PROJECT SUMMARY

This project is for a crumb rubber water filtration system for developing countries. Waterborne diseases such as cholera kill approximately 2 million people a year. Many of these deaths could be avoided with simple filtering of the contaminated water before it is consumed.

Research conducted at Penn State by Dr. Yuefeng Xie suggests the use of rubber from old tires as a filtration medium for wastewater. (https://edge.rit.edu/content/R11007/public/Crumb%20Rubber%20Filtration.pdf) The rubber is ground up into small pieces called crumbs. An example of this material can be seen on turf fields. The rubber pellets on the field are typically crumb rubber. The objective of this MSD project is to utilize this method to create a low cost drinking water filter from old tires, most of which currently sit in landfills unused. With proper design it could be possible to reduce waste here in the United States while providing better drinking water around the world.

Current sand filters have issues associated with them which the crumb rubber solution should fix. Sand filters have low flow rates with limited use before a backwashing process must be performed. Due to how particulates are trapped in the rubber filter, it is easier to backwash the system and the flow rates are higher. This means that the maintenance would be easier, and more water can be filtered in a shorter period of time. If combined with a disinfection method, such as SODIS (http://www.sodis.ch/index_EN), treated drinking water could be provided to developing countries with old tires and water bottles. It will not be the team's responsibility to utilize the SODIS method, however it should be understood that after the filtering process other methods could be used to further improve the quality of the water if desired.

The overall mission statement for the roadmap this project is a part of is as follows. "Our mission is to provide a compelling solution to the problem of sufficient, accessible, economical and sustainable potable water supplies for the world's population" This project fits in with this overall mission statement on the individual scale, and if it proves successful could be scaled up to provide for a larger group.

ADMINISTRATIVE INFORMATION:

Project Name:	Low cost water filtration system for developing countries	Faculty:	TBD
Project Number:	TBD	Industry Guide:	Sarah Brownell, Gerald Garavuso
Project Track:	Energy and Sustainable Systems	Project Customer:	TBD
Project Family:	Water Filtration Systems	Project Sponsor:	TBD
Parent Roadmap:	Open Source / Open Architecture Sustainable Water Systems (R1107)	Project Budget:	TBD
Planning Term:	20101		
Start Term:	20102		
End Term:	20103		

PROJECT CONTEXT:

This project is part of the Open Source / Open Architecture Sustainable Water Systems (R11007). The homepage for this family can be found on EDGE.

https://edge.rit.edu/content/R11007/public/Home

Research has been conducted in Design Project Management which should be of use in identifying the need for a sustainable filtration device. Stakeholders were identified, and a wide range of interviews were conducted. The page below has these interviews. This information applies to the need for a sustainable water system, not just a filtration system, but is should provide a good starting platform for understanding the need.

https://edge.rit.edu/content/R11007/public/Stakeholders

Some facts which show the need of this project are listed below, from Water.org.

- Less than 1% of the world's fresh water (or about 0.007% of all water on earth) is readily accessible for direct human use.
- The UN estimates that by 2025, forty-eight nations, with combined population of 2.8 billion, will face freshwater "stress" or "scarcity".
- The water and sanitation crisis claims more lives through disease than any war claims through guns.
- Every 20 seconds, a child dies from a water-related disease.

The project is meant to begin the filter systems on the roadmap which can be seen below. Notice that this project is the 1st generation, encompassing both chemical and turbidity cleaning. It is vital that usable documentation is recorded in order to provide future teams a platform to build off of.

Function	Previous Projects	AY 2010-11	AY 2011-12	AY 2012-13
Collection		Rainwater	Groundwater	Body of water
Storage		Water for 1 person	Water for 1 family	Water for 1 community
Distribution		Personal container which can be disinfected	Family size container which can be disinfected	Municipal water (small community)
Control / Monitoring		Metering	Perform automatic functions	Failure & Security monitoring
Biological Cleaning	P07402 UV-Tube	2nd Generation UV tube	2nd Generation Filter	Chemical
Biological Cleaning	P07401 Solar Pasteurizer	2nd Generation Solar Pasteurizer	2nd Generation Filter	3rd Generation Solar Pasteurizer
Chemical Cleaning		Filter	2nd Generation Filter	Chemical
Mineral Cleaning	P08401 Water Desalination	Desalinization for Dubai	2nd Generation Filter	Desalination
Turbidity Cleaning		Filter	2nd Generation Filter	Chemical

PROJECT HOUSE OF QUALITY:

Sustainable Water

Cleaning

Engineering Requirement	a.1	a.2	a.3	a.4	a.5	a.6
Number of different harmful contaminants filtered						
Number of environments it can work in (ex. Desert, ocean, jungle, tundra, etc.)	++					
Turbidity of the water (ex. Appearance, clarity, palatability)		+				
Amount of harmful biological contaminants	++	++				
Amount of harmful chemical contaminants	++	++				
Amount of harmful mineral contaminants	++	++				
Amount of water which can be stored		+				
Shelf life before contamination		+		++	++	
Input flow rate		+				
Output flow rate		+				
Flow rate (internal to distribution system)						
# of customers						
Distance covered						
Indication of working vs. not working, including early warning				+	+	+
Measures the amount of flow through system						
Budgeting or Rationing of Supply						
Number of sources which can be collected from (ex. Flowing, Standing, Water Vapor , Rainwater, Animal Waste)						
Input flow rate						
Output flow rate						
Spec	a.1	a.2	a.3	a.4	a.5	a.6

Our mission is to provide compelling solutions to the problem of sufficient, accesible, economical, and sustainable potable water supplies for the world's population.

VOC - Affinity Groups	CO #	VOC - Customer Objectives	Customer Weights	Number of different harmful contaminants filtered	Number of environments it can work in (ex. Desert, ocean, jungle, tundra, etc.)	Turbidity of the water (ex. Appearance, clarity, palatability)	Amount of harmful biological contaminants	Amount of harmful chemical contaminants	Amount of harmful mineral contaminants
			Preferred Direction	Up	Up	Down	Down	Down	Down
Economical	1.1	Supply water that will not exceed 15% of gross income and considered completed once below 5% of gross income.	20.0%						
Sustainable	2.1	Use a device that is compatible with multiple water sources.	20.0%	1	9	1			
	2.2	Minimized educational requirement for safe operation and environmental responsibilities.	20.0%						
	2.3	Incorporate a concise and well organized structured action plan.	20.0%						
	2.4	Utilize environment specific sustainable power source.	20.0%		9				
	2.5	Have products readily available where required and needed.	20.0%		3				
	2.6	Ensure processed water is maintained at its cleaned condition.	20.0%			1	1	1	1
Sufficient	3.1	Own a device to meet consumption demands (2 liters/person/day).	60.0%						
	3.2	Own a device to provide safe and clean drinking water (palatability (taste, smell, clarity)).	60.0%	3	3	3	3	3	3
	3.3	Available testing methods to substantiate cleanliness.	60.0%				3	3	3
	3.4	Device desingned for storage and water cleaning that is robust to damage.	60.0%	3	3	3	3	3	3
Accessible	4.1	Strong societal support to assist with producing clean sustainable water.	0.0%	3	3	3	3	3	3
	4.2	Operate a device that has simple usage.	0.0%						
	4.3	Operate a device that requires time efficient maintenance.	0.0%						
	4.4	Limit collection time to fit within the range of 50% to 5% of current collection time.	0.0%						
	4.5	Modified water transportation that requires less human effort.	0.0%						

Measure of Performance	#	#	NTU	ppm	ppm	ppm
Nominal Value	0	0	0	0	0	0
Marginal Value	1	1	0	0	0	0

CUSTOMER NEEDS ASSESSMENT:

Affinity Group Name	Customer Objective Number	Customer Objective Description	Measure of Effectiveness
Economical	1.1	Supply water that will not exceed 15% of gross income and considered completed once b	Analytical calculate the percentage of average regional gross income to cost of water, to deter
Sustainable	2.1	Use a device that is compatible with multiple water sources.	Experiment with device's capability with multiple water sources.
	2.2	Minimized educational requirement for safe operation and environmental responsibilities.	Experiment with users to see how much time it takes for them to learn the required content.
	2.3	Have products readily available where required and needed.	Analytically calculate the distance/availability of products.
Sufficient	3.1	Own a device to meet consumption demands (2 liters/person/day).	Analytically calculate the region's available water sources and capacity of developed device.
	3.2	Own a device to provide safe and clean drinking water (palatability (taste, smell, clarity)).	Experiment with operation of device with variable water sources and test cleanliness.
	3.3	Available testing methods to substantiate cleanliness.	Analytically determine effect testing methods for applications.
Accessible	4.1	Strong societal support to assist with producing clean sustainable water.	Analytically calculate support of resources from government, churches, charities, etc...
	4.2	Operate a device that has simple usage.	Experiment with a representative group to observe simplicity.
	4.3	Operate a device that requires time efficient maintenance.	Experimentally measure time required to maintain per period of time basis.

ENGINEERING SPECIFICATIONS:

List of Engineering Specifications

Engineering Spec.	Derives from Customer Needs	Relative Importance (-,1,3,9)	Description	Measure of Performance	Engineering Units	Marginal value	Ideal Value	Validation Method
a.1	2.1, 3.2, 3.3		Number of different harmful contaminants filtered	Measure quantity of contaminants removed from highly contaminated water source with minimal time allowance.	(integer)			Experimental
a.2	2.1, 2.4, 3.2,		Number of environments device can work in (ex. Desert, ocean, jungle, tundra, etc.)	Measure the device's effectiveness in extremely diverse environmental conditions.	(integer)			Experimental
a.3	2.6, 3.2, 3.3		Turbidity of the water (ex. Appearance, clarity, palatability)	Compare the water conditions under maximum capacity.	(NTU)			Experimental
a.4	2.1, 3.2, 3.3		Amount of harmful biological contaminants	Measure quantity of contaminant removed from highly contaminated water source with minimal time allowance.	(ppm)			Experimental
a.5	2.1, 3.2, 3.3		Amount of harmful chemical contaminants	Measure quantity of contaminant removed from highly contaminated water source with minimal time allowance.	(ppm)			Experimental
a.6	2.1, 3.2, 3.3		Amount of harmful mineral contaminants	Measure quantity of contaminant removed from highly contaminated water source with minimal time allowance.	(ppm)			Experimental

Customer Needs Descriptions:

2.1: Use a device that is compatible with multiple water sources.

2.4: Utilize environment specific sustainable power source.

2.6: Ensure processed water is maintained at its cleaned condition.

3.2: Own a device to provide safe and clean drinking water (palatability (taste, smell, clarity)).

3.3: Available testing methods to substantiate cleanliness.

PROJECT INTERFACES:

This project is meant to be an individual system in its first iteration. It is important that the water, after being treated, can interface with the user for consumption, or with a storage system being developed by other MSD groups in the family roadmap. Other interfaces, such as with distribution systems, are a low priority and can be disregarded for this initial phase.

STAFFING REQUIREMENTS:

Position Title	Position Description
Mechanical Engineer	This engineer will be responsible for the modeling and physical design of the system. They will create package drawings, perform any structural analysis required and provide assistance to the other engineers wherever required. A background in design would be beneficial for this role. Knowledge of Pro/ENGINEER or Solidworks is preferable. Interest in sustainable and simple design is a must.
Mechanical Engineer	This engineer will be responsible for the fluids aspect of this project. Understanding what biological contaminants are involved, as well as how to remove them will be their main responsibility. They will perform any calculations required dealing with fluid mechanics. A background in water purification and fluid mechanics would be beneficial for this role. Knowledge of materials for filtration would also be of great use.
Industrial Engineer	This engineer will be responsible for the manufacturability and sustainability of the design. They will assist the Design Mechanical Engineer in designing the system, with the idea of true manufacturability in mind. They will develop the process of manufacture, and perform any Data Analysis required. A background in sustainability, specifically focusing on design, would be vital for this project. They must want to create a product which can be used all around the world.
Industrial Engineer	This engineer will be responsible for the engineering economics and performance analysis of the project. They will assist the Fluids Mechanical Engineer in developing test methods for their filtration system. There will also be a focus on the Product Lifecycle assessment. A background in testing and performance assessment would be important to this position. A desire to develop test methods, as well as a drive to create a truly sustainable product from beginning to end would be valuable.

It is difficult to identify all the responsibilities that an engineer will take on during this project, these are just basic outlines of what will be needed and are not meant to limit the scope of responsibility of one individual.

PROJECT CONSTRAINTS:

- The team is expected to meet with *Storage, Collection, and Distribution project teams* from the R11007 roadmap prior to Week 2 to agree upon the appropriate interfaces to satisfy all team requirements.
- The cost of the final product, available to customers, must not exceed 15% of the gross income of the community for which its use is intended.
- This filtering device must work in a variety of environments.
- This filtering device must interface with the appropriate subsystems in the OS/OA Sustainable Water Systems (R11007) roadmap.
- This filtering device must produce water that has improved turbidity and a decrease in particulates.
- This filtering device must be robust to damage and must be easily maintained and cleaned.

- The team must provide instructions on how to use and maintain the unit.
- Students are expected to understand the social value of this project and the impact it has on people's lives.

REQUIRED FACULTY / ENVIRONMENT / EQUIPMENT:

Category	**Source**	**Description**	**Resource Available (*mark with X*)**
Faculty			
Environment			
Equipment			
Materials			
Other			