

AutoAquaponics Project Completion Plan

July 2021

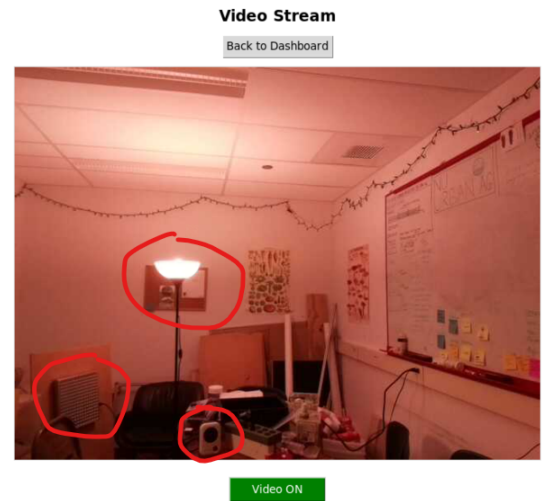
The AutoAquaponics team will seek to complete this project in December of 2021 by continuing to finish the plumbing and controls portion of our design. Throughout Spring Quarter, we have completed the following:

- Two 40 gallon grow beds that hold water
- The structure and waterproof coating of our 110 gallon fish tank
- Fish tank stand
- 3D CAD model of the entire plumbing system minus the PVC pipes
- The monitoring portion of our software that includes a live stream of the system and the ability to export data and send warning messages to users
- Approximately half of the controlling software that will allow us to toggle an outlet box remotely and set it on a timer

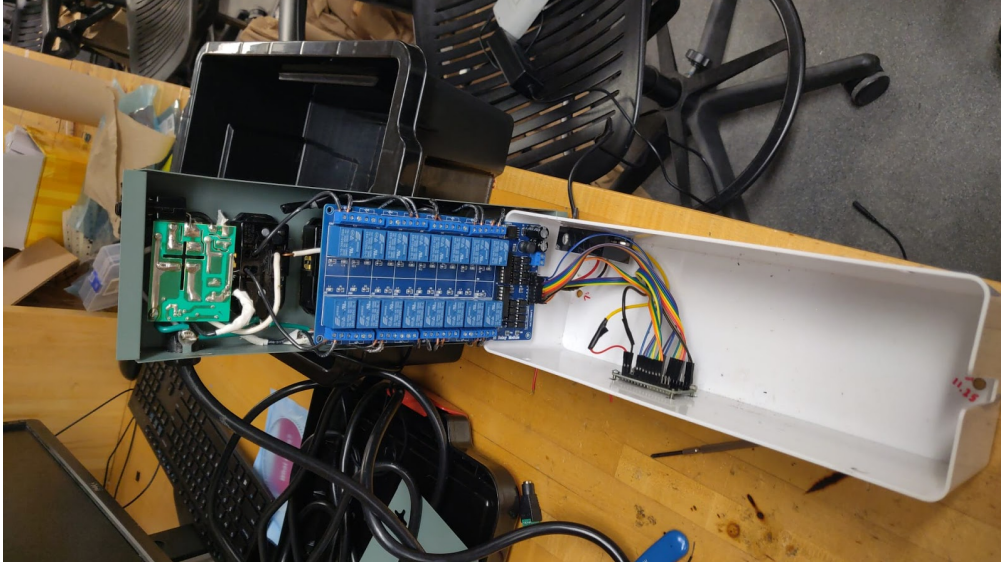
Throughout these past few months, AutoAquaponics ran into a number of complications that slowed down the progress of this project. Namely, we experienced numerous problems with using our school network to provide Internet access to our Raspberry Pi and ran into a few hiccups during the construction of our grow beds and fish tank. The network issue prevented our hardware team from working on the controlling software, as most of our members require remote access to be able to program our microcontrollers. After working with our school IT department for about two months (February to April), we were able to resolve the issue and reconnect our device to Northwestern's wifi. As for our grow bed and fish tank construction, a lot of the wood we received in our order were severely warped, making it necessary for us to bend them straight with a series of clamps, significantly increasing our build time. The fish tank was also supposed to be finished during the Spring, as the only remaining step is to install a sheet of ½" glass behind the front cutout. During our attempt to install the glass, however, not enough silicone was added to form the gasket between the glass sheet and the wood, which resulted in water leaking out. Unfortunately, our glass cracked in the process of removing the glass to reapply silicone, making it necessary for us to get a new sheet, which will arrive at some point over the summer. As a result, we will aim to complete the fish tank prior to the end of December instead.



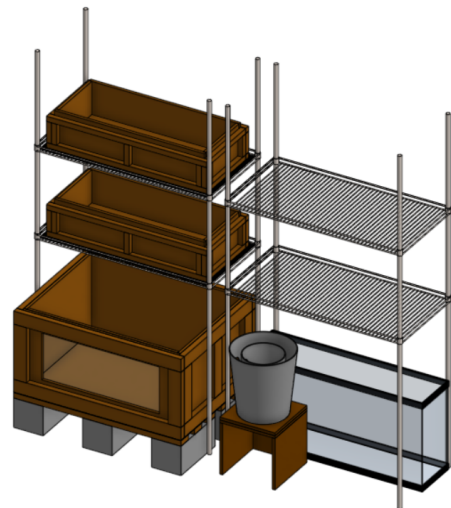
New export data feature



Setup with camera and lights plugged into programmable outlet box we are using to do hardware work over the summer (image on right is view from Raspberry Pi video stream with controlled equipment circled, image on left is a picture of the setup from the side, which also shows the Raspberry Pi camera taped to the metal cabinet)



Closeup of outlet box with ESP32 microcontroller and 16 channel relay



Fish tank, fish tank stand, sump tank, and grow bed (left) and CAD of system minus the pipes (right)

To complete AutoAquaponics' first prototype by December of 2021, we will follow the project completion schedule detailed below:

Summer:

Plumbing (goals will be completed in this order)

1. Perform flow calculations to determine the height that each of our water reservoirs will need to set at in order to provide enough head to drain water at a rate equal to or greater than our pump's flow rate (1000 gph)
2. Finalize radial flow filter design/dimensions
3. Add PVC pipes into our 3D plumbing model so we can calculate the pipe lengths we need and generate a precise cutlist for pipes, which will be very useful as we plumb our system parts together
4. Order all plumbing fittings and pipes to be picked up/delivered during the beginning of Fall Quarter

Electronics (goals will be completed in this order)

1. Finish the remaining part of our code that will allow us to send messages from our Raspberry Pi to an ESP32 microcontroller (this physically toggles the outlet box) wirelessly using Bluetooth Low Energy. Specifically, we will ensure that the Pi can automatically reconnect itself to the ESP32 when it gets disconnected for any reason (power outage, etc).
2. Complete our timer functionality that allows the individual outlets to turn on or off at designated times.

Software (goals will be completed in this order)

1. Finish the function that sends weekly update email to registered users to give them snapshots of the average state of the system (average temperature, pH, humidity, etc)
2. Fix any bugs/make any adjustments if necessary

Fall (before December 31st):

Plumbing (goals will be completed in this order)

1. Complete building the fish tank by attaching a new piece of glass to the cutout window with ample silicone
2. Build our radial flow filtration device for solid removal
3. Drill holes on all the water reservoirs (fish tank, grow beds, sump tank, filter) and plumb them together
4. Conduct water test and begin trial run of system

Electronics (goals will be completed in this order)

1. Install pump and LED plant lights and work with plumbing to integrate automatic outlet box into the system
2. Troubleshoot any sensor issue as we test their performance in biologically active water

Software (goals will be completed in this order)

1. Fix any bug/make any adjustments if necessary

Budget:

With the support of ESW's grant, AutoAquaponics have been able to purchase the below items:

Item Name	Description	Quantity	Unit Cost (\$)	Total Cost (\$)	Link
Birch Plywood (Common: 3/4 in. x 2 ft. x 4 ft.; Actual: 0.728 in. x 23.75 in. x 47.75 in.)	Plywood for grow bed construction	4	\$27.99	\$111.96	https://www.homedepot.com/p/Birch-Plywood-Common-3-4-in-x-2-ft-x-4-ft-Actual-0-728-in-x-23-75-in-x-47-75-in-154148/203504324
2 in. x 4 in. x 10 ft. S4S Green Western Red Cedar Lumber	Lumber for stand construction	10	\$14.77	\$147.70	https://www.homedepot.com/p/2-in-x-4-in-x-10-ft-S4S-Green-Western-Red-Cedar-Lumber-0509240/207050298
Pond Shield Epoxy Black 1.5 Quart Kit	Waterproof coating for fish tank	1	\$79.95	\$79.95	https://www.pondarmor.com/shop/pond-shield-epoxy-black-1-5-quart-kit/
Fiberglass Cloth Tape, E-Glass Fiber Fabric Plain Weave Cloth, 5CM x 30M	Line the edges of the fish tank interior	1	\$23.95	\$23.95	https://www.amazon.com/Fiberglass-Cloth-Tape-Wide-Yards/dp/B0885B3W5K/ref=sr_1_7?dchild=1&keywords=Fiberglass+Cloth+Tape%2C+E-Glass+Fiber+Fabric+Plain+Weave+Cloth%2C+5CM+x+30

					M&qid=1606282450&sr=8-7
Cinder blocks (8" x 8" x 16")	For building the stand	6	\$1.28	\$7.68	https://www.homedepot.com/p/8-in-x-8-in-x-16-in-Concrete-Block-100825/202323962?source=shoppingads&locale=en-US&mtc=Shopping-VF-F_D22-G-D22-22_9_CONCRETE-Generic-NA-Feed-LIA-NA-NA-CONCRETE&cm_mmc=Shopping-VF-F_D22-G-D22-22_9_CONCRETE-Generic-NA-Feed-LIA-NA-NA-CONCRETE-7170000051996260-58700005018934920-92700043802102557&gclid=ds
1 in. Mini 4 Outlet Indexing Valve with 2, 3 and 4 Zone Cams	Valve to flood one grow bed at a time	1	\$39.97	\$39.97	https://www.homedepot.com/p/FIMCO-1-in-Mini-4-Outlet-Indexing-Valve-with-2-3-and-4-Zone-Cams-9254/202524611#product-overview

Total = \$411.21

The below items are projected to be purchased in August so we can be ready for in-person work in the Fall (minor adjustments may occur as we continue our design process):

Item Name	Description	Quantity	Unit Cost (\$)	Total Cost (\$)	Link
2" PVC 90 Degrees Elbow	Plumbing component	15	\$2.70	\$40.50	https://www.homedepot.com/p/Charlotte-Pipe-2-in-PVC-Schedule-40-90-Degree-S-x-S-Elbow-Fitting-PVC023001600HD/20

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2" PVC Slip Union	Plumbing component	8	\$12.36	\$98.88	https://www.homedepot.com/p/Homewerks-Worldwide-2-in-PVC-Slip-Joint-x-Slip-Joint-Union-511-14-2-2H/204202885
2 in. x 24 in. PVC Sch. 40 DWV Pipe	Plumbing component	15	\$3.98	\$59.70	https://www.homedepot.com/p/VPC-2-in-x-24-in-PVC-Sch-40-DWV-Pipe-2202/202300507
2" Uniseal	Plumbing component	4	\$2.99	\$11.96	https://www.aussieglobe.com/2-Uniseal-U200.html
2" PVC Tee Slip Fitting	Plumbing component	1	\$2.97	\$2.97	https://www.homedepot.com/p/Charlotte-Pipe-2-in-PVC-Schedule-40-S-x-S-x-S-Tee-PVC024001600HD/203812205
PVC Primer	Helps glue PVC	1	\$5.93	\$5.93	https://www.homedepot.com/p/Oatey-8-oz-Clear-CPVC-and-PVC-Primer-307511/202985691
PVC Cement	Helps glue PVC	1	\$2.98	\$2.98	https://www.homedepot.com/p/Weld-On-Weld-On-700-PVC-Solvent-Cement-Clear-Low-VOC-High-Strength-Regular-Bodied-Fast-Setting-1-2-Pint-8-Fl-Oz-10081/202309206
Water flow sensor (inline)	Senses pump flow rate	1	\$28.99	\$28.99	https://www.amazon.com/DIGITEN-Sensor-Flowmeter-Contro

					l-10-200L/dp/B00VKAT30C/ref=asc_df_B00VKAT30C/?tag=hyprod-20&linkCode=df0&hvadid=312343076837&hvpos=&hwnetw=g&hvrnd=13350155171115407797&hvpone=&hvtwo=&hvqmt=&hvdev=c&hvdvcmld=&hvlocint=&hvlocphy=9021486&hvtargid=pla-358034729211&psc=1
Water pump	Drives overall system, 1200 GPH	1	\$67.87	\$67.87	https://www.amazon.com/Adjustable-950-4200-Submersible-Frequency-Hydroponics/dp/B076SBBW1T/ref=sr_1_3?dchild=1&keywords=1200+GPH+Submersible+Frequency+Water+Pump+Aquarium+Fish+Pond+Hydroponics&qid=1607205338&sr=8-3
ANTLUX Full Spectrum LED Grow Lights (4 Pack)	4 feet 50W LED grow light with daisy chains included	1	\$129.99	\$129.99	https://www.amazon.com/dp/B07PBMG1J1?axitk=sCGSFW28eMYmswyD.vwzIQ&pd_rd_i=B07PBMG1J1&pf_rd_p=591760d1-6468-480f-9b10-0ee9c85706fd&hsc_cr_id=6723173890301&sb-ci-n=productDescription&sb-ci-v=ANTLUX%204FT

					 %20LED%20Grow%20Lights%2050W%20Full%20Spectrum%20Integrated%204%20Foot%20Growing%20Lamp%20Fixtures%20for%20Greenhouse%20Hydroponic%20Indoor%20Plant%20Seedling%20Veg%20and%20Flower%20C%20Plug%20in%20C%20on%20Off%20Pull%20Chain%20Included%20C%204%20Pack&sb-ci-a=B07PBMG1J1
Water heater	300W aquarium heater	1	\$22.99	\$22.99	 https://www.amazon.com/Orlushy-Submersible-Heater-Fish-Thermostat-freshwater/dp/B07H2KRWFF/ref=sxin_7?ascsubtag=amzn1.osa.63c238a9-0082-4001-aaf1-90e6bcfac6d8.ATVPDKIKX0DER.en_US&creativeASIN=B07H2KRWFF&cv_ct_cx=aquarium%2Bheater&cv_ct_id=amzn1.osa.63c238a9-0082-4001-aaf1-90e6bcfac6d8.ATVPDKIKX0DER.en_US&cv_ct_pg=search&cv_ct_wn=osp-single-source&dchild=1&keywords=aquarium%2Bheater&linkCode=oas&pd_rd_i=

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Air pump	Tetra Whisper Air Pump for Deep Water Applications , up to 180 gallon (operatable under 8ft depth), 3.5W	1	\$34.96	\$34.96	https://www.amazon.com/dp/B000V7KM32/?tag=8121-20
Air diffusing wand	Alegi Air Stone Bar Bubbler 3 Piece for Aquarium, Air Stone Bar Hydroponics (16 inch), total Size:17" x 0.8" x 0.6"(L*W*	1	\$12.99	\$12.99	https://www.amazon.com/dp/B087JR1V4J/ref=sspa_dk_detail_4?psc=1&pd_rd_i=B087JR1V4J&pd_rd_w=mdpLg&pf_rd_p=48d372c1-f7e1-4b8b-9d02-4bd86f5158c5&pd_rd_wg=FZkZS&pf_rd_r=61VEQ46YMX6P2ZV5WAEA&pd_rd_r=db8dd1e7-e217-40e9-bfb3-a8ff

	H) Fits for 3/16" inner diameter tube				3e3b0fae&spLa=ZW5jenlwdGVkUXVhbGlmaWVyPUEyUzU2NDZCWEtKMkM2JmVuY3J5cHRlZElkPUEwMzM1MzQ3MU1LS0hDUTEzTzJYUyZlbnNyeXB0ZWRBZEIkPUEwNjU0MTAxMIFHV0gwQU5BV0M2RyZ3aWRnZXROYW1lPXNwX2RldGFpbCZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWRnRXPYdWU=
Dosing pump	hygger Aquarium Dosing Pump, Timing Quantitative Programmable Auto Titration Pump for Marine Coral Tanks, 4 Channel Dosing Heads with 8 Titration Long Hoses	1	\$66.99	\$66.99	https://www.amazon.com/dp/B087Q47Q7K/ref=sspa_dk_detail_0?psc=1&spLa=ZW5jenlwdGVkUXVhbGlmaWVyPUEyVVI5CVRlZElkPUEwNDMyNzI5MlM2QzEzQ1VLQVA2NSZlbnNyeXB0ZWRBZEIkPUEwOTE3MzQwMVg3Mlc4R0Y0VktUTSZ3aWRnZXROYW1lPXNwX2RldGFpbDI0YWN0aW9uPWNsaWRnRmVkaXJlY3QmZG9Ob3RMb2dDbGljaz10cnVl

Total = \$587.70