Design Document Spring

Team: Lakota

Project: Greenhouse

Date: 04/19/19

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Executive Summary

The Purdue EPICS LAKOTA Team is a three-way partnership between Purdue University, Oglala Lakota College (OLC), and the South Dakota School of Mines and Technology (SDSMT). Purdue University itself has two teams involved with this project: An EPICS team and a Senior CEM design team. This partnership was established with the goal to combat the issue of food sovereignty on the Pine Ridge Reservation in South Dakota, as well as assist with cultural learning on the OLC campus.

There are currently two different projects being worked on in this subdivision of the LAKOTA team: a learning center located on the Oglala Lakota College (OLC) Rapid City Campus near Pine Ridge Reservation, and two greenhouses; one on the same campus which is an ordered kit, as well as one in the city of Kyle in South Dakota (The Kyle Project has been marked as a future development plan and no work has been done on it other than initial brainstorming). The original goals for the learning center and greenhouse projects were to have a connected multipurpose facility on OLC Rapid City campus, that would assist with teaching OLC students and community members about their culture. Oglala Lakota College received a grant for $40,000 from AIHEC (American Indian Higher Education Consortium) to construct a pre-built greenhouse on their Rapid City Campus. The Greenhouse team has been working with OLC on the interior design for the greenhouse, while the CEM senior design team has been assisting OLC with obtaining quotes and building permits for the structure.

The Purdue EPICS Learning Center team has been working with the CEM (Construction Engineering Management) Senior Design Team. The CEM team has been tasked with handling the design of the exterior and some of the interior of the building while the Purdue EPICS team is focusing on the permanent seating and heating structure for the interior of the building, labeled the Rocket Mass Heater. While CEM has continued to work on computer models for this structure, the immediate development of this project has been put on hold due to a lack of funds for the learning center. CEM has continued to work on the structural plans and hopes to finalize by the end of spring 2019 semester. This will then allow for the Learning Center team to continue the project once we have funds. As of where learning center left off, Fall 2019, they are in the detailed design phase and have prepared a final design for the Rocket Mass Heater. It is in need of design approval by professionals before it can be built in the structure.

The Greenhouse team is currently working to finalize all interior components: Beds, Tables, Shelving, and Irrigation. While most have been completed, there are still final adjustments that need to be made with the irrigation layout and design. Under the current project timeline, all of these interior components will be finalized before the end of the semester.

Team Members

Team Member	Year	Major	Role
Marshall Beard	Freshman	FYE – First Year Engineering	Team Member - Greenhouse
Sami Bijonowski	Junior	Civil Engineering	Team Member - Greenhouse Add-ons
Jonathan Damon	Sophomore	Civil Engineering	Project Manager
Bridget Fitzgerald	Freshman	FYE – First Year Engineering	Design Lead - Greenhouse
Katie Johnson	Sophomore	Aerospace Engineering	Team Member - Greenhouse
Russell Kim	Freshman	FYE – First Year Engineering	Team Member - Greenhouse Add-ons
Jacob Lundgren	Sophomore	Civil Engineering	Design Lead - Greenhouse Add-ons
Thao Nguyen	Junior	Chemical Engineering	Team Member - Greenhouse
Abigail Thompson	Freshman	FYE – First Year Engineering	Team Member - Greenhouse Add-ons

Budget/Operating Costs

Water		
Month	$, 5/8 meter	$, 3/4 meter
January	12	15
February	12	15
March	12	15
April	12	15
May	12	15
June	12	15
July	12	15
August	12	15
September	12	15
October	12	15
November	12	15
December	12	15
Annual	150	180

Electricity	
Month	$
January	44
February	40
March	44
April	43
May	44
June	43
July	44
August	44
September	43
October	44
November	43
December	44
Annual	518

	Gas	
Month	Price $, residential	Price $, wholesale
January	49	42
February	23	19
March	-23	-20
April	-61	-52
May	-106	-91
June	-147	-127
July	-191	-165
August	-189	-163
September	-132	-114
October	-72	-62
November	6	5
December	55	47
Annual	132	114

Overall Timeline

Greenhouse Construction

Item	Dates	Completion
Greenhouse Delivery	March 3 - May 12	In Progress
Contractor Selection	March 20 - May 1	In Progress
FDN Building Permit Submission and Approval	March 3 - April 9	
Utility Building Permit Submission and Approval	April 10 - April 24	
Contractor Coordination	April 7 - April 21	In Progress
Greenhouse Foundation Construction	April 21 - April 27	To Be Completed
Greenhouse Structure Erection	April 28 - May 4	To Be Completed
Greenhouse Utility Connections	April 28 - May 18	To Be Completed
Greenhouse Internal Electrification	May 5 - May 11	To Be Completed

Interior Components

Item	Dates	Completion
Construct Seed Start	March 3 - April 26	In Progress

Design and Purchase Vertical Trellis	March 3 - April 26	In Progress
Research Ways to Improve Heating Efficiency	March 3 - April 14	In Progress
Research Aquaponics	March 24 - May 4	In Progress
Finalization of table model	March 3 - March 9	Completed
Finalization of bed model	March 3 - March 9	Completed
Irrigation system selected	March 10 - March 23	Completed
Finalization of Shelves	March 3 - March 9	Completed
Tables ordered & delivered	April 14 - April 27	To Be Completed
Beds ordered & delivered	April 14 - April 27	To Be Completed
Shelves ordered & delivered	April 14 - April 27	To Be Completed
Plant layout design	March 31 - April 13	To Be Completed
Plants sourced	April 14 - April 20	Completed
Plants ordered	April 21 - May 4	Completed

Background

Description of the Community Partner

Our community partners are Oglala Lakota College and the residents of the Pine Ridge Native American Reservation. This reservation is home to about 3,500 people facing a poverty rate of 47.4%. Despite this, the Lakota tribe has been able to sustain a very rich and vibrant culture, especially in agriculture. The Lakota people have a variety of prayers for growing, nurturing and harvesting plants. They also have special techniques for farming that have been passed down through generations. By having these strong traditions, the Lakota people have been able to stay connected with their ancestors and their history.

Stakeholders

Our stakeholders include the Oglala Lakota College (OLC) and the residents of the Pine Ridge Indian Reservation. The Greenhouse/Learning Center team at Purdue are creating a design that will serve to benefit mostly the residents of the reservation by designing a facility and learning environment to use for a cultural and educational benefit. Since the learning center will be located on the Oglala Lakota College Campus they are a vital stakeholder, but since the project's goal is to impact the community, the voices of the residents and elders are just as important. We have several student and faculty contacts at OLC and SDSMT that we work side by side with to help us contact the stakeholders and gather information. OLC and SDSMT are working closely with the He Sapa (Black Hills) Lakota elders and the Cultural Advising committee that has been established in sharing the heart of this vision.

Social Context

The greenhouse and learning center will function to create a hands-on learning environment where the Lakota culture can be preserved and taught to the younger generations by the elders of the tribe. Lakota culture is a significant factor throughout the entire design processes. For example, one of the requirements for the greenhouse is an east facing door that signifies the directions connection to the rising sun and the beginning of a new day. Another example is that the learning center will be seven-sided to represent the 7 rites of the Lakota people. These requirements along with others listed below allow us to create a project that will “connect the Lakota back to the land.”

Project Identification and Specifications

User Needs

Project	**Greenhouse/Learning Center**	
Number	*User need*	*Stakeholder*
1	Learning center 7 sided	The tribes that make up OLC.
2	Door facing east	The tribes that make up OLC.
3	Cultural plants (will be picked by them)	The tribes that make up OLC.
4	Separate room for mushrooms	The tribes that make up OLC.
5	No cement floor	The tribes that make up OLC.
6	Try to make as energy efficient as possible	The tribes that make up OLC.
7	Try to involve the community as much as possible	The tribes that make up OLC.

Specifications

Project	**Greenhouse and Learning Center**		
Number	*User need*	*Specification number*	*Specification*
1	Fit the cultural wants (Learning Center)		

		1.1	7 sided learning center
		1.2	Door facing east
		1.3	Cultural plants (picked out by the Lakota people)
		1.4	Separate room for mushrooms
		1.5	No cement floor
2	Greenhouse specifications		
		2.1	20 by 48 ft
		2.2	As energy efficient as possible
		2.3	Use solar panels
		2.4	Do not use electricity for the primary source of heating
		2.5	Have an irrigation system that conserves water
		2.6	Window roof
3	Learning Center Specifications		
		3.1	Must be 7 sided
		3.2	Must have enough space for a classroom of people
		3.3	The door must be facing east
		3.4	Related to food sovereignty
4	Both structures must withstand the weather		

		4.1	Large hail (“baseball”) 70 mph winds 100+ f degree weather <0 f degree weather snow pile up

Greenhouse

Requirements

The purpose of this greenhouse is to provide a place for students to go to learn about indigenous plants important to the Lakota people, and how to grow them to combat the issue of the food desert. The greenhouse needed to have enough room to teach a group of students as well as storage space. In order to make the greenhouse more efficient, the project partners wanted to also have space for an aquaponics system.

Decision Process

Originally, the teams did extensive research on other greenhouses, materials, and dimensions. In January, Oglala Lakota College received a $40,000 Grant from AIHEC for a greenhouse kit, and the team shifted its focus to finding a kit that fit the requirements. Working with John Girka and the CEM Senior Design team, two greenhouse kits from the Greenhouse Megastore were chosen, differing only in dimensions, and the smaller of the two was eventually chosen due to the limited space on the chosen site.

Final Decision

The final decision was the Junior Teaching Greenhouse from the Greenhouse Megastore. The size of the greenhouse is 18 x 36 x 10.5 feet.

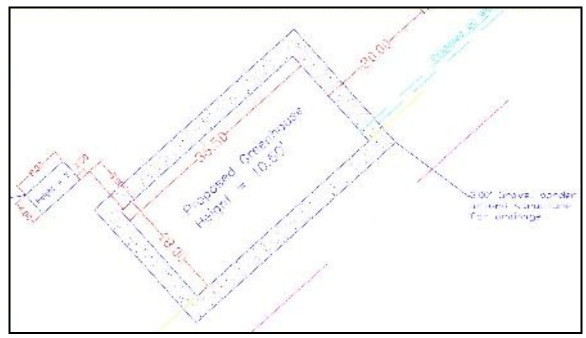
Location

Oglala Lakota College, Rapid City Campus

1275 Knollwood

Rapid City, South Dakota 57701



Interior Components

Irrigation

Requirements/Specifications

Requirements for the irrigation system included safety, running cost, cultural impact, flexibility, warranty adherence, amount of labor required, water consumption, sustainability, maintenance, initial cost, and opportunity for expansion. The first three are weighted at 5 points each. These are our biggest focuses. We want our partner to be safe, while keeping cost low and the cultural impact positive. The rest are weighted according to how important they are, with flexibility being a four and going down to a one at expansion.

Sprinklers

A sprinkler system is cheap to install and provides a uniform watering pattern, but a lot of water is wasted and plants with thick foliage may not be adequately watered. The system is safe, with the only concern being a wet floor. It does not have efficient use of water, so that would be the biggest impact on the running cost. It could be bought through the Greenhouse Megastore and thus it would not void the warranty. It allows for the interior layout to be reconfigured, as it waters the entire area, but it would not be possible to expand the system itself. It would not require a lot of maintenance with the pipes need replacing every 50 years or so, and it can be set to a timer so there would be minimal labor associated with it. Although it meets most of the requirements, the high water usage is enough that this would be adverse for our partner because there is a high change that they would not be able to support the cost of the excess water from the sprinklers.

Drip Irrigation

Drip irrigation minimizes water usage as it is applied directly to the plants, and a zone watering system can be implemented, but the pipes and emitters need to be checked and cleaned often and it would be cluttered to use the system with raised beds, which could be a tripping hazard. Water is only applied where needed, so there is low water waste and running cost. It is not very flexible, inhibiting the movement of the beds. It can be set to a timer, but plants would have to be checked daily to make sure none of the emitters or lines are clogged. The cost of this system would be over $1,000, substantially higher than the other systems. This also does not include the cost of the drip emitters than would need to be replaced every 5 to 7 years. This system does not meet our initial requirements because of the lack of flexibility. Although it would be ideal for plants, bed flexibility is a priority.

Hand Watering

Hand watering minimizes the amount of water that is wasted and can be used for any greenhouse configuration, but it requires the most labor and is subject to the most human error. It has low water waste and is very safe, and it can be easily adapted or expanded for any interior layout, but it requires the most labor as it cannot be put on a timer and a person has to use a hose or a nozzle to water the plants. This is arguably the best option, however the labor requirement prohibits the use of this system because our partner's were concerned that they could not support the labor. Additionally, our partner has long breaks where plants would not have access to water, which is troubling.

Plug and Play

A plug and play system has maximum flexibility and can be used to implement other types of irrigation, but it is more work at the beginning of the setup and there may be additional cost once a more permanent system and layout are chosen. It can be used to implement a system that uses water efficiently, and the only running cost would be the water, with components needing to be replaced every 50 years or when they break. The initial cost would be for putting in the framework pipes, with some additional cost later to adapt the system into a more permanent solution. This is the choice that we went with because it has the best of both hand watering and drip irrigation methods. Initially, we will be using the hand watering until our partner has decided where they want they beds, then we will switch to drip irrigation. The switch will be easy with the initially set up piping in the ceiling.

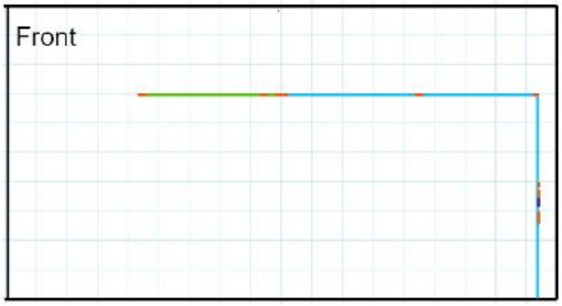
Decision Matrix

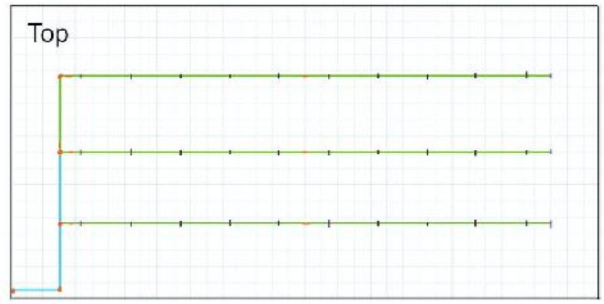
	Weighting	Overhead Sprinklers	Drip Irrigation and Table Sprinklers	Overhead Misters	Hand Watering	Plug and Play
Safety	5	4	4	4	4	4
Running Cost	5	3	4	4	4	4
Cultural Impact	5	3	3	3	3	3
Flexability / Reconfigurability	4	4	3	1	5	5
Warranty	4	5	5	5	5	5
Labor (Higher # = Less Labor)	3	4	4	4	1	4
Water Consumption	3	2	5	4	4	4
Sustainability	3	3	4	4	4	5
Maintence (Higher # = Less Work)	3	4	3	4	5	4
Initial Cost (Higher # = Cheaper)	2	3	2	4	5	4
Expansion	1	2	3	2	5	5
Total:	190	133	142	137	152	157

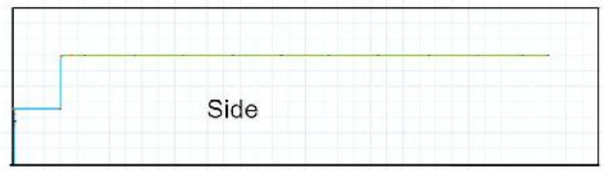
This is the decision matrix for the irrigation. This is the second iteration of the decision matrix, and has been updated accordingly. The first column is the requirements, the second column is the weighting of the requirements, and each following column is the different types of irrigation. We went with the Plug and Play system because it met our requirements the best. It scored equally or better in almost every category. The reason we chose Plug and Play however, was our partners need for flexibility. None of the other systems met the flexibility requirement like Plug and Play while also keeping cost down.

Final System Drawings

The following images show the views of the greenhouse irrigation system. In the individual views, parts are labeled and sizes are given.

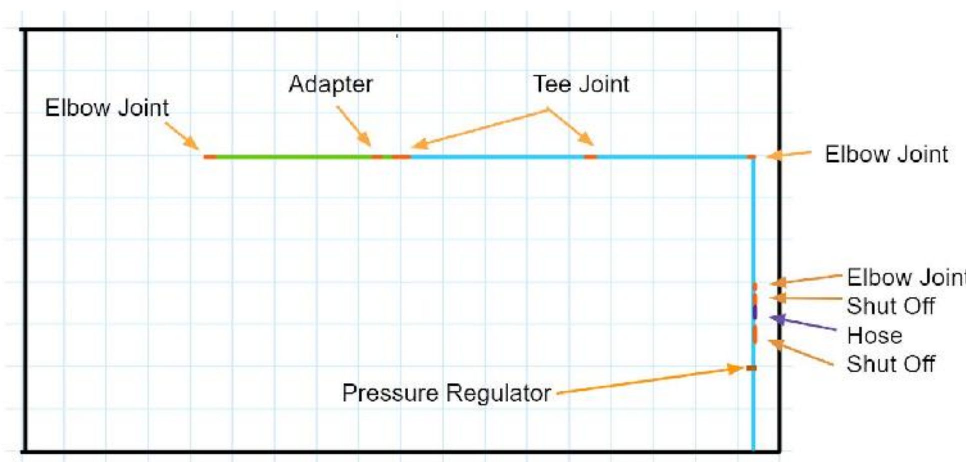






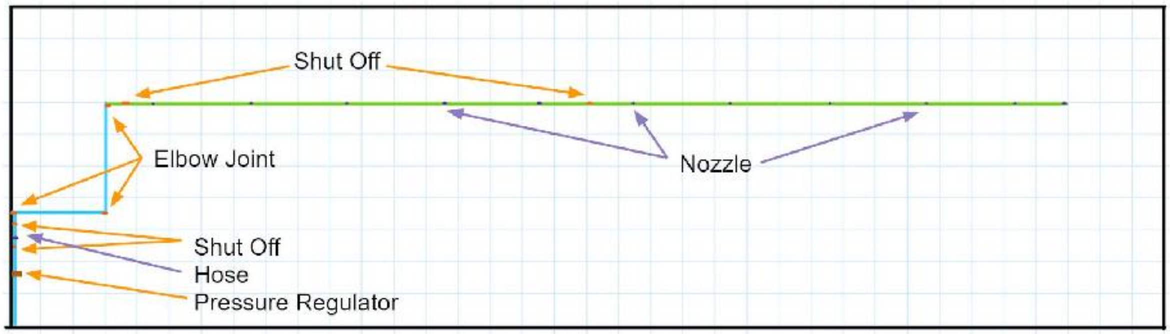
1 box = 1 sq ft
Green - ½" Pipe
Blue - ¾" Pipe
Orange - Joint or Shut Off Valve
Purple - Hose Attachment/Nozzle

Front View/Door View



1 box = 1 sq ft
Green - ½" Pipe
Blue - ¾" Pipe
Orange - Joint or Shut Off Valve
Purple - Hose Attachment/Nozzle

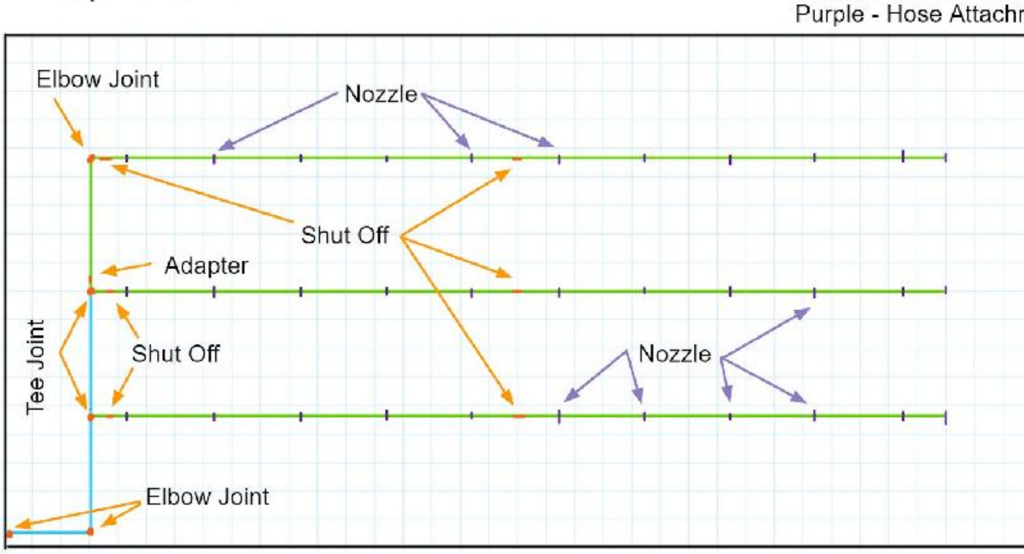
Side View



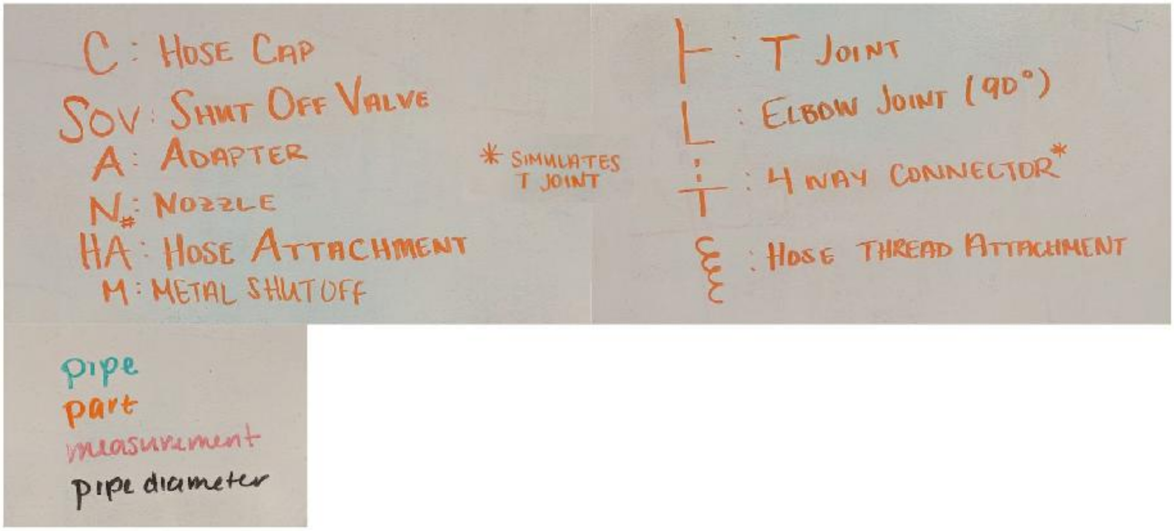
1 box = 1 sq ft
Green - ½" Pipe
Blue - ¾" Pipe
Orange - Joint or Shut Off Valve
Purple - Hose Attachment/Nozzle

Top View

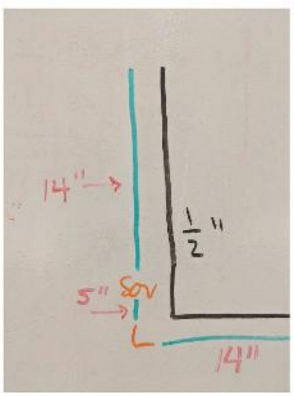
1 box = 1 sq ft
Green - ½" Pipe
Blue - ¾" Pipe
Orange - Joint or Shut Off Valve
Purple - Hose Attachment/Nozzle

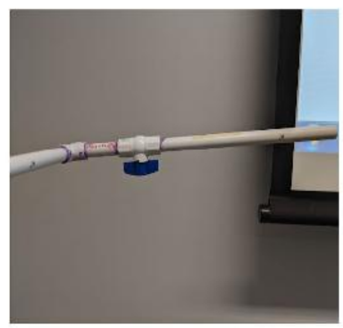


Final System Model

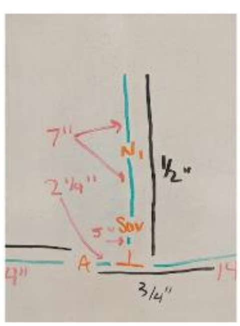


Key

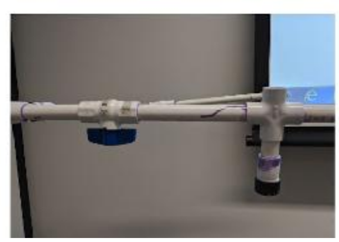


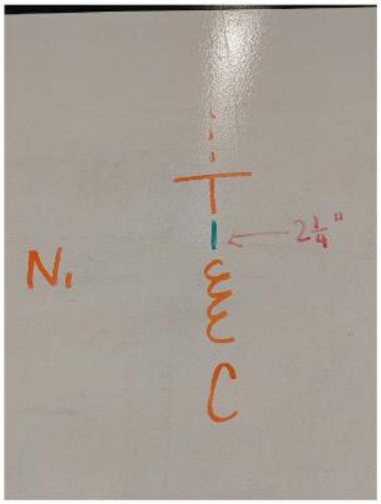
Left Branch

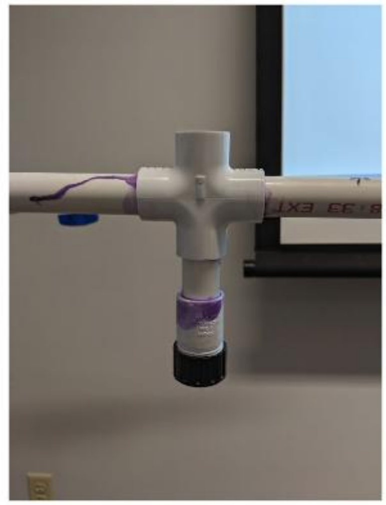




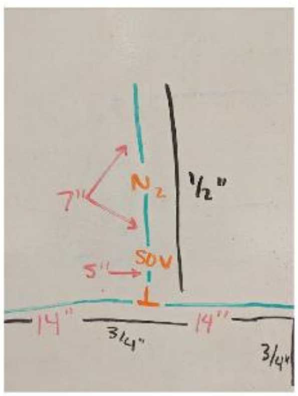


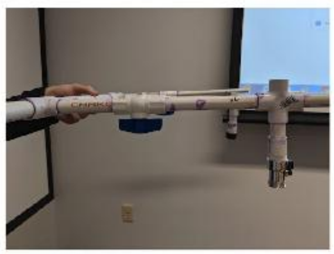
Middle Branch



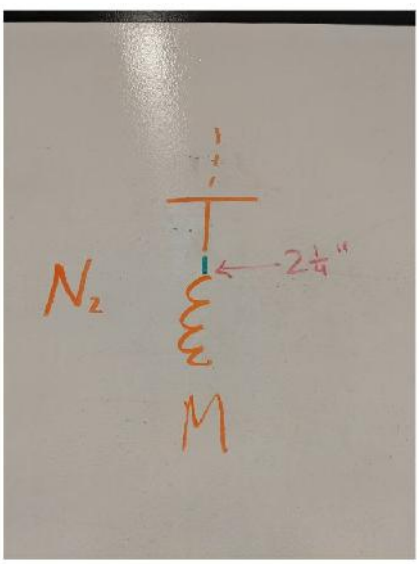


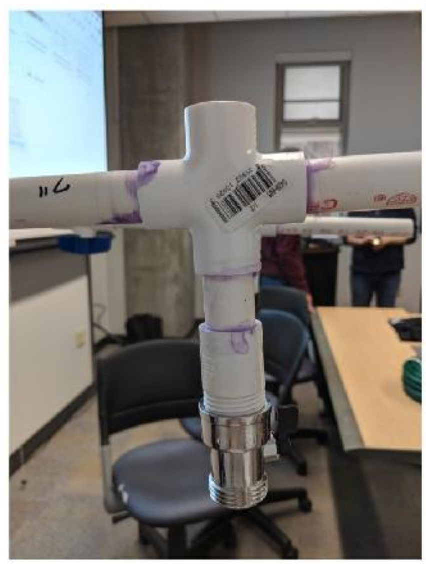
Nozzle 1



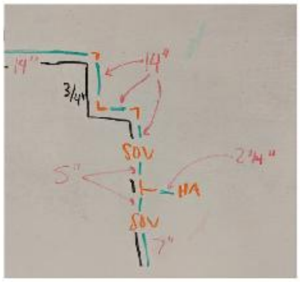



Right Branch



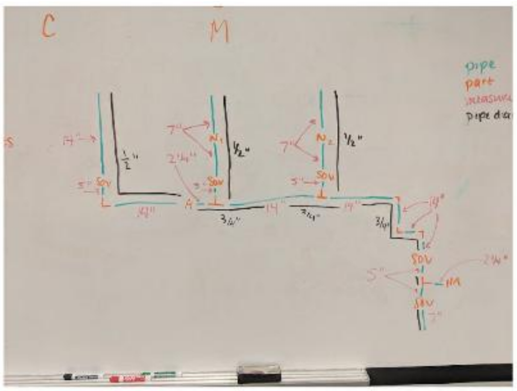


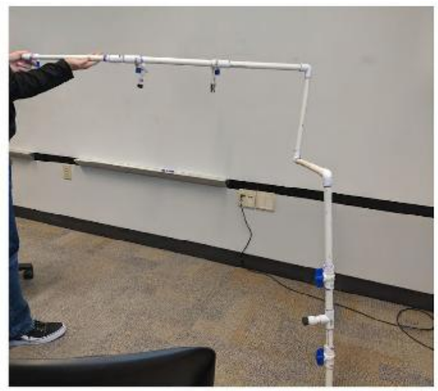
Nozzle 2





Floor to Ceiling





Whole System

Final System Parts List

Irrigation Items	Link	Cost Each	Quantity	Total	Who	Status	Notes	Notes		
3/4" Pipe	https://www.menards.com/m	$1.99	3	$5.97			10ft increments	~21 ft		
3/4" Ball Valve	https://www.menards.com/m	$2.79	2	$5.58						
3/4" T Joint	https://www.menards.com/m	$0.39	1	$0.39						
3/4" Hose Attachment	https://www.menards.com/m	$1.58	1	$1.58						
3/4" to 1/2" T Joint	https://www.menards.com/m	$0.77	2	$1.54						
3/4" Elbow Joint	https://www.menards.com/m	$0.29	3	$0.07						
3/4" to 1/2" Female Adapter	https://www.menards.com/m	$0.19	1	$0.19			not completely sure			
1/2" Pipe	https://www.menards.com/m	$1.59	12	$19.08			10ft increments	~108 ft		
1/2" Ball Valve	https://www.menards.com/m	$2.39	6	$14.34						
1/2" Elbow Joint	https://www.menards.com/m	$0.19	1	$0.19						
1/2" to 3/4" Male Adapter	https://www.menards.com/m	$1.14	1	$1.14						
1/2" T Joint	https://www.menards.com/m	$0.26	33	$8.58			every 3 feet			
1/2" Hose Attachment	https://www.menards.com/m	$1.47	33	$48.51						
Hose Cap (Or Control Valve)	https://www.menards.com/m	$0.99	9	$8.91			pack of 4			
Hose Control Valve (Or Cap)	https://www.menards.com/m	$1.99	33	$65.67						
UV Resistant Paint	https://www.homedepot.com	$25.98	1	$25.98			water based latex paint?			
Ceiling Suspension				0			made like ceiling in arms		talk to GH Megastore	
Hose (25ft)	https://www.menards.com/m	$9.99	12	$119.88			one for each bed			
Pressure regulator	https://www.dripdepot.com/i	$12.99	1	$12.99			30 psi			
PVC Joint Compund	https://www.menards.com/m	$6.84	1	$6.84						
			Total:	$282.86	$339.62					
				low end	high end					

Bed Irrigation

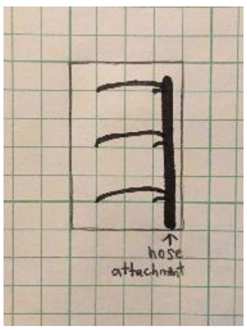
We are currently looking at 2 different options to distribute the water to the plants in the beds. In both of the options, a timer is attached at the top of the plug and play system above the hose, and a pressure regulator is attached to the bottom end of the hose.

Our first option is to connect a ¾ inch poly tube to a 15 psi pressure regulator. The ¾ inch tube would run the length of the bed and have 4mm poly tube attached to it, with emitters at the other end of the 4mm tube. The end of the ¾ inch tube will be closed with a barb tubing end cap.

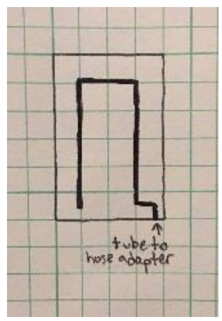
Our second option is to connect ¼ inch poly dripline to a 20 psi pressure regulator, and to lay the line out around the bed around the plants, keeping it in place with stakes. The end of the dripline will be closed with a goof plug end cap.

We are currently leaning towards the second option, as it is simpler to set up than option 1 and it is cheaper.

Option 1



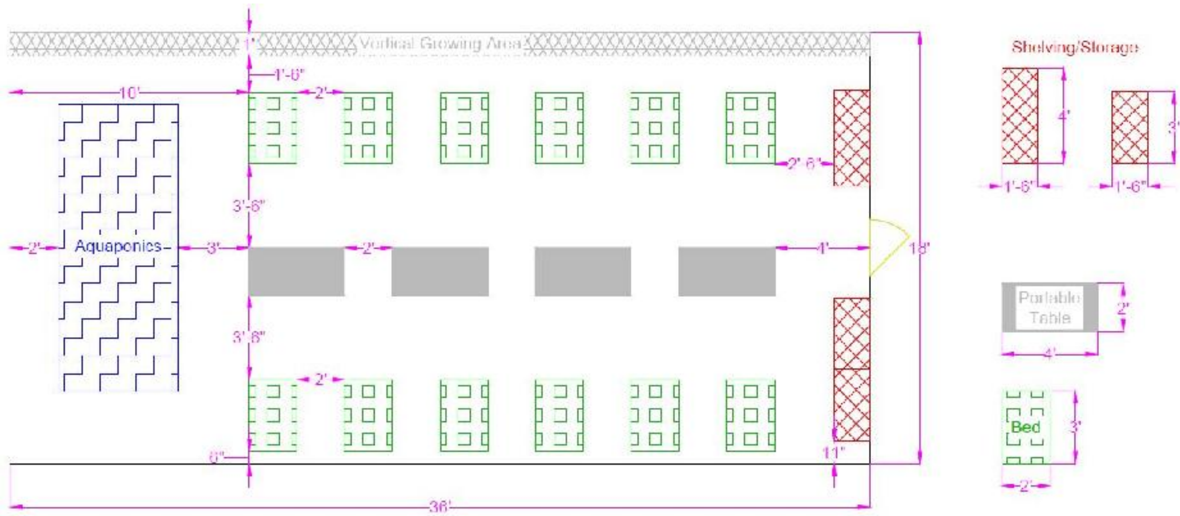
Option 2



Drip Irrigation Items (Option 1)	Link	Cost Each	Quantity	Total	Who	Status	Notes	Notes
Timers (Drip)	https://www.homedepot.com	$28.25	12	$339.00			one for each bed attached to branches	
3/4 inch poly tubing	https://www.dripdepot.com/	$23.50	1	$23.50			100 feet	
4mm poly tubing	https://www.grainger.com/pr	$15.71	2	$31.42			100 feet	
Antelco 360 Stream Bubblers	https://www.sprinklerwareho	$0.89	96	$85.44			8 per bed	
15 psi pressure regulator	https://www.dripdepot.com/	$7.95	12	$95.40			1 per bed	
3/4 inch Barb tubing adapter	https://www.dripdepot.com/	$2.59	12	$31.08			1 per pressure regulator	
3/4 inch worm gear clamp	https://www.dripdepot.com/	$0.02	12	$9.04			1 per barb tubing adapter	
4 mm punch	https://www.amazon.com/O	$7.35	1	$7.35			maybe find a better one but it has to be 4mm	
Barb tubing end cap	https://www.dripdepot.com/	$0.42	12	$5.04			1 each bed	
			Total:	$628.07				

Drip Irrigation Items (Option 2)	Link	Cost Each	Quantity	Total	Who	Status	Notes	Notes
Timers (Drip)	https://www.homedepot.com	$28.25	12	$339.00			one for each bed	
1/4 inch poly dripline	https://www.dripdepot.com/	$17.49	1	$17.49			100 feet	
Male hose to 1/4 dripline adapter	https://www.dripdepot.com/	$0.75	12	$9.00			1 per pressure regulator	
20 psi pressure regulator	https://www.dripdepot.com/	$7.95	12	$95.40			1 per bed	
Goof plug end cap	https://www.dripdepot.com/	$0.09	12	$1.08			1 each bed	
Stakes	https://www.amazon.com/6-	$16.69	1	$16.69			used to keep the tubing in place	
			Total:	$478.66				

Interior Structures



This is our initial layout for the greenhouse. It is off-center by 1ft to account for a vertical growing area. We have 12 growing beds measuring 3 ft long by 2 ft wide by 3 ft tall. There are also a shelving unit, portable tables, and a potential aquaponics system.

Beds

We discussed over beds and raised planter options' pros and cons and ultimately chose the raised planters. The bed models are more floor irrigation friendly but shows disadvantages in spacing and user accessibility - essential criteria of a teaching greenhouse. It eliminates the hands and knees work in plant work and teaching. These beds also provide extra storage space with a shelf under the planter box. The

model being selected is Houzz Raised Planter, made of press treated cypress wood. The dimensions are 36"x24"x36".

Tables

The team learned from Purdue Horticulture greenhouse using the polyethylene plastic dunnage tables with detachable legs and tabletop. Users could adjust the table height by replacing the legs. On average, the table model has a 500 lb weight capacity (All-American Associates, Inc.). The table's plastic materials, unlike metal nor woods, contains no easily degradable part (rusting, rotting i.e.), prevents insects and fungus growth. It also introduces the commercially available strongest UV resistance materials, to ensure the model's durability.

Benchmaster Model BM661801S

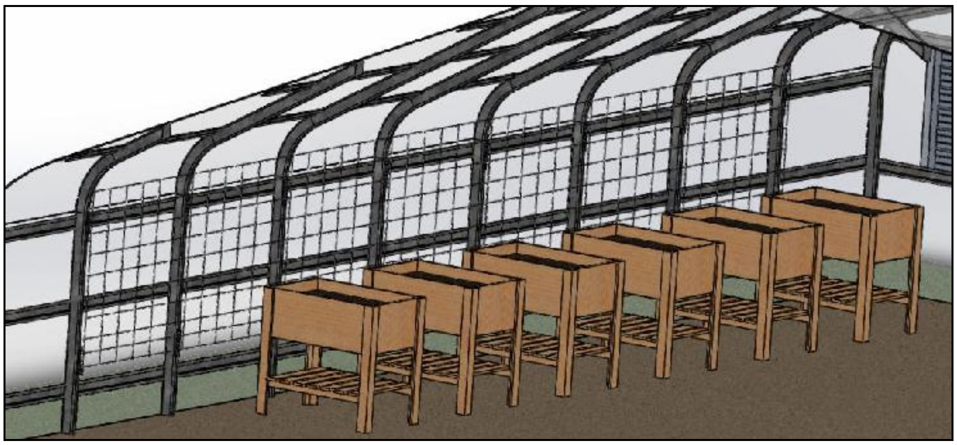
OLC also proposed portable working stations consist of a polyethylene tabletop and coating metal legs. The model can hold up to 300 lbs. The tables are light slimmer, lightweight and foldable, making it easy for both transport and storage. Although it does not have an advantage over weight capacity, we later went on with this model due to its convenience and storage, which is a priority for the demonstration and teaching purposes of the greenhouse.

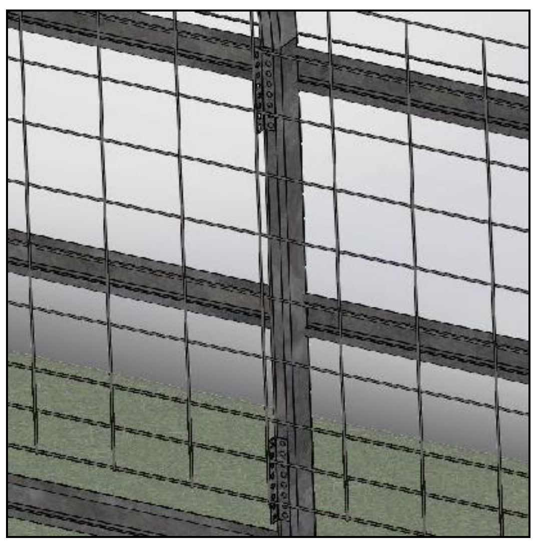
Shelves

OLC decided to use the Iron Horse 2300 Series Riveted Wire Deck model from Home Depot. The boltless racks have the original dimensions of 18" x 36" x 72", comprising of stainless steel frame and zinc powder coated wire shelves. The height between the racks is adjustable within 1.5" increment. This shelving unit can hold 2300 lbs of total capacity. Each of the 4 shelves withstands 460 lbs. of evenly distributed weight. The shelves can be assembled either vertically or horizontally, depends on users' need.

Vertical Trellis

The vertical trellis will be constructed along the North wall of the greenhouse. The trellis would be constructed out of two 16' cattle panels mounted to the uprights of the greenhouse using angle brackets. The panels would be attached to the brackets by wire. All parts are galvanized for moisture resistance. A CAD of the trellis as well as a close-up view of the attachment to the uprights are shown in the images below.





The parts list for this design is shown below. All of the parts come from local stores, so sourcing them would not be an issue.

Item Name	Store	Item Price	Quantity	Item Total
16 ft. 4-Gauge Cattle Panels	Runnings	$28.00	2	$56.00
1-1/4" x 1-1/4" x 48" Steel Perforated Angle	Menards	$9.89	3	$29.67
14-Gauge 50' Steel Galvanized Wire	Menards	$2.99	1	$2.99

#14 x 1" Hex Stainless Steel Sheet Metal Screws	Menards	$6.49	3	$19.47
1/4" Grade 2 Hot-Dipped Galvanized Flat Washer	Menards	$2.99	1	$2.99
			Total:	**$111.12**

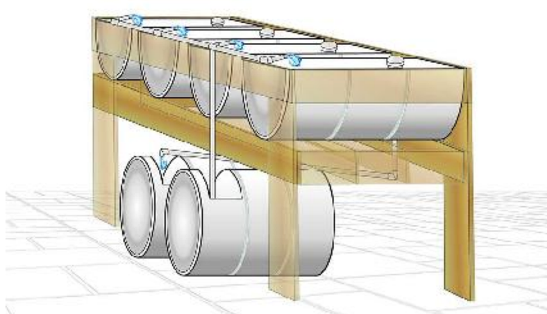
Additional Inclusions

The greenhouse will also need gardening supplies such as trowels, hand cultivators, gloves, and weed barrier to lay in the bottom of the raised planters to keep the soil all in one place in the planter.

Miscellaneous Gardening Items	Link	Cost Each	Quantity	Total
Gardening Gloves	https://www.amazon.com/W	$14.98	1	$14.98
Garden Trowel	https://www.menards.com/n	$4.98	6	$29.88
Weed Barrier	https://www.menards.com/n	$15.98	1	$15.98
Hand Cultivator	https://www.homedepot.con	$4.97	6	$29.82
			Total:	$90.66

Aquaponics

The figure below shows an example of a small aquaponics system. There are many different aquaponics systems each with many variables that can be changed to meet desired outcomes.



The waterbed material is typically made out of 55 gallon or larger barrels or a form of a fish tank. Typical growing media is either river rock or pea sized gravel. Some of the recommended plants for aquaponics growing are basil, mint, chives, and anything leafy such as lettuce or kale. There are several species of fish that work well in aquaponics systems. Goldfish, tilapia, blue gill, sunfish, crappie, and koi are all known to be successful in aquaponics systems.

Western Dakota Tech has two different aquaponics systems. The Aqua 2.0 system is shown below. This system is estimated to be around $3,450.

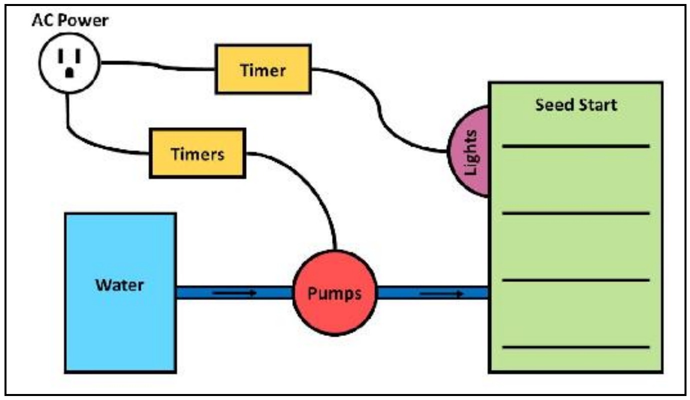
Some other elements of an aquaponics system need to be considered based on the setup of the system and desired results. Many times chemicals will be added to the water to control the pH and provide ultimate growing conditions. The ratio of plant to water also must be controlled based upon the plants being grown and the set up of the tanks. Aquaponics systems can have certain levels of automation added to them for ease of operation. The amount of automation added to an aquaponics system will need to be determined based upon the cost and need. Many aquaponics systems have some type of added aeration which helps the fish as well as the plants to get the needed oxygen. There are many options for aeration which all depend on the amount of aeration needed to support a specific system. With this aquaponics system being used in a greenhouse the climate of the tank needs to be considered for the fish. During the winter the fish will need to have a source of heat to stay alive. There are heating systems that could be added to the system, the fish could be moved inside during the coldest months, or the fish could be replaced each year. The formation of algae is likely to occur in aquaponics systems. Algae can be helpful or detrimental to the system based on the type and amount so it requires some regulation.

Seed Start

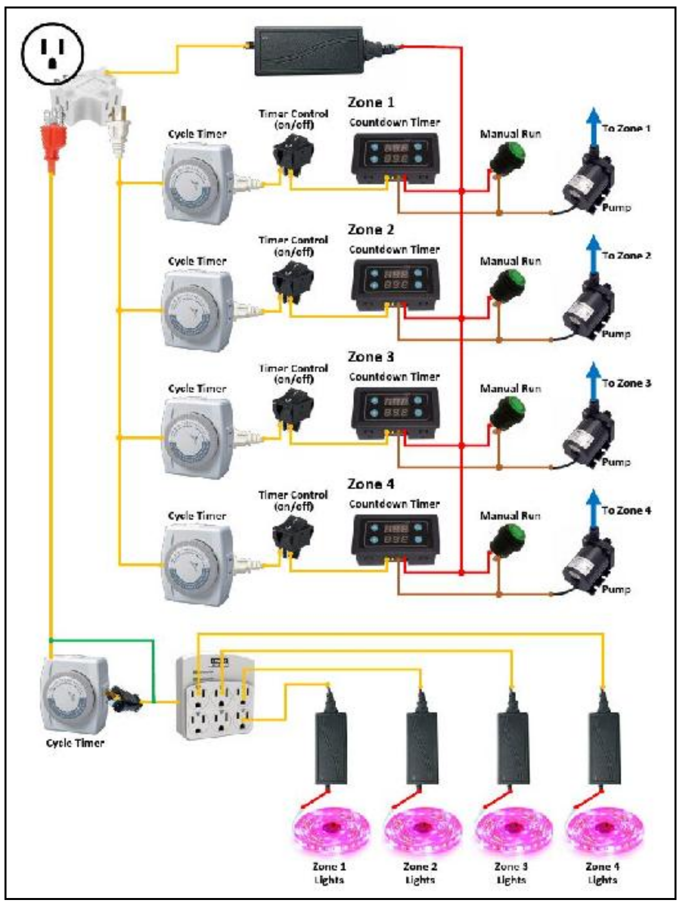
The purpose of the seed start is to begin growing plants prior to moving them out to the greenhouse. The seed start will provide automated watering and lighting for the plants in four independently controlled zones. The seed start will be constructed using a shelving unit with four shelves. The design is based on another seed start created by the SDSM&T EPICS iGrow team.

System Design

A diagram of the system is shown below. The lighting and irrigation will be operated by two independent timer systems. The timer for the lights will allow the user to choose which hours of the day the lights will operate. The irrigation system will have the option to choose times of day as well as duration for watering the plants. The settings will be specific to each zone. The design also includes a manual override toggle to allow users to water plants without using the automated features.



The control components for the system will be attached to a plywood board which will be mounted to the side of the structure. A diagram of these components is shown in the figure below.



Parts Summary

A breakup of the various subsystems with their prices and major components is shown below.

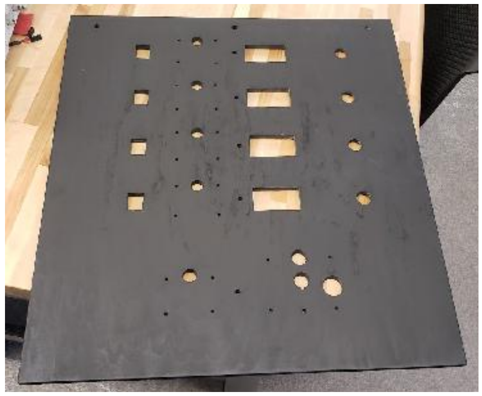
Lighting	Irrigation	Structural & Growing
• DC Power Supplies • LED Light Strips • 24 Hr Mechanical Timer	• DC Power Supply • Water Pumps • Vinyl Tubing • 24 Hr Mechanical Timers • Countdown Timers • Buttons and Switches • Trash Can • Dolly	• 24”x48” Mobile 4-shelf Wire Shelving Unit • Vinyl Sheeting • Growing Trays • Seedling Inserts • Seed Starting Mix
$103.64	**$268.01**	**$353.91**

Total:	$725.56

System Assembly

At the time of writing this document, the seed start has not yet been completed. Currently, all parts have been purchased, and assembly has begun. The structure has been built and the lighting has been attached. Also, material for the cover has been cut and is in the process of being sewn together.

The board for the controls has been cut and painted. Currently, the team is in the process of attaching parts to it.



Even though this part of the project is somewhat behind schedule, the plan remains to complete it before the end of the semester.

Plants

(provided by OLC Rapid City)

- Milkweed
- Blueberries
- Prairie Turnips
- Wild Onion
- Wild Rose
- Oregon Grape
- Buffaloberry
- Elderberry
- Ground Cherries
- Currant
- Raspberries
- Sage
- Wild Licorice
- Mint
- Strawberries
- Prickly Pear Cactus
- Wild Plum
- Bergamot
- Chokecherry

Greenhouse Add-on Options

This section includes the work done by the "Greenhouse Extras" team in the Spring 2019 semester. The goal of this team's work was to develop ideas for alternate and additional projects that could work with the greenhouse. They were intended to be potential replacements for the learning center, and as were also options the team could utilize to spend any extra money left over from the grants.

Initial Brainstorming list of potential ideas:

- Propane and Propane Accessories
- Exterior firepit and seating
- Log seating
- Weather station system
- Water tank
- Rain barrels $150 on Amazon
- Compost setup
- Trees $50 each

- Arbor

Arbor

The arbor was originally an independent idea but provided a good opportunity to tie in several other Add-on options from the list above. The design developed into using trees and log seating centered around a fire pit.

One of the initial concerns for the arbor idea was vandalism. The project partners quickly informed us that anything outside was an easy target for vandalism. This caused us to adjust the concept for the firepit and seating and making sure it is a permanent feature that could not be bothered.

The final design for the arbor involved purchasing 7 Ponderosa pine trees spaced 6 feet apart from each other in a heptagonal circle 10-15 feet from the boundary border in the triangular corner of the plot of the school. There would be heavy log seating placed inside the circle to make it hard to remove and the firepit would also be built into the ground so that it cannot be vandalized too easily.


Compost

As a greenhouse, we will be needing nutrient-rich soil for the plants and will be producing lots of plant waste at the turn of the seasons. Thus, composting is a perfect opportunity to reuse the materials used in our greenhouse for soil. It will also help save money with soil and help dispose of all plant waste.

To compost, one needs to put plant waste in an enclosed area that is kept damp and rotated consistently. Keeping this in mind, we looked at 3 different options for the greenhouse; an open-air wooden enclosure, a plastic closed air tumbler system, and a plastic closed air container.



Decision Matrix for compost looking at all three options: High - Good Low - Bad

Compost Options	**Durability x4**	**Smell x3**	**Efficiency x3**	**Size x2**	**Price x3**	**Ease of use x5**	**TOTAL**
Option 1 - Wooden	**16**	**9**	**6**	**10** ~ Depends	**15** ~ $125	**10**	**66**
Option 2 - Tumblers Home Depot	**12**	**9**	**15**	**8** ~ 100 gallons	**9** ~ $250	**25**	**78**
Option 3 - Plastic Bin Gardeners Supply Company	**20**	**2**	**9**	**10** ~ 240 gallons (38 ft^3)	**12** ~ $200	**10**	**73**

By looking at the decision matrix we have decided on the Black Tumblers as the best option. It is the most user friendly and efficient as it is easy to add, rotate, and remove from. It is also a good price and size for how efficient and easy it is to use. It will also be able to withstand the South Dakota weather as long as proper weights are added. A problem is it does not keep out all of the smell, but if the compost is checked regularly and rotated smell should not be an issue. However, it might be a good idea to keep the compost dry during hot months to combat smell as this was a huge concern from our project partners.

Water Collection

Water collection is a great way to reuse and save money on water. In Rapid City, South Dakota there is an average annual rainfall of 18 inches and for every inch of rain in a square foot there is .6 gallons of water produced. As seen water collection would be perfect opportunity for our greenhouse. We initially looked into three types of collection wet collection, dry collection, and rain barrels. Wet collection is when water is collected and sent to a barrel using pipes away from the collection structure. Dry collection is when water is collected and sent to a barrel next to the collection site without the use of added pipes. Rain barrels are a type of dry collection system with a smaller barrel. All use rain gutters to collect rain from the roof of the structure.



Later in the research we found out that we could not put gutters on the greenhouse without voiding the warranty. That was not an option so we then looked into collection systems without gutters. The first involving “ground” gutters next to the greenhouse and the other a collection system separate of the greenhouse. As of now there has not been any more research or decisions made about water collection, but we plan to continue to look into solutions

Future Plans

Moving forward with the project, our goal is to replicate our success on other OLC campuses on Pine Ridge Reservation. We have been in contact with Kyle campus to gauge interests and needs for a similar project. We plan to meet with them during our trip to South Dakota on May 5th - May 9th. During this trip, we will also be assisting in the construction of the greenhouse on Rapid City OLC campus and meeting with our project partners face to face. Regarding future funding for the project, we discovered that Bush Foundation Community Innovation grants are specifically fit to our project. Bush Foundation offers a generous amount of funding (ranging from $10,000 to $200,000) into improving the economic and racial disparities among Native Americans, especially those in the Minn-Kota area.

In the upcoming semester, we plan to revisit the designs for the cultural center and develop a final plan fit for our project partners. We also plan to look at possible grants and places to cut back in the design to make the learning center feasible. We plan to implement the researched greenhouse add-ons and aquaponics into the greenhouse. We will also make sure everything is working properly and efficiently with the Greenhouse.

Design Review Feedback

After design review, the team received feedback from three different reviewers about the final presentation and the project.

Kanshik Manchella -

- “What makes you think this project will be maintained in the long run?”
  - We have been working fervorously with our project partners and have designed the greenhouse to last and be maintained by our partners
- “How much will the community gain from the investment they make in running and maintaining the greenhouse?”

    - The community seeks to gain the ability to teach people and help design a system to improve the food issues in the community

Paul Riley -

- Irrigation Pipes should be off-level to help drain
    - This suggestion will be taken into serious consideration in our design in the future

Jeremy Byrd -

- Look at local fish types or places for the aquaponics