1. Sensor Interface Subsystem Testing

Highest Relative Weight: ER23 = 8%, Total Relative Weight: 25%

Goal:

The purpose of this testing is to verify the existing sensor system, and all of its upgrades, are functioning properly.

Overview: Ensure that the system is functional and powered sufficiently for the expected time period. Results should be recorded successfully on the SD card in the system. Additionally, verify the overall correctness of the data/information collected and displayed; cross verify between what the LCD screen shows, what the mobile app shows, what the data recorded on the SD card shows, and perhaps even what physical testing of the water (PH test strips/solution and thermometer) shows.

Owner: Armand and Jacky

Timeline:

Start Date: Week 1 MSD II Dependency: None

Duration: 4 weeks

Materials:

Existing sensor system

PH test strips/solution

Thermometer

Solared powered capacitor as battery (or alternate power source)

Mobile device

Assumptions: Latest version of mobile app source code is loaded onto the Arduino. Latest version of the mobile app is compatible and installed on the mobile device used for testing. Power source is charged (if necessary). SD card with free space is loaded into the system to record data.

Setup Steps: Connect system to power supply. Turn on power. Place sensors in the water.

Testing Steps: Ensure the system is able to run for the expected time period (based on power source). Verify that O2, PH, turbidity and temperature values match between the LCD display, mobile app display, SD card recorded data, and manual testing (with thermometer, pH test strips/solution, etc.).

Related ERs:

ER	Description	Technical Targets	Relative Weight (%)

1	Ability to sense and record temperature	Yes	3
2	Ability to sense and record turbidity	Yes	3
3	Ability to sense and record pH	6-7 pH	3
4	Ability to monitor O2	4 mg/L	3
9	Amount of electricity supplied	0 V	5
23	Total cost	</= $200	8

2. Environmental and Structural Subsystem Testing

Highest Relative Weight: ER8 = 9%, Total Relative Weight: 31%

Goal:

The purpose of this testing to determine the durability of the plant bed and fish tank.

Overview:

The plant tank and fish tanks will be filled to the appropriate level and be allowed to sit outside for some time. The water loss will be recorded. The tanks must be adequate to meet target fish and plant densities as well as the optimal fish:crop ratio. To test this, we will need to measure out the max amount of lettuce our plant bed can sustain, from this, we can apply the ratio to determine how many fish we can safely sustain.

Owner: Thomas and Kesh

Timeline:

Start Date: Week 1 MSD II Dependency: None

Duration: 2 weeks

Materials:

Rubbermaid 100 Gallon Container

PVC Plant Beds, x6 as per initial concept

Water, accompanied with nitrate testing kit

Measuring equipment for measuring water loss

Assumptions:

No other loss other than evaporation

Proper plant/fish ratio is

Setup Steps:

Setup 100 gallon rubbermaid tank outside/in greenhouse, if available.

Fill to approximately 80-90% capacity

Allow tank to sit

Testing Steps:

Measure how much water is going into the system, and solve for the relationship between volume and height of water.

Every week, measure the height of the water and solve for the corresponding volume.

Related ERs:

ER	Description	Technical Targets	Relative Weight (%)
8	Fish:Crop Ratio is maintained through the structure	.576 kg/head	9
14	Fish tank volume must be adequate for containing multiple fish	400-500 L	3
15	Plant bed area must be adequate to contain multiple plants	2-4 m^2	3
23	Total cost	</= $200	8
24	Ensures that the materials being utilized are readily available in Colombia	Yes	5

3. User Interface Functionality Subsystem Testing

Highest Relative Weight: ER17 = 6%, Total Relative Weight: 18%

Goal:

The purpose of this testing is to ensure all features of the user interface work correctly and are user-friendly.

Overview:

All features of the user interface will be tested, both by the MSD team and by participants with no knowledge of the system, to make sure nothing is confusing or misleading. Aspects of the

user interface to be tested include the intervals at which the farmer must interact with the system to ensure water is appropriately cycled. These intervals will also be impacted by the amount of water the buckets can hold. The volume of these buckets will also impact the weight necessary to replace the drainage bucket down to begin refilling.

Owner: All

Timeline:

Start Date: Week 1 MSD II Dependency: Test Plan #2, 4, 5

Duration: 2 weeks

Materials: Full Bom

Assumptions: Test plans 2, 4, and 5 are successful

Setup Steps: All dependent test plans complete and combined

Testing Steps:

1. Complete setup system
2. Prototype steps to maintaining the system
3. Clearly document all steps completed in step 2 in the instruction manual
4. Once preliminary manual complete, invite outsider to test system and use instruction manual to operate
5. Reiterate step 4 with new participants until satisfactory

Related ERs:

ER	Description	Technical Targets	Relative Weight (%)
16	Time allocated to setting up and tearing down system	</= 1 day	3
17	Comprehensive and intuitive instructor guide	Yes	6
19	Amount of farmer interaction needed daily	< 30 min	4
26	Adherence to safe amount of load carrying for farmer	</=60lbs/hr	5

4. Solids Filter Subsystem Testing

Highest Relative Weight: ER25 = 8%, Total Relative Weight: 24%

Goal:

The purpose of this testing is to evaluate the performance of the solid waste filter.

Overview:

Solid waste will be simulated and allowed to flow into the solid waste filter. The amount of solid that passes through the filter and the speed at which the filter clogs will be recorded. Also, the ease of removing and replacing the filter will be evaluated. The solid waste filter will be applied to the buckets. Intervals of maintenance will be determined for cleaning the buckets.

Owner: Caleb

Timeline:

Start Date: Week 1 MSD II Dependency: None

Duration: 2 weeks

Assumptions:

- Waste will be combination of crushed up dirt, grass, leaves to mimic fish waste

Materials: 5 gallon bucket, rocks, sand

Setup Steps:

1. Acquire materials
2. Drill a hole approximately 1 cm in diameter to permit drainage

Testing Steps:

1. Test net filtering capability
    a. Place netting beneath the bucket
    b. Place bucket on shelf within the fish tank
    c. Pour water with waste in it into the bucket
    d. Observe the amount of waste collected by the system and cleanliness of water in tank
2. Reiterate step 2 using alternative netting as the filtering mechanism
3. Compare filtering capability by measuring turbidity
4. Select more effective filtering solution
5. Continue testing of the filter until test plan 7

6. Record how often the filter must be cleaned

Related ERs:

ER	Description	Technical Targets	Relative Weight (%)
5	Must be able to reuse water, and minimize how much is replaced per week	</=5% loss	5
25	Max filter level must be greater than or equal to the minimum amount of water needed by the fish in the tank	>/=60 L	8
24	Materials of the filter must be easily procured in Colombia	Yes	5
27	Water Conditions (ammonia, nitrite, nitrate) must be maintained	0, 0, 5-40 ppm	6

5. Flow Rate Subsystem Testing

Highest Relative Weight: ER25 = 8%, Total Relative Weight: 29%

Goal:

The purpose of this testing is to make sure water can be pumped at a reasonable rate to support fish and plant vitality and with a safe amount of user effort.

Overview:

2 5-gallon buckets will be used in conjunction to regulate cycling. As the top bucket empties, the bottom bucket is filled up to near max capacity, which will be in line with at least the minimum amount of water needed for fish in the tank. At this point, the farmer will need to replace the other side so the filled water can rise and drain out. To test this, we will need to determine the force necessary to lift and replace the buckets. Final tests will incorporate the architecture founded in Test Plan #2 to see how it functions with the system.

Owner: Thomas and Kesh

Timeline:

Start Date: Week 1 MSD II Dependency: Test Plan #2 and 4

Duration: 2 weeks

Materials: 2x Bucket, PVC pipes, Rock, fish net

Assumptions:

- No external forces, As the water fills up the lower filter, it will stop once it reaches the same level as the fish tank

Setup Steps: Ensure the structure of the system is in place (test plan 2) and filter testing complete (test plan 4)

Testing Steps:

1. Fill 5 gallon bucket with a layer of rocks and water until max capacity is almost reached
2. Have volunteer lift bucket up to a height of 31 inches
3. Weight bucket
4. Complete Niosh equation to find the ergonomics of the system
5. Empty bucket of water and rocks
6. Drill a hole into the bucket, keeping in mind the diameter of the hole
7. Place a plug into the hole, ensuring no water is leaking out
8. Add a layer of rocks and exactly 4 gallons of water
9. Remove the plug and begin timing until no more water leaks out of bucket

Related ERs:

ER	Description	Technical Targets	Relative Weight (%)
5	Must be able to reuse water, and minimize how much is replaced per week	</=5% loss	5
24	Materials of the filter must be easily procured in Colombia	Yes	5
25	Max filter level must be greater than or equal to the minimum amount of water needed by the fish in the tank	>/=60 L	8
26	Adherence to safe amount of load carrying for farmer	</=60lbs/hr	5
27	Water Conditions (ammonia, nitrite, nitrate) must be maintained	0, 0, 5-40 ppm	6

6. Nitrate Cycling Testing

Highest Relative Weight: ER25 = 8%, Total Relative Weight: 24%

Goal:

The purpose of this testing is to ensure optimal aquatic conditions can reached as well as a documented process to achieve the conditions.

Overview:

This testing is crucial in ensuring that the system is able to sustain aquatic life. Testing will involve applying a variety of different inputs to a small scale system (5-gallon bucket) and tracking the evolution of the nitrate cycle over time. Given that this testing requires time to understand results, testing will be ongoing throughout MSD 1 and 2. Once optimal levels are reached without fish, goldfish will be introduced to the small-scale system to test how the current parameters accommodate fish.

Owner: Melissa

Timeline:

Start Date: Week 5 MSD 1 Dependency: None

Duration: Ongoing throughout MSD 1 and 2

Materials: Nitrogen Cycle testing kit, 5 gallon bucket, Ammonia (solution or fish food), water, surface for bacteria growth (rocks or net), way/form to oxygenate and heat tank

Assumptions:

- successful with a small-scale system → successful with a large-scale system
- 5 drops per 10 gallons of water

Setup Steps:

1. Fill up 5 gallon bucket of water with approximately 4 gallons
2. Mark water level and keep bucket in a controlled environment
3. Add 2 drops of ammonia to bucket
4. Add surface with bacteria already introduced
5. Add way to oxygenate system
6. Add light to heat up water

Testing Steps:

1. Measure ammonia, nitrite, and nitrate levels daily
2. Add 2 drops of ammonia daily
3. Maintain water level by adding water to the initial mark
4. If ammonia and nitrite levels are too high, switch out 1/2 of the tank with fresh water
5. Once nitrite levels are > 0ppm, reduce ammonia addition to 0.5 drop daily
6. Measure ammonia, nitrite, and nitrate levels every 2 to 3 days until there is 0 ppm of ammonia and nitrites

7. Add goldfish

Related ERs:

ER	Description	Technical Targets	Relative Weight (%)
5	Must be able to reuse water, and minimize how much is replaced per week	</=5% loss	5
24	Materials used in cycling must be easily acquired in Colombia	Yes	5
25	Max filter level must be greater than or equal to the minimum amount of water needed by the fish in the tank	>/=60 L	8
27	Water Conditions (ammonia, nitrite, nitrate) must be maintained	0, 0, 5-40 ppm	6

7. Short-term: No-fish No-plants System Testing

Highest Relative Weight: ER23 = 8%, Total Relative Weight: 49%

Goal:

The goal of this testing is to make sure there are no apparent issues with the system when it is fully assembled and put into use. To focus on specifically functionality and structure, we will not use fish or plants in this test. This testing cannot begin until all previous plans are completed.

Overview:

This testing requires a fully-assembled prototype system. It will be set up and filled with water just like it was going to be put to use, but no fish or plants will be added. The system will be operated with any daily maintenance that would be required if it were actually functioning. It will be monitored for O2, pH, temperature, turbidity, nitrates, and water loss regularly throughout this period. Additionally, the amount of time each day spent maintaining the system will be recorded, including how much time spent to maintain proper nitrate cycle. This testing phase will also mark our first test of our systems resistance to environmental risk factors. Since this will include full architecture and components, we will also utilize this testing stage to benchmark our current total cost and continue to look at possible cost reductions through this phase and following testing. This phase will also be used to test the effectiveness of the instructor manual by measuring efficiency to setup and accuracy.

Owner: All

Timeline:

Start date: Week 6 MSD II Dependency: Test Plans #'s 1-6

Duration: 2 weeks

Materials: Full BOM minus plants, soil, and fish

Assumptions:

- All preceding plans completed and successful

Setup Steps:

1. Combine results from plans 1-6 to construct the full system
2. Throughout the build process, maintain detailed accounts of the process
3. Begin rough draft of instruction manual - setup
4. Record improvement opportunities for manual
5. Record the time it took to build
6. Pour water into system at 70% of total volume
7. Make note of starting water volume
8. Record parameters from sensor system once water introduced

Testing Steps:

1. Conduct daily cycling that would be required of a full system (fish and plants)
2. Continue to record parameters daily
3. Make note of the weather for the day corresponding to the parameters
4. Record any additional observations about the state of the system
5. Repeat steps 4 to 8 for a second week
6. Record water volume loss and final parameters
7. If water parameters successfully achieved and maintained, proceed to test plan 8

Related ERs:

ER	Description	Technical Targets	Relative Weight (%)
1	Ability to sense and record temperature	Yes	3
2	Ability to sense and record turbidity	Yes	3
3	Ability to sense and record pH	6-7 pH	3
4	Ability to monitor O2	4 mg/L	3
5	Water volume replaced per week	5%	5
9	Amount of electricity supplied	0 V	5
10	Contaminant protection	Yes	2
12	Rain resistant	Yes	1
13	Temperature resistant	24 *C	3
16	Set-up and teardown time	</= 1 day	3
17	Comprehensive instructor guide	0 errors	6
19	Farmer interaction required per day	</= 30 min	4
23	Total cost	</= $200	8

8. Medium-term: No-fish With-plants System Testing (Hydroponics)

Highest Relative Weight: ER23 = 8%, Total Relative Weight: 54%

Goal:

The purpose of this testing is to evaluate the prototype of our system only for hydroponic use (no fish).

Overview:

The system will be set up and plants will be added into their designated locations. Hydroponic plant food, and possible extra ammonia to simulate the fish waste if needed, will be added to the fish tank each day, along with any general maintenance like pumping. All water parameters and the growth of the plants will be tracked. This testing will help us understand how well our system supports the plants vitality as well as how our current cycling methods satisfy the plant constraints. While we will still be monitoring the same requirements outlined in the previous phase, our primary focus will be on the plants vitality and the interaction between maintaining it along with our other requirements.

Owner: All

Timeline:

Start Date: Week 8 MSD II Dependency: Test Plan # 7

Duration: 1 week

Materials: Full BOM minus the fish

Assumptions:

- Test plan 7 was successful in reaching and maintaining optimal water parameters

Setup Steps:

1. Utilizing test system from plan 7, add crops to the PVC plant bed
2. Record parameters from sensor system and ammonia testing
3. Record starting volume
4. Clean filter if needed

Testing Steps:

1. Add ammonia to fish tanks
2. Conduct daily cycling that would be required of a full system
3. Record parameters again
4. Make note of the weather for the day
5. Record any additional observations about the state of the system
6. Repeat for 2 weeks
7. Record water volume loss

Related ERs:

ER	Description	Technical Targets	Relative Weight (%)
1	Ability to sense and record temperature	Yes	3
2	Ability to sense and record turbidity	Yes	3
3	Ability to sense and record pH	6-7 pH	3
4	Ability to monitor O2	4 mg/L	3
5	Water volume replaced per week	5%	5
7	Crop density	9 heads/m^2	3
9	Amount of electricity supplied	0 V	5
10	Contaminant protection	Yes	2
11	Hours of light per day	12-15 hrs	2
12	Rain resistant	Yes	1
13	Temperature resistant	24 *C	3
16	Set-up and teardown time	</= 1 day	3
17	Comprehensive instructor guide	0 errors	6
19	Farmer interaction required per day	</= 30 min	4
23	Total cost	</= $200	8

9. Long-term Full Aquaponics (Fish+Plants) System Testing

Highest Relative Weight: ER08 = 9%, Total Relative Weight: 80%

Goal:

The purpose of this phase is to bring together all of our knowledge and past testing to formulate our final product with both fish and plants included.

Overview:

The system will be set up and fish and plants will be introduced. It will be maintained every day for the remainder of the semester. All water parameters will be tracked, and daily maintenance time will be recorded. The rate of fish growth will also be recorded. Accurate details regarding fish food intake will also be recorded. Nitrate cycling tests will be finalized through final tests with fish included. Finalization of the instructor guide will take place to ensure completeness and accuracy.

Owner: All

Timeline:

Start Date: Week 11 of MSD II Dependency: Test Plan #8

Duration: 2-3 weeks, this will be our final phase of testing and take place during the final weeks of the semester and into Imagine RIT.

Assumptions:

- Optimal water parameters were reached and maintained through test plan 7
- Remainder of the semester will be sufficient time to observe performance of system and make and record adjustments if needed
- All preceding test plans were successful

Setup Steps:

1. Use full system from test plan 8
2. Add fish to the fish tank
3. Make note of starting water volume
4. Record starting water parameters
5. Record water volume loss
6. Add water if needed
7. Clean filter if needed

Testing Steps:

1. Conduct daily cycling of the water
2. Record parameters again.
3. Adjust pH, oxygen levels, etc. as needed
4. Observe current cycling schedule. Record and adjust as needed
5. Feed the fish until they stop eating each day
6. Record farmer interaction time
7. Make note of the weather for the day corresponding to water parameters
8. Record any additional observations about the state of the system

9. Repeat for remainder of school semester

Related ERs:

ER	Description	Technical Targets	Relative Weight (%)
1	Ability to sense and record temperature	Yes	3
2	Ability to sense and record turbidity	Yes	3
3	Ability to sense and record pH	6-7 pH	3
4	Ability to monitor O2	4 mg/L	3
5	Water volume replaced per week	5%	5
6	Fish Density	0.019 kg/L	6
7	Crop density	9 heads/m^2	3
8	Fish:Crop Ratio	.576 kg/head	9
9	Amount of electricity supplied	0 V	5
10	Contaminant protection	Yes	2
11	Hours of light per day	12-15 hrs	2
12	Rain resistant	Yes	1
13	Temperature resistant	24 *C	3
16	Set-up and teardown time	</= 1 day	3
17	Comprehensive instructor guide	0 errors	6
19	Farmer interaction required per day	</= 30 min	4
20	Fish protein requirement per day	28 g/day	1

21	Fish carbohydrate requirement per day	62 g/day	1
22	Fish fat requirement per day	3 g/day	1
23	Total cost	</= $200	8
27	Water Conditions (ammonia, nitrite, nitrate) must be maintained	0, 0, 5-40 ppm	6