Richmond Community High School Greenhouse

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Introduction

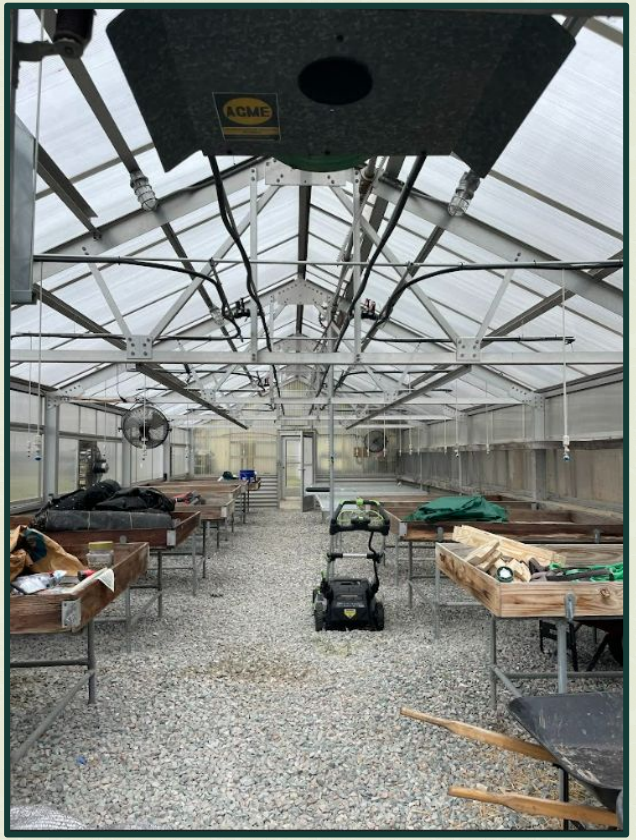
- Primary Client: **Richmond Community High School (RCHS)**
  - A college preparatory high school with the mission of providing gifted students from disadvantaged backgrounds with opportunities to succeed.

- Secondary Client: **Highland Support Project (HSP)**
  - A nonprofit organization dedicated to advocating for communities that have experienced high levels of historical trauma.

Project Overview

- Improve raised garden beds
- Add spirulina shelving to existing greenhouse
- Design a rainwater collection and/or irrigation system
- Design an shaded pavilion

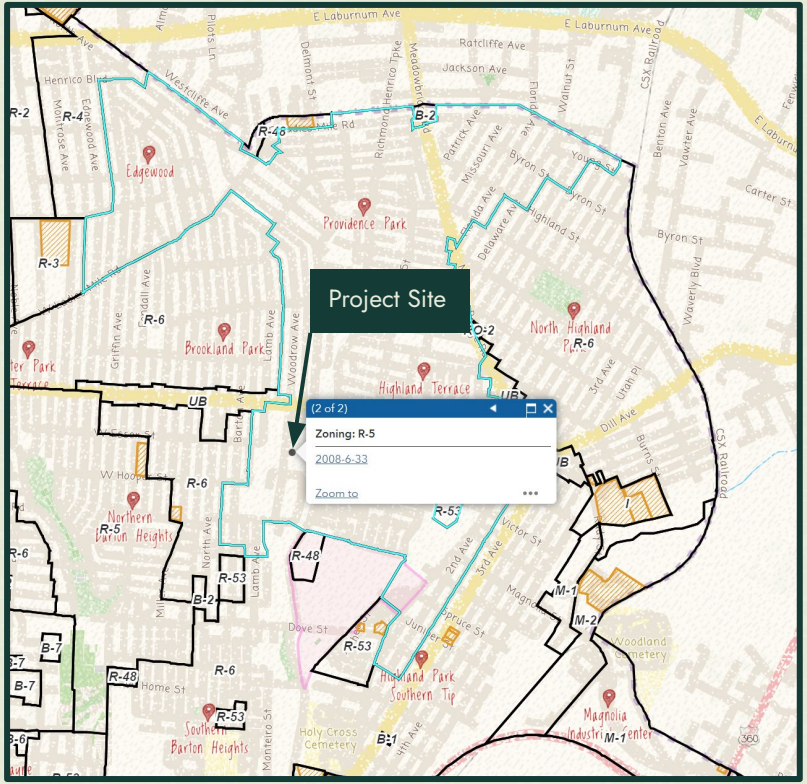
Existing Conditions



Constraints and Considerations

Constraints

- Zoning
  - Land use
  - Lot coverage: < 35%
  - Max. Building height: < 35ft
  - Setbacks: 25ft front, 5 ft back and sides
- Minimum Garden bed dimensions (4′ wide) and spacing
- Cost: non-profit organization; most of the funding will come from grants or donations



Zoning Map of Richmond, VA.

Considerations

- Community Engagement: Bring community together through the community garden and local farmers market.
- Culture: Honor the indigenous groups in the area by ensuring that their culture is reflected in our designs.
- Materials: Some of these designs will be replicated using common materials that can be found in areas such as Arizona and Guatemala where resources are scarce.
- Primary vs Accessory Use: Ensure each stage of the process abides by the definitions outlines in the City of Richmond ordinances.

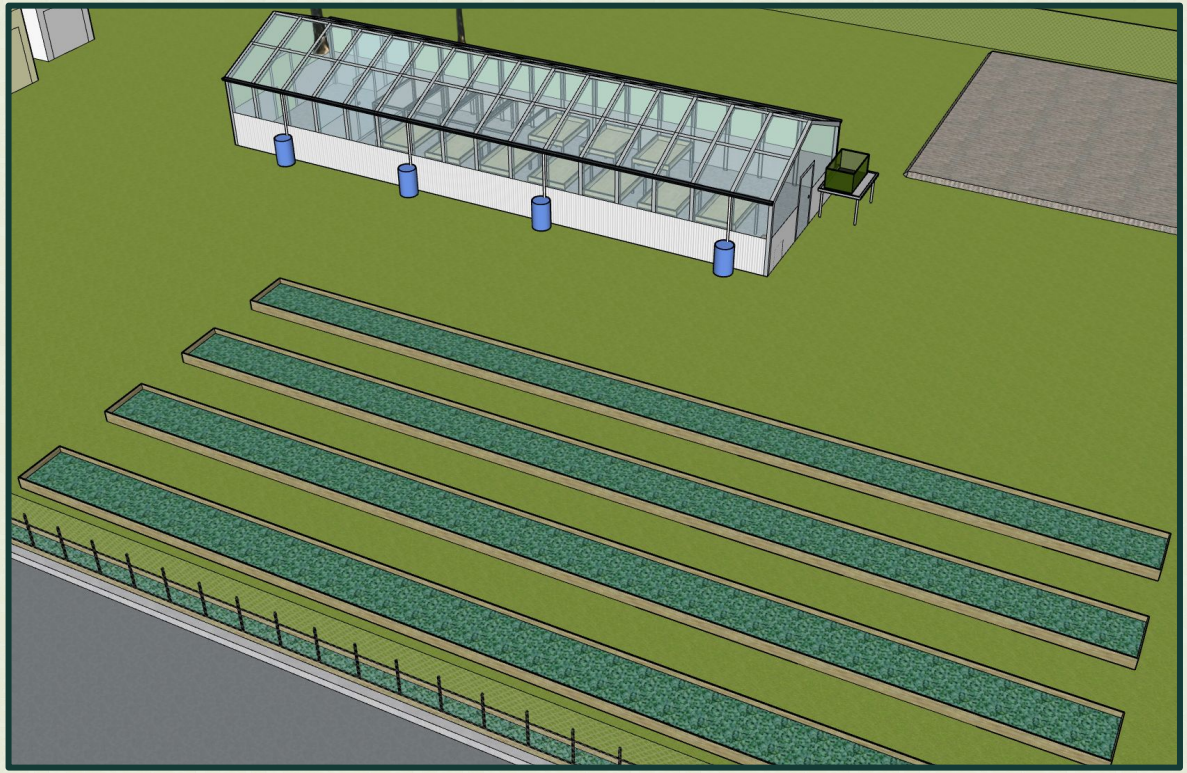
Earth Cross representing cardinal directions in Indigenous culture.

Local farmers market that occurs at the project site.

Garden Box Design Alternatives

Garden Box Design Alternative #1

Boxes aligned with existing boxes along west fence

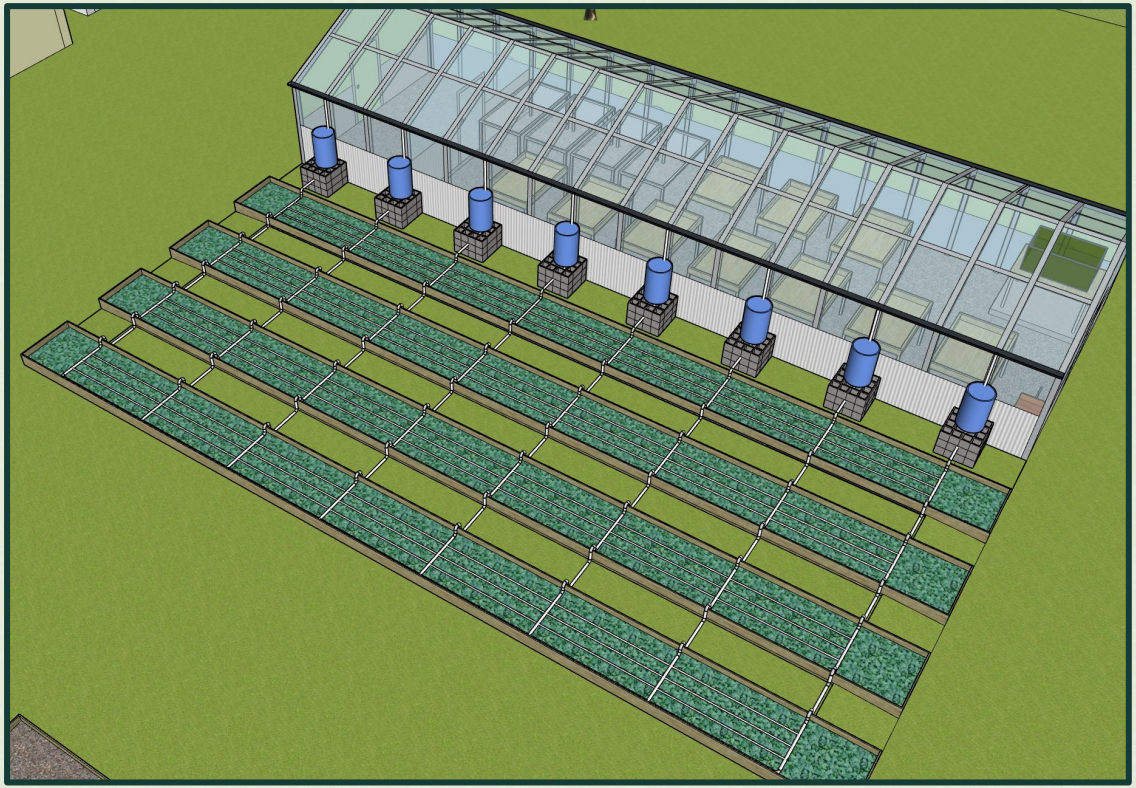


- Minimum height: 1′-0″
- Minimum spacing: 4′-0″
- Recommended width: 4′-0″
- ~100′-0″ length
- Wood: ~$500/bed
- Cinder blocks: ~$750/bed

Garden Box Design Alternative #2

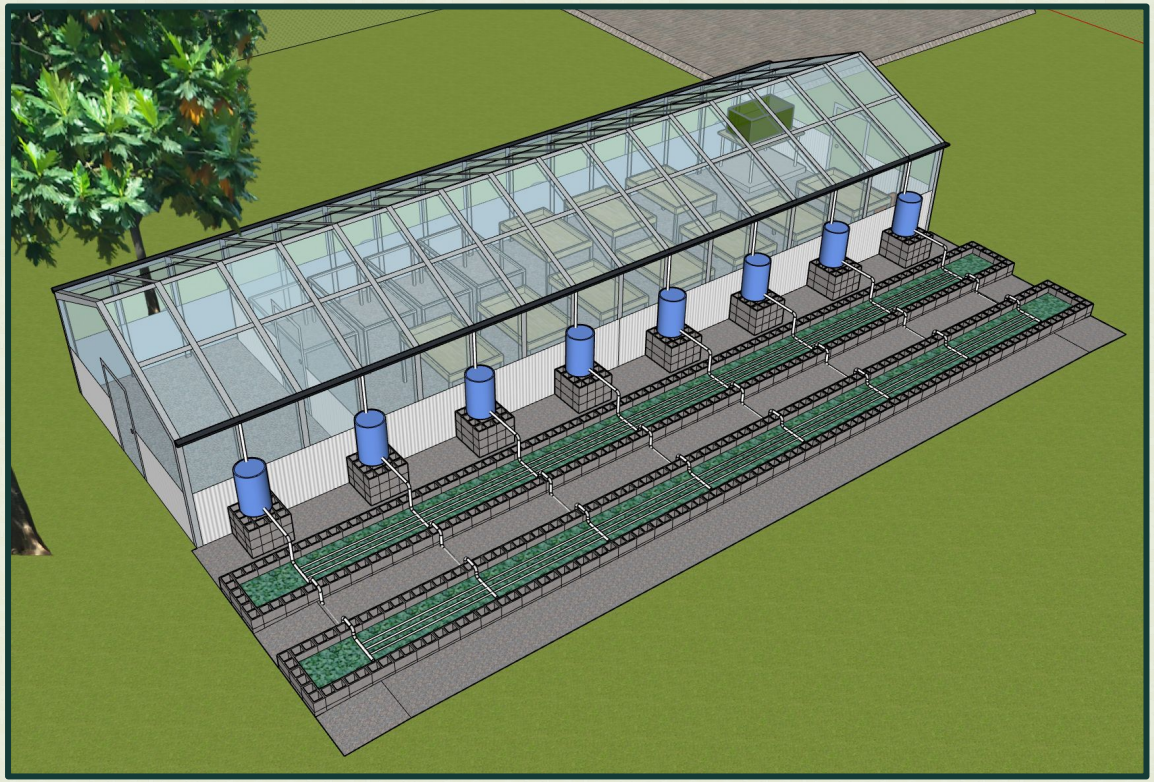
Boxes aligned with west side of greenhouse, grass between beds

- Minimum height: 1′-0″
- Minimum spacing: 4′-0″
- Recommended width: 4′-0″
- ~62′-0″ length
- Wood: ~$350/bed
- Cinder blocks: ~$500/bed

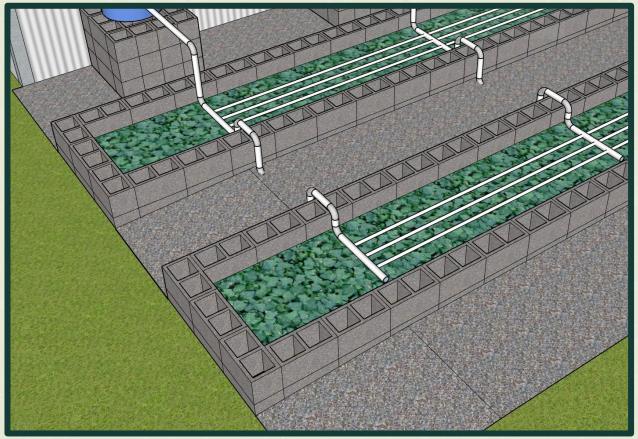


Garden Box Design Alternative #3

Boxes aligned with west side of greenhouse, gravel between beds

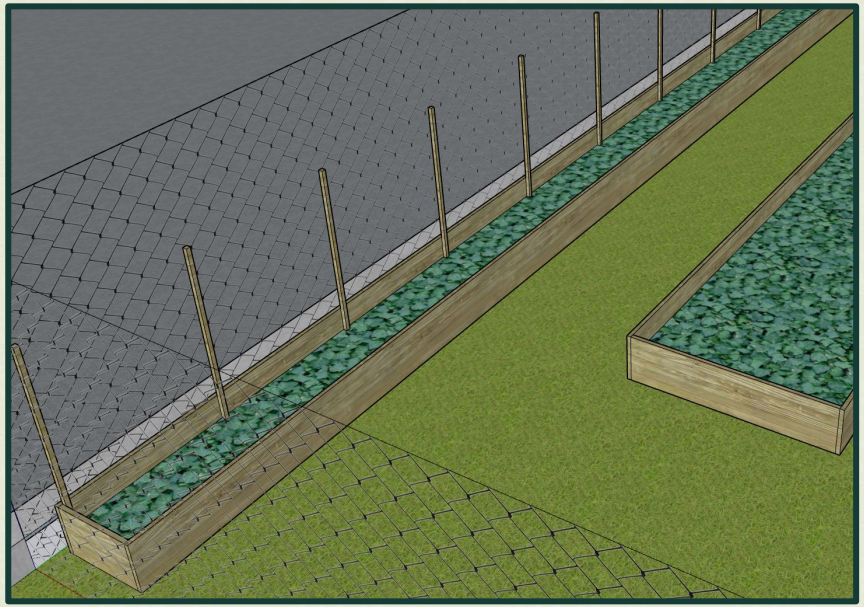


- Minimum height: 1′-0″
- Recommended width: 4′-0″
- Minimum spacing: 3′-0″
- ~62-0″ length
- Gravel: ~$100/space
- Wood: ~$350/bed
- Cinder blocks: ~$500/bed



Garden Box Design Add-On

Narrow boxes along west fence



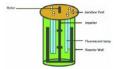
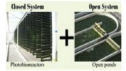
- Minimum height: 1′-0″
- Width: 1′-2′
- ~100′-0″ length
- Wood: ~$450/bed
- Cinder blocks: ~$750/bed

Spirulina Shelving Design Alternatives

What is Spirulina?

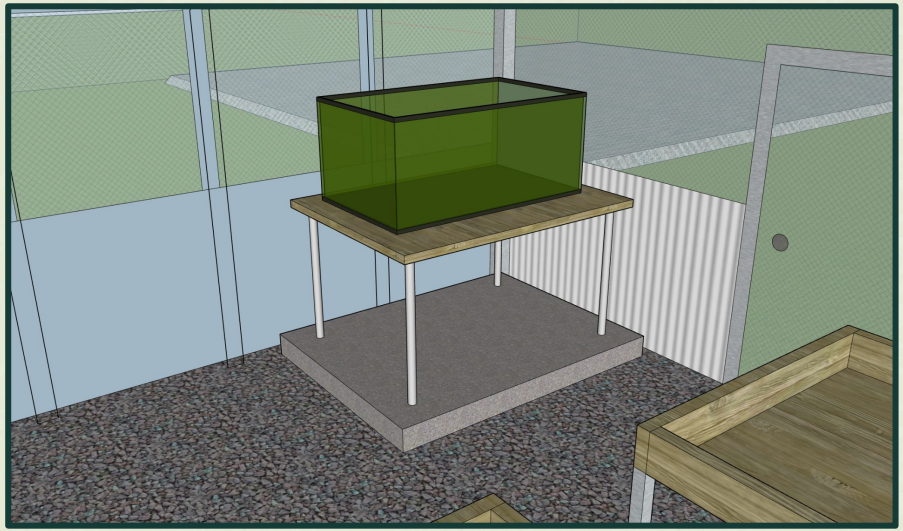
- Algae, cyanobacteria, & biofuel high in macronutrients
- Significant supplement against scarcity of food, crops, resources, etc.
    - Malnutrition
- Variety cultivation techniques & each technique provides different benefits
- Replication in developing areas

Table 3
Prospects and limitations of various cultivation systems (Chojnacka & Noworyta, 2004; Vymazal, 1990; Ugwu et al., 2008; Vree, Bosma, Janssen, Barbosa, & Wijffels, 2015; Newsted, 2004).

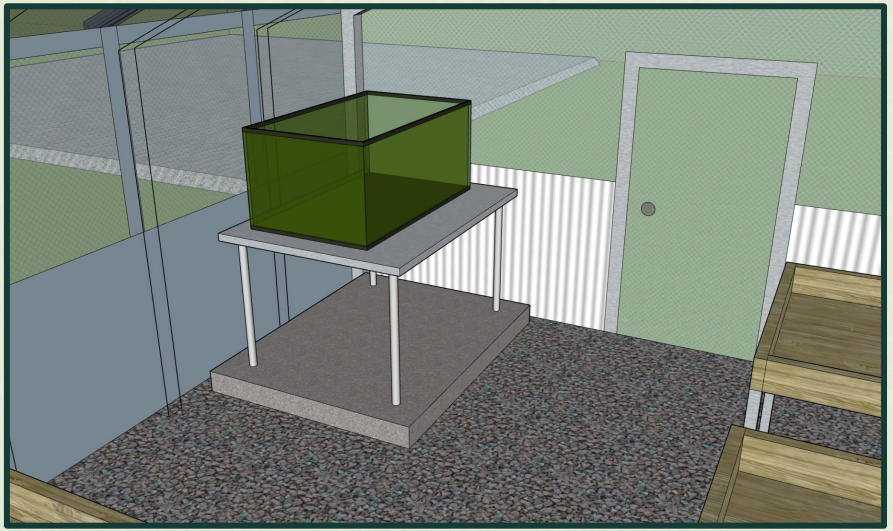
Culture systems	Dimensions	Specific growth rate	Prospects	Limitations	Images
Open systems	Variable	0.30day^{-1}	Relatively economical, easy to clean up after cultivation, good for mass cultivation of algae	Little control of culture conditions, difficulty in growing algal cultures for long periods, poor productivity, occupy large land mass, limited to few strains of algae, cultures are easily contaminated	
Vertical Column PBR	0.2 m diameter and 4 m column height	0.015 ± 0.002 h^{-1}	High mass transfer, good mixing with low shear stress, low energy consumption, high potentials for scalability, easy to sterilize, good for immobilization of algae, reduced photoinhibition and photo-oxidation	Small illumination surface area, construction require sophisticated materials, shear stress to algal cultures, the decrease of illumination surface area upon scale-up	
Flat plate PBR	0.07 m wide, 1.5 m height, 2.5 m length Volume 250lts Productivity - 1.0 g/L day		Large illumination surface area, suitable for outdoor cultures, good for immobilization of algae, good light path, good biomass productivities, relatively cheap, easy to clean up, readily tempered, low oxygen buildup	Scale-up require many compartments and support materials, difficulty in controlling culture temperature, some degree of wall growth, the possibility of hydrodynamic stress to some algal strains	
Tubular PBR	D = 3–10 cm	0.055 h^{-1}	Large illumination surface area, suitable for outdoor cultures, fairly good biomass productivities, relatively cheap	Gradients of pH, dissolved oxygen and CO2 along the tubes, fouling, some degree of wall growth, requires large land space	
Internally Illuminated PBR	Not Specified		Large illumination surface area, can utilize both solar and artificial light system, contamination can be minimized in this system	Outdoor mass cultivation of algae require some technical efforts.	
Hybrid System	Not Specified		Minimize microbial contamination, maximize biomass and product yield, Maximize CO_2 supply	Requires large areas of land and some technical efforts	
Poly Bags	D < 30 cm	0.20day^{-1}	site flexibility, Low-cost materials, easy scalability, optimal light exposure, isolation of the crop from predators, very high biomass concentration, low energy consumption effective weather protection	Polyethylene bag cultures have a relatively short life because the internal surface attracts culture debris and bacteria, which collectively reduce light penetration and are a source of contamination	

Source: *Spirulina – From growth to nutritional product: A review*

Spirulina Shelving Design Alternatives

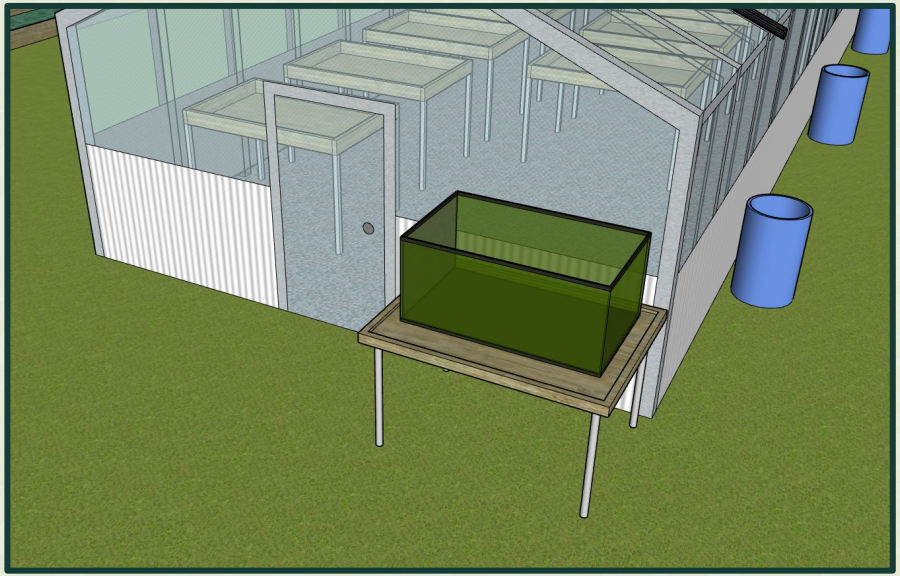


Alternative #1a: Indoor wooden shelving with concrete slab.

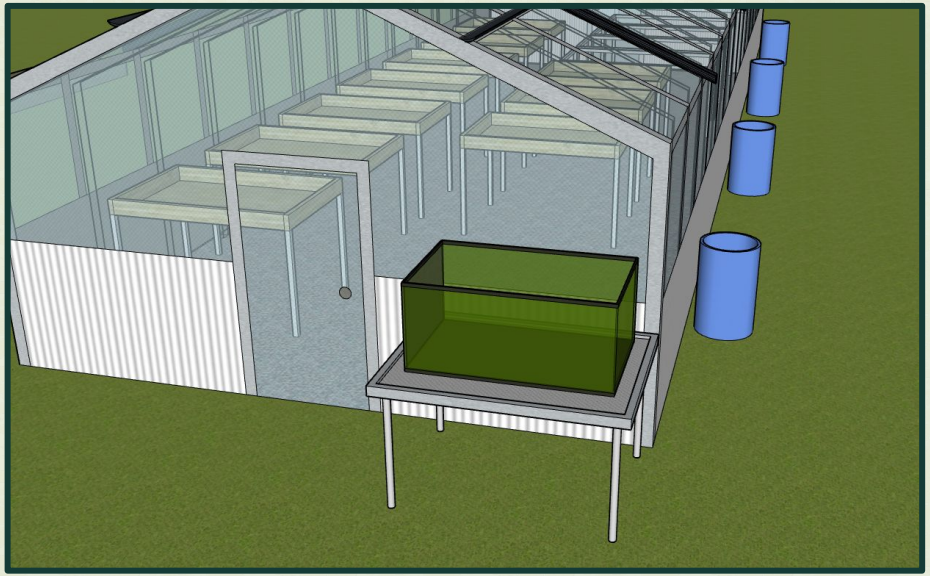


Alternative #1b: Indoor metal shelving with concrete slab.

Spirulina Shelving Design Alternatives



Alternative #2a: Outdoor wooden shelving

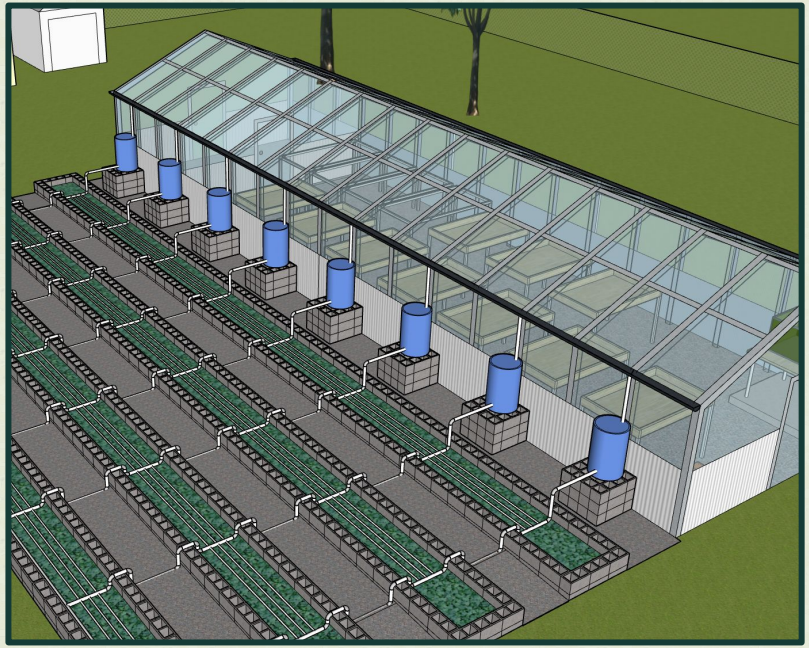


Alternative #2b: Outdoor metal shelving

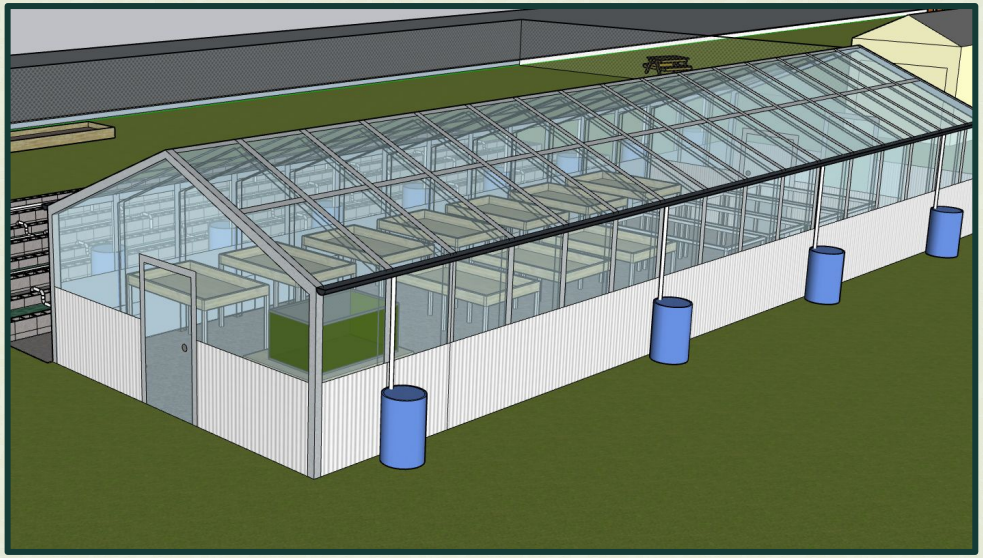
Rainwater Collection Design Alternatives

Rainwater Collection Design Alternative #1

Gutter collection with drip irrigation system on east side and rain barrels on west side



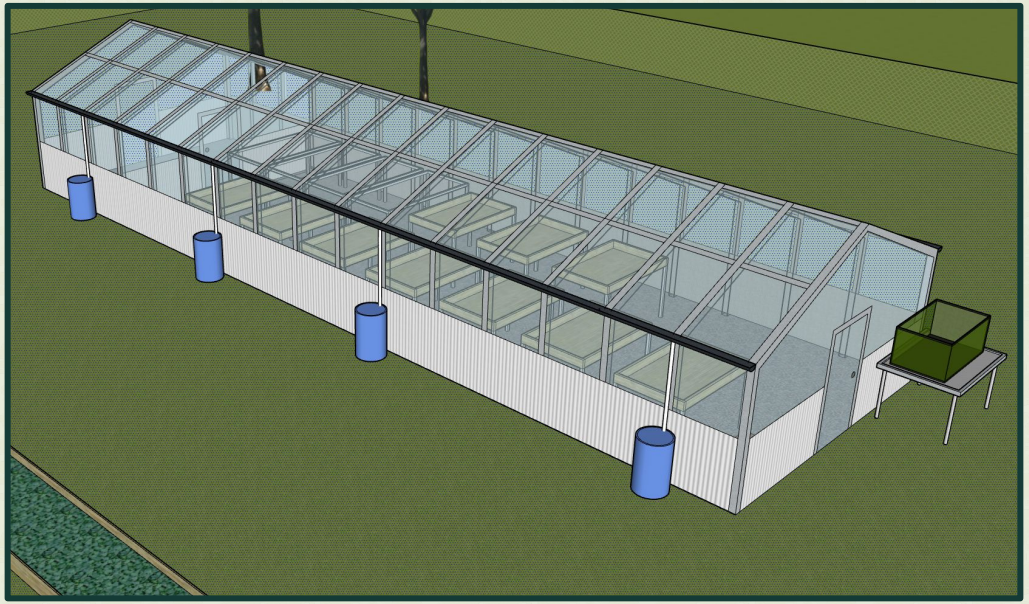
3D Model of proposed west side.



3D Model of proposed east side.

Rainwater Collection Design Alternative #2

Gutter collection with rain barrels on both sides

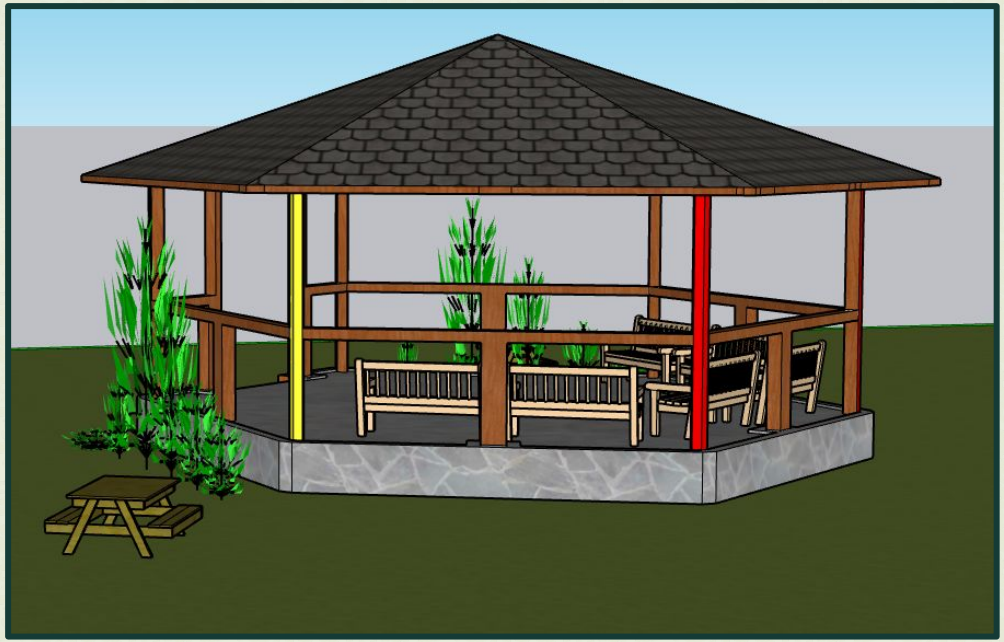


3D Model of proposed rainwater collection system.

Shaded Structure Design Alternatives

Shaded Structure Design Alternative #1

Pavilion with Cultural Design Factors



3D model of the proposed pavilion from the east side

Aerial view of site with pavilion location outlined in red

Shaded Structure Design Alternative #2

Traditional Pavilion

3D model of the proposed pavilion from the west side

Possible option for a prefabricated pavilion

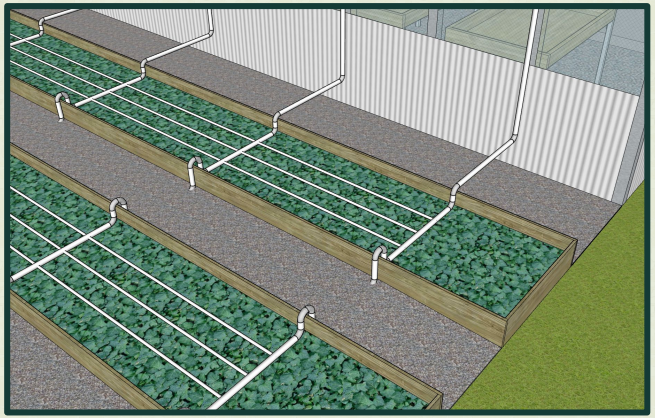
Shaded Structure Design Alternative #3

Shaded Seating Area

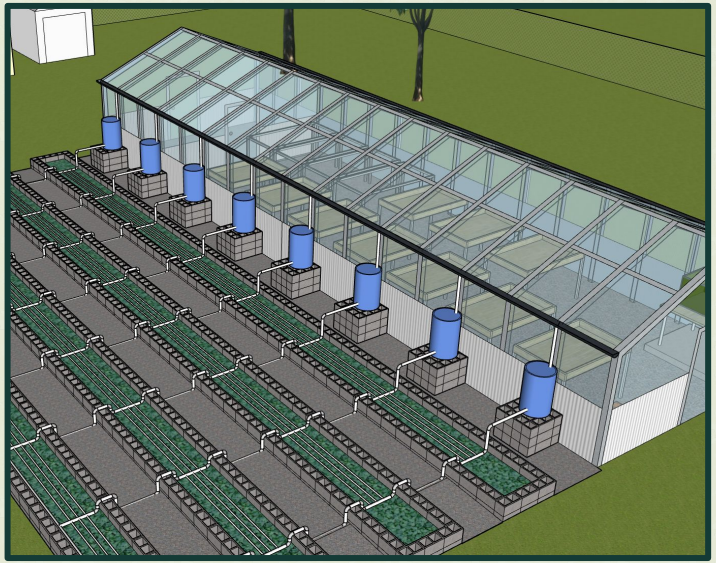
3D model of the proposed shaded area

Recommendations

Recommendation #1



- Irrigation system
- Gravel between beds.
- Materials (wood, Cinder blocks)
- Cost effective
- Long term efficiency
- Cost $6,667

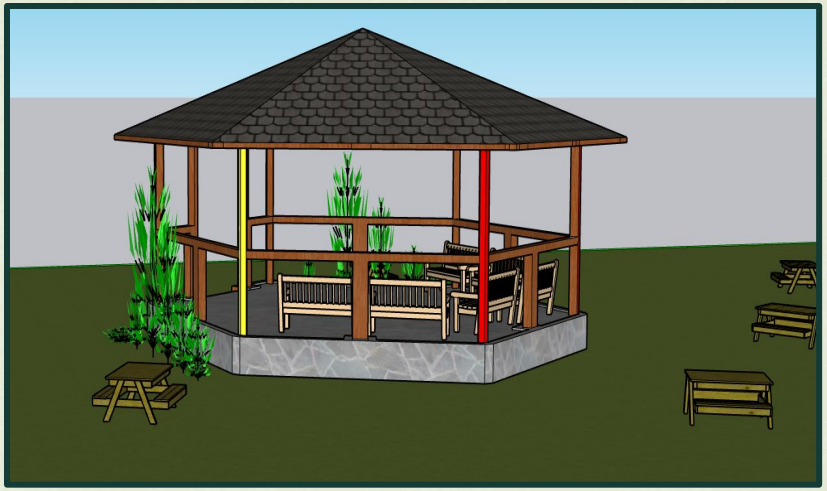


Alternative 1 Garden Box Design (Gravel)					
No.	**Materials**	**Quantity**	**Unit**	**Cost/Unit**	**Total**
1	Cinder blocks	1017	sf	3.4563	$3,515.06
2	Corner Brackets	5	ea.	24.99	$124.95
3	Gutter Downspouts	16	ea.	12.98	$207.68
4	Downspouts Elbow	32	ea.	3.38	$108.16
5	Gravel (colored)	744	sf	1.5375	$1,143.90
6	Drip Irrigation Tube	240	LF	1.2	$288.00
7	Rain Barrels	8	ea.	159.99	$1,279.92
				Total	**$6,667.67**

Table 1: *Alternative #3 cost estimate Garden bed with gravel and irrigation water system cost estimate.*

Recommendation #2

- Outdoor activities (Farmer's market, and classrooms)
- Cultural designed
- Structure element (concrete)
- Safety
- Aesthetically pleasant
- Gather the community
- Less maintenance



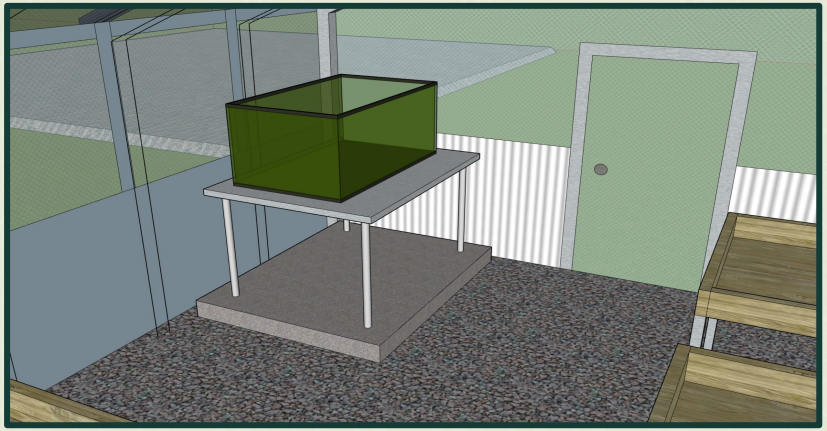
Pavilion Structure with Cultural Design Factors.

Tradational Pavilion					
No.	**Materials**	**Quantity**	**Unit**	**Cost/Unit**	**Total**
1	Pavilion	112.0	sf	51.66	$5,785.92
2	Wooden Bench	6	ea.	176.95	1061.7
3	Shrubs	4.0	ea.	$103.00	$412.00
4				**Total**	**$7,259.62**

Table 2: Cost estimate for a standard pavilion

Recommendation #3

- Material
- Moisture resistant
- Durable
- Wheels (indoor/ outdoor)
- Long term growth
- Temperature monitoring



Metal Spirulina Shelving station

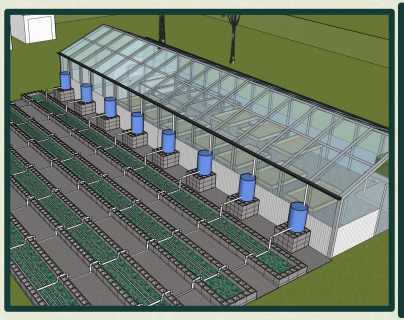
Spirulina Shelving					
No.	**Materials**	**Quantity**	**Unit**	**Cost/Unit**	**Total**
1	50 Gallon Tank	1	ea.	395.86	$395.86
2	Metal Table Incl. Wheels	1	ea.	189.99	$189.99
3				**Total**	**$585.85**

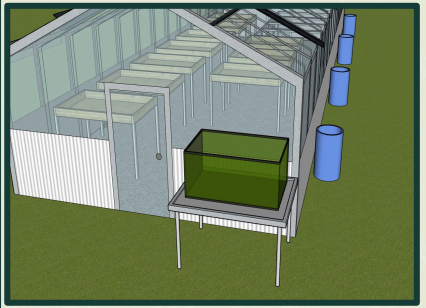
Table 3 : Cost estimate for spirulina shelving

Recommendations

Recomandation Estimated Cost	
Garden beds Inc. Rainwater Harvesting System	$6,667.67
Spirulina Shelving	$585.85
Tradational Pavilion	$7,259.62
Total Cost	**$14,513.14**

- Rough Estimate **(+- 50%)**
- Varies materials
- Don't include labor cost Or maintenance cost
- Assuming materials are bought.
- Total= $14,513.14





Thank you!

Any questions?