Statement of Work

Conscious Cultivation

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Final SOW for Agreement to Perform Engineering Services to NAU Clubs and CECMEE

Date	Services Performed By:	Services Performed For:
May 10, 2016	**Conscious Cultivation** Abrar Aleebani, CE Yasmin Ashkanani, ENE Daniel Monar, ENE Tonowynn Sam, CE	**CECMEE** **NAU Volunteer Clubs**

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Abbreviations

ASCE – American Society of Civil Engineers
CECMEE – Civil Engineering, Construction Management, Environmental Engineering
GEO – Global Engineering Outreach
MFB – Media Filled Bed
NAU – Northern Arizona University
NFT – Nutrient Film Technique

1.0 Project Understanding

Conscious Cultivation will provide the committed NAU volunteer clubs with a carbon neutral aquaponics system that will sustainably grow both aquatic life and plants. This system will be built / operated / demonstrated, perennially, in a newly constructed greenhouse located at the NAU CECMEE Field Station. This greenhouse will be used as a 'living laboratory' for students and faculty alike and will house the aquaponics system.

1.1 Project Purpose

The purpose of this project is to provide a number of NAU volunteer clubs with an aquaponics system that will be used as a demonstration piece to educate the NAU community and also assist these clubs in recruiting members from diverse backgrounds around campus. The United States, along with other countries around the world, are struggling for access to fresh water and reliable food sources. This aquaponics system will be a carbon neutral system, meaning that it will have zero net-carbon emissions. Aquaponics systems are beneficial because they do not require any soil to yield crops, they use 90% less water than traditional soil agriculture, they grow plants 30% faster than traditional soil agriculture, and they do not require the use of pesticides, herbicides, or artificial nutrients for the crops to proliferate. Furthermore, an aquaponics system will deliver both aquaculture and plants, in sufficient quantity to sustain a pescatarian diet. This system will demonstrate the potential of a new, sustainable form of agriculture that will eventually be used around the world. Subsequent to the project's completion, NAU clubs such as the Green Jacks, ASCE, and GEO have each committed their support of this project and will appoint volunteers to help maintain, operate, and demonstrate this system.

As part of this project, CECMEE will benefit from the addition of a year-round greenhouse, engineered for Flagstaff's cold / harsh winter climate, which will be home to Conscious Cultivation's aquaponics project. The greenhouse will have the ability to house other engineering capstone projects and faculty research projects. This project will help increase the culture of sustainability within the Engineering Department, expand the awareness of sustainability campus-wide, and create new laboratory applications for engineering students. The response we have heard through our design phase is that a greenhouse laboratory would be a welcome addition to the Engineering Department at NAU.

1.2 Project Background

The aquaponics system will be constructed and remain in the greenhouse being constructed at the CECMEE Field Station. An aerial view of the site can be seen in **Appendix A: Project Site**. This system will serve as an educational tool for all who view it and will generate compost and food for the NAU community year-round. Ultimately, we will rely on those Clubs that have committed to this project as to what will be done with the aquaculture and plants grown in the system. Conscious Cultivation will provide its recommendations of potential outcomes to the Clubs. In addition, this aquaponics system will educate its viewers about commercializing this system and providing safe and healthy food to the world**,** while using less resources than traditional agriculture. Information boards will be strategically placed around the aquaponics system to educate viewers about its unique components.

The greenhouse will be purchased as a kit from *Growing Spaces / Growing Domes*. These growing domes can be constructed off the grid and are engineered to handle harsh weather and freezing temperatures. This greenhouse uses passive solar heat, solar powered cooling vents, and an above ground pond in order to regulate the temperature inside. This design enables the greenhouse to sustain temperatures up to 30°F warmer than outside temperatures.

This greenhouse will be accessible to the entire NAU community to observe the innovative research and projects that are taking place inside. Students will be able to volunteer to operate, maintain, and demonstrate the projects inside. Faculty will be able to move their research into the greenhouse and perform demonstrations to their classes in a safe and unique environment. These greenhouses have a 15-20 year expected lifespan with the proper care. The polycarbonate glazing panels have a 10-year warranty against yellowing and hail damage. An image of the greenhouse can be seen in **Appendix B: Growing Dome by Growing Spaces**.

1.3 Technical Considerations

There are several technical aspects that are associated with this aquaponics project that are integral to the engineering design process.

1.3.1 Aquaponics Piping and Pumping

One technical aspect that is important to the project is its water piping system. Conscious Cultivation will need to design a water distribution system that will carry water from the aquaculture tank**,** through a clarifier and bio-filter, to the growing beds, and then back to the aquaculture tank. The project must be designed to recycle water throughout the aquaponics system, and the only 'new' water added will be what is needed to replace what was lost due to evapotranspiration. Water pumps will also need to be chosen to transport the water throughout the system.

1.3.2 Water Quality Monitoring

Another technical aspect that must be considered is the monitoring of the water quality in the system to ensure the health of the aquaculture and plants. Water quality parameters that will need to be monitored are pH, conductivity, and temperature. Disease control must also be considered in order to protect the health of the system as a whole.

1.3.3 Aquaculture and Plants Introduced into System

The types of aquaculture and plants introduced into the system will need to be considered. Dr. Terry Baxter, the design team's technical advisor, suggested that tilapia, perch, or koi should be used in the aquaponics system since they can survive in a wide range of water quality limits. Further research will be done to ensure that the chosen species of aquaculture can flourish in this system. The design team also needs to research the types of plants that can be grown in this type of system and environment. Another consideration is where Conscious Cultivation and the client will obtain the aquaculture and plants to be grown.

1.4 Potential Challenges

Conscious Cultivation has already come across several challenges and predicts that there are more to come in the future. The primary challenge the design team is currently facing is finding funding for the system and its components. The design team has applied for the Green Fund and hopes that it will cover all capital costs. Donations will be sought afterwards to obtain any additional funds, or materials, not covered by the Green Fund. Some potential challenges that the design team may come across in the future will primarily come during the construction phase of the project. Conscious Cultivation may have to endure some aquaculture and plant casualties until the water has the proper characteristics to support life. The water will be supplied, via garden hose, to the system and run through the system until conditions are favorable for aquaculture and plants to thrive. The system might also need repairs as time goes on. An Operations and Maintenance manual will be provided to help with foreseeable repairs that might need done.

Challenges to construct the greenhouse will primarily come to light during the site determination phase of the project. Conscious Cultivation is currently seeking approval from the Space Committee at NAU in order to construct this project on-campus. Another challenge that may arise could be finding a site at the CECMEE Field Station that will provide a minimum of 5-6 hours of daylight, year-round. Lastly, the construction of the geodesic dome and its components could be challenging and might require assistance and knowledge from engineering instructors.

1.5 Stakeholders

The primary stakeholders include CECMEE and the clubs who will be working with the aquaponics system. CECMEE will be the 'Owner' of the greenhouse, once it is fully operational, and will be responsible for treating it as any other laboratory asset that is managed by the department. Gerjen Slim has agreed to be the faculty member who will 'manage' the greenhouse, as he is the current lab manager for the CECMEE Department. The NAU volunteer clubs will be responsible for operating, maintaining, and demonstrating the system. Other stakeholders will be those who will view demonstrations of the system and benefit from what they have learned. The clubs in charge of the system will have complete control of what aquaculture and plants are grown in the system and what is done once those plants and aquaculture are harvested. They will also have the liberty of experimenting with the system to optimize its performance. The system will provide and constant supply of compost from the captured solids and plant trimmings. This compost can be used at the soil gardens on-campus, or used by environmental engineering classes to observe bio-remediation techniques. Those who use the compost and potentially receive aquaculture and plants will also be stakeholders in this project. Lastly, engineering professors will be allowed to move research projects into the greenhouse and perform class demonstrations in the greenhouse. For example, Dr. Terry Baxter is currently growing algae to research wastewater treatment. This research project can be moved into the greenhouse and receive more sunlight than it currently does in the laboratories of the Engineering Building. Dr. Baxter would also like to demonstrate phytoremediation in the greenhouse for his CENE 410L class. Other engineering professors can utilize this unique space for similar applications upon approval of CECMEE.

2.0 Scope of Services

The design team has been tasked with designing and constructing an operational aquaponics system. This system will house and grow different types of aquaculture and plants. The design will be cost-efficient, energy-efficient and low maintenance. The main components that will be constructed are the clarifier, the biofilter, the growing beds, and piping for the hydraulic infrastructure. Other items may need to be designed and constructed once there has been a final system-design chosen. Once the aquaponics system has been built, and the water has stabilized, it will be able to sustain both aquaculture and plant life.

The design team is also tasked with purchasing and erecting a greenhouse kit that will serve as an operational laboratory facility for students and faculty alike. This greenhouse will house the aquaponics system and other approved projects in the future.

2.1 Funding

Conscious Cultivation will need funding and donations in order to fund this project. The design team is currently applying for the Green Fund and will seek donations from potential sponsors if additional funding is required.

2.1.1 Green Fund

Northern Arizona University has a student-led organization, known as the Green Fund, which helps with financing for student and faculty projects. The Green Fund's mission statement is: "The NAU Green Fund promotes student participation in and provides funding for projects that reduce NAU's negative impact on the environment and create a culture of sustainability." This project's focus is to expand the culture of sustainability on the NAU campus, thus applying for the Green Fund. The final proposal date for the Green Fund is March 15, 2016.

2.1.2 Donations

The design team will seek funding and material donations that will contribute to the construction and operation of the project.

2.2 Greenhouse Acquisition

This greenhouse will be purchased from *Growing Spaces / Growing Domes* and built at the CECMEE Field Station. The design team will need to determine which size greenhouse is best suited for its use, plus considerations for renewable energy sources to power the systems inside the greenhouse.

2.2.1 Site and Size Determination

Conscious Cultivation will need to determine which site at the CECMEE Field Station is best situated for the greenhouse. The site must be level enough so as to not require much grading**,** and be in an open space to allow 5-6 hours of daylight at a minimum. After speaking with a representative from *Growing Spaces / Growing Domes*, Conscious Cultivation will decide on whether to purchase a 22' or 26' diameter greenhouse. The size of the greenhouse depends on the amount of funding provided by the Green Fund, donations received, space allowed for construction at the CECMEE Field Station, and the room needed to house all of the potential projects that could be introduced into the space.

2.2.2 Considerations for Renewable Energy

The greenhouse itself is able to run optimally without the need of supplemental energy sources. However, the project that will be implemented into this space will need to be powered by either renewable energy or energy from the electrical grid. Conscious Cultivation will seek funding and donations in order to acquire solar panels and batteries in order to supply 24-hour electricity to the greenhouse and its projects. Wind energy can also be utilized if a turbine is built at the site**,** as a separate project.

2.3 Technical Research

As part of the design process, the design team will need to do additional research on certain technical aspects of the aquaponics system, such as the bio-filter, clarifier, and food that will be introduced into the system.

2.3.1 Biofilter Design

A bio-filter is required to ensure that all the ammonia produced by the aquaculture is converted into usable nitrate. The bio-filter will be downstream of the clarifier, and will consist of a plexiglas cylinder filled with aggregate. The aggregate in the cylinder will serve as a 'home' for naturally forming bacteria and other organic matter necessary to assist with the nitrification process. Conscious Cultivation will need to research and calculate the necessary surface area needed to sustain an optimal amount of bacteria.

2.3.2 Clarifier Design

A clarifier is used to remove suspended solids such as fecal matter and the food used to feed the aquaculture. If left in the system, these solids will introduce an excess amount of ammonia in the system, and make the water toxic to both the aquaculture and the plants. The design team will need to research how to build a clarifier that will remove these solids. The design team has chosen to construct the clarifier out of Plexiglas so that the solids-removal process can be viewed during demonstrations.

2.3.3 Vegetation

The design team will need to determine which plants will be able to thrive in an aquaponics system, as well as in the greenhouse environment.

2.3.4 Aquaculture

The design team will need to determine which types of aquatic life will be able to thrive in an aquaponics system, as well as in the greenhouse environment.

2.4 Analysis

Conscious Cultivation will perform the necessary analysis to ensure that the design of the system will be sustainable, cost efficient, and perform optimally.

2.4.1 Hydraulic Analysis

Conscious Cultivation will conduct a hydraulic analysis to determine the size of pumps that are needed to transport water throughout the aquaponics system. This will also model the flow rates, velocities, head losses, and energy grade lines associated with the flow of the system. The analysis will take into consideration the ability for future expansions to the system.

2.4.2 Water Quality Analysis

Conscious Cultivation will perform analysis to determine what quality of water is most beneficial for the plants and aquaculture that are being chosen for the aquaponics system. The design team will need to determine how much waste the aquaculture will supply, and how much water-surface area is needed to grow beneficial bacteria to support total-nitrification. Another consideration is to determine the optimal pH, conductivity and temperature of the water in the system.

2.4.3 System Space Requirements

The size of the greenhouse being erected at the CECMEE Field Station will depend on the approved final budget. Once the optimal size of the designed greenhouse is decided, the size of the aquaponics system can then be determined. Conscious Cultivation envisions the system being large enough to perform as designed, but also allow for expansion of the system for future research and projects being housed in the greenhouse.

2.4.4 Economic Analysis

Continual analysis of costs being incurred will be performed to ensure that the project remains within the approved budget. Also, a comparative analysis will be done to ensure that the operational aquaponics system uses less energy and water, yields more crops over time, and has a lower overall cost-per-harvest, as compared to traditional agriculture.

2.4.5 Environmental Sustainability Analysis

Analysis will be done to ensure that all facets of the project design, construction, and its operation remain sustainable. This project will need to remain carbon-neutral throughout its lifetime.

2.5 Design

The design of the aquaponics system has two integral parts, the aquaculture portion of the system and the hydroponic portion of the system. The aquaculture portion of the system includes the aquaculture tank, the clarifier, the bio-filter, and the pipes interconnecting the different sections. The hydroponic portion of the system starts downstream of the bio-filter. This portion includes the system(s) within which the plants will grow, the pumping equipment, and the necessary piping required to make the entire aquaponics system a continuous loop.

2.5.1 Aquaculture

In order to determine the maximum amount of plants that can be grown, the aquaculture system will be designed first.

2.5.1.1 Aquaculture Selection

First, Conscious Cultivation and the Green Jacks will collaborate in order to determine the ‘type’ of aquaculture that will be introduced into the system. The NAU volunteer clubs will have the ability to choose a different species of aquaculture that will survive in an aquaponics environment, upon the approval of the appointed student-manager. These aquaculture will either be harvested or kept in the system for the duration of their lives pending a decision from the student-manager. If it is decided that the aquaculture is to be harvested, they will be grown in different intervals of age, so that the average amount of nutrient-output is stable. If it is decided that the aquaculture will not be harvested, the aquaculture will be introduced into the system as fingerlings and will be extracted from the system once they die. The amount of plants introduced into the system will increase as the nutrient-output increases. Once an aquaculture dies, another fingerling will be introduced and plants will be removed or added depending on the available amount of nutrients.

2.5.1.2 Aquaculture Tank Design

The greenhouses engineered by *Growing Spaces* are equipped with an above-ground pond to assist in regulating temperatures within the greenhouse. This pond will be used for the aquaculture that is introduced into the system. The size of the tank varies with the different sizes of greenhouse. The size of the pond will be known once Conscious Cultivation has chosen a final greenhouse size.

2.5.1.3 Clarifier Design

Upon further technical research on the design and functionality of clarifiers, the design team will then be able to identify how to construct a clarifier that will remove all the suspended solids produced by the aquaculture in the system. The size of the clarifier depends on the maximum size of the aquaculture and the amount of aquaculture used in the system.

2.5.1.4 Bio-filter Design

Upon further technical research on the design and functionality of bio-filters, the design team will then know how to construct a bio-filter that will convert the remaining ammonia into nitrate**,** and ensure that the water is safe and beneficial once it reaches the plants. The size of the bio-filter also depends on the maximum size and quantity of the aquaculture used in the system.

2.5.2 Hydroponics

Once the aquaculture-portion of the system is designed, the design of the hydroponic-portion can commence. This will include deciding on the 'type' of growing system, determining the equipment size of the water-circulation system ensuring that the pumps selected can adequately move water throughout the system, plus the final design of the entire system.

2.5.2.1 System(s) Selection

The three types of growing systems that are available are the NFT-system, the media-filled grow-bed system, and the raft system. Conscious Cultivation will determine which of these systems or combination of systems will be used once the square footage of the greenhouse is determined.

2.5.2.2 Pump Selection

The design team will choose a pump or series of pumps that will move the water throughout the system at a flow rate calculated during the design of the system. Considerations will be given to future expansion of the system and redundancy in the event of pump failure.

2.5.2.3 System(s) Design

Once the design team has chosen the growing system, the system design will commence. The design of the system will first be hand-drafted for review and comment, and then presented in AutoCAD format, with different isometric views**,** to fully communicate what the system will look like.

2.6 Material Acquisition

2.6.1 Aquaponics System

Conscious Cultivation will acquire the materials needed to build the aquaponics system. The primary materials necessary to construct such systems are**:** aquaculture tanks, PVC piping, grow-beds, bubblers, pumps, and related wiring. Once a final design has been approved, the design team will be able to ascertain the type, quantity and cost of the required materials. Conscious Cultivation will be applying to the Green Fund to cover a majority of the construction costs, and will solicit donors to help with the purchase of any specialty items as well as operations costs.

2.6.2 Greenhouse

All sizes of growing domes offered include UV resistant, shatter-proof, insulating polycarbonate glazing panels, a full-set of pre-cut /color-coded struts, hubs and framing plus all hardware, automatic opening vents, cooling fans, a solar-powered climate control system, reflectix insulation, select-materials for the above-ground pond, a shade cloth, a snow-shed entryway with door and a window, and a 24”-high foundation wall with structural siding. The greenhouse will also utilize metal glazing strips to seal the seams between the polycarbonate glazing panels, drip-edge flashing to protect the wood on the inside of the top of the foundation wall from moisture and long-term degradation, and a redwood bottom plate that is resistant to decay for many years. *Growing Spaces / Growing Domes* identifies a list of construction materials that are best bought locally, rather than shipped from Colorado.

2.7 Construction

2.7.1 Aquaponics System

Construction of the system is scheduled to begin in August of 2016. The physical labor will be provided by Conscious Cultivation, with the help of the Green Jacks as well as Dr. Terry Baxter. The aquaculture portion of the system will be constructed first to ensure that healthy bacteria have colonized in the system to convert the toxic ammonia into nitrate. Once the outflow of water is suitable to sustain plant life, the hydroponic system will be constructed and connected to the aquaculture portion. Plants that have been germinated from seeds will then be introduced into the system. Once the system is stable, the design team will monitor pH fluctuations, DO fluctuations, and the overall health of the aquaculture and plants. Informational boards will be strategically placed around the system to educate it’s viewer about the unique components of the system and how this system can be scaled to a commercial-size, along with the benefits of doing so.

2.7.2 Greenhouse

Conscious Cultivation will construct the greenhouse, being assisted by volunteers and technical advisors. Construction will begin with the grading of the site in order to provide a level area on which to situate the greenhouse. A layer of compacted gravel will then be placed on top of the graded native soil. The blue-board subgrade insulation will then be installed horizontally on the outside of the greenhouse and then covered with gravel. The greenhouse and its components will then be constructed following the installation manual provided by *Growing Spaces / Growing Domes*.

2.8 Testing and Monitoring

Once the greenhouse and aquaponics system are constructed and operational, Conscious Cultivation will spend the rest of the scheduled time testing and monitoring the system. This will include observing fluctuations in water quality, making the proper adjustments, introducing aquaculture into the system once the water quality has stabilized, propagating plant material, introducing the plants into the system, and making any alterations to the system that will optimize its performance.

2.8.1 Water Stabilization

The water in the system will require time to grow the beneficial bacteria, as well as other characteristics that will support the aquaculture. Before any aquaculture is introduced into the system**,** the water needs to be stable and ready to support aquaculture growth.

2.8.2 Aquaculture Introduction

Once the water in the system is stabilized, aquaculture will be introduced into the system. The amount of aquaculture introduced will depend on the size of the above ground pond.

2.8.3 Plant Propagation

While the water in the system is stabilizing, Conscious Cultivation will start to propagate the seeds that were procured. The types of seeds that will be purchased are described in the list of materials that can be seen in the 'Cost of Engineering Services' section of this statement of work.

2.8.4 Plant Introduction

Once the seedlings have developed a complex root system, they will be transferred into the aquaponics system where they will start to receive nutrients from the aquaculture and, in-turn, assist in filtering the water of the system.

2.8.5 System Monitoring

Once the aquaculture and plants are integrated into the running system, Conscious Cultivation will closely monitor the water quality and observe the growth of the food.

2.8.6 System Alterations

The design team will continually monitor and make adjustments to the system for the remainder of the schedule to ensure that it is running as efficiently as possible, prior to Project Turnover to the clients.

2.9 Maintenance and Operations

Conscious Cultivation will provide the clients with all of the necessary documents needed to operate and maintain the greenhouse and aquaponics system. These documents include a Future Use Plan and an Operations and Maintenance Manual.

2.9.1 Future Use Plan

Conscious Cultivation will provide the clients with a Future Use Plan that describes how the aquaponics system should be utilized and what future projects can be implemented to make the greenhouse even more sustainable.

2.9.2 Operations and Maintenance Manual

Conscious Cultivation will provide the users of the aquaponics system with an Operations and Maintenance Manual. This manual will include the complete Bill of Materials used to build the system, a step-by-step process of how the system was built, and instructions on how to operate and handle the technical sensors used to monitor the water quality. This manual will provide all the necessary information needed to operate and maintain the aquaponics system, as well as identify any considerations of future expansion that were included in the design of the project.

2.10 Project Management

Daniel Monar, team-leader of Conscious Cultivation, will lead project Management.

2.10.1 Meetings and General Management

Weekly meetings will be scheduled to discuss the schedule, costs, budget, plus potential meetings with advisors, stakeholders, and clients. The project manager will ensure the project will be completed on-time and on- budget.

2.10.2 Project Schedule

A project schedule will be formulated based on the approved scope of work and will span from March 2016 to December 2016.

2.10.3 50% Design Report

Conscious Cultivation will deliver a 50% design report to the volunteer clubs, the Green Fund committee, Mark Lamer, and Dr. Terry Baxter. This report will keep the client and instructors informed of the design team's progress, identify any problems encountered, the resolutions to said problems, and any schedule modifications needed to achieve Project Turnover by the specified date.

2.10.4 Final Design Report

A final design report will be delivered to the volunteer clubs, the Green Fund committee, Mark Lamer, and Dr. Terry Baxter at the time so-stated in the project schedule. This report will notify the clients and instructors that the project is complete and operational, ready for punch list and, barring any remedial comments, ready for turnover to the clients.

2.10.5 Final Presentation

Conscious Cultivation will offer a final presentation demonstrating how the aquaponics system works and how it is to be operated, maintained, and demonstrated by the volunteer clubs and CECMEE.

2.10.6 Website

Conscious Cultivation will create a website for the project.

3.0 List of Exclusions and Clarifications

1. The scope of this project is subject to change and the design team will take any proposed additions into consideration.
2. Conscious Cultivation will determine if any proposed additions can be incorporated within the timeframe of the project and are more than willing to meet the needs of the clients.
3. Conscious Cultivation will not accept any additions to the aquaponics system after November 11, 2016.
4. The appointed student-manager will be in charge of approving and coordinating all additions to the system subsequent to November 11, 2016.
5. Conscious Cultivation's scope-of-work will be limited to constructing the greenhouse and its primary components.
6. CECMEE will be responsible for approving all projects being added to the greenhouse.
7. CECMEE and the committed volunteer clubs will be responsible for any and all maintenance and repairs to the greenhouse and aquaponics system following its turnover.
8. Conscious Cultivation will provide instruction manuals to assist in any scheduled maintenance or needed repairs.
9. Conscious Cultivation is not responsible for the costs to operate and maintain the greenhouse and aquaponics system following its acceptance and turnover. CECMEE has committed to funding these costs.
10. Conscious Cultivation will only purchase the items listed in the materials list. There have been no considerations made for Attic Stock materials.
11. Conscious Cultivation is not responsible for any application fees, nor the cost of producing stamped/engineered drawings necessary to obtain any Building Permits that may be required.

4.0 Project Schedule

This project duration will span from March 28, 2016 to December 15, 2016. Construction of the greenhouse will be completed by October 25, 2016**,** at the earliest. A Gantt Chart of the schedule can be seen in **Appendix B: Gantt Chart**. The critical path is identified in the chart.

5.0 Cost of Engineering Services

Conscious Cultivation is comprised of (4) team members who will work under the following (5) Job Headings to complete this project.

Table 1: Project Job Headings

Classification	Code
Senior Engineer	SE
Engineer	E
Administrative Assistant	AA
Engineering Intern	EI
Laborers	L

Every team member will rotate through each of the Job Headings throughout the course of the project. The scope of this project has been categorized into the different tasks that are required to be completed, with each task being assigned to a specific Job Heading. The estimate of hours that each Job Heading is anticipated to expend to complete each task is described in the table below.

Table 2: Task Designation by Hour

Task	SE hrs.	E hrs.	AA hrs.	EI hrs.	L hrs.
Task 1: Funding					
1.1 Green Fund	10		10		
1.2 Donations		12			
Task 2: Greenhouse Acquisition					
2.1 Site and Size Determination	10	10			
2.2 Considerations for Renewable Energy		12			
Task 3: Technical Research					
3.1 Bio-filter Design		10		10	
3.2 Clarifier Design		10		10	
3.3 Vegetation		10		10	
3.4 Aquaculture		10		10	
Task 4: Analysis					
4.1 Economic Analysis		15		15	
4.2 Environmental Sustainability Analysis		15		15	
4.3 Hydraulic Analysis		15		15	
4.4 Water Quality Analysis		15		15	
4.5 System Space Requirements		5		5	
Task 5: Design					
5.1 Aquaculture					
5.1.1 Aquaculture Selection		10		10	
5.2.2 Aquaculture Tank Design		10		10	
5.2.3 Clarifier Design		10		10	
5.2.4 Bio-filter Design		10		10	
5.2 Hydroponics					
5.2.1 System(s) Selection		10		10	
5.2.2 Pump Selection		10		10	
5.2.3 System(s) Design		10		10	
Task 6: Material Acquisition					
6.1 Aquaponics System				20	20
6.2 Greenhouse				20	20
Task 7: Construction					
7.1 Aquaponics System					80

7.2 Greenhouse					80
Task 8: Testing and Monitoring					
8.1 Water Stabilization		5		5	
8.2 Project Schedule		1		1	
8.3 Plant Propagation		3		3	
8.4 Plant Introduction		1		1	
8.5 System Monitoring		20		20	
8.6 System Alterations		10		10	
Task 8: Maintenance and Operations					
		20			
Task 9: Project Management					
9.1 Meetings and General Management	20	20	20	20	20
9.2 Project Schedule	10		10		
9.3 50% Design Report	10	10		10	
9.4 Final Design Report	10	10		10	
9.5 Final Presentation	10	10		10	
9.6 Website				20	
Total (man-hours)	**80**	**319**	**40**	**325**	**220**
	984				

The total man-hours required to finish this project is estimated at (984) man-hours. The design team determined commensurate pay rates for each Job Heading based on base pay, benefits, overhead, and profit. Based on the number of man-hours each role has been assigned, the total 'Cost of Services' has been calculated in the table below.

Table 3: Cost Estimate of Services

Classification	Hours	Rate, $/hr.	Cost
SE	80	190.00	$14,995.00
E	319	75.00	$23,925.00
AA	40	60.00	$2,400.00
EI	325	30.00	$9,750.00
L	220	20.00	$4,320.00
Total			**$55,390.00**

Our estimate for the Total Cost of Services is the sum of $55,390.00. This, however, is not the total cost of the project. Noted below is a list of materials required to complete the project, and the cost of those materials.

Table 4: Estimated Cost of Materials

Item	Quantity	Price	Description

Fingerlings	25	$150.00	Price for blue tilapia fingerlings. This breed of aquaculture can handle water temperature as cold as 60°F.
Propagation Cubes	1	$17.00	1”x1” sheet of 200# Rockwool used to germinate seeds
Propagation Cube Tray	5	$24.00	21.25”x10.75”x1.33”. Used to hold propagation cubes and water.
Water Pump	3	$75.00	4 gal/min. Used to transport water throughout the different systems.
Plexiglas	1	$55.00	10”x10” Cylinder to build bio-filter
Aggregate	1	$0.00	Media to fill bio-filter
Plexiglas	1	$55.00	Cylinder and cone to build clarifier
Clarifier Valve	1	$7.00	Used to discharge settled solids
PVC Pipes	10’	$11.00	4”-dia PVC pipe used in NFT system
PVC Pipes	10’	$11.00	2”-diameter PVC pipe used to transport water throughout the system
PVC Pipe Elbow	2	$3.00	90° elbow to raise elevation of pipe system
Air Pump	1	$30.00	Used for oxygenating aquaculture pond
Air Stone	6	$30.00	Used for oxygenating aquaculture pond
Trimming Shear	4	$28.00	Used to trim plants and harvest food
Netted Pots	100	$27.00	3” pots for NFT and MFD systems
Growing Media	1	$33.00	Hydroton expanded clay grow media, 50L
Raft	1	$140.00	2.5’x3’ includes 4 rafts with 8 holes in each raft and 32 netted pots
Growing Basin	2	$200.00	3’x3’ Blue Earth Sustainable (Active aqua flood table)
Standpipe Siphon	1	$38.00	Livinggreen Adjustable Bell Siphon Kit
Fingerling Aquaculture Feed	1	$30.00	5 lb. bag
Intermediate Aquaculture Feed	1	$35.00	10 lb. bag
Grow-out Aquaculture Feed	1	$30.00	10 lb. bag

Herb Seeds	1	$40.00	Dill-150, Fennel – 150, Sage – 100, Cumin – 150, Thyme – 500, Oregano – 1500, Chives – 300, Cilantro – 200, Basil – 200, Parsley – 200
Vegetable Seeds	1	$40.00	Lettuce – 1000, Beets – 300, Broccoli – 200, Cucumber – 200, Red Oak – 1000, Rose Tomato – 40, Carrot – 1000, Green Bean – 200, Cherry Tomato – 40, Bunching Onion – 850, Bell Pepper – 30
Bluelab Guardian Monitor	1	$365.00	24-hour monitoring of pH, conductivity, and temperature
Lumber	40’	$25.00	2”x4” wood to build supports for aquaponics system
Growing Spaces 26’ Growing Dome	1	$15,450.00	26’-dia geodesic greenhouse
26’ Metal Glazing Strips Upgrade	1	$580.00	Strong roofing tape covered by custom built aluminum strips to seal the seams of the greenhouse
26’ Drip Edge Flashing	1	$95.00	Protects wood on the inside of the top of the foundation wall from moisture and long-term degradation
26’ Redwood Bottom Plate	1	$120.00	Strut on the foundation wall of the greenhouse that lays flat against the ground. Resistant to decay for many years.
26’ Miscellaneous Materials	1	$1,050.00	Estimated price of materials that must be bought separately
Shipping and Handling	1	$1,150.00	Pagosa Springs, CO to Flagstaff, AZ
Total		**$20,000.00**	

All prices for these materials were found on various catalogs online. A contingency of 10% was added to all of the costs to cover shipping and tax. The 26’-diameter greenhouse was chosen because it is the largest size that Conscious Cultivation is seeking. The estimated cost of materials will not exceed the above amount if a different greenhouse is chosen. As stated previously, the size of the greenhouse is dependent on the funding available. The materials for this project have been estimated to cost $20,000.00. Overall, the job is estimated to cost $75,390.00.

Total Cost Estimate	**$75,390.00**

6.0 Appendices

Appendix A: Project Site

Figure 1: CECMEE Field Station

Appendix B: Growing Dome by Growing Spaces

Appendix C: Gantt Chart