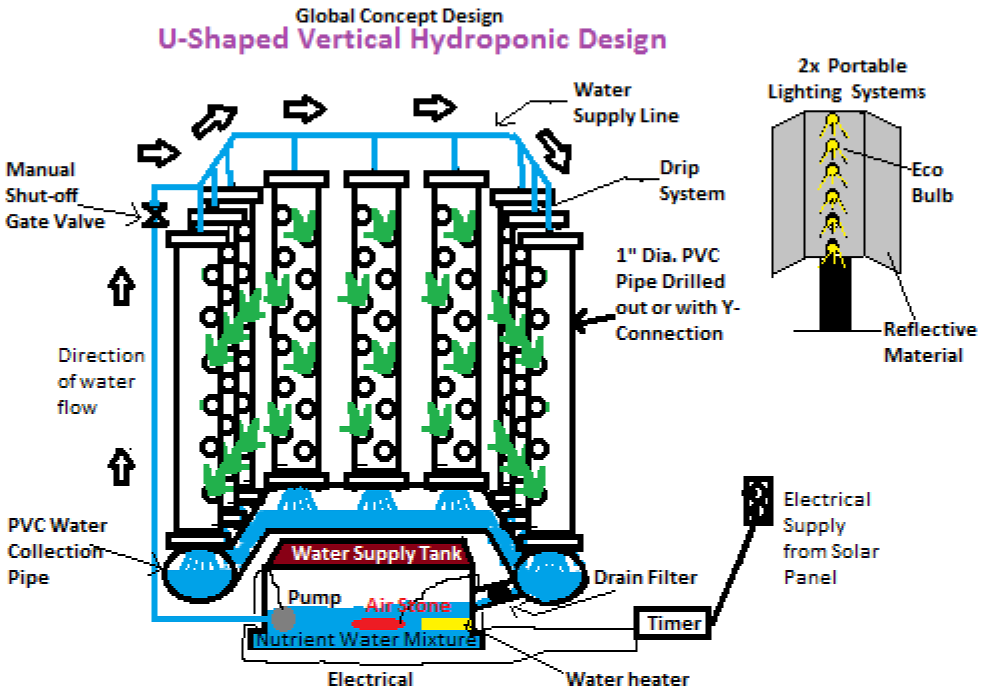


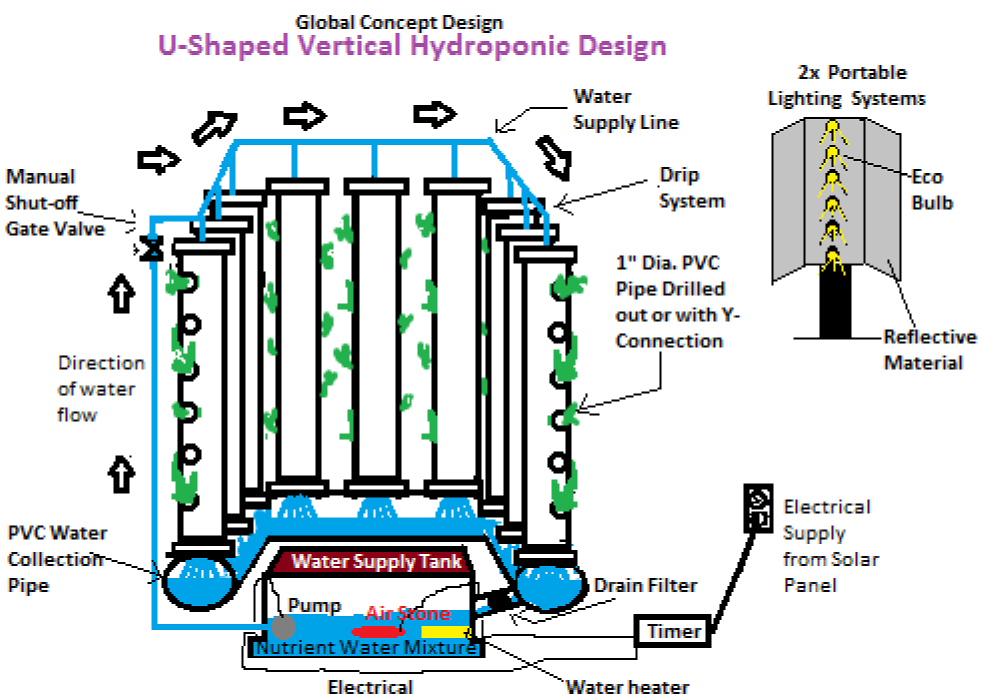
Design 3: This resembles the first system but instead of using PVC pipes as the housing for the plants it uses a larger and wider box which contains its own piping system that feeds the plants. The boxes need to be inclined in order to allow gravity to bring the water down using a drain pipe. A view from the top/inside indicates how the piping will be made. Once again the a reservoir that contains water and nutrients, it also contains an air stone and air pump in order

to allow the intake of oxygen; located at the bottom of the system will pump the water up. The number of boxes can also be changed depending on the size. This system allows for a lot more plants to be housed and also accommodate larger plants that need bigger holes.

Advantages :
-Saves space as it will be vertical
-Can house different plant sizes depending on holes made
Disadvantages:
-Flow system means it will need a lot of water
-Pump needs to work against gravity
-Boxes will be heavy and need to be supported properly

Final Design:





Specifications	General Hydroponics EcoGrower Drip Hydroponic System	Hydroponic Site Grow Planting System Kit	General Hydroponics GH4720	Our Design
Cost ($ CAD)	303.88	159.00	677.00	100.00
Weight (lbs)	30.8	25.8	46.3	28
Size (m)	.66x.58x.46	1.2x1.2x1	.62x.62x.62	1x1x2
Reservoir size (liters)	64.35	None	79.5	60
Plant Slots	6	72	8-12	54
Style	Drip	Ebb and Flow	Ebb and Flow	Drip
Modularity	No	Yes	Yes	Yes

Specifications	Importance (weight)	General Hydroponics EcoGrower Drip Hydroponic System	Hydroponic Site Grow Planting System Kit	General Hydroponics GH4720	Our Design
Cost ($ CAD)	4	2	3	1	3
Weight (lbs)	3	2	3	1	3
Size (m)	3	2	1	3	2
Reservoir size (liters)	4	2	1	3	2
Plant Slots	5	1	3	2	2
Style	2	2	2	2	2
Modularity	3	1	3	3	3
Total		40	56	51	58