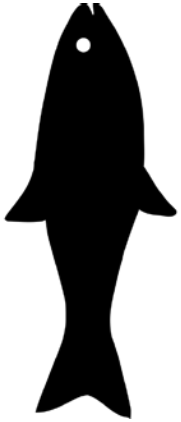

Sustainable Agriculture Design Project

Conscious Cultivation

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Acknowledgements

- Grading Instructor: Mark Lamer
- Technical Advisors: Dr. Terry Baxter and Gerjen Slim
- Northern Arizona University Green Fund
- Northern Arizona University Facility Services
- Northern Arizona University Office of Space Management
- Northern Arizona University CECMEE Department
- Growing Spaces

Project Description: Location

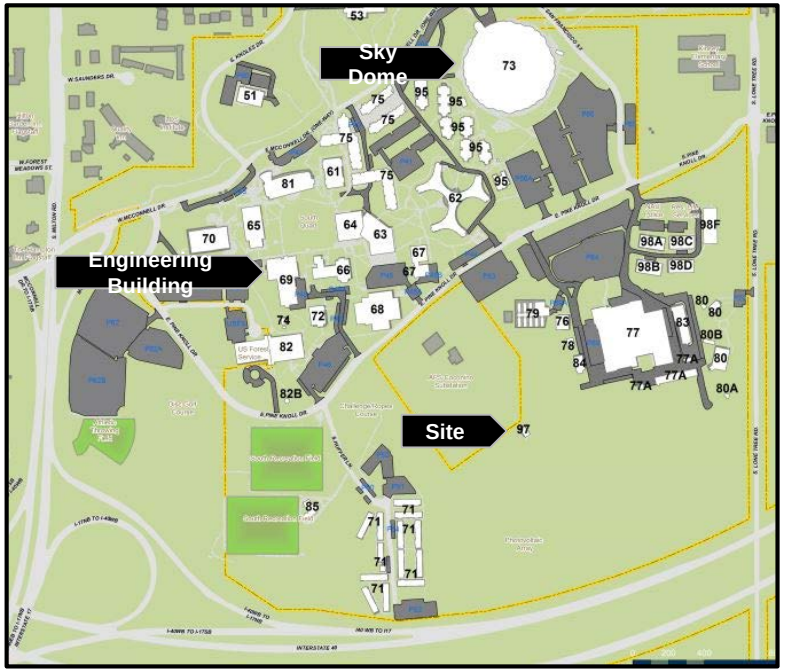

Figure 1: Project Site [1]

Figure 2: Building 97 [2]

Project Description: Constraints/Limitations

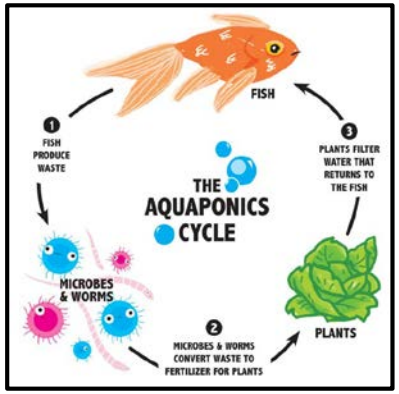

Figure 3: The Aquaponics Cycle [3]

Original Scope

Aquaponics System in a 22’ Growing Dome at the CECMEE Field Station

Limitations

Northern Arizona University Office of Space Management rejected proposal to have a growing dome erected at the CECMEE Field Station

New Scope

Design and construct an aquaponics system to be used indoors during the winter months and outdoors during the summer months utilizing Building 97.

Figure 4: Growing Dome by Growing Spaces [4]

Project Description: Tasks

Task 1: Funding
- 1.1: Green Fund
- ~~1.2: Donations~~

~~Task 2: Greenhouse Acquisition~~
- ~~2.1: Site and Size Determination~~
- ~~2.2: Considerations for Renewable Energy~~

Task 3: Technical Research
- 3.1: Biofilter Design
- 3.2: Clarifier Design
- 3.3: Vegetation
- 3.4: Aquaculture

Task 4: Analysis
- 4.1: Hydraulic Analysis
- 4.2: Water Quality Analysis
- 4.3: System Space Requirements
- 4.4: Economic Analysis

Task 5: Design
- Sub-task 5.1: Aquaculture
  - 5.1.1: Fish Selection
  - 5.1.2: Fish Tank Design
  - 5.1.3: Clarifier Design
  - 5.1.4: Biofilter Design
- Sub-task 5.2: Hydroponics
  - 5.2.1: System(s) Selection
  - 5.2.2: Pump Selection
  - 5.2.3: System(s) Design

Task 6: Material Acquisition
- ~~6.1: Greenhouse~~
- 6.2: Aquaponics

Task 7: Construction
- ~~7.1: Greenhouse~~
- 7.2: Aquaponics

Task 8: Testing and Monitoring
- 8.1: Water Stabilization
- 8.2: Fish Introduction
- 8.3: Plant Propagation
- 8.4: Plant Introduction
- 8.5: System Monitoring

Task 9: Operation and Maintenance Manual

Task 10: Project Management
- 10.1: Meetings and General Management
- 10.2: Schedule
- 10.3: 50% Design Report
- 10.4: Final Design Report
- 10.5: Final Presentation
- 10.6: Website

Testing/Analysis: Hydraulic Analysis

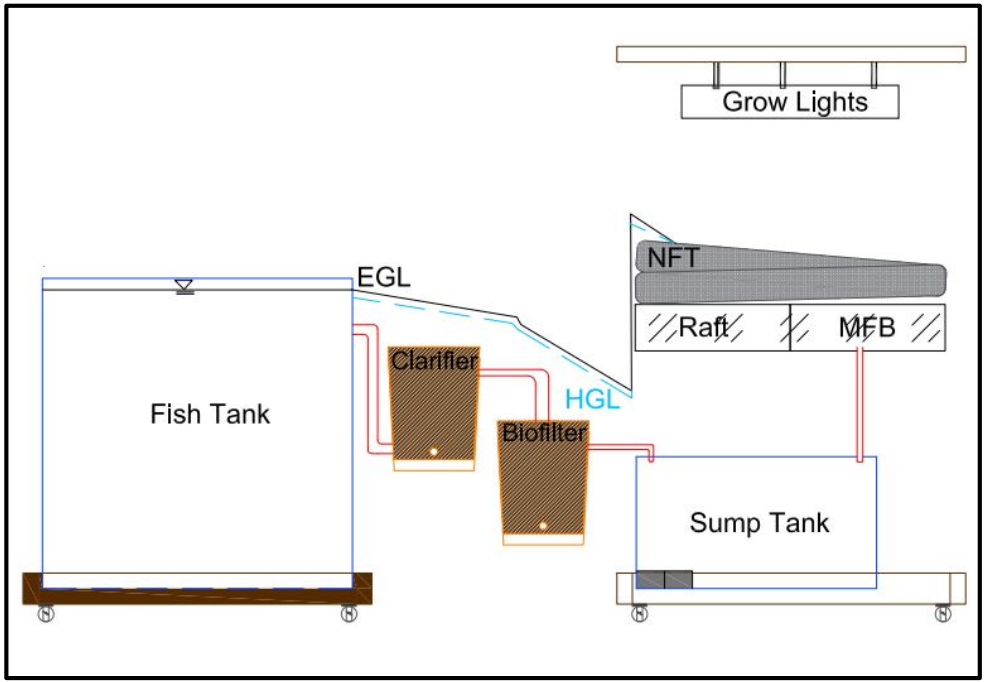

Figure 5: EGL and HGL Lines

Assumptions

Pipe Diameter = 1”

$h_{p,max}$ = 5 ft

Calculations

Using the Energy Equation: $\frac{P_1}{\gamma} + \frac{V_1}{2g} + Z_1 + h_p = \frac{P_2}{\gamma} + \frac{V_2}{2g} + h_t + h_l$

$v = (2gh_{p,max})^{½} = ((2)(32.2\ ft/s^2)(5\ ft))^{½} = (322\ ft^2/s^2)^{½} = 17.94\ ft/s$

$Q = vA = (17.94\ ft/s)(\pi(0.0415^2\ ft^2)) = 0.097\ ft^3/s$

$P = (Q\gamma h_{p,max})/(550\ ft\text{-}lb/s) = ((0.097\ ft^3/s)(62.4\ lb/ft^3)(5\ ft))/(550\ ft\text{-}lb/s)$

$= 0.055\ hp = 41.03\ W$

Testing/Analysis: Water Quality Analysis

Parameters of Interest

1. Dissolved Oxygen
   a. >6 ppm
2. pH
   a. 6.0-8.5
   b. Phosphoric Acid
   c. Potassium Hydroxide
3. Temperature
   a. Effects DO and ammonia concentrations
4. Total Nitrogen
   a. Ammonia converts to nitrite and nitrate (nitrification)
   b. $NH_3 \rightarrow NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$
5. Water Hardness
   a. Total hardness and carbonate hardness

Parameters to be Measured

1. pH
2. Ammonia
3. Nitrite
4. Nitrate
5. Temperature

Figure 6: Water Testing Kit [11]

Testing/Analysis: System Space Requirements

Criteria

1. 275 gallon IBC Tank donated by Mark Lamer
2. Less than 60 $ft.^2$ of space to house system in Building 97
3. Water to fish ratio
    a. 3 gallon water/1 pound fish
4. Fish to plant ratio
    a. 100 grams fish feed/m^2 plant space/day

Decision

- 15 fish
- 50 plants

Figure 7: IBC Tank [12]

Testing/Analysis: Economic Analysis

- Green Fund approved project for a total of $2,500.00
- Based on analysis thus far, how can we design our system to fit in the given budget?
- Created a materials list based on research to fall well below budget.

Figure 8: Green Fund Logo [13]

Identification of Selected Alternatives

System Selection

- Educational
- Space requirements met
- Funding met

Figure 9: MFB System [5]

Figure 10: Raft System [6]

Figure 11: NFT System [7]

Fish Selection

- Survive in wide range of temperatures
- Withstand higher levels of toxicity
- Other species could be selected after further evaluation of system

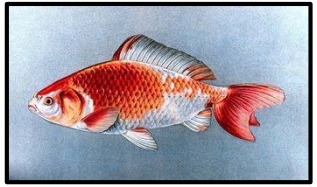

Figure 12: Koi [10]

Site Selection

- CECMEE Field Station
- Easier access for stakeholders
- Able to build all 3 systems
- Able to grow edible plants
- System can be mobile

Figure 13: Building 97 [2]

Plant Selection

- Winter plants
- Plants currently growing
  - Chard
  - Endive
  - Tatsoi
  - Romanesco
  - Calabrese
  - Cauliflower
  - Lettuce
  - Spinach

Figure 14: Propagated Plants [2]

Final Design: System Schematic

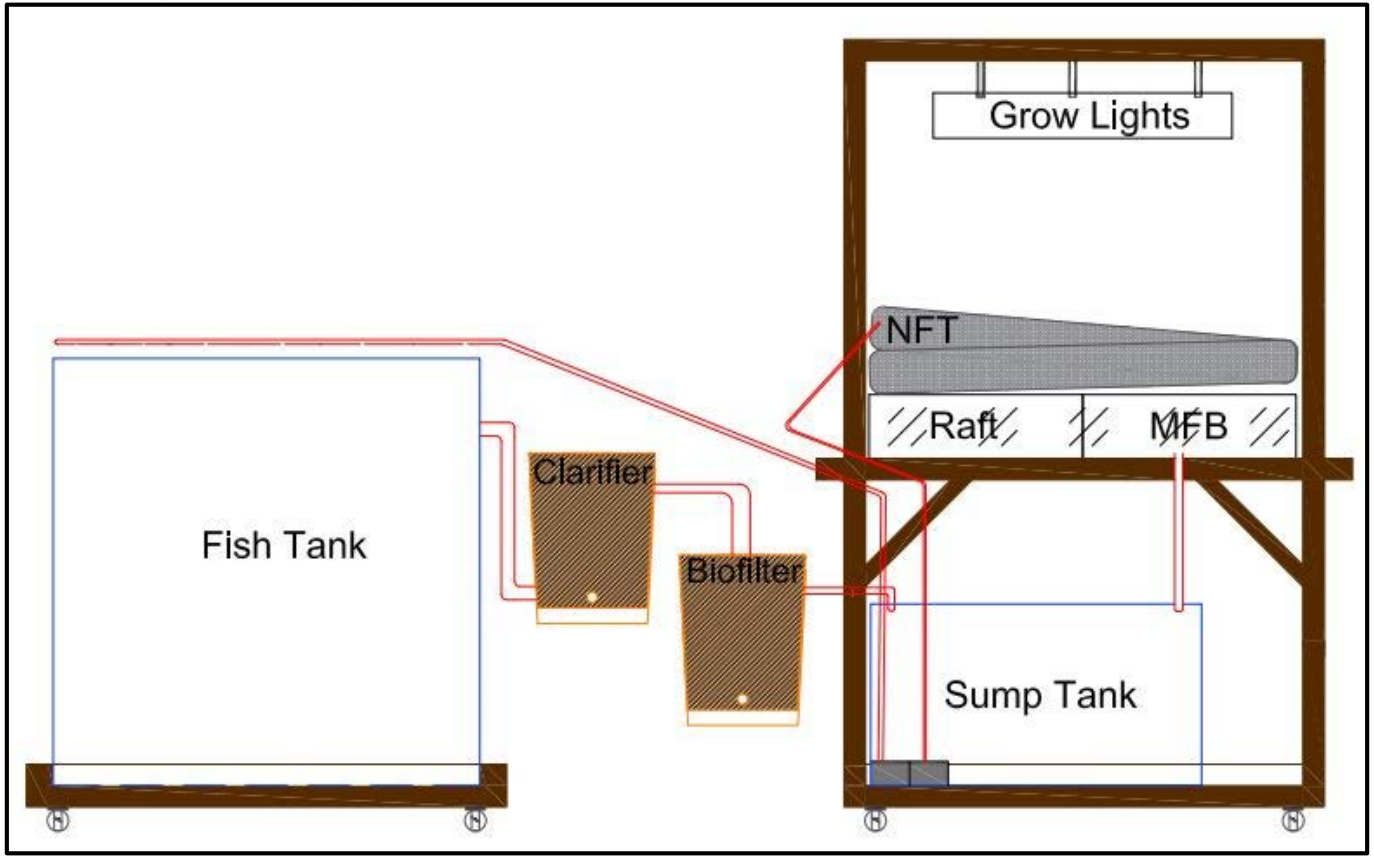

Figure 15: System Design

Final Design: Biofilter and Clarifier

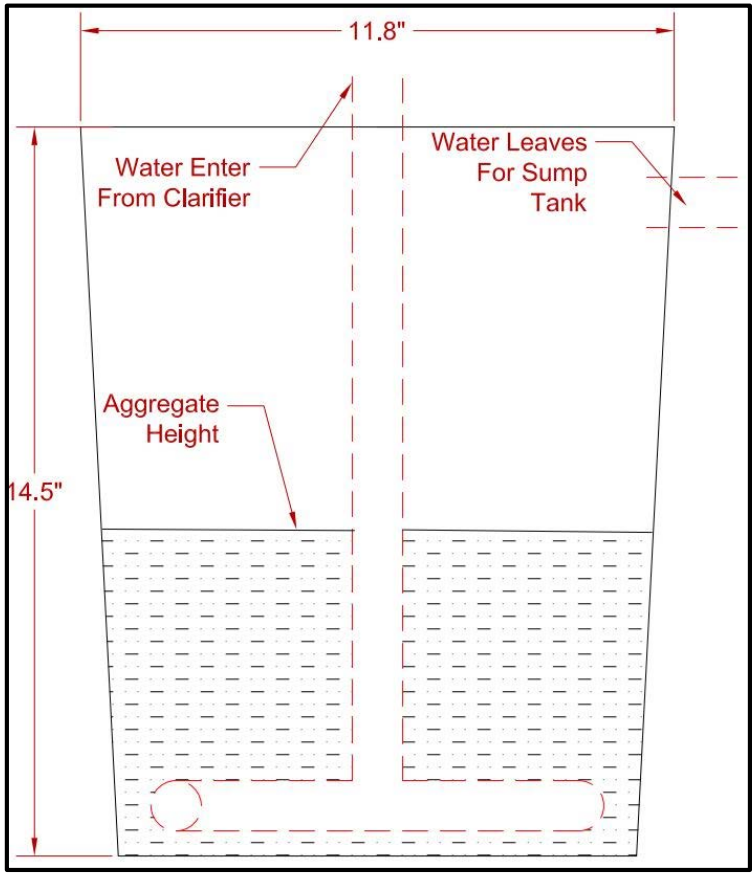

Figure 17: Biofilter Design

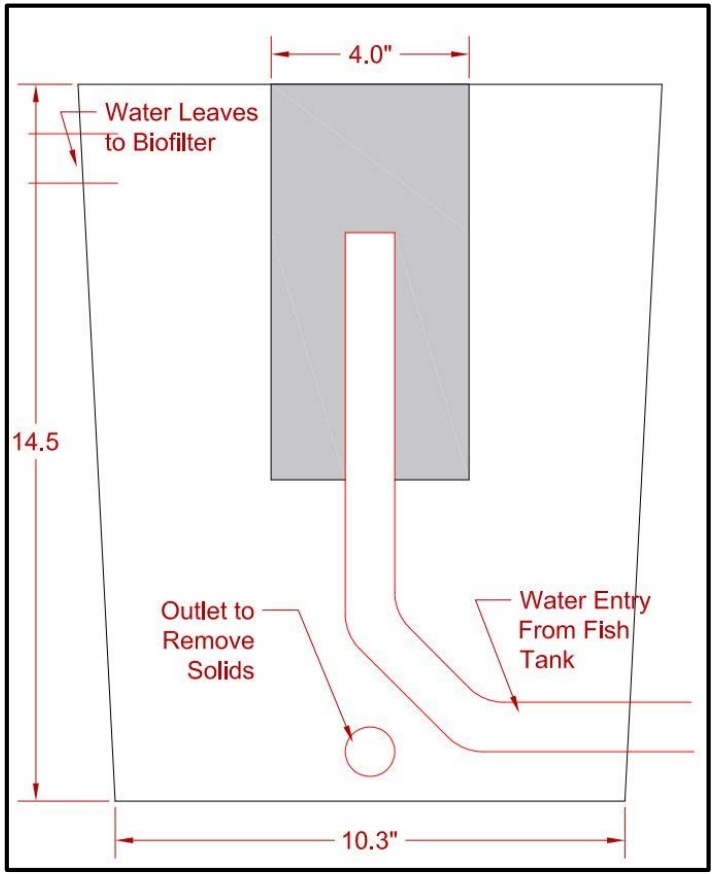

Figure 18: Clarifier Design

Cost of Implementing Design

Total Cost of Aquaponics System:

- $2,500.00

Future Costs of Aquaponics System:

- Propagation cubes
- Seeds
- Fish feed
- pH chemicals
- Water quality testing kit

Simple Payback Period (Hypothetical):

Fish

- Tilapia can be harvested every 6 months
- Adult tilapia is 6 lbs.
- Average price for tilapia: $3.51/lb.
- Tilapia fingerling $1.25
- **Savings per year = $594.30**

Plants

- Broccoli can be harvested every 3 months
- Average price for broccoli: $3.00/lb
- Broccoli seed: $0.10
- **Savings per year = $580.00**

Payback Period: 2.13 years

Summary of Project Costs: Schedule

Task	Original Start Date	Original End Date	Start Date	End Date
Task 1: Funding	April 1	December 1	April 1	December 1
~~**Task 2: Greenhouse Acquisition**~~	~~April 1~~	~~May 15~~	~~April 1~~	~~October 1~~
Task 3: Technical Research	April 1	December 1	April 1	December 1
Task 4: Analysis	Mat 16	June 10	May 16	November 25
Task 5: Design	May 16	June 10	May 16	October 1
Task 6: Material Acquisition	May 16	June 10	May 16	November 25
Task 7: Construction	June 7	Jun 22	June 7	June 22
Task 8: Testing and Monitoring	June 7	June 9	June 7	June 9
Task 9: Maintenance and Operations	June 10	June 14	June 10	June 14
Task 10: Project Management	June 15	June 17	June 15	June 17

Summary of Project Costs: Cost Estimate

1.0 Personnel	Classification	Original Hours	Actual Hours	Rate, $/hr	Original Cost	Actual Cost
	SE	40	90	187.43	$7,497.00	$16,869.00
	E	297	263	75.60	$22,455.00	$19,883.00
	AA	55	30	59.06	$3,250.00	$1,772.00
	EI	315	241	28.59	$9,005.00	$6,890.00
	L	220	130	19.64	$4,320.00	$2,554.00
Subtotal					**$54,025.00**	**$47,968**
2.0 Materials	**Project**				**Original Cost**	**Actual Cost**
	Aquaponics System				$1,555.00	$2,500.00
	Greenhouse				$18,445.00	$0.00
Subtotal					**$20,000.00**	**$2,500.00**

$50,470.00

Total Cost

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