Go Green by Going Grey:
A Perspective on Grey Water Catchment Systems

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0.0 Glossary

- DOE: Department of Ecology – WA state
- DOH: Department of Health – WA State
- ES: Environmental Science Building at WWU
- Flushometer: tankless toilets served by a water main as opposed to having individualized tanks
- GW: greywater
- GWS: greywater systems
- Sustainability: to prioritize our actions to protect and improve natural, social, and economic systems/resources for the health and well-being of Earth and its constituents now and into the future
- WAC: Washington State Administrative Code

1.0 Introduction & Executive Summary

Through this project we aim to set up a water catchment system from sink to toilet to capture lightly used greywater. To make this happen we have been working with Western Washington University plumbers and engineers to create the most efficient and visible system possible for our campus.

A large component of this project has been making sure that all of the elements are in compliance with Washington State Administrative Codes (WAC) regarding greywater and water catchment systems. There is a lot of reading material on codes regarding water catchment but we have attached pdfs of these in our appendix and specific codes (WAC's) may be found on the Washington State Legislature Site.

After completing our preliminary research, we have decided that the optimal location for installing a greywater toilet would be in the ground floor of the Environmental Science (ES) building. We have come to this conclusion based on the ease of installation in the basement; that the pipes will mainly be gravity fed in that location requiring less pumps to bring the water from the basement to the ground floor and back (Morrow 2013). Furthermore, being located in the ES building has other benefits. Seeing as that building houses a large number of Huxley classes, Huxley students already have some knowledge regarding sustainability and are excited to see a greywater system implemented. Installing the system in the ES building puts the system close to students who are excited and support the project from its inception.

2.0 Statement of Need

Western Washington University currently spends $154K on water for its academic buildings alone. In total, Western spends $386K per year on water consumption across campus (WWU, Water Meters 2013). That is yearly tuition of approximately 48 full-time students! There is a large amount of water waste on campus and one of the largest sources of this waste is the toilets on campus. The water that comes out of the drinking fountains is the same water that can be found refilling all of the toilets. We believe it is unnecessary and unsustainable to use pure and drinkable water to flush the toilets. This can be remedied by setting up a greywater catchment system connected to the toilets. This greywater toilet will not only cut down on water consumption but can also be used to educate the student body, prospective students, and the public about how greywater works and why it is important.

3.0 Significance to Western Washington University

This project falls in line with Western's comprehensive plan to be on the cutting edge of sustainable practices. Western is always striving to become a greener university. With the help of the green fee and the numerous environmental clubs on campus, the student body has spearheaded several successful environmental campaigns. We believe that setting up a greywater system is the next step to a more sustainable campus.

All of Western's sustainability projects can be utilized as educational tools to help students understand the importance of sustainability and the role it plays in their day-to-day lives. The greywater project will focus on educating the public on the importance of water conservation. Recently the world's population surpassed 7 billion. Coupled with the fact that drinkable water is less than 1% of earth's' total available water, the need for mindful water consumption is becoming more and more essential (United Nations 2013). Additionally, Washington State water usage rights are given to those who have the earliest historical claim. These firms or individuals who have the earliest claims to water hold the usage rights. As the world's population continues to grow, mindful water consumption is rapidly becoming a greater issue and thus progressive water usage and conservation needs to be addressed.

We are hoping to install informational plaques at the sites of our greywater systems. We will have a picture of the plumbing system to show how the system works. In the graphic, we will color all of the greywater pipes green to illustrate that they are part of the sustainable water system. Above the toilets we will place a plaque reminding people that this is a greywater system and that this water is not available for consumption. This is a WAC requirement. These small reminders about the system will make people think about their personal water usage and how they can cut down on their water consumption.

3.1 What is Greywater?

Greywater is "lightly used" water that requires little to no purification. It can come from domestic activities such as laundry, washing dishes or showering. It is called greywater, as it is the intermediate phase between "white water" which is clean, drinkable water and "black water" which cannot be reused and may contain sewage (Glassmen 2009). (See Figure 4 in Appendix) For the Western greywater project, the greywater will come from the bathroom sinks where students wash their hands. This will create a sufficient flow of greywater into the toilets to keep the system working. With the system we are planning to implement, the greywater will be filtered and lightly purified before reaching to toilet tank. The toilet tank itself will hold 65 % greywater to 35% white water because the greywater holding tank is not large enough to fill the entire toilet tank. (Chandler & Bus 2010)

3.2 Potential Impacts of Project

This project will reflect well on Western's image as a sustainable community. If Western is seen as a pioneer university in the field of sustainability it may attract more prospective students. It can be used as a great advertising or marketing campaign for the University. Hopefully, this would also inspire other universities to implement their own greywater systems. Several of the case studies that we have found thus far have analyzed the feasibility of a greywater system without any progress past the planning phase. Therefore, a successful greywater system at Western will open the door for other universities to implement their own greywater systems.

3.3 Rules and Regulations

One of the predominant barriers to the success of this project lies within meeting the rules and regulations delineated by the Washington State Administrative Code (WAC) as well as regulation by the Department of Ecology (DOE) and the Department of Health (DOH). Within the WAC this project must also comply with uniform plumbing code measures which differ from county to county. It is the purpose of this section to identify which codes apply in order to aid in a smoother implementation. Note that this section is not an exhaustive list but rather a guiding document to help understand some of the main barriers to implementation. The complete code may be found in the cited WACs and appropriate appendices.

Western Washington University is a public university, which means that it is subject to more stringent regulations than a private home or university. Overall there are three tiers identified in the WAC for possible greywater systems. For a full delineation of the tier systems please see the appendix.

A tier 3 (T3) GW system - which WWU is subject to- requires an approved treatment component to treat dark greywater or light greywater stored for longer than 24 hours. Much like the T2 system, the T3 utilizes a system surge tank, storage tanks, or pump(s). Although the use of dark greywater is outside the scope of this project the fact that WWU is a public institution limits the project to a T3 system. Additionally the system must not exceed 3500 gallons of greywater per day but does not have any limit on how long the greywater may be stored (WAC 246-274-003). It is important to note that the pilot phase of this project will not likely exceed this limit and this information was included to allow for future project expansion (WAC 246-274-300). As this system is the most complex the cost of implementation is the highest. For more information regarding budget see section 5.0.

The location of the system is also subject to minimum horizontal setbacks. As the proposed location will be in a restroom it will be adjacent to a pressurized public water main. The edge of the greywater system components must be 10 horizontal feet away from the pressurized public water main and shall be 10 feet away from the tank and other system components (WAC 246-274-405). Permits will be issued by the local health authority and should be sought after the design process is complete.

3.4 Permit and Testing

As previously mentioned the system must also conform to the uniform plumbing code under WAC 51-56-1600. The first step is applying for a permit which must contain the complete plumbing plans, with appropriate data satisfactory to the local health authority which must be submitted and approved. The design of the system must include dimensions for each component used in accordance with WAC 51-56-1616.0 and must be signed by a person registered or licensed to perform plumbing or design work. Additionally the system shall be protected against back-pressure and backsiphonage in accordance with sections 602.0 and 603.0 under chapter 16. Additionally the collection reservoir and components but meet requirements of filtration, required valves, overflow precautions, drainage, disinfection, and water makeup standards delineated in WAC 1618.1-.6.

After the instillation a cross-connection test will occur in conjunction with a dual system inspection under the supervision of the local health authority and other authorities having jurisdiction (most likely WWU plumbing staff). Western Washington University is also required to keep a record of the system which includes; the system location, the fixtures which are a source of the greywater, a description of the system design and how it fits within the requirements of WAC 246-274-410 and 246-274-415, the identity of the person responsible for the system design, and finally a description of the maintenance requirements. The system must also be marked with a warning sign (see Figure 1) visible at each fixture from which greywater is diverted at a nonresidential building. These signs must notify the employees and the public that water from the fixture is reused for flushing the toilets and that chemicals and other hazardous materials may not be poured down the drain. Additionally the sign must include the statement that you should not drink this water in compliance with WAC 51-56-1619.2.

Figure 1

Enforcement of these policies will be carried out by the local health authority (the board and the lead officer) as shown in WAC 246-274-450 and all regulations are effective as of July 31st 2011.

3.5 Maintenance Requirements

After installation, the maintenance requirements fall to the property owner – i.e. WWU - in accordance with WAC 51-56-1631.0. Projected upkeep of the system is minimal and is limited to the filter and purification table replacement. Industrial filters have a lifespan of around 20 years while purification tablets need to be re-administered every 6 months (STiR 2013). Management of the system maintenance would fall to facilities management. Costs accrued from additional billing hours would be minimal due to the low time commitment.

3.6 Decision Matrix

A decision matrix is a policy tool which helps decision makers view policy alternatives in a visual manner. The scale includes a low rating (1) a medium rating (2) and a high rating (3). The farthest left column entitled Current System which reflects where WWU is today (i.e. status quo) – relative to the two proposed alternative actions. The first alternative action is the GW Pilot Project in which a greywater reuse system would serve two restrooms on the ground floor of the Environmental Science building. The second alternative action is the future expansion of the GW project to serve additional restrooms on campus. The color coding is an attempt to make similarities and divergences within the matrix more apparent as the numbers in green cells represent an improvement to the current system whereas numbers in red cells represent a drawback to the current system. The numbers assigned are estimates based off of the knowledge obtained during this project and do not represent hard data directly.

Criteria	Current System	GW Pilot Project	GW Future Expansion
Cost	1	2	3
Water Conservation	1	2	3
Complexity	-2	-2	-3
Feasibility	3	2	1
Efficacy	1	2	3
Education/Outreach	1	2	3
New Student Capture / Marketing	1	3	3
Total:	6	11	13

Figure 2

Legend
3=high
2=medium
1=low

Improvements from the current system (green)
Drawbacks from the current system (red)

- Complexity: how difficult or convoluted a policy or action may be. This category is negatively correlated as complexity reduces adaptability and feasibility

- Cost: how expensive the projects are

- Feasibility: how easy it is for a firm to remain the same or change

- Efficacy: fairness in water usage – WWU uses a large volume of water from Lake Whatcom and as a large consumer it benefits the greater community to reduce water consumption

- Education/Outreach: how well the system provides education about water usage

- New Student Capture/ Marketing: as WWU would be the first academic public university in WA state to implement a greywater system such as the one purposed – it would allow for the university to market this system to prospective students

- Water Conservation: how effectively water is conserved

After considering the aforementioned criteria both the pilot project and the future expansion both achieved higher scores than the current system. It is important to note that none of the categories were weighted by an estimated level of importance. Doing so would have put a larger emphasis on cost – but was omitted as the other external benefits (such as efficacy and new student capture) are believed to be of a greater importance. As the matrix suggests the best course of action would be to implement a GW pilot project and re-evaluate its worth post instillation. Additionally, if WWU determines this project a success expanding the GW project to other restrooms would be the next course of action.

4.0 Program Development

It is the intent of this project to implement a Tier-3 light greywater system on campus. The system will be installed on the basement floor due to easier installation (Morrow 2013). Ideally, the location would be a high traffic area in addition to a high water consumption area. This would allow for the greatest educational output coupled with greatest water use reduction. Each building on campus has a complex plumbing system but some of the highest areas of water use are within three plumbing loops (or macro-systems) which are; Edens Loop, Wilson Library Loop, and the College Way loop. While many buildings meet the credentials, Arntzen Hall and the Environmental Studies (ES) building may be the best candidates due to the high student traffic and the close proximity to Huxley College (WWU, Water Meters 2013). Keeping in compliance with WAC codes –see section 3.4 - 3.6 - we may not design the system itself as we are not licensed plumbers but may recommend certain types of designs.

The most basic of designs begins with a 5.5 gallon storage tank which collects the reused water. This water goes down the bathroom sink and is then filtered and sanitized. The water is stored until it is needed to fill the toilet tank. When the toilet is flushed, a 12 volt submersible pump automatically turns on. Any reused water in the storage tank is pumped to the toilet to be used for flushing the toilet. This system works with flushometer (or tankless toilets) as the recaptured water is housed in a tank specific to reclaimed water beneath the two bathrooms served in the ES building. If there is not enough stored water to sufficiently refill the toilet tank, system allows the fresh water supply that normally fills the tank to make up the difference (WWU, Water 11-12, 2012).

Beyond the need to comply with the limitations imposed by local and state regulations, the project retains other uncertainties which need to be visible. For example, the implementation costs are somewhat diffuse as pricing of materials can be quantified but the labor needed to install the system is harder to estimate. Additionally, there are not any other academic public universities[1] which utilize a similar proposed greywater system; this results in a lack of precedent in which Western could look to for guidance. The bottom line is that the success of the project requires commitment, courage, and guidance from WWU in navigating these challenges in order to continue to be a leader in the fields of sustainable education and environmental consciousness.

The Tier 3 greywater system that we are hoping to implement on the ground floor of the ES building would have a water catchment tank in the basement with pipes connecting to the already existing plumbing fixtures. Given that the current plumbing system is already in place, once a greywater system is installed it could service both men's and women's restrooms on the ground floor (Morrow 2013). The only physical difference between servicing one restroom or two is the additional piping that would bring the greywater from each sink to the catchment tank and back up into the restroom to be used in the toilets. It would be more effective to create two greywater toilets, one in each restroom, than to only create one and have to go back later and install the second.

4.1 Education and Outreach

The installation of a greywater system will provide education benefits to the University. Along with being the first public academic University to implement greywater usage, the installation can be used to educate students, parents, faculty, staff, prospective students, and the public of the many benefits that greywater systems and water catchment can provide.

4.2 Benefits and Projected Results

The installation of a greywater system will provide educational and environmental benefits to the university.

We would be saving water with every flush! The AQUS system, which we are basing our designs off of, uses 65% greywater with 35% white water. (Chandler & Bus 2010) This means that the majority of the water being used is greywater. In the case that not enough water is

[1] University of Washington Tacoma Center for Urban Waters does utilize greywater but as they are a LEED Platinum building designed and built by the city of Tacoma a direct comparison between WWU and the Center for Urban Waters is difficult to make.

generated through sink usage, white water can replace the missing greywater. However, from our research we have found that a sufficient amount greywater should easily be generated daily to support this system.

Upon implementation we will also create either a plaque or a poster to draw attention to the use of greywater and provide education information on the technical aspects of water reclamation. Advertising the benefits of greywater will help to spark interest, support, and further advancements in greywater usage on our campus. As previously mentioned, we want students to look at the greywater system and reflect on their own water usage and what it means for the Bellingham Community as a whole. We believe that this system will not only save water on campus but it will encourage and inspire students, staff, and faculty to cut back on their water consumption in their day to day lives.

5.0 Budget

Through our research, we have found that the largest costs incurred will be from the labor and construction costs. (Figure 5 in Appendix) The normal rate for the average Bellingham plumber contractor is $100+ dollars per hour. In addition to this, our on campus facilities management staff earns approximately $65 per hour (WWU Facilities Management 2013). This project would require the reworking of the a section of the plumbing system for the basement of the Environmental Science building. Our main advisor, Steve Morrow, the Facilities Manager at Western Washington University told us that the construction costs may be slightly elevated because it will cost more to rip up the tile floors and replace them.

The cost of the materials not including the pump needed to get the water from the basement up to the ground floors would be approximately $3,000 - $5,000. The pump alone (which is not included in the material costs because it is unique to a Tier 3 greywater system) would be $800 - $1,500. One member of Western's Facility administration estimated that the labor costs in total would be from $5,000 - $8,000 to gain access to the piping, hooking up the greywater tank and any related plumbing efforts (WWU Facilities Management 2013).

With all of this information, we estimate that the total costs of installing two greywater systems (one for the womens' bathroom and one for the mens') will be in the range of $16,600 - $29,000.

6.0 Case Studies

In the course of this project we found several case studies to which we compared our project. These are some of the case studies that helped further our research and provided us with information or contacts.

6.1 University of Regina
(http://www.uregina.ca/news/webonly.php?release=477)

Our first case study involved the University of Regina in Canada. One of their professors, Stephanie Young, is hoping to create a commercial scale water reclamation plant. She states that greywater systems can help extend the current fresh water supplies and can also substantially decrease the wastewater load into sewage collection systems. The main goal of this system is to conserve water and protect aquatic ecosystems.

The Western Economic Partnership (WEPA) gave the University a $349,000 grant and a later WEPA awarded the project $202,400 to further pilot test the greywater system technology. Additionally, the organization Communities of Tomorrow contributed $75,000 to the project.

While we could find no official timeline for the project it seemed as if two years was the amount of time the project was expected to take. The main barriers to the project were it's funding and getting the project implemented on a wide scale.

6.2 City of San Luis Obispo, California
(http://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=1118&context=theses)

The intent of this project is to provide tools for public administrators to implement and evaluate the cost of an alternative on-site residential water supply using rainwater harvesting and greywater reuse in their jurisdiction. These tools are then applied to the city of San Luis Obispo, California as a case study to demonstrate how rainwater harvesting and greywater reuse could be implemented to supply all residential potable and non-potable water needs, completely replacing the current centralized publicly-managed water system.

6.3 Humbolt State University
(http://humboldt.edu/sustainability/sites/default/files/projects/envs411_080007-12.pdf)

General research into the design for a greywater treatment marsh to be implemented on-site at the Campus Center for Appropriate Technology (CCAT) at Humboldt State University.

Project includes greywater classification, site considerations, applicable law/ regulations, system components, necessary monitoring parameters and overall preferred system design.

6.4 Stanford University
(http://esw.stanford.edu/cgi-bin/resources/projFiles/Greywater.pdf)

Stanford University students collaborated with SARAR Transformación in an effort toward a sustainable water and sanitation program for the community in San Miguel Suchixtepec in Oaxaca, Mexico (population: 2,500). The overall program is broken up into four sub-projects: water quality, greywater systems, popostero design, and dry sanitation and hygiene. This sub-project concerns the development of domestic greywater systems.

6.5 UC Berkeley
(http://sustainability.berkeley.edu/cacs/pages/initiatives/UC_BERKELEY_WATER_CONSERVATION_REPORT_CACS_2010.pdf)

Due to recent water usage complications due to a state-wide drought, UC Berkeley has implemented a water usage and conservation study to better understand their use of water and to also help reduce any unnecessary use of limited water resources.

The project involved analyzing the water consumption patterns of nine main campus buildings and 98 other water consumption sources outside of the campus boundaries but still in connection with the institution. The project would cost approximately $1,527,281 but would give a net annual savings of $259,320. This would take approximately 6 years to incur the upfront costs of the project.

The biggest challenges to this project are identifying a source of nonpotable water to meet current irrigation demands and that costs are hard to estimate; cost-benefit analysis shows that the monetary values and water consumption values yield little savings. The results of this case study showed that greywater system would not be economically feasible. However, UC Berkeley has committed “to reduce potable water usage by 20% and to use no potable water for irrigation by 2020” and also to has committed to “ensure all buildings larger than 50,000 square feet have working water meters that allow real time monitoring of usage and are web enabled.”

6.6 AQUS Grey Water System
(http://aqusgreywatersystem.com/)

The Aqus Grey Water Recycling System 2010 recycles greywater from sinks to fill toilets. Each system costs $295.99 and would need to be installed for every toilet. Each tank holds 5 ½ gallons of water and fills with 65% non-potable water. Installation time of the AQUS system should only be a few hours at most due to it's simplistic nature. The AQUS system has a very long payback period because the price of water is so cheap. It would take approximately 40 years to pay back in full. However, approximately 2000 - 5000 gallons of water would be saved per toilet with this greywater system.

6.7 UC Davis
(http://extension.ucdavis.edu/unit/green_building_and_sustainability/pdf/resources/greywater.pdf)

UC Davis wishes to assess the feasibility of a greywater system on campus. In doing this they are looking into two different possible systems. One option is from Earthships who designs complex and highly efficient systems that reuse rainwater. It is, however, not easy to retrofit a building with the Earthship design. The other system they were looking into was the AQUS system. AQUS is designed to be retrofitted into any building and reduces water consumption by pumping greywater from the sink to toilet.

One of the biggest challenges to this project is legal issues as it is hard to get around or compromise with certain state policies. If the water is not metered it is likely that the customer will not see a return in their economic investment. Therefore it is of the utmost importance that UC Davis correctly and efficiently retrofits their buildings for either greywater system.

This was a hypothetical study and no actual greywater system was put in place and therefore there was no results section. However they are looking into using rainwater for irrigation of the campus grounds.

6.8 UW Tacoma – Figure 5
(http://www.urbanwaters.org/uwt)

The only public university we found that currently has a greywater system in place was University of Washington Tacoma. The building, the Center for Urban Waters, was located off campus and was actually built by the city and houses city offices, offices for Puget Sound Partnership, as well as a few labs for UW Tacoma.

While they do have a greywater system the building was originally designed to be LEED Platinum so every aspect of the building was designed to meet the LEED criteria. The greywater system was a large part of meeting that criteria. The Center for Urban Waters has a green roof through which rainwater is collected. This water is then sent into the greywater system and used for heating/cooling the building as well as for use in their restrooms.

What they created goes way above and beyond what we hope to implement on campus but it serves as proof that what we want to implement, a single greywater system in one building, is completely feasible.

7.0 Recommendations

After completing preliminary research we highly recommend Western Washington University consider implementing greywater systems at the next available opportunity. Inserting restrooms that utilize greywater plumbing in dorms or other high traffic buildings such as the Environmental Science building would provide ample visibility and provide the most opportunities for greywater education. We realize that building redesigns are done out-of-house and years in advance but by putting a greywater system in the future building designs and renovations now, the time lapse will provide time for greywater technology to advance thus resulting in a better system. At this point in time we recommend adding greywater restrooms to basement floors as it allows for an easier system because pumps will not be required to transport the water down. Through our research we have chosen the groundfloor of the ES building as the most appropriate location for a greywater system to be installed at this time.

Currently, there are not many documented public universities in the United States with greywater systems implemented. If WWU were to utilize greywater they would be one of the first public universities to do so. This is in line with the University's strategic goals of "serve[ing] as a model for institutional effectiveness, innovation, diversity, and sustainability".

We realize that implementing greywater campus-wide is a complex goal dependent on a variety of factors but we are confident that it can be achieved with foresight and planning. It is imperative that the administration, engineers, faculty, staff, and students coordinate with one another in the efforts to implement a greywater system. Communication and coordination are key factors that can bring the idea of a greywater system on campus to fruition.

8.0 Future Works

To create this system we need to continue the discussion. Part of this ongoing communication involves the stakeholders- including the administration, campus facilities management, campus engineers, and architects. To avoid fragmentation, stakeholders should be kept with constant open and honest communication that is required to keep the vision clear and going.

Further communication with contacts from this project would be strongly advised. During research we have created connections with the biology department, campus facilities management, the Water Conservation Program of Bellingham, Sustainable Connections, 2020 Engineering, and the city of Tacoma's environmental services department.

While we do not know exact costs and savings we do know that each greywater system will save approximately 65% of the water from being wasted. Seeing as there are 7 billion people and only about 1% of all water on earth is freshwater, saving water is important (United Nations 2013). UW of Tacoma realizes the importance of saving water and proves it through their laboratories at the Center for Urban Waters. Karen Bartlett, an Environmental Services representative for the City of Tacoma informed us that within the labs 1 out of 8 gallons of water actually goes into the making of deionized (D.I.) water meaning that 7 gallons is wasted every time they make D.I. water. With that significant amount of waste being generated in the laboratories they reroute that "wasted" water into the greywater system so that it can be used and not simply sent to the sewer (Bartlett 2013)..

At the time of this document's completion we still have a handful of uncertainties that need to be fleshed out before implementation can occur. Firstly, the state, county, and city policies regarding greywater usage and installation need to be fleshed out. Our group was bogged down the deluge of esoteric policies regarding greywater. As our group is comprised of students, we recommend the University reach out to a policy specialist to work with them to ensure all policies are met.

Further research should be invested in the costs of installing and implementing a greywater system. This group found figures a few years old that were quite reasonable however, the figures were for small scale greywater systems. Depending on what the University decides to implement, cost researching will be necessary. As of this paper's completion we can confirm that the majority of the cost will be from installation and plumber's fees rather than the physical parts that compose the system itself. However, the estimate we are putting forward is that the system will cost approximately $23,000 for a single restroom. (See Appendix)

The basement of the ES building houses the plumbing and pipes for the restrooms in the building and we have been informed that there is more than enough room for a water catchment tank in there. The tank would be centrally located with the rest of the plumbing and be unobtrusive. Once the tank is situated a pump would need to be purchased to send the water from the pump back up to the main pipes and restrooms, then back down. Pipes would also need to be connected from the catchment tank and pump up to the rest of the plumbing pipes towards the ceiling (Morrow 2013). See figure 3.

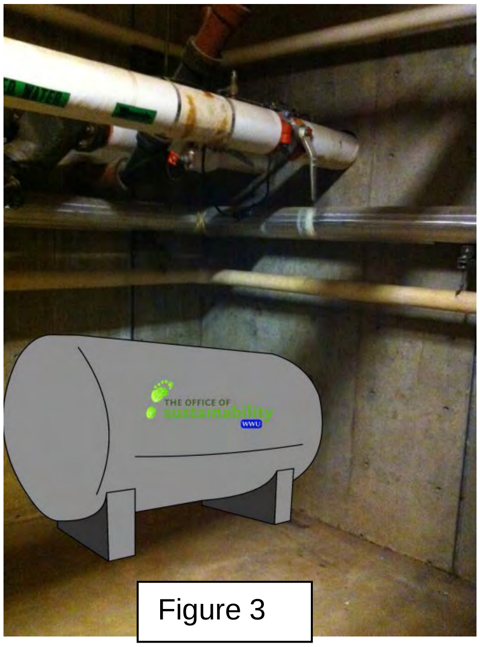

Figure 3

As Western Washington is a large, public university we recommend the implementation of a Tier 3 greywater system. Tier 3 systems involve water treatment, have a maximum total flow of 3,500 gallons per day, and must have proper signage denoting that greywater is being used among other requirements. Several of the case studies that we found concluded that a greywater system would not be economically feasible due to the long term return on investment. To cut down on the economic costs, we suggest that it may be more feasible to incorporate a greywater system into the plans for a building that is going to be remodeled in the near future. Ideally, we would like it to be in the environmental science building but if another building is up for remodel sooner, we can audit this building for it's greywater potential.

8.1 Conclusion

Implementation of the greywater pilot project allows Western Washington University the opportunity to enhance their standing and a leader in the fields of sustainability and environmental education. The education to students and faculty this project would provide seeks to raise Westerns' collective consciousness in how we view and utilize our scarce water resources. Beyond these benefits we firmly believe that action toward more mindful water conservation is a responsibility which Western not only has to its student body but to the greater Bellingham community as we all share the water derived from Lake Whatcom. Through a visible and educational greywater catchment system older wasteful water usage paradigms will begin to shift towards a more community based, altruistic, and sustainable view of water use in Washington State.

9.0 Works Cited

STiR Industrial Water Filter." *STiR Industrial Water Filter | Remove Suspended Solids and Oil*. N.p., n.d. 2013.

Morrow, S. (2013, Feburary). [Personal Interview]. Stakeholder interview.
WWU Facilities Management (Anonymous). (2013, Feburary). [Personal Interview]. Stakeholder interview.
Bartlett, K. (March 2013). Center for Urban Water. [Personal Interview]. Stakeholder interview.

"Washington Administrative Code (WAC)." *Washington Administrative Code (WAC)*. N.p., n.d. Web. 2013.

United Nations. (2013). Statistics: Graphs and maps - water use. Retrieved from http://www.unwater.org/statistics_use.html

Chandler, Crary, and Bus Katie. "AQUS Grey Water Recycling System." N.p., n.d. Web.

Cates, P. (2012, May). *An education on growing water scarcity and the benefits of domestic greywater recycling systems*. Retrieved from http://tinyurl.com/d2w5mfe

Glassman, J., Kanegawa, B., Lee, D., & Martinez, A. (2009, June 8). Grey Water Systems. *Engineers for a Sustainable World - Stanford University*. Retrieved February 10, 2013, from esw.stanford.edu/cgi-bin/resources/projFiles/Greywater.pdf

Mack, Sarah. *Washington's Rainwater Collection Policy Lets 12,000 Rain Gardens Bloom*. Western Water Law & Policy Reporter, n.d. Web. 17 Mar 2013. <http://www.tmw-law.com/news-pdf/WWLPR-July-2012-article-rain gardens.pdf>.

WWU, *Water Meters*. Bellingham: WWU, 2012. Print.
WWU, *Water 11-12*. Bellingham: WWU, 2012. Print.

10.0 Appendix

Figure 1

Criteria	Current System	GW Pilot Project	GW Future Expansioin
Cost	1	2	3
Water Conservation	1	2	3
Complexity	-2	-2	-3
Feasibility	3	2	1
Efficacy	1	2	3
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Legend
3=high — Improvements from the current system
2=medium — Drawbacks from the current system
1=low

Figure 2

Figure 3

	Potable/Non-Potable	Sources
White Water	Potable	Drinking fountains, faucets, garden hoses. Any municipal water line.
Light Grey Water	Non-Potable	Showers, tubs and sinks (washing hands)
Dark Grey Water	Non-Potable	Washing machines, sinks (for cleaning dishes, other uses)
Black Water	Non-Potable	Toilets, any input of fecal matter of urine creates black water

Figure 4

Cost Estimate Per 1 Restroom

	Low Estimate	Upper Estimate
Materials*	$ 2,500.00	$ 5,000.00
Pump	$ 800.00	$ 1,500.00
Labor	$ 5,000.00	$ 8,000.00
Total	$ 8,300.00	$ 14,500.00
2 Restrooms	$ 16,600.00	$ 29,000.00

*Materials = piping, fixtures, tank, filter

Figure 5

Figure 6

10.1 Additional Policy information

A tier 1 (T1) system is the simplest system available which uses gravity to distribute light greywater. Additionally a surge or storage tank may not be used. The cost of installing a tier 1 system is less expensive than a tier two or three system due to the absence of a water pump – that is the system utilizes gravity to distribute the water. A drawback to the T1 system is the distribution of greywater is not as even or precise as pressure systems (i.e those which utilize a water pump) (WAC 246-274-100).

A tier 2 (T2) system uses a surge tank, storage tanks, or pump(s) and allows for light greywater to be stored light for less than 24 hours. Due to the time restriction a timer must be attached to the pump so the system can auto-purge itself once every 24 hours (WAC 246-274-200).

10.2 External Resources

WA DOH pdf relating to Greywater Reuse Document 1
http://www.doh.wa.gov/Portals/1/Documents/Pubs/337-062.pdf

WA DOH pdf relating to Greywater Reuse Document 2
http://www.doh.wa.gov/Portals/1/Documents/Pubs/337-063.pdf

WA DOH greywater information and introductory resource page (simplified overview)
http://www.doh.wa.gov/CommunityandEnvironment/WastewaterManagement/GreywaterReuse.aspx

WAC's
Washington State Legislature Site