Collecting Today, Saving For Tomorrow:
A Proposal for on Campus Rain Cisterns

Fall Quarter 2013

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0.0 Glossary

CCF: Cubic Feet of Water

COB: City of Bellingham

CV: Carver Gym

DOE: Department of Ecology – WA state

LEED: Leadership in Energy and Environmental Design

PW: Potable Water

RCW: Revised Code for Washington

Sq. Ft.: Square Feet

1.0 Executive Summary:

In the Pacific Northwest, climate change is expected to decrease our snowpack in winter months. Due to this decreased winter snow pack there will ultimately be less summer water available in Lake Whatcom, which will increase the city's water rate and cost per CCF for drinking and irrigation. It is important that Western tries to limit its local watershed impact and find a sustainable alternative. WWU aims to "serve as a model for institutional effectiveness, innovation, diversity, and sustainability," and be a "responsible steward of resources." In order to solve this problem, we suggest implementing a rainwater cistern pilot project on the north side of Carver Gym that harvests rainwater to reduce Westerns water use.

Western spends a lot of money on water bills every year. Specifically, the SMATE irrigation area uses 10% of all irrigation water on campus at a rate of $3.73 per CCF. This amount roughly equals $4,088.08 for an entire year. We calculated that WWU will spend roughly $122,000 over the next 30 years on water bills alone. We think this money can be put to better use. By installing our two 5,100 gallons rain cisterns, the campus would save $95,000 over that time period resulting in about a seven year return on investment.
The amount of water we would be able to collect would be enough to completely cover the entire SMATE irrigation area throughout the summer months.

The great advantage to these cisterns is not only can they be used for outdoor irrigation uses, but there is a potential to use the water inside the CV bathrooms to flush toilets. During the winter months there would be enough water to fully cover the CV's current toilet flushing needs. Future research should be conducted on the viability of this future works idea.

2.0 Introduction

2.1 Purpose of Project

There are a two main purposes to this project. The first being able to collect, store and reuse rainwater in order to significantly reduce landscape irrigation costs around the Carver Gym. By accomplishing the first goal, the second purpose falls into place, which is the sustainable practice of conserving water and lessening WWU's impact on Lake Whatcom.

2.2 Problem

To begin, WWU consumes a significant amount of potable water resources used for irrigation. In order to calculate the below table, we assume SMATE is the water meter for Carver Gym due to its close proximity. In the 2012 fiscal year (July 2012 - June 2013), Western used approximately 109,600 cubic feet (CCF) of water to irrigate around SMATE Hall,[1] (See Appendix A). That amount totals to 819,864 gallons of water in one year.[2] This is enough water to fill one and a half Olympic sized swimming pools![3] In comparison to the entire campus irrigation usage for WWU, the SMATE area alone uses 10% as shown in table 1. Therefore it can be derived that targeting the SMATE irrigation area is a good start for water reduction.

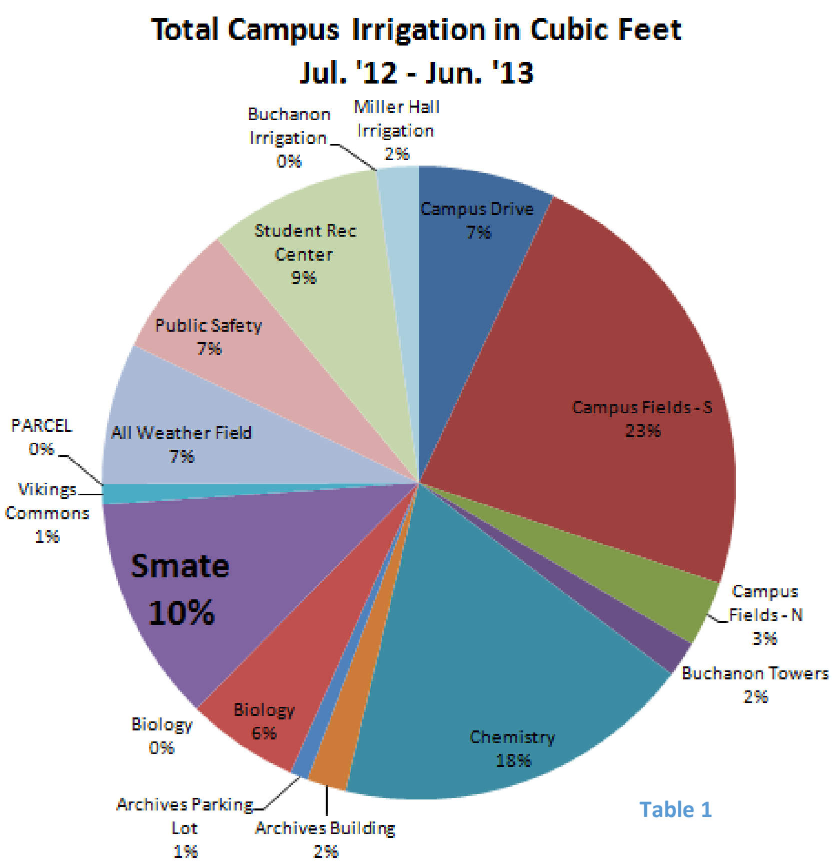

Table 1

[1] 1 cubic feet of water = 7.48 gallons
[2] 109,600 ccf x 7.48 gallons = 816,864 total gallons used
[3] (816,864 gal / 660,430 gal per Olympic size pool = 1.24)
Source: WWU Water 12-13 Consumption Spreadsheet

2.3 Solution

In order to reduce water usage for irrigation for the Carver Gym area, two rainwater cisterns can be connected to the existing outside gutter system between Bond Hall and the North wall of Carver Gym when the future remodel occurs in the 2015-2017 biennium.

- Tank 1 can be placed in the Northeast corner or to the right of the main gym entrance. We chose this corner because the cistern can easily tie into an existing outside downspout. This will be able to collect rainwater that washes off the roof to help water the planting bed immediately North of the gym.

- Tank 2 can be placed on the North side of the building as shown in figure 1. Both cisterns would be used to water the same bed which currently covers about 3,800 sq ft.

*Our group was not able to identify any alternative placement or exterior gutter connections at this time due to new design blueprint specifications.

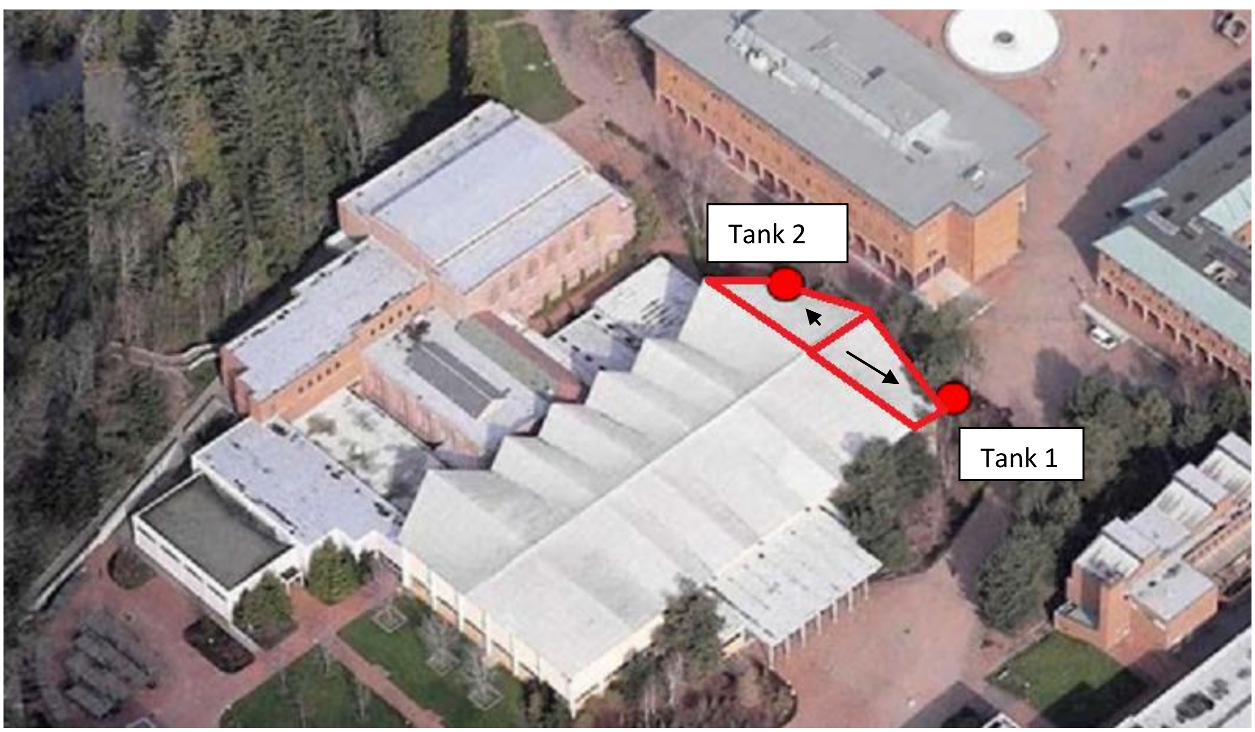

Figure 1 Red circles = Proposed placement of cisterns. Red lines = Area of rain water collection. Arrows = Direction of water flow.

3.0 Statement of Need

According to the U.N., it is estimated that by 2030, two-thirds of the world will live in high water stress areas. To Washingtonians, it may seem as though the Northwest may be considered to be a part of the lucky few due to our consistency of rain. As the global climate changes even more, it has become increasingly important that we start to act now to prepare ourselves for a future of uncertainty. The connection between climate change and the need to use rainwater is even more apparent according to researcher Eric Sproles from Oregon State University. He states, "the rising temperatures of global warming will reduce snowpack in the Cascades slopes...creating significant impacts, especially in summer when water demands peak," (Sproles, Nolin, Rittger, Painter, 2013). His study is one of the most precise of its type done on an entire watershed by basing his research on 21 years of past snowpack data and temperatures. A predicted increase of 3.6 degrees affects the Western Cascades because a few degrees can be the difference between a snow day and rain day for low elevation regions. This is critical because it illuminates the need to separate drinking water and irrigation water for the 85,000 residents of Bellingham and Whatcom County, whom currently use Lake Whatcom as its source of water. Our project fills the need to use this rain for irrigation, lessen WWU impact on Lake Whatcom and fills the university's future needs to save money. By doing this, we are following the strategic goals the university has set upon itself by "applying Western's expertise and collaborative approach to scholarship, creativity, and research in ways that strengthen communities beyond the campus." [4]

One of WWU's strategic goals states, "serve as a model for institutional effectiveness, innovation, diversity, and sustainability." It also states Western is a "responsible steward of resources."[5] In order to adhere to these principles on which Western is built, implementing a rainwater catchment system is the right thing to do, morally, ethically and environmentally. According to the Department of Ecology "implementing a rain cistern is not just about making a sound investment, it's about doing good for the environment – investing in the Sound," (Rainwater, 2008). The biggest thing about this idea is that it makes sense! In a study conducted by an EPA partnership program called Watersense, "28% of overall

[4] (Source: Western Strategic Goals)
[5] Source: Western Strategic Goals)

university water goes towards irrigation costs." (Dziegielewski, 2000). [6] Table 2 below visually shows areas of water usage in educational institutions.

End Uses of Water in Schools

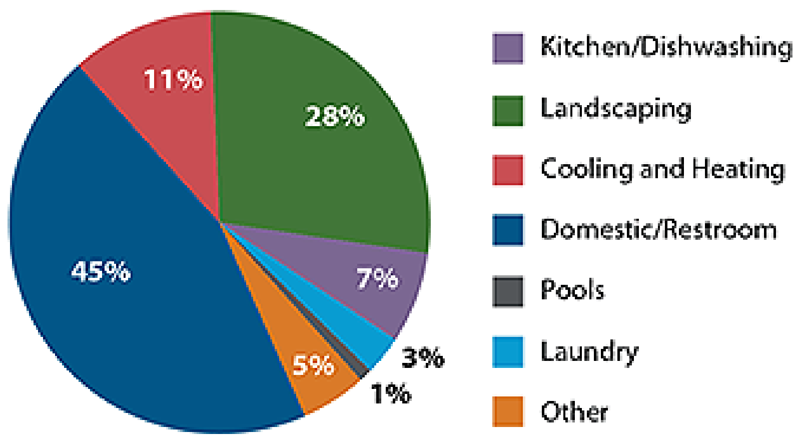

Table 2

3.1 What is Rainwater Harvesting?

Rainwater Harvesting is the process of collecting water from an impervious surface, such as a roof, and routing it to a location where it is beneficially used. (Accetturo, 2013).

Beneficial uses identified on campus include:

- Toilet Flushing
- Landscape Irrigation
- Washing Tools/Equipment

3.2 What is Potable Water?

Potable water is often used interchangeably with "drinking water." Potable water is safe enough to be consumed by humans or used with low risk of immediate or long term harm.

Potable water is also used for:

- Toilet flushing
- Washing
- Bathing
- Consumption

Landscape irrigation

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[6] Created by analyzing data from: New Mexico Office of the State Engineer, American Water Works Association (AWWA), AWWA Research Foundation, and East Bay Municipal Utility District.

The PW that is used for all of Bellingham comes from Lake Whatcom. According to Western's Office of Sustainability, Western's annual water consumption would take an estimated 4 inches off the top layer of the Lake.[7] Therefore, it is extremely important to try and lessen our impact on Bellingham's only water supply.

Is Rainwater Considered Potable?

The water that would be collected in the rain cisterns would not be for human consumption and therefore not potable. To remind people of this we can install a sign on the tank itself. That said, rainwater can be exposed to considerable contaminants. As rainwater falls through the air it can pick up soot and other airborne microscopic contaminants. Once on the roof, the rainwater can be exposed to herbicide or pesticide sprays which may have adhered to leave or dirt particles. Bird, raccoon, possum or other animal droppings may be on the roof as well. Once in the piping and collection system, the rainwater can be exposed to synthetic compounds used in plastics, glue, and other manufactured products.[8]

3.3 What is the Difference between Rain Barrels and Rain Cisterns?

When we think of rain barrels, we often think of the small plastic barrels on the sides of someone's house. As a result, one might think that this project would not be worth the time and effort. On the contrary though. This idea has to do with rain cisterns which are built for a more industrialized scale. Table 3 below gives comparisons between the two.

Table 3

Rain Barrels	Rain Cisterns/Tanks
• Come in different shapes and sizes	• Comes in industrial shapes and sizes
• Range from 55 to 95 gallons	• Range from 250 to 30,000 gallons
• Mostly used for residential	• Used in commercial and institutional zoning purposes
• Can be used alone or in sets	• Can be used alone or in sets
• Holds water for a few days	• Can hold water for months
• Often plastic or wood	• Can be constructed with different materials

[7] Source: Office of Sustainability
[8] Source: http://www.whollyh2o.org/rainwater-stormwater/item/122-rainwater-quality-and-filtration.html

3.4 Why is Stormwater Runoff Bad?

According to the COB Rainwater Pamphlet, "capturing rainwater helps reduce stormwater runoff that can become contaminated with pollutants and travel down storm drains and into our streams, rivers, lakes and bays. Storm water runoff can cause flooding and erosion, and increase pollutant loading in our waterways." [9]

3.5 Why is Rainwater a Better Use for Irrigation than Treated Drinking Water?

Landscapes do not require treated drinking water for irrigation. Potable water, produced by the COB's Water Treatment Plant, requires filtration, disinfection, and energy use to transport it to its customers, including Western. Installing a rain cistern for irrigation use instead of using our treated drinking water supply at Western will help reduce these costs to the utility as well as water rates to Western, and will provide for a more sustainable water use on campus. According to the City of Bellingham collecting rainwater pamphlet, "Rainwater is an easy way to conserve water - and save money on the water bill. During the drier season, water consumption city-wide often doubles; using collected rainwater reduces the strain on the city's water supply, reduces treatment and conveyance costs, and keeps more water available for fish and wildlife. Rainwater is also naturally "soft" and free of minerals and chemicals, making it ideal for plants and lawns." [10]

4.0 Rainwater Cistern Pilot Project

4.1 Educational Value

This pilot project would add to Western Washington University's sustainability education opportunities. Below are four ideas that will provide such thinking.

1. Both cisterns will have a water level gauge visible to public, much like the tank in figure 2. Students and community members can see first-hand how much water the tanks are holding.

[9] Source: www.cob.org/services/environment/conservation
[10] Source: www.cob.org/services/environment/conservation

2. An information kiosk can be constructed in front of the cisterns, except ours would be more of a diagram describing the process and importance of the project to the public.
3. An electronic meter could be attached to the outflow of the tank. This meter would track consumption, how much PW is not being used on landscaping and how much water we are saving from Lake Whatcom.
4. These cisterns can also provide an educational aid to courses around campus. Students and teachers ranging from the biology department, environmental studies and science classes as well as the engineering department, could use this site as a workshop for observation. Students and faculty could observe the design aspects of the tanks as well as structural characteristics.

Figure 2 shows an educational metering system located on a 1,000 gallon tank next to the Biology greenhouse.

4.2 Aesthetics

When thinking of a rain cistern, there is probably a misinterpretation that these are giant plastic tanks that are not very nice to look at. The fact of the matter is, rain cisterns can be installed multiple ways to actually enhance the area it surrounds. The two tanks we propose could potentially be surrounded with brick in order to match the overall theme of Western. The below pictures are examples of different aesthetically pleasing rainwater cisterns.

Figure 3 shows a galvanized metal tank that is covered with a visually pleasing, stained wood siding.

Figure 4 shows a plain metal corrugated tank.

Figure 5 shows a rock wall built around a 10,000 gallon tank in order to blend in to the natural settings. The proposed tanks could incorporate something like this using brick to match Western overall architectural theme.

4.3 Rainwater Collection Process

Below are the following steps of rainwater collection in detail.

1. Water is collected from the roof via gutters and directed toward the existing North East corner downspout as well as the North corner downspout. One gutter covers 2,450 sq ft.

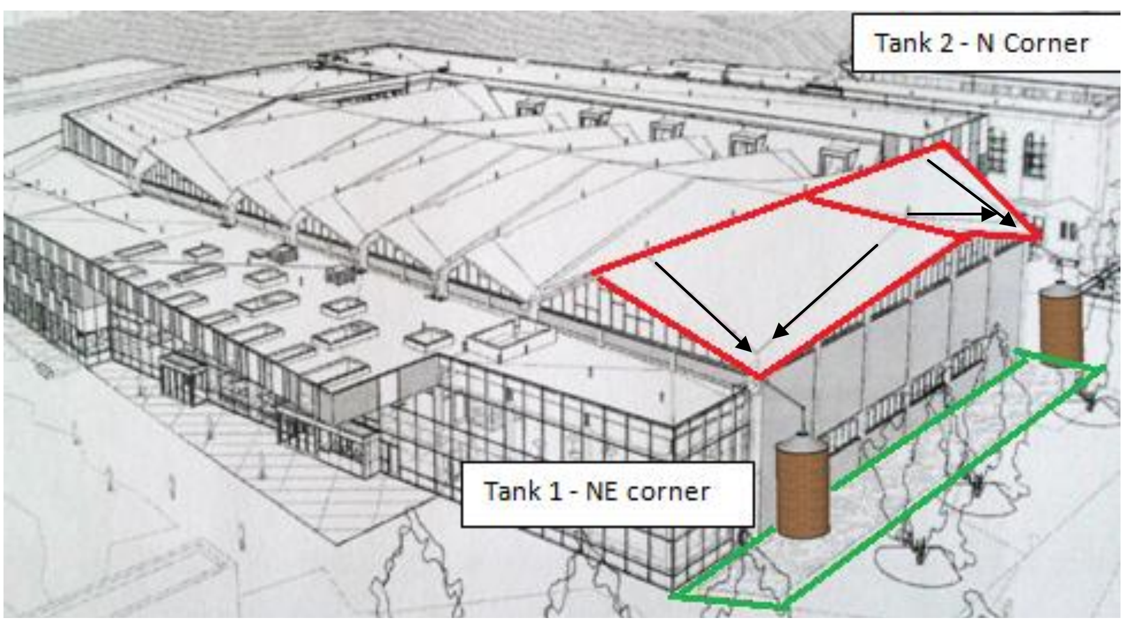

Figure 6 Shows three dimensional placement of tank 1 and 2. Green lines = area of planting bed in sq ft.

2. Prior to entering the tanks, the rainwater pass through a debris filter and enters two separate tanks via piping.

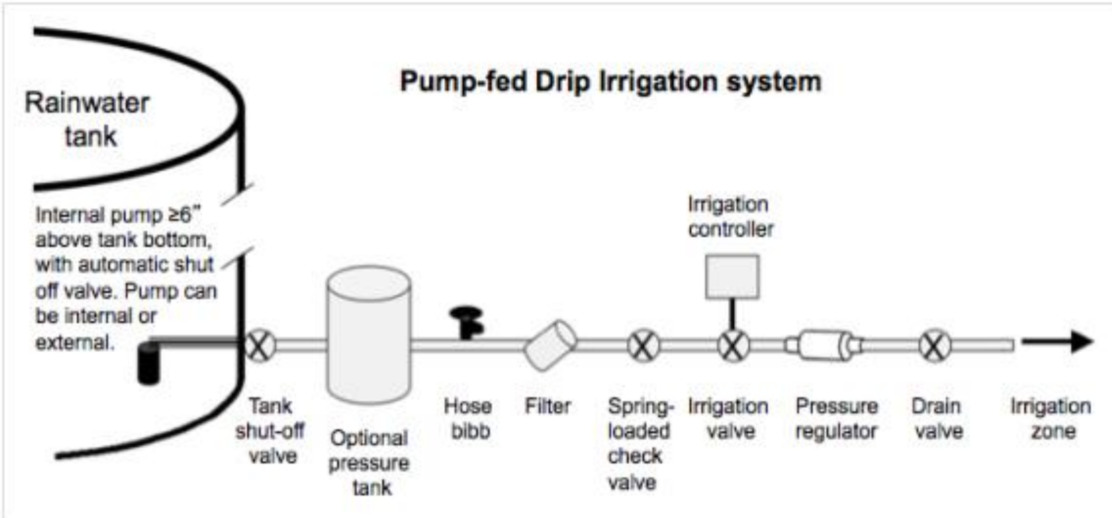

Figure 7

Pre-filtering

The importance of pre-filtering rainwater before it enters the storage container is often overlooked. Complaints of stored water smelling or turning "rotten" can always be traced to improper pre-filtration. If rainwater is not pre-filtered, a large amount of organic matter in the form of leaves and dirt can enter the storage tank. Aerobic bacteria begin to consume the organic matter and use up all the dissolved oxygen. Other benefits of pre-filtering rainwater are reduced sediment buildup at the bottom of the storage tank and less tank maintenance.[11]

A combination of filters would be necessary to ensure that no organic matter enters the cisterns. We suggest to implement downspout filters and in tank filters as a low cost option. However technical decisions can be made later on in the design process with engineers.

Types of Filters

- Downspout filters
- In tank filters
- Sand filters
- First flush diverters

[11] Source: http://www.whollyh2o.org/rainwater-stormwater/item/122-rainwater-quality-and-filtration.html#filtering

3. After filtration, the water can then be used for irrigation purposes. This process will be gravity fed to save electricity costs and could have multiple methods of application including drip lines surrounding plants. This water is then spread out into the 3,800 sq. ft. of planting bed space identifiable by the green box in figure 6 above.
4. The final step includes an overflow system. This system would look something like figure 8,[12] which consists of a pipe located toward the top of the cistern allowing excess water to drain out. Excess water should be directed into the nearby stormwater runoff drains to prevent soil erosion in planting beds. These storm water drains are no more than 20 -25 feet away and should be easy to connect to.

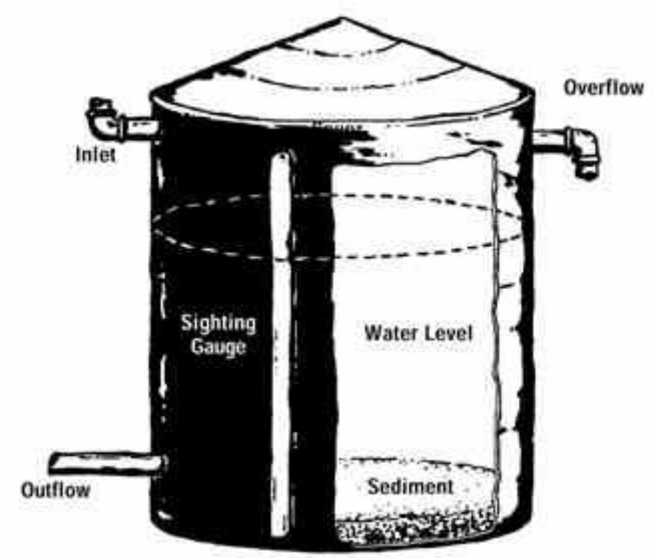

Figure 8

5.0 Calculations

5.1 Budget

In table 9 below, we give a brief list of basic materials needed to install the tanks, as well as estimates for those materials necessary to build the first and second cistern. All of the necessary parts come with the tanks including all assembly components, slide roof access

[12] Source: Texas Guide to Rainwater Harvesting. Photograph. Retrieved from http://www.lid-stormwater.net/raincist_home.htm

and 6" overflow assembly. In order to determine the labor we took 50% of the tank and accessory costs. Shipping costs associated with transporting the tank here are not included.

Materials	Estimate for First Cistern	Estimate for Second Cistern
5,100 gallon corrugated metal tank and accessories	$ 9,395.00	$ 18,790.00
Passive Filtration System	$ 30.00	$ 60.00
Labor and Extra Costs	$4,700	$9,395
Total	**$ 14,125.00**	**$ 28,245.00**

5.2 Size of Cisterns

We were able to obtain the overall dimensions of the tank we have chosen to research in table 10 through a company called RainHarvest Systems LLC.[13]

Nominal Tank Dia.(Ft.)	Nominal Tank Gallons[1]	RainMaster Part No. (CGS)	Tank Dia.[2]	Eve Height[2]	Overall Height[2]	Std Package	Pro Package
9	5,100	0903	8'-11"	11'-3"	13'-10"	$9,395	$10,095

Table 4

5.3 Current Water Usage

In order to determine the current water costs for the SMATE area we had to derive information from the total university water utility costs for the fiscal year of July 2012 to June 2013. Once again we are analyzing SMATE Hall irrigation data because we are assuming that the Carver Gym irrigation area is connected. Figure 9 below is a visual aid for the assumed irrigation area for the SMATE watering meter. The data tells us that 1,096 CCF's were used for irrigation at a

[13] Source: Rain Harvest Systems LLC - Harvest Water For Life
http://www.rainharvest.com/commmercial-and-industrial-rainharvesting-systems.asp

rate of $3.73 per CCF giving a total irrigation cost of $4,088.08 for the entire 2012 fiscal year.[14] (Specific calculations can be seen in Appendix B).

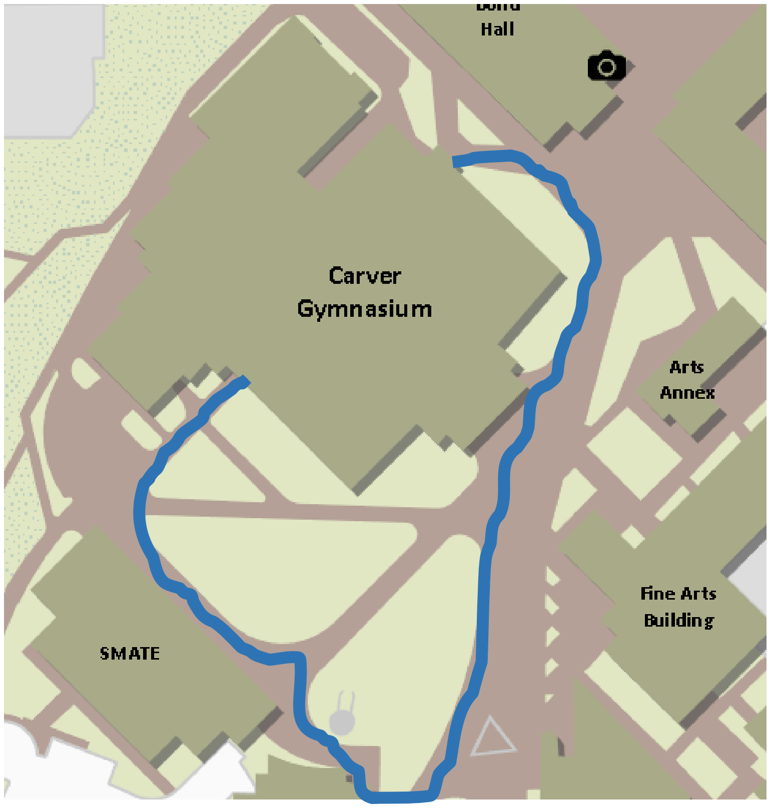

Figure 6 Blue Line = Assumed irrigation perimeter for SMATE water meter.

5.4 How Much Water Will the Rainwater Cisterns Collect?

The Washington State Department of Ecology, (DOE), provides tools for calculating water collection using weather averages, square footage of the roof size, square footage of the space you are trying to keep green and the capacity of the storage tank in gallons. Although our total planting bed space is 3,800 Sq. Ft. we reduced it by 25% when doing our calculations in order to factor in drought resistant plants since they require less water than the lawn area the DOE is meant to calculate. (A sample of our DOE data can be found in Appendix C). We calculated that the total amount of rainwater the cisterns will collect per year is about 90,154 gallons or 12,051 CCFs. According to the DOE calculator, our proposed planting bed area only needs 22,377 gallons per year or 2,991 CCFs, in order to irrigate. That is only 25% of the total amount of water we will be collecting over the course

[14] Total University Water Utility Costs July 2012 - June 2013

of one year. The next step is see how much irrigation water WWU will need over a 30 year time span. This came out to be 89,730 CCFs.

Much of our information came from this rainwater calculator including Bellingham's average rainfall of 36 inches per year allowing us to see typical city weather patterns. Typically for Bellingham, the months of October through March provide the heaviest amount of rain. This creates the challenge of storing the water for months at a time until it is needed in June, July, August, and September when Bellingham only records 4.17 total inches on average over that four month span.[15]

5.5 What is the Cost Per CCF for Collected Rainwater Compared to Potable Water?

For our rain cisterns to be viable, it is important that the cost of CCF is cheaper than what WWU is paying for right now. We took the total cost of the two cisterns which was $28,185 divided by 30 years to get $0.31 per CCF. Using rainwater to irrigate is $3.42 cheaper than the $3.73 Western is currently paying for irrigation on the SMATE area. It is obvious that rainwater is the cheaper alternative. (See Appendix D for calculations).

5.6 Future Water Usage

If WWU continues to pay the same water rate of $3.73 per CCF and use the same amount of water as in the 2012 fiscal year of 1,096 CCFs, then they will pay $122,640 and consume 32,880 CCFs over the next 30 years. Once again, our cisterns would be able to collect more than enough to meet that demand making it even more apparent that rain cisterns are a better alternative.

In February 2012, the COB engaged FCS Group, a solutions oriented consulting firm, to perform a comprehensive water rate study for the city's water and sewer utilities. The assessment reports that water usage, including irrigation, is expected to go up, (FCS, 2012).

According to the city, customers pay the same fixed rate (based on meter size) as non-residential customers. Therefore by finding information about WWU's water meters we were able to compare to the cities report on increasing future water costs. It is somewhat difficult to

[15] Source: Department of Ecology Rainwater Calculator Data

track because there is no main meter for all of WWU. Instead, there are seven main water pipe feeds from the city's system.

The information about WWU meter diameter in inches are as follows:

Quantity of Water Meters	Diameter in Inches
1	20
1	12
2	10
1	8
2	6

Table 5

There are also water meters that combine both domestic water and irrigation around WWU. This number totals around 50 separate meters that range from 2 inches to 8 inches. Specifically, Carver Gym currently shares its indoor water usage with College Hall that is 3 inches. The SMATE lawn area also has a 3 inch meter therefore allowing us to predict percentage increase over a predicted amount of time based on the COB's comprehensive study.

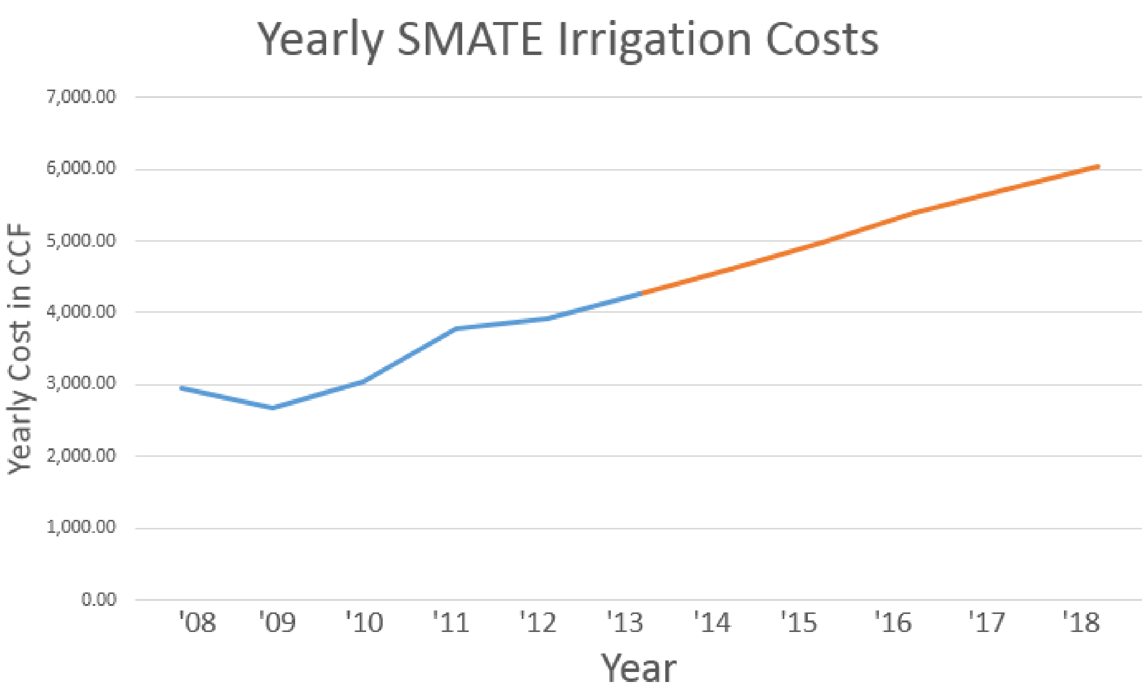

Table 6

The FCS Group was able to take the current monthly fixed rate for meters ranging from ⅝ inches to 12 inches. In the case of Carver Gym and SMATE Hall, the current 3 inch meter will increase from $268.90 in 2012 to $425.38 in 2018. That is an average increase of about $22 per year.

Below is a graph showing an estimate increase in water usage over the next five years for all the meter sizes according to the COB Final Draft Report 2012. Whatever the increase in future water costs depends on the size of the meter. They are estimating an increase of 58.2% of water usage over this time. The cost is in turn expected to rise to the price of $2.35 per volume of CCF for irrigation. Meaning the bigger the meter size in diameter, the bigger increase in cost. So essentially, the rate of water per CCF and the overall cost of water is going to increase exponentially over the next decade.

Table 8 below shows the predicted upward trend in water costs in relationship with the diameter of different water meters.[16]

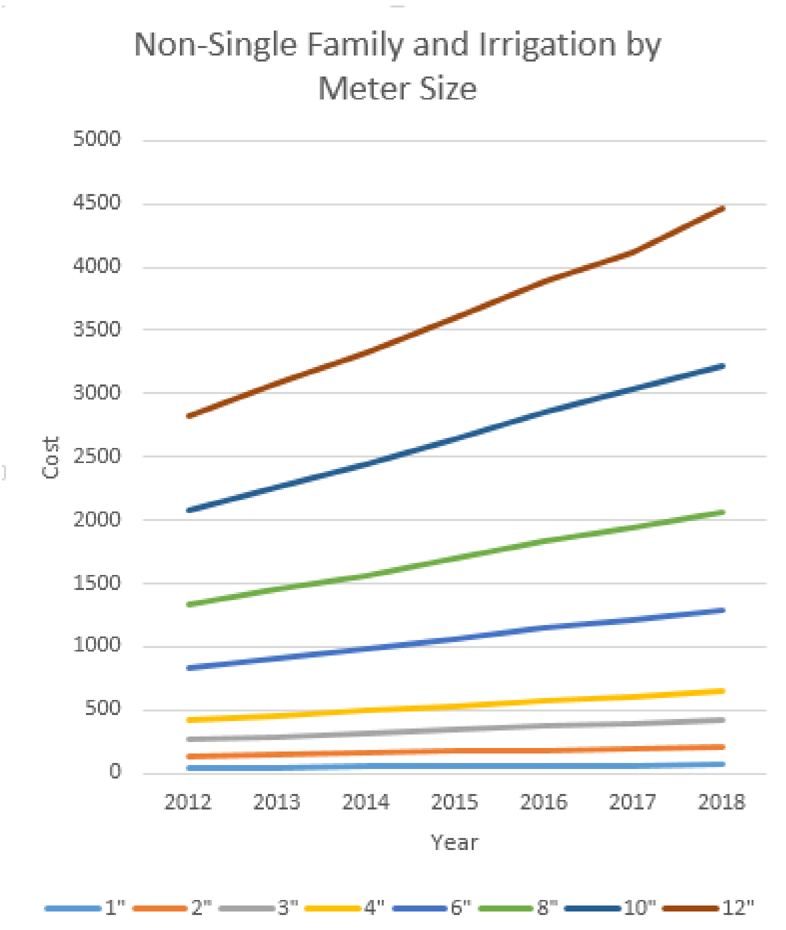

Table 7 shows increase in price of water depending on water meter size

[16] Information gathered from FCS Group Final Draft Report for Water and Sewer Rate Update.

5.7 Generated Savings

The graph below indicates the amount of rainfall caught in gallons from our combined tanks. The blue shows how much water our desired planting area needs based on the Washington State Irrigation guide. The red shows how much rainwater our cisterns will actually be collecting in that time period. As you can see, we will have enough water to water our proposed area, hence completely cutting SMATE irrigation costs. Our cisterns will save the university $94,455 over the 30 year lifespan of the tanks and give a return on investment in about seven years time.

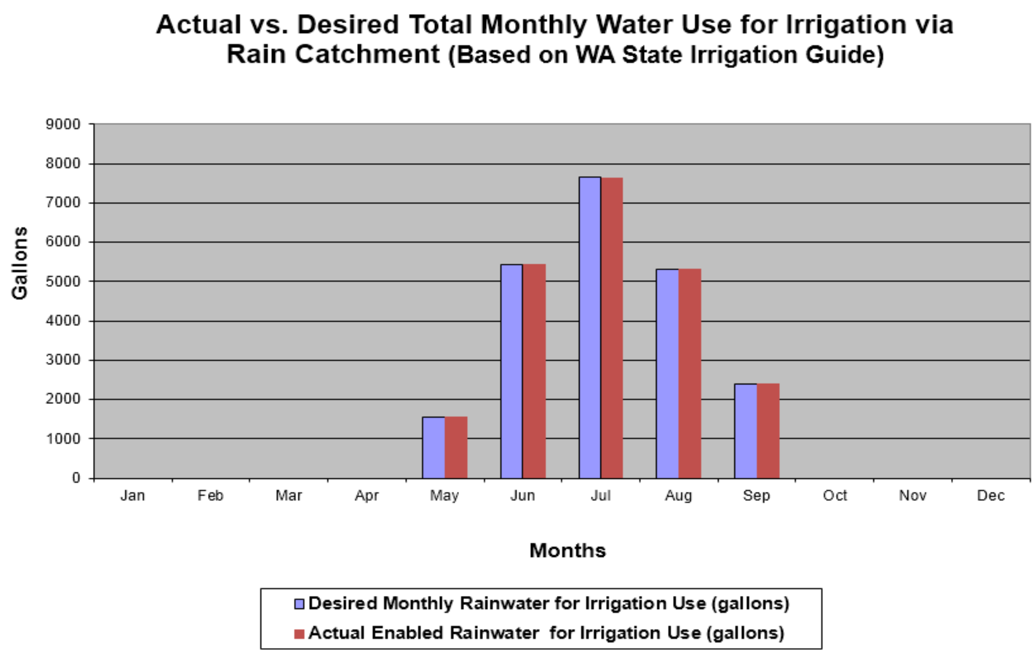

Table 8 shows the amount of rainfall caught by two cisterns.

5.8 Potential Funding

Much of this funding can potentially come from the Green Energy Fee. The students elected to implement a $7 fee in order to provide funding for projects that help Western become a leader in sustainability. Another method of potential funding includes the allocated money from the state capital budget towards the remodel itself. On top of that, buildings that meet LEED requirements often get different tax breaks and price reductions. from the state for the the grant money that is associated with any LEED certified remodel.

6.0 Rules and Regulations

The DOE's policy clearly states that according to RCW 90.03 "the on-site storage and/or beneficial use of rooftop or guzzler collected rainwater is not subject to the permit process," (Beitel, 2009). The DOE has also made clear that in accordance with RCW 90.54, they only intend to monitor the storage of rooftop collected rainwater if and when the cumulative impact of such rainwater harvesting is likely to negatively affect in stream values or existing water rights," (Beitel, 2009).

There are also potential benefits from the government regarding on site stormwater retention. Stormwater treatment systems are becoming more common in U.S. cities. When this happens taxes on stormwater will increase. This means that by having rainwater catchment in place, Western will be able to save money on PW costs, lower the amount of stormwater taxes paid and receive tax benefits from Washington State. More research needs to be conducted to determine specifics and the amount of tax breaks Western can potentially accrue.

7.0 Conclusion

Without a doubt the world climate is already in the process of changing. Snowpack is estimated to lessen which will create stress on local watersheds. In the midst of population increase, resources such as water will become more scarce ultimately leading to an increase in water rates and cost. The fortunate benefits of being located in Bellingham is that rain is an abundant and sustainable source of water. However the trick is collecting the water and saving it for the dry, summer months. The rain cistern pilot project can ultimately be a win-win scenario for WWU, its students, and the Bellingham community. Our rain cisterns will be able to collect water and cut water costs, saving the university money in the long run. Western has the opportunity to become an even more progressive green university with the implementation of this pilot project and should seize the moment. Although the Northwest is known for the amount of days it rains, this may not always be the case in a future where the effects of climate change are unknown. The question we have to ask ourselves is this. Why wait? Why not now?

8.0 Future Works: (Our Involvement With Stakeholders)

- Given more time, we believe there are other important future research aspects that can propel this project forward. The next step of installing rain cisterns to Carver Gym is convincing facilities management, the architects and the student body that this project makes sense, is worth investing in, and is wanted by the students. A good idea might be to create a survey in order to really gain student support. The more people who care about this, the more facilities management will listen.
- Another interesting aspect of these cisterns are determining whether or not there could be future indoor water use. Considering these tanks are holding maximum storage capacity from November through March, and not being used to due to wet weather, there could be a possibility of using this saved water to flush toilets, rather than sitting uselessly. Table 9 shows that 75% of the total amount of water we collect during the course of one year can be directed towards another use. We highly recommend researching the full potential of this indoor water use inside the CV as a means to give the rain cisterns a double purpose and thus increasing their value towards Western's strategic goals.

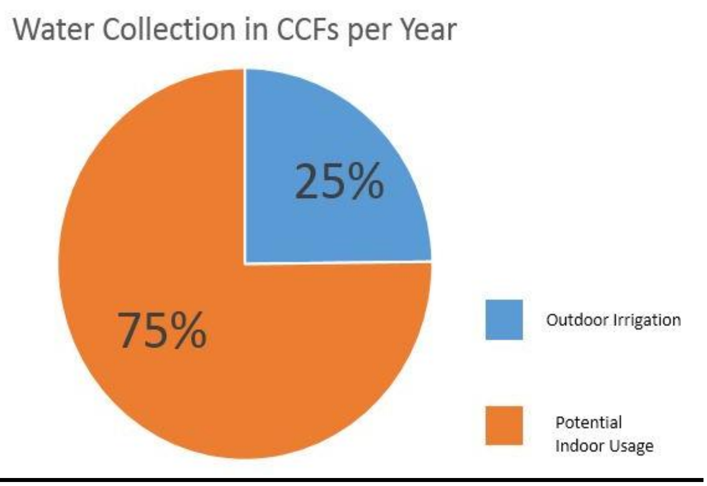

Table 9

- More research can be done by proposing an Environmental Economics class do a feasibility study and/or cost.-benefit analysis of this pilot project to see the savings associated with installation and use of rainwater for irrigation over the long term. Another name for this cost/benefit analysis is called NPV or net present value. We recommend future researchers to really look into this.

- We understand that according to the 2005 legislation session, Washington State passed Chapter 39.35D which was the country's first law requiring that all new building and renovation projects that receive state funding be built to one of the three green building standards (Washington). Future additional research could be conducted about whether or not the construction of these two cisterns could add points to the overall LEED system. Determining this could perhaps move the Carver Gym remodel from its current LEED Silver standard to LEED Gold.

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Appendix A

Water Consumption - 100's Cubic Feet July 12 - June 13					
Area Served	**Address**	***PO***	***Loc ID***	**Account#**	**YTD**
Irrigation					
CAMPUS DRIVE	516 HIGH ST (339 E College Way)rc - #IRR			22176	**664**
CAMPUS FIELDS - S	707 21ST #18A - #IRR			22178	**2,200**
CAMPUS FIELDS - N	421 21ST - #IRR			22182	**319**
BUCHANON TOWERS	2516 (2416)rc BILL MCD PKY - #IRR		BT	22232	**174**
CHEMISTRY	200 21ST ST - #IRR		GB	24958	**1,751**
ARCHIVES BUILDING	808 25TH ST		AB	25224	**189**
ARCHIVES PARKING LOT	805 25TH ST - #IRR			25434	**88**
BIOLOGY	3101 BILL MCD PKY - #IRR		BI	26023	**545**
BIOLOGY	140 21ST ST - #IRR		BI	26134	**0**
SMATE	S111 WWU #IRR (SCIENCE ED)		SL	27662	**1,096**
VIKING COMMONS	730 HIGH ST		VC	28810	**97**
PARCEL 370201491361				31500	**0**
ALL WEATHER FIELD	1700 BILL MCD PKY			32092	**689**
PUBLIC SAFETY	1880 BILL MCD PKY - #IRR		CS	32570	**652**
STUDENT REC CENTER	1800 BILL MCD PKY - #IRR		SV	33079	**834**
BUCHANON IRRIGATION	2401 (2416)rc Bill MCD PKY - #IRR		CS	45396	**3**
MILLER HALL IRRIGATION	516 HIGH ST (339 E College Way)rc - #IRR			45997	**206**
OLD MAIN IRRIGATION	516 HIGH ST - #IRR		OM	30966	
	TOTAL IRRIGATION				**9,507**

Appendix B - Current Water Use Calculations

Outdoor irrigation use for SMATE

1,096 total ccf used in '12-'13

Total ccfs used for irrigation in 30 yrs = 1,096 ccfs * 30 yrs = 32,880 ccfs in 30 yrs

Water rate in '12-'13 WWU is paying per ccf for SMATE = $3.73

1,096 ccf * $3.73 (water rate for SMATE) = $4,088.08 = **Total amount paid for SMATE**

Assuming the rate of $3.73 stays the same: $4,088 per year * 30 yrs = $122,640 total amount WWU will spend on water in 30 years

* we are using 30 yrs because that is the average lifespan of rain cisterns

Difference in costs using one tank

(Total cost for SMATE in 30 years) - (Total cost of one cistern in 30 years) = $122,640 - $ 14,092.50 = $108,547.50 in total savings over 30 years

Difference in costs using two tanks

(Total cost for Smate in 30 years) - (Total cost of two cisterns in 30 years) = ($122,640) - ($28,185) = $94,455 in total savings over 30 years.

Appendix C - DOE Rainwater Calculator Data

Washington State Department of Ecology Rainwater Harvesting Calculator

n your own numbers in all green cells and view results under the blue highlighted rows below and graphs on other sheets – see details right of entry boxes for

Rainwater Harvesting Water Usage & Storage (gallons)	
Select the city nearest where you live. This determines your precipitation and irrigation duties so try to choose a city with a similar climate.	Bellingham
Estimate household or building daily indoor use in gallons per day (gpd)	0
Enter lawn in square feet that you want to keep green (1 acre = 43,560 s.f.)	3,800
Above square foot of lawn converted to acre	0.087
Enter rainwater harvesting cistern storage capacity (gallons)	10,200
Enter roof size in s.f. (assumes 100% roof dedicated to catchment and 80% or rain/snow that falls on roof is captured)	4,900
Are you concerned if your cistern goes dry during the summer (is rainwater your sole source or is it a source augmentation)? If you are concerned, click yes. If not, click no. A yes entry will trigger a reduce/resize message below under Desired Use below if your cistern runs dry - this ensures your needs can be met.	○ Yes ◉ No

Precipitation varies locally even within a city, so be sure the precipitation on the Precip & Irrig Data sheet accurately reflects what you receive. If it doesn't, enter your own data there under the city nearest you and choose that city at left.

See Avg Indoor Use sheet for help determining how much water you really need. A typical average use is 60-65 gpd per person, less with conservation.

While a larger cistern is necessary to get you through the summer, more often than not it's the size of your roof that's the limiting factor. Try experimenting

If you are concerned about your cistern going dry in the summer, please see the blue safety factor consideration box bottom left.

Given inputted indoor use and lawn size, this shows how much water you annually want to use and actually can use (indoor use is prioritized over outdoor use if all needs ...)	Gallons	
	Actual Use	Desired Use
Your total indoor use	0	0
Your total outdoor use	26,210	30,368
Total annual use (indoor and outdoor use)	26,210	30,368

If you see a "resize/reduce" message under the Gallons heading, your desired use is too high for the size of your roof/cistern. If you don't care if your cistern goes dry, change that setting above.

Safety factor consideration: The box to the right shows your average monthly cistern levels. August/September is when Washingtonians have the lowest cistern levels due to the dry summer. If you're relying on rainwater for potable supply, you want to make sure that you don't let your cistern get too low during that time period as we don't always receive average precipitation every year.

Month	Cistern Volume Carryover	Cistern Overflow
Jan	10,200	11,221
Feb	10,200	8,257
Mar	10,200	7,375
Apr	10,200	6,395
May	10,200	3,208
Jun	7,121	0
Jul	0	0
Aug	0	0
Sep	1,264	0
Oct	9,863	0
Nov	10,200	12,446
Dec	10,200	11,760

Given your inputted lawn size, these are your estimated irrigation requirements (values from Washington State Irrigation Guide)		
Month	**Inches**	**Need (gallons)**
Apr	0	0
May	0.89	2,108
Jun	3.12	7,391
Jul	4.38	10,375
Aug	3.05	7,225
Sep	1.38	3,269
Oct	0	0
Total	12.8	30,368

Appendix D - Estimated Cistern Cost and Savings

Scenario 1: One 5,100 gallon above ground steel tank with all parts.

Although our total planting bed space is 3,800 Sq. Ft. we reduced it by 25% when doing our calculations in order to factor in drought resistant plants since they require less water than the lawn area the DOE is meant to calculate.

25% of 3,800 = 2,800 sq ft

Cost of tank plus labor: $9,395 + $4,697.50 = $14,092.50

14,236 gallons used in one year (DOC calculator) = 1,903 ccfs used per year for irrigation

Total amount rain cistern will collect per year = 31,641 gallons = 4,229 ccf

1,903 / 4,229 = 44% will be used for irrigation

1,903 ccf * assumed 30 yr lifespan = 57,090 **ccfs used for irrigation over 30 yrs**

Cost per ccf over lifetime: $14,092.50/ 57,090 ccfs = $0.24

Cost of cistern per year: $14,092.50/ 30 yrs **=** $469.75 *Assuming life of tank lasts 30 years.

Cost of water over lifetime: $0.24 per ccf * 57,090 ccfs collected = $ 13,701.60 over 30 years

Scenario 2: Two 5,100 gallon above ground steel tanks with all parts. 10,200 total gallons collected.

Although our total planting bed space is 3,800 Sq. Ft. we reduced it by 25% when doing our calculations in order to factor in drought resistant plants since they require less water than the lawn area the DOE is meant to calculate.

Combined cost of tanks plus labor: $18,790 + $9,395 = $28,185

25% of 3,800 = 2,800 sq ft

22,377 gallons used (DOE calculator) **=** 2,991 ccf used for irrigation over one year

Total amount rain cisterns will collect per year = 90,154 gallons = 12,051 ccf

2,991 / 12,051 = 25% of rainwater collected per year will be used for irrigation

2,991 ccfs * assumed 30 yr lifespan = 89,730 **ccfs used for irrigation over 30 yrs**

Cost per ccf over lifetime: $28,185/ 89,730 ccfs = $0.31

Combined cost of cisterns per year: $28,185/ 30 yrs = $939.50 Assuming life of tanks both last 30 years.

Cost of water over lifetime: $0.31 per ccf * 89,730 ccfs collected = $27,816.30 over 30 years

Source: Rain Harvest Systems LLC

Appendix E - Future Works Calculations

Indoor water use for SMATE

223 total ccf used in '12-'13

Current water rate WWU is paying for Indoor water use in SMATE = $21.70

223 ccf * $21.70 = $4,839.10 = **Total amount paid for SMATE**

Assuming water rate stays the same every year: $4,839 * 30 years = $145,173 total amount spent in 30 years

Total ccfs used indoors in 30 years = 203 ccf * 30 years = 6,090 ccfs

Appendix F - Case Studies

Georgia Institute of Technology

Our first case study came from the Georgia Institute of Technology whom have had great success using rainwater cisterns for landscape irrigation. The campus includes 19 different buildings with rain cisterns, with a total capacity of 2,225,000 gallons. Over a third of the campus irrigation is done with cistern collected rainwater. Their Old Engineering building includes one of its small scale above ground cisterns (shown in figure 7 below) which contains up to 6,000 gallons, (BRAE, 2011).

Seattle Public Library

The Seattle Public Library has implemented a 40,000 gallon rainwater collection tank to provide drip irrigation when needed for the site, (Barker, 2004). By doing this they eliminated potable water use for irrigation and have contributed to their LEED certification. The location of this tank could not be determined.

Seattle City Hall

Seattle City Hall is another great example of a local building harvesting rainwater. The city uses this non-potable water for irrigation and low flow lavatories. According to City 2008, collection is done with a 225,000 gallon tank in order to meet their water demand of 1,033,276 gallons per year. Over the course of a year, the tank collects 913,400 gallons and helps reduce storm runoff by 27%, indoor potable water use by 30%. Overall, 100% less potable water is used for their drip irrigation system and a 88% total PW reduction rate.