UBC Social, Ecological Economic Development Studies (SEEDS) Student Reports

An Investigation into the Feasibility to Implement Rain Water Harvest in the new Student Union Building at UBC

Stanley Chen

Jennie Thunman

Elle Xu

University of British Columbia

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Jennie Thunman

Elle Xu

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Instructor: Professor Dawn Mills

ABSTRACT

The new SUB building that is being planned at UBC is aiming to implement Net Zero Water, a technology that aspires to make the water consumption equal with the water production. To encounter this problem this report's purpose is to analyze the feasibility of Rain Water Harvest, a very significant part of Net Zero Water. With its high annual precipitation Vancouver is a very suitable place to apply Rain Water Harvest and with the specifications of the new SUB, about 705 850 gallons of water per year is estimated to be collected. Even more water can be collected from the garden that is being planned on the SUB roof, if implementing the technology of a green roof, and maybe also from mist collection. Collected water will then be suggested to be stored in a fiberglass tank, and be purified and/or filtered depending on the usage of the water. To further implement the idea of Net Zero Water, the harvested rain water should be recycled after usage in the building.

Rain Water Harvesting can be concluded as feasible for the new SUB as it basically only take advantage of the rich precipitation existing in Vancouver, without having many impacts on social, environmental or economic factors. Except from demanding somewhat of an increased cost in the building plan because of the storage tank etc, the system would stand as a good example for a sustainable implemented technology. What should be taken into consideration though, is that creation of a new SUB, may also be the cause of new problems, despite its feasibility.

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LIST OF ABBREVIATIONS

PVC	Polyvinyl chloride
SUB	Student Union Building
RWH	Rainwater Harvesting

1.0 INTRODUCTION

The New Student Union Building that is being planned on the new University Square at UBC, Vancouver will provide 50% more space than the current SUB with a budget of $110million. The new building that is planned to being finished in 2014 is aiming for LEED Platinum+, which is the highest Green Buliding rating in North America (AMS, 2010). Managing this, the building will be among the future UBC campus buildings that have taken on the new approach to be more environmental friendly and sustainable, while at the same time economical. In this project, the focus will be on the aspect of net-zero water, which stands for that the building will produce as much water as it uses within the time of a year. The project aims to analyze the feasibility of harvesting and store rainwater, so that it can be used in the operation of the building. The three major components that will be discussed are water collection, water storage/purification and water usage, which will be followed by a triple bottom line analysis the impact of this new building and the feasibility.

2.0 WATER EFFICIENCY

When analyzing potential rainwater harvesting (RWH) it is obviously very important to examine the water efficiency, which depends on the actual precipitation, the properties of the catchments area and the expected water loss.

2.1 PRECIPITATION

Vancouver is well known for its rainy climate and few dry periods, and this should make UBC a suitable place for RWH. In fact, according to the weather office of Canada the precipitation at UBC is on average 48 inches rain/year and days less than 0.02 inches of rainfall is only on average 60 days a year. Furthermore, Vancouver has also few days with heavy rainfall (8.3 days/year with more than 1 inch) which also works in Vancouver's advantage in the aspect of RWH, because heavy rainfall can often increase the water loss as the system can overflow (National Climate Data and Information Archive, 2010).

2.2 CATCHMENTS AREA

Even if there are various places to install catchments areas in RWH systems, the roof is undeniably very appropriate. The new SUB is planned to have a roof of a total area of 50 000 ft^2 (AMS, 2010), but as a garden is planned to take up 50% of the roof (J. Mitch, e-mail, March 2010), only 25 000 ft^2 will be available for purely rainwater catchments surface. However, it will be possible to harvest rainwater absorbed in the garden as well, if it is constructed as a green roof (a technology that will be discussed later on).

The roof that will not be taken up by the garden will have to be designed in such a way that all water falling on the surface will be collected. This is however unaffected by the pitch of the roof (Texas Water Development Board, 2005, p. 23), as long as gutters will be installed in such a way that all water entering the collection surface, will be collected. The efficiency raises however with a longer watercourse, so the lesser the watercourse the better. The gutters should be constructed so they can manage a bit of an oversize, in events of heavy rainfall. It is also wise to install a bypass to allow direct drainage of rooftop runoff when tanks are full. (City of Tuscon, 2005, p. 32).

2.3 ESTIMATED WATER LOSS

As mentioned above, there will unavoidable be some water loss and this is due to evaporation, wind, leaks, infiltration into the catchments areas etc (Lancaster, 2010). The amounts of water that will be lost are very much dependable on the roof material used. The material that are calculated to have the lease water loss is metal (5% loss), compared to example concrete/asphalt (5-20%) or tar roof (15%). Galvalume for instance, is a mix of aluminium and zinc and is a metal that is commonly used for rainwater catchments surfaces as it decreases the water loss (Texas Water Development Board, 2005, p. 11).

2.4 CALCULATION OF RAINWATER HARVEST POTENTIAL

After knowing the precipitation and the area of the collection surface it is possible to calculate the annual amount of water that can be collected. The formula used for this is as following (The Portland Bureau of Planning and Sustainability, 2010):

Collection Area (ft^2) x rainfall (in/yr.) / 12 (in/ft) = ft^3 of water/year
ft^3 / year x 7.43 (Gallons / ft^3) = gallons/year

For the new SUB that would be:
25 000 x 48/12 = 100 000 ft^3 of water/year
100 000 x 7.43 = 743 000 gallons/year

After taken into consideration the water loss of 5%, the total amount of water that could be collected from the new SUB roof would be 705 850 gallons/year.

3.0 ADDITIONAL COLLECTION OF RAINWATER

As mentioned above the estimated collection of water can be increased if the rainwater absorbed in the planned garden will be collected, which will be possible if a green roof will be implemented. Another source to increase the collected rainwater potential is mist collection.

3.1 GREEN ROOF

A green roof is basically a conventional roof with a garden that has layers of drainage underneath. These kinds of roofs are often used in storm water management as they absorb rainfall and release it more slowly. Implemented in a RWH system, the water released from the garden would simply be collected from the drainage system, instead of just running off. The technology would not only be suitable to implement in a RWH system because it will increase the total water that could be collected, but it would also be accommodating in case of heavy rainfall. The green roof would namely collect the overload of rainwater, that otherwise just would run off, and release it more slowly to the system.

The disadvantage with a green roof is that it will increase the water loss, which is dependable on the gardens soil, amount and types of trees and plans etc. But since a garden is planned on the roof of the new SUB, the total amount of rainwater that can be collected will increase anyway if a green roof is installed.

The green roof can be designed in different ways though, that will have different affects in the aspect of water harvesting. Just as for catchments surface in RWH, the pitch of the roof has not much effect on the runoff, but should in the case of the green roof be less than 45˚. Apart from that there are two different types of green roofs, extensive and intensive. Extensive green roofs are shallow growing gardens, and are only able to contain lighter plants like grass and mosses. The garden can therefore not take any heavy load and is inaccessible to public. On the other hand it releases water more quickly as the water will run through the shallow soil more easily. An intensive green roof is deep-growing (8-40 inches) and can therefore support trees, outdoor furniture, etc. It can be used for recreational purposes and be accessible to the public. Because it is deep-growing it must be considered in the building plan, and it will also be more costly than an extensive green roof (Metro Vancouver, 2009).

3.2 MIST COLLECTION

Mist can be another source of water. Although Vancouver is not a humid place, water from mist collection could possibly be used as back up water if the mist collection unit is efficient enough. It is a matter of whether it is worthy to have a mist collection system because there is a steady rainfall in Vancouver. If the climate changes in the future, it should be considered as an additional way of water collection.

Information on mist collection (specifically on water mist) is not available. Mist from the oil refinery industry is normally collected simply because it is too expensive to ignore and it is bad for the environment when disposed. As a contrast to water mist, there seem to be not enough attention given at this point.

4.0 STORAGE SYSTEM

In order assess the feasibility of the RWH, we would need to look the cost of each individual components. The following sections will discuss the cost associated with some of the major components of RWH system. In order to store the rainwater from the catchment surface, the following components are used in most rainwater collection facilities:

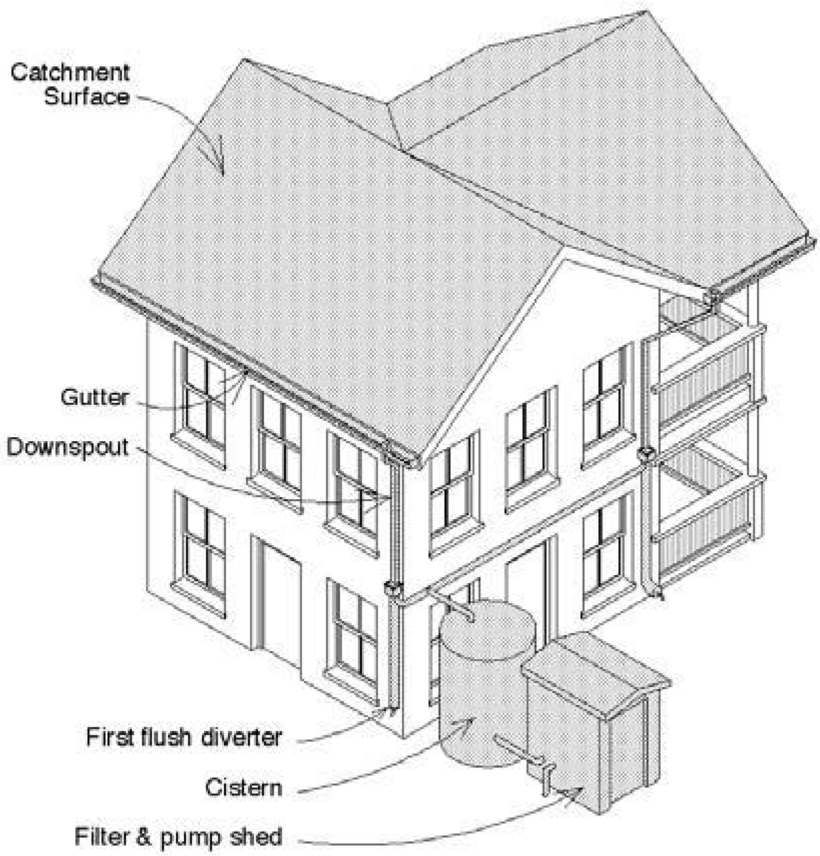

Figure 4 - A typical rain collection system

Source: Texas Water Development Board

4.1 GUTTERS AND DOWNSPOUTS

The gutters are installed to catch water running off the eaves of building. The water in gutter is then channelled into the downspouts. The most common materials used for gutter and downspouts are polyvinyl chloride (PVC), vinyl, pipe, seamless aluminium, and galvanized steel. Lead should not be used because the acidic property of rain can dissolve and contaminate the captured rainwater.

4.2 LEAF SCREENS

Leaf screens prevent debris getting into the gutters and downspouts (See figure below). Essentially, it can be in a form of a mesh installed on the gutter to filter out debris such as leaf or other large particles.

Figure 5 - A commercial leaf screen installed on a gutter

Source: Texas Water Development Board

4.3 FIRST-FLUSH DIVERTER

During non-raining days, a roof can collect and accumulate dust, leaves, animal feces, and other airborne residues. The first flush diverter can prevent these from getting into the storage tank by diverting the first flow of water away from the tank. Referring the picture below, the diverter is T-shape which allows the first flow to go to the bottom of the pipe. After some amount of water has been diverted, the water will be directed to the main collection piping through the outlet. The faucet at the bottom will gradually leak out the water at the bottom.

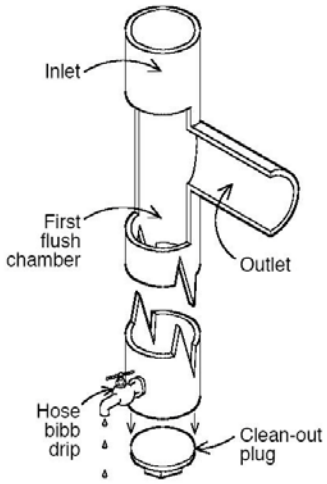

Figure 6 – standpipe first flush diverter

Source: Texas Water Development Board

4.4 TANK/CISTERN

The storage tank is the most expensive component in the rainwater collection system. Typically, for a 20,000 gallon fibreglass tank, the price can range from $10,000 to $40,000 USD. Therefore, it is worthwhile to compare the material used to build the storage. The table below can help the engineers to decide which material to use.

	Cost	Size	Comments
Fiberglass	$0.50–2.00/gallon	500–20,000 gallons	Can last for decades w/out deterioration; easily repaired; can be painted
Concrete	$0.30–1.25/gallon	Usually 10,000 gallons or more	Risks of cracks and leaks but these are easily repaired; immobile; smell and taste of water sometimes affected but the tank can be retrofitted with a plastic liner
Metal	$0.50–1.50/gallon	150–2,500 gallons	Lightweight and easily transported; rusting and leaching of zinc can pose a problem but this can be mitigated with a potable-approved liner
Polypropylene	$0.35–1.00/gallon	300–10,000 gallons	Durable and lightweight; black tanks result in warmer water if tank is exposed to sunlight; clear/translucent tanks foster algae growth
Wood	$2.00/gallon	700–50,000 gallons	Esthetically pleasing, sometimes preferable in public areas and residential neighborhoods
Polyethylene	$0.74–1.67/gallon	300–5,000 gallons	
Welded Steel	$0.80–$4.00/gallon	30,000–1 million gallons	
Rain Barrel	$100	55–100 gallons	Avoid barrels that contain toxic materials; add screens for mosquitoes

Table 1 - Storage Tank

Source: Texas Water Development Board

4.5 COMPARISM OF MATERIAL OF STORAGE TANK

The storage tank can be made in various materials with different characteristics that are of relevance to a potential rain water harvest system in the SUB, and they are presented in this section.

Fiberglass

Fiberglass storage tank is reasonably priced and holds a fair large amount of water. It is the most durable material and can last for decades.

Concrete

Concrete is an economical material, but it is prone to cracks and leaks. This implies that repair cost can incur and the leaking can cost a problem to the building if the tank is placed in the building. In this case, the building might need to be repaired due to leak of water.

Metal

Metal is another economical solution but the volume of water held by metal storage tank is not enough for building like SUB.

Polypropylene

Polypropylene is used in many plastic items like food container since it enables the plastic to withstand high-temperature so the food container will not melt in dish washer. It is a good candidate because of its price and durability, but it is less durable than the fibreglass storage tank.

Wood

It can hold large amount of water, but it is more expensive than most of the materials.

In conclusion, fiberglass material is recommended because it seems to be the most durable and priced reasonably.

4.6 PLACEMENT OF STORAGE TANK

The placement of the storage can raise some problem with the building design. If the tank is placed in the building and leaking occurs, it might necessary to repair the building beside the tank itself. A RWH project, initiated by Robert and Sara Moore in Taft, Texas, places the storage tank in their basement. This is a good solution for the new SUB as the storage tank is heavy and can raise the budget to design for extra support for the tank if it was not placed underground.

If the storage tank was placed beside the building, then it is harder to manage since exposure to the public may cause unexpected damage from animal, people, etc.

5.0 WATER PURIFICATION

To be able to use the water for the drinking and other purpose, certain filtering and purification process be carried out. Uses of water can be categorized into potable and non-potable. Potable water is used for human consumption whereas non-potable is not intended for human consumption, and usually used for purpose such as flushing toilets, watering gardens, etc.

Potable Water

For potable water, a combination of filter and purification processes is recommended.

Filter

Slow Sand

- Traps particulate matter
- Cost around $150-500

Activated charcoal

- Remove chlorines

Purification

Chemical Treatment with Chlorine

- Kills micro-organisms
- Cost around $150-500

Ultraviolet Light

- Kills micro-organism by inactivating bacteria and viruses
- Cost around $350-1000; $80 to replace UV bulb

Reverse Osmosis

- Removes dissolved solids and salts by forcing molecules into tiny pores
- Cost around $400-1500

Non-potable water

For non-potable water, depends on purpose, filtration and purification may not be needed at all.

6.0 WATER USAGE

Grey water refers to the water that is not clean enough for potable use. It is obvious that using clean water to flush the toilet is a wasteful way of using water. In the new SUB building, where there will be more water used for sanitation or food service, all the grey water should be recycled or reused in order to reduce the amount of water needed to operate the building.

City of Guelph is already having a head start on this matter by introducing a device that collects grey water, and connects it to the toilet after some minor treatment. The city launched a pilot program to promote residential grey water reuse.

The new SUB building could use this idea to recycle the grey water on a larger scale. For example, the water used by food service should also be recycled as grey water, which will largely reduce the amount of fresh water usage, especially during the summer time when the rain fall is limited. The idea of grey water recycle is shown in the figure below. In a larger scale, the storage tank need to be bigger, and treatment of grey water need a higher standard than the household.

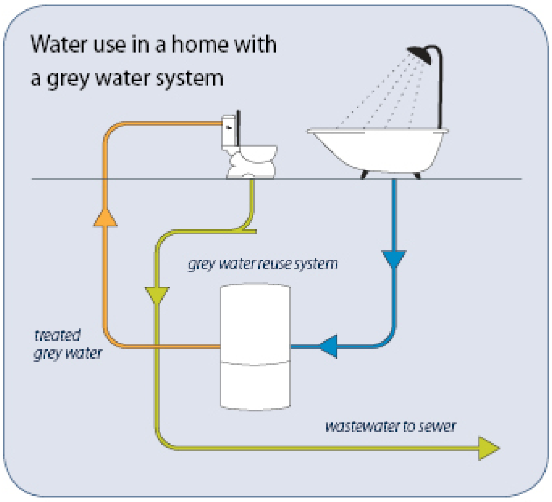

Figure 4: Grey Water Reuse System.

Source: City of Guelph, pilot program

The household idea could be used in a bigger place like the new SUB building. Instead of using a bigger tank for the grey water treatment, the grey water can be stored in different sections, and used in different places. For instance it would be possible to set up a few grey water systems throughout the building instead of having one large system which will probably more expensive.

7.0 TRIPLE-BOTTOM-LINE

To examine the feasibility of rainwater harvest, a so-called Triple-Bottom-Line assessment can be done, where social, environmental and economic impacts are taken into account.

7.1 SOCIAL

The construction of a sustainable SUB building will not only benefits the environment, but educates the public and raises the awareness of the public about sustainable development. During the research of this project, the most answer received when asked about sustainable development at UBC was “I do not know” or “I don’t have that information”, which is shocking because clearly people know very little about net-zero projects or sustainable development in general. Bringing a rather new technology to a place like UBC should have more impact on the society than many other places. The new SUB building will be a good way to introduce more people to sustainability, and truly show people that it can work with certain input of technology.

As mentioned by people working in the C.K. Choi building, which is also a net-zero water one, people do not actually feel a difference working in a net-zero water building.

7.2 ENVIRONMENTAL

Since the new building will require a less water supply from the city, it instead takes advantage of the water already naturally provided by rain and it is beneficial for the environment. By constructing a catchments area with as little water loss as possible, the potential water to be collected will be very beneficial for the various water systems that will operate in the building.

The instalment and maintenance of the system are furthermore not very complicated. For instance, the technology for the catchments area is mainly implemented in the roof design, and it will therefore not raise extra concerns compared to if the building would not be built with a RWH system. Some considerations need to be taken in account. For instance, the building plan needs to include the placement of the storage tank if it is design to be placed in the building.

The proposed green roof would also work as a habitat for birds, insects, native plants, and rare or endangered species, which obviously is an advantage in the environmental aspect as well.

With all these benefits, there are still certain aspects that should be taken into consideration though. It is, for instance, worthwhile to question, if it really is necessary to have the new SUB while the old one is still running. Because while the new SUB is aiming to be more environmental friendly, the process of building a new SUB is probably less energy efficient than the actual old building itself.

In the long run though, the new SUB will probably benefit the environment. Although taking up a piece of green land may seem to be disturbing to the natural environment, however a green roof will be a good compensation for it.

7.3 ECONOMIC

The material required for the new SUB building, such as the gutters and roof material, is relatively inexpensive. The most costly part of the RWH system is the storage tank, and it was estimated to be a very small part of the budget. Purification and filter cost, is another economic part that has to be into consideration, but is very much dependent on what type of water usage is planned. Another additional cost is the maintenance that is required for the rainwater harvesting system. For instance, cleaning gutters and repairing leaks, but that will more or less be the same cost that will be required for a regular roof. Green roof is another costly aspect, but as garden was already planned there are not much additional cost needed for that either. The RWH system will also help save on the water bill once the system is installed since not as much water will be required from the grid.

8.0 CONCLUSION AND RECOMMENDATION

With the amount of rain water estimated to be collected annual from the new SUB roof, the idea of rainwater harvesting seems to be very suitable for the building. The system will not require a high capital cost and maintenance cost, except for the storage and potential purification system. It will not have any negative environmental impact, and mostly work in the environments advantage. If a new SUB is decided to be necessary, we think that it is feasible to implement a rainwater harvesting system as it has been implemented around the globe in either a small scale or large scale. We definitely recommend and urge such system be implemented as it will not only help save the environment but raise the awareness of the public about sustainable development which, we feel, is an important goal because everyone plays an important role in building a sustainable society.

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