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

An Investigation Into Net Zero Water System For New Student Union Building of University of British Columbia

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Abstract

A feasibility study was done for the new Student Union Building at the main University of British Columbia campus for a net-zero water consumption system. The objective of the study was to design a system that would entail net-zero water consumption for a one year period. Various methods of capturing and storing rainwater, recycling wastewater and limiting water consumption were researched and analyzed. It was soon realized that due to a large expected inflow of occupants and various UBC food services facilities, a true net-zero water system could not be achieved. Therefore, a near net-zero water consumption system was designed that utilizes a large water tank to capture and store rain water, a solar aquatic wastewater treatment centre and various water limiting devices.

A Triple Bottom Line assessment was performed to examine the economical, environment and social impacts of the design. The economic analysis revealed the initial cost of the project will be $250,000 with a payback period of approximately nine years. Environmentally, the need for municipal water will be reduced and the building will be able to generate and reuse its own water. However, areas downstream will receive less rainwater. Socially, the SUB can become a showcase for UBC's sustainability movement and provide jobs and create further awareness. Based on this analysis, the design proposed is recommended due to its strong environmental and social impacts.

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Glossary

Grey water	Wastewater generated from domestic activities and does not contain human waste
Black water	Wastewater containing human waste
Triple bottom line	Decision making that takes into account social, environmental and economic impacts (both positive and negative).
Net zero water	The difference of water consumption and water production is zero over a one year period

List of Abbreviations

SUB	Student Union Building
UBC	University of British Columbia
CIRS	Centre for Interactive Research on Sustainability
sq. ft.	Square feet

1. Introduction

This report investigates the feasibility of a net-zero water consumption system for the new Student Union Building (SUB). The SUB is going to be the central building for the student body at the University of British Columbia's (UBC) Main Campus. The study is done using a Triple Bottom Line assessment which examines the economic, environmental and social impacts of the project. Various methods of water production and water reduction were researched and analyzed and will be described in upcoming sections. A net-zero water consumption system is presented which utilizes some of the most efficient methods for water storage and usage.

The significance of this project is that it provides UBC with a sustainable alternative for the water system for one of its major buildings. By incorporating the design, UBC remains proactive in sustainable building designs and reducing its carbon foot print. This will further cement UBC's place as one of the most sustainable university campus in the world.

The scope of this report includes but is not limited to the following:

- Provide the background information and objectives of the project
- Describe alternative water sources
- Describe methods of recycling wastewater
- Introduce water limiting devices
- Present a net-zero water consumption system design
- Perform a Triple Bottom Line Assessment to justify the design

The report contains the following sections: Introduction, Background, Objectives and Requirements, Available Methods, Design, Economic Impact, Environmental Impact, Social Impact and Conclusion and Recommendations.

2. Background

UBC is building a new student union building and this SUB renewal project is aiming to be sustainable through the structural and system design of the facility. The old SUB was opened in 1968 and it is a three story building with an area of 200,000 square foot while the new SUB is estimated to be a five story building with an area of 251,000 square foot (Alma Mater Society, 2009). The new SUB will be divided into fifteen sections such as offices, food services, common domains, recreation area, and etc. At the moment of the research, the building is still under the design phase, so it is easier to implement new solutions than later in construction. One way to achieve sustainability is to implement a net zero water system because all these areas in the SUB will need water in one form or another. Net zero water means that overall water consumption is equal to the overall water production of the building over a year period. Availability of fresh water and water storage are the two possible sources of direction to make this project possible. This document records the feasibility and the environmental, social, and economic impacts of an implementation of a net zero water system.

3. Objectives and Requirement

In order to come up with the design for the water system of the new student union building, we highlight the major objectives and requirement. The goal of the project is to achieve a near net zero water cycle for the building over a year period. Even though the concept of net zero water is quite sustainable, the process of making and operating such system need to also be sustainable. Sustainability is a key objective to the project. We need to reduce the impacts on the surrounding environment; thus, triple bottom line assessment of the design is required. This net zero water system has to be capable of satisfying the water demand of the new SUB. The new SUB has an area of 251,000 sq. ft. over five floors and around 82,600 L per day of water consumption as shown in Appendix A. Of which, we assume 73,350 L for toilet flushing and 9,254 L for potable water.

4. Concepts

4.1. Rain Water Collection

In order to achieve near net-zero water consumption for the new SUB alternative water sources need to be implemented. The high precipitation rate in Vancouver presents an excellent opportunity as highlighted in Figure 1. This water can be collected and utilized in the new SUB for general use. This section highlights some of the methods that are used to collect rain water.

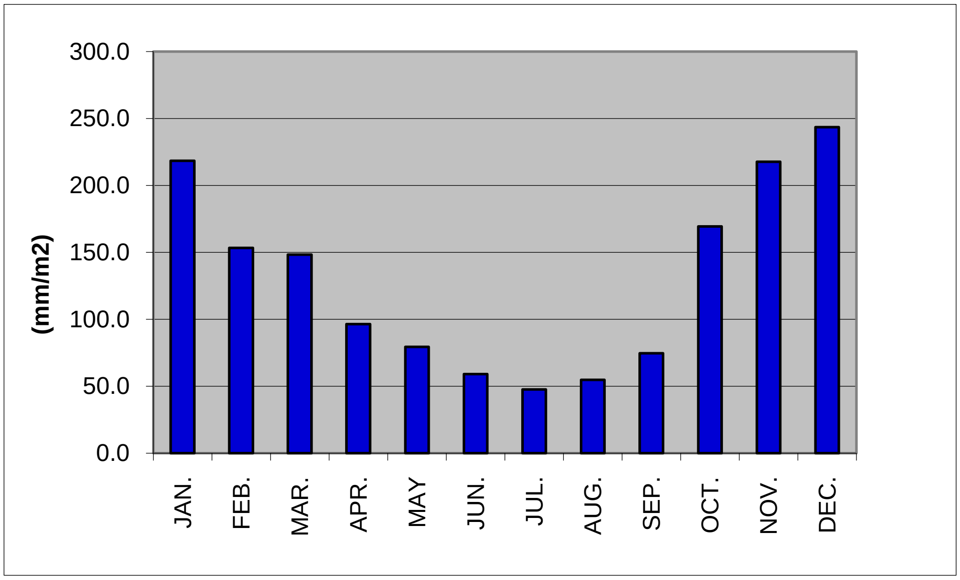


Figure 1 Rainwater Collection in Vancouver based on Appendix A-3

4.1.1. Water Tank

One of the ways to harvest rainwater is to collect it in a large water tank located within the facility. This water tank can be built into the facility during construction or be a modular attachment. This is one of the most effective ways of collecting rain water as the water is collected on site and does not require an intricate pipeline system for water distribution. Furthermore, it is also relatively safe from outside contamination as the water is stored in an enclosed environment away from public access, airborne pathogens and pollution. If the tank is built during the building construction, some of the initial cost can be incorporated into the overall project cost providing some cost savings.

There are two ways of directing rain water towards the tank: a standard roof or green roof. A standard roof will have drains and gutters which can guide the water towards the tank during precipitation. This is the most commonly used method as ordinary building roofs are slightly slanted and equipped with drains on the perimeter therefore there is no need for additional equipment. Refer to Figure 2 for an implementation of a rainwater collection water tank using a standard roof in a residential facility.

Green roof refers to a garden or lots of vegetation on the roof. The rainwater is passed through the plants and the water they do not absorb is collected in the tank. This serves two benefits as it prevents a high flow of water rushing towards the tank and it is an environmentally friendly alternative to the standard roof. However, it does add extra capital, operation and maintenance costs to the project.

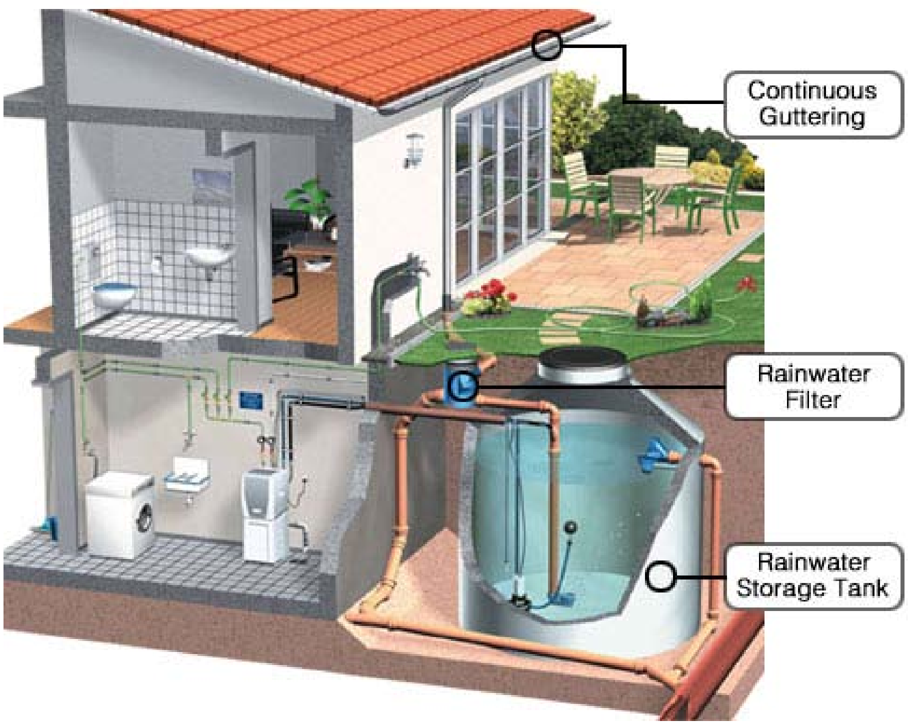


Figure 2 Water Tank

http://www.aquavalor.fr/images/installationG3.jpg

4.1.2. Pond or Other Water Body Acting as a Small Dam

Another way for harvesting rainwater is through the use of nearby ponds or any other natural water collection bodies. By converting such a facility into a dam we can collect rain water and utilize it when required. This option is rarely used as it is uncommon to find water bodies that can be converted to harvest rainwater near buildings. They also require a complicated pipeline network to bring water to and from the destination. The water is also prone to contamination as it is fairly easy for pollutants and hazardous materials to get into the water along with debris and wildlife.

4.1.3. Storm Water Tanks

An unorthodox way of collecting rainwater is through the use of storm water drainage systems. Rainwater that is found on roads and other surfaces is cleared through the drains that are located on roads and it can be directed to tanks for collection. This water is considered to be grey water as it can be contaminated by pollutants on the road surface. For this reason it needs to go through the same treatment process as grey water from washrooms and kitchens. This process has a much higher capital cost as not only tanks but grey water treatment equipment have to be purchased and implemented.

4.2. Rainwater Filtration

Many people consider rainwater as clean for drinking but due to pollution, dust particles, and other chemicals from the surfaces rainwater are collected from, rainwater requires some filtration to meet city health standards. In the following section, rainwater filtration methods are listed.

4.2.1. Cartridge (Reverse Osmosis)

Reverse osmosis is a method which forces dirty water at high pressure through a membrane to get clean water. The filters are very fine and only allow water molecules to pass through, making it incredibly slow when compared to other methods. This type of filtrations has a very high recovery rate due to the closed system where water is not wasted in filtration. Although it is very effective in removing salts and minerals in the water, more dangerous chemicals like pesticides and chlorine are molecularly smaller than water and therefore, it must be in combination with carbon filters.

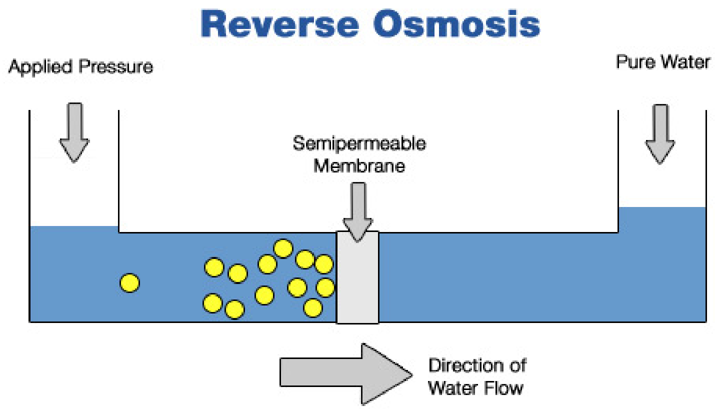


Figure 3 Reverse osmosis

http://innovative-water.com/images/reverse_osmosis.jpg

4.2.2. Cartridge (Carbon Filter)

Carbon filters are similar to reverse osmosis filtration in the high recovery rate. It does not require the water to be pumped at high pressures. It is very effective in removing harmful chemical sin the water source. In doing so, salts and other minerals are left in the water which are beneficial to the human body. It is widely available and already in use in kitchens and water filter jugs (eg. Brita water filters).

4.2.3. Sand Filter

Sand filters are large filtration devices that force the water through a layer of sand and collect the water afterwards. All the particles are trapped inside the sand and accumulated over time. After time, the sand filters have to be backwashed with the water flowing backwards, dislodging the particles and sent to the sewer. The time interval for such a task depends on the quality of the water source and therefore can last a long time given that large particles are filtered prior entering the sand filter.

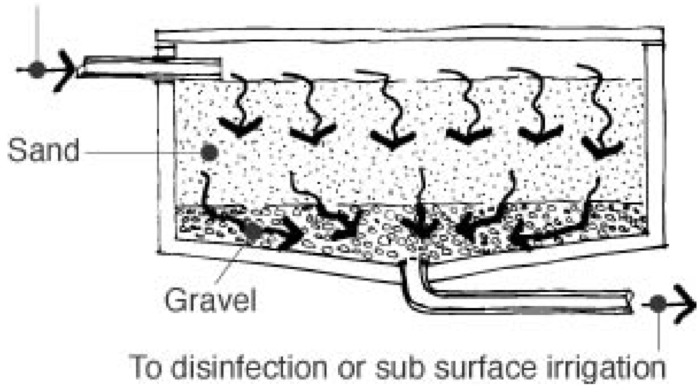


Figure 4 Sand filter

http://www.reuk.co.uk/OtherImages/greywater-sand-filter.jpg

4.2.4. Distillation

Distillation is a process to purify water by boiling it and collecting the steam for drinking. It requires a constant boiler to continually produce enough steam to generate drinking water for the occupants. Furthermore, the heat is wasted when the energy requirements for boiling water far exceeds the potable water produced for the SUB.

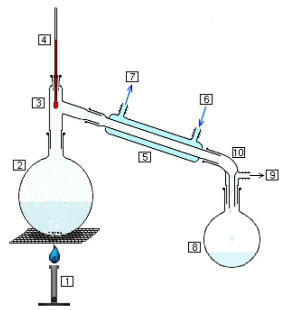


Figure 5 Distillation

http://upload.wikimedia.org/wikipedia/commons/0/0e/Simple_chem_distillation.PNG

4.3. Water Conservation

Apart from collected more water from different sources to meet our needs, it is necessary to make the best use of each drop. By being more efficient and conserve water use, it is possible to extend the use of a given amount of water. In the following section, several methods to conserve water are described.

4.3.1. Waterless Urinals

To conserve water in many buildings, the urinals have turned to waterless technologies (eg. Falcon Waterfree Technology). Essentially the urine is collected at the basin and the urine passes through a cartridge. The cartridge has a fluid which floats on top of the urine, trapping odor and smell, and the urine is drained from below. This technology requires the cartridge to be replaced approximately three to four times a year.

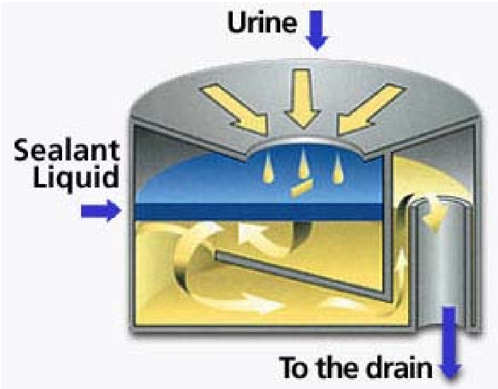


Figure 6 Waterless Urinals

http://www.falconwaterfree.com/images/color_cutout.jpg

4.3.2. Low Flow Fixtures

Low flow fixtures can be used in a wide range of areas. They can be used for toilets, urinals, sinks, and showers. Most of the toilets introduce two types of flushing options, one for short flush (three liters) and one for long flush (six liters). Similarly, urinals have reduced their water consumption to approximately three liters per flush. For sinks and showers, the majority of these fixtures have introduced aerators and smaller openings which the water comes through, creating a stronger stream of water for washing. Low flow fixtures also allow for renovations of some existing washrooms by only replacing the aerators and flow valves in urinals.

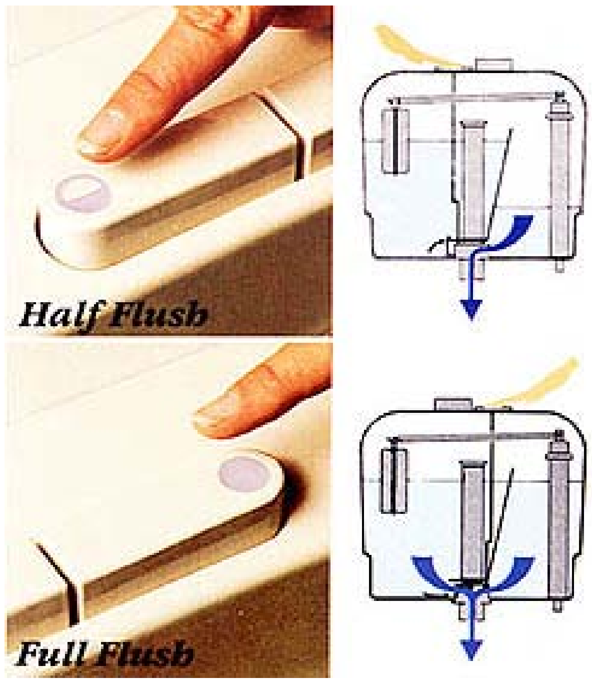


Figure 7 Low Flow Fixtures

http://www.powerhousemuseum.com/education/ecologic/img/flush.jpg

4.4. Wastewater Treatment

Wastewater is a combination of water collected from sinks, toilets, urinals, and showers. In treating the wastewater, we have to consider the health risks involved in treating our own sewage on site. On site, the water after treatment is monitored continually by sensors and as a backup system, the wastewater can be directed to the municipal sewer. In the following section, some possibilities to treat the wastewater are listed.

4.4.1. Sewer

Direct discharge of the wastewater to the municipality will put a higher load on the city sewer system with every additional building.

4.4.2. Septic Tank

This is the main method to trap waste solids usually located at the beginning of the wastewater treatment. By allowing the sewage to settle in a tank, the heavier sludge settles at the bottom, while lighter scum floats to the top. After the solids and scum are separated, the liquid portion of the sewage travels to the next treatment method. A septic tank needs to be large enough to be able to collect the amount of sludge generated by the SUB. Once the tank has too much sludge, the treatment has to be stopped and the solids manually removed.

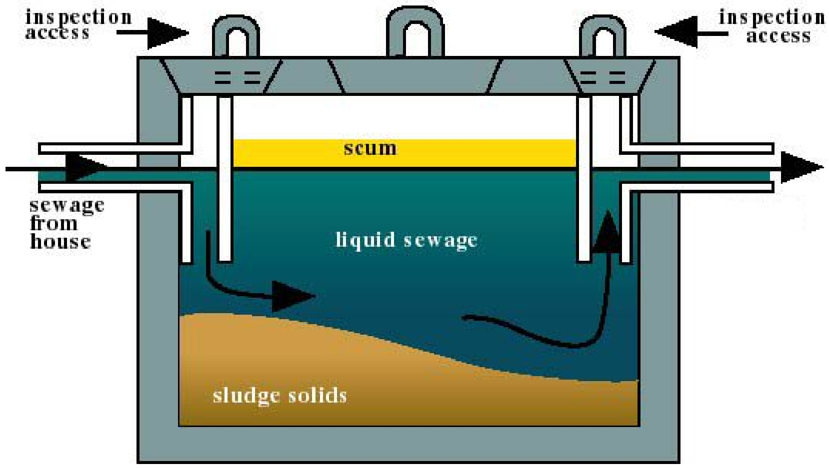


Figure 8 Septic Tank

http://www.databaseanswers.org/data_models/septic_tanks/images/septic_tank_diagram_lge.jpg

4.4.3. Suspended Growth Process/Sand filters/ Membrane filters

Further filtration methods after the septic tank involves the removal of suspended organic matter. This is achieved through a series of processes involving the use of bacteria to digest and compost most of the suspended matter. After the solids and bacteria are separated by gravity from the water due to heavier weight, the effluent is transferred to either sand filters and membrane filters. These provide extra steps of filtration to remove the bacteria and solids left in the system.

4.4.4. Solar Aquatics

Solar Aquatic System is a method of treating wastewater through means that are similar to the natural water purification process. The wastewater is directed through a series of aerated tanks with specific plants, snails, fish, and bacteria to purify the water (Eco-Tek, 2009). The whole process takes place in a greenhouse which controls the environment and aids growth. This method of treatment provides primary treatment (removal of solids), secondary treatment (dissolved organics), and tertiary treatment (removal of nitrogen and phosphorus). Most solar aquatic systems are clean and are publicly viewable for everyone, making the treatment plant plausible for education.

4.4.5. Disinfection

All the systems listed above are not able to remove or kill pathogens in the water such as coli form, E. coli, parasites, and other virus. To remove such pathogens, several methods are available such as chlorine additives, ozone disinfectant, or ultraviolet light. Both chlorine and ozone methods involve additives which react with the pathogens and kill it in the process. Ozone is relatively expensive because of its high reactivity and more complex to handle. It also has an application in swimming pools in replacing chlorine and therefore, it is better for people with allergic reactions high chlorine concentrations. Ultraviolet disinfection does not contact the water directly and only requires an ultraviolet light source.

5. Design

Implementing a net-zero water consumption system for the new SUB is an obstacle because the building has an extremely high number of occupant as well as several UBC food services facilities. Services such as restaurants and cafeterias pose a challenge to water conservation as they require a large volume of water to carry out their duties. For this reason a near net-zero water consumption approach was taken to design the water system.

After analyzing the water demands of the building, it become clear that no one method would satisfy the needs of the building. A system consisting of the various procedures outlined in the previous sections is required. Given Vancouver's high annual precipitation levels, rainwater is the best alternative water source. Therefore, the system designed uses a combination of rainwater harvesting and wastewater treatment. In addition, water limiting devices will be utilized throughout the building to reduce water waste and consumption. The system proposed is similar to the CIRS building water system design found in Appendix B. Refer to Figure 9 for a block diagram that outlines the process for the new SUB.

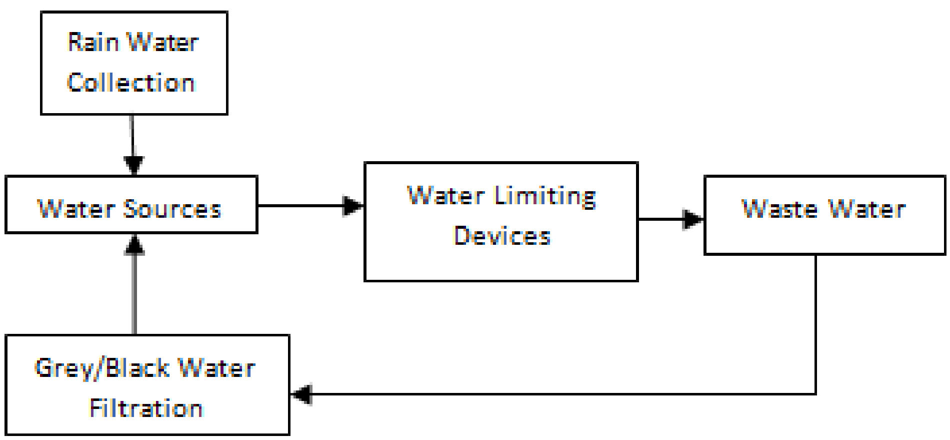


Figure 9 Block Diagram for SUB Water System

To capture the rainwater, a water tank should be incorporated into the SUB building structure. This is recommended because it has a lower cost than the other alternatives. Furthermore, this will be more convenient when incorporating the tank to the rest of the system. The standard roof, described previously, is also recommended for its good functionality and low maintenance cost. Space will need to be allocated to house the tank as well as the wastewater treatment apparatus. A solar aquatics wastewater treatment system is recommended to filter and purify the grey and black water. This system will perform all the necessary tasks to ensure the wastewater is recycled and can be reused. Water limiting devices such as low flow faucets and shower heads, dual flush toilets and low water urinals will be used where required. This will limit consumption and reduce the amount of water wasted. The capital cost for this design is high but it is justified by its social and environmental impacts using the Triple Bottom Line Assessment.

6. Economic Impact

The major economic issue is to find sources of funding to build the extra system we proposed on top of the original water system. Given by the committee of CIRS building, the wastewater filter system of their building costs $130,000 and rainwater collection costs $75,000 (Cayuela, 2010). We are expecting a similar amount for implementing the same system in the new SUB; however, since the building is bigger and has higher occupants, the cost will be around $150,000 for the wastewater filtration and $100,000 for rainwater harvesting system. Based on the utility metered rate for water and sewage, we are able to calculate the approximate value we save from this system. Through this estimation in Appendix A, we determined that this system is able to save $84.7 a day or $30,900 a year, so it will take about eight to nine years before it breaks even between the money we would save from using less domestic water and the initial cost we would have to invest. Assuming that the life of the new SUB is 50 years, it will save money by the end of the life cycle.

In order to reduce the maintenance cost, we tried to avoid certain water saving system. For example, waterless toilet was a great invention when it came out because it does not require water to rinse the urinals. Many buildings have adopted this system in order to reduce daily water usage. However, this type of system requires frequent maintenance and therefore, higher cost. From our research, we found that the operation cost for the gray and black water filtration is around $14,000 per year (Eco-Tek, 2009). Although we did not acquire the maintenance and the operation cost for the rainwater filtration system, we believe that these two are minimum since only periodic replacements of sand and carbon filters are needed.

Being one of the most sustainable buildings around the campus, the new SUB can be shown as a showcase to the prospective students, the current students and the community. The school will then be able to attract more students to study here because it demonstrates the leading edge building within the campus. It shows that UBC is able to provide the technologies and resources for students to concentrate on studying. UBC will stand out from the rest of the universities in the country or even in the world. Since the new sub requires high initial building cost, one way to seek sources of funding is by increasing the student tuition. This is the most common financial solution for new construction on campus. By having more students means that the source of income for the school also increases.

7. Environmental Impact

One of goals for the New SUB is to become water self-sufficient and the greenest building on campus. Our strategies include collecting rainwater for potable use and treating wastewater on-site. These strategies will allow us to operate locally, lowering fresh water demand and sewage load to the city. Net-zero water will be one of the achievements for this building.

All the technologies we use in this project is pre-existing off the shelf technology. It is the combination of the technologies that help us achieve self-sufficiency. Rainwater collection is a common technology which can be implemented for reducing water demand on the municipal water grid. Collecting rain water can also minimize the storm water run-off in the area which is a concern for the cliffs on the west side of UBC campus. Water from the whole campus seeps into the ground and flows along the water impermeable clay layer towards the cliffs overhanging the beaches around UBC. That water continually erodes the cliff face and increases the speed at which the cliffs move inwards. Not only is it an issue to the disappearing property in the perimeter and SW Marine Drive, the road which encircles the campus, the eroded material changes the composition of the sand beaches to rocks.

Although collecting rain water is great to generate a water supply for the building itself, we should also consider where the rain water would run off prior to the existence of the building. Since the rain water is collected and held, areas around the new SUB as well as downstream will receive a reduced amount of water. This includes collecting water that was previously a source to the Point Grey aquifer. Our solution for depleting aquifer water level is to create a well which water can be sent down to the aquifer. The redirection of water saves the cliffs around UBC due to storm run-offs and gives a safer environment to the trails around the cliffs.

The solar aquatic wastewater treatment system implemented requires a process area slightly smaller than the size of a volleyball court (Meyer, 2010). The system is built inside an active greenhouse with bacteria, plants, and other small organisms to simulate similar filtration methods in nature. As the water moves through each ecosystems created in each solar aquatic tank, the water is purified more and more. At the end, the water is clean since the plants collected all the sludge. Periodically, the plants' roots collect all the sludge and need to be replaced with new plants with clean roots. The removed plants are either sold to recover some costs or disposed of at the compost. This would be the only solid waste resulting from the treatment system since most of the solids would be broken down and absorbed by the plants as nutrients.

8. Social Impact

The last part of the Triple Bottom Line Assessment is to analyze the social impact that a project can have. This refers to the project's influence on occupants and workers, the nearby society, peoples' jobs and any other social matters. Being at the heart of the campus and student body, the new SUB building provides the UBC with a great opportunity to further establish itself as one of the most sustainable university campus in the world. Incorporating a net zero water system has the potential for drastic social impact.

As mentioned before the new SUB building is designed to house thousands of students at any given time. This high traffic of students is a perfect opportunity to showcase UBC's goal to become a front runner in sustainable building technologies. By integrating a sustainable water distribution system, UBC can create further awareness within students, faculty and staff members and visitors to the campus. It also provides an opportunity to create additional programs to promote sustainable building construction and lifestyles throughout the campus. The new SUB can provide a benchmark for buildings on campus and will encourage other buildings to seek innovative ways to reduce their energy consumption and waste emission.

A net-zero water infrastructure for the new SUB will also create some new jobs. Contractors will need to be hired to build the structure as well as to perform regular maintenance. It also provides the possibility to create partnerships with other international or local companies to further promote sustainability worldwide. Consultants and coordinators can be hired to create programs to assist other corporations or institutions to enhance their infrastructures and become energy efficient.

Implementing the methods suggested for achieving Net-Zero Water Consumption will also affect the regular occupants and workers of the building. Constructing buildings with sustainable technologies is only effective if the occupants of the building are willing to utilize these technologies in the matter intended. It will still be the responsibility of the kitchen workers and custodial staff to utilize water in a responsible manner when carrying out their duties. Occupants and visitors to the new SUB will also have to be aware of their water consumption when utilizing the amenities. The washrooms and other water facilities are going to utilize low pressure water taps and shower heads as well as low flow toilets and it will require a little time to get acquainted with these systems.

With the wastewater treatment on site, there are some health issues raised by the UBC Health and Safety as well as the BC Health and Safety committees. There is a large concern for the quality of the water after the harvested rainwater or wastewater is properly treated. If the wastewater is not treated properly health risks such as consumption of airborne pathogens or contact with improperly treated wastewater can occur. Furthermore, continual monitoring of water pH, color, dissolved oxygen content and other pathogens is required by law in the BC Building code (Vassos, 2010). As the grey water is going to be filtered and reused it is critical that no hazardous chemicals or cleaning products are disposed through the plumbing system. Environment friendly cleaning supplies should be purchased and utilized to minimize hazardous materials entering the water system. A program for the occupants and workers should be created to educate them about the functionality, maintenance and safety concerns of the new system.

Amalgamating sustainable water collection and distribution technologies into the new SUB promises to increase UBC's profile as a world leader in sustainability. Measures will need to be taken to ensure that the workers and occupants of the building are aware of the functionality of the new system in order to receive maximum benefit. By being a pioneer in sustainable building design, UBC has the opportunity to assist others in the world in following in its footsteps and become a benchmark for future buildings.

9. Conclusion

After reviewing the options for water sources and reuse alternatives for the new Student Union Building, we have designed a system which collects rainwater for use in the building and reuse the water for flushing washrooms and irrigation. Using the roof of the building to funnel the water towards a central water tank, we collect enough rainwater throughout the year to support the public and office space in the new SUB. At the same time, the low flow water fixtures in sinks, toilets, and showers are installed to reduce water consumption at least by thirty percent. After the water is used, it is treated by a solar aquatic system and the resulting water is pumped back to the building as water for flushing urinals and toilets. Given the high traffic demand of the SUB, there will be a constant supply of wastewater for reuse. Using a Triple Bottom Line assessment, the system is assessed for economic, social, and environmental impacts.

After doing the triple bottom line assessment, we identify the economic, social, and environmental impacts. One of the major economic impacts is the initial cost of around $250,000. However, the SUB will break even after eight to nine years of operation due to a lower demand of municipal water. On the positive side, the new building will be a showcase to the public as a leading edge sustainable structure, which means that it will be likely to attract more prospective students to attend to the school. Looking at the environmental impact, we reduce the need of municipal water and generate water on site. Also, we minimize the storm runoffs to the nearby cliffs which reduce the speed that the cliff is disappearing. On the other side, we cut off the water source for the downstream area because the system is collecting the rainwater. Small amount of solid wastes may be created due to the periodic replacement of clean roots in the solar aquatic system. From a social standpoint, we are changing the behavior of the occupants including students, janitors, and restaurants, but UBC SUB will become a pioneer in sustainable building design. This creates more job opportunities for students to assist others who want to follow UBC's footsteps.

Our recommendation for the SUB Sustainability project is to use the system we described based on social and environmental impacts. It will make the new SUB net zero water excluding the demand and waste of the food services in the building. This is due to the high demand and purity of water required for potable use in restaurants for food preparation, cooking, and washing.

Apart from the restaurants, the high traffic demand for the rest of the space will be net zero water. We hope the net zero water system will be incorporated into the new building itself as a functional showcase for both the community but for students as well. Since the building is designed for a life time of at least 50 years, extra space for future expansion of the solar aquatic treatment plant is recommended to meet increasing demands.

Appendix

Appendix A – Calculations

See following pages

SUB Building Water Balance

INPUTS

AMS Offices

Input numbers in blue coloured cells. Grey cells are calculated. Results are in red.

4000	Total floor Area (m^2)						
150	occupants	27	m^2 / person	2	toilet uses per day (s	3	L per flush (small flush)	0.8 Gallons/flush
				1	toilet uses per day (l	6	L per flush (large flush)	1.6 Gallons/flush
70	% occupied on weekdays	105	people	4	hand washings per day			
15	% occupied on weekends	23	people					
				15	second hand-washin	0.5	gpm lavatory flow	0.5 L/use
6	% of occupants have showers >>	9	people	3	minute shower durat	1.5	gpm shower flow	17 L/use

Potable Water	320 L/day	3.0 L/day.pers
Black Water produced	1670 L/day	15.9 L/day.pers

Student Space (study space and eating lounges)

Input numbers in blue coloured cells. Grey cells are calculated. Results are in red.

0	Total floor Area (m^2)			1	Number of Auditorium classes per day
8000	occupants	0	m^2 / person	1	toilet uses per class (small flush or urinal)
				1	toilet uses per class (large flush)
100	% occupied on weekdays	8000	people	2	hand washings per class
0	% occupied on weekends	0	people		
1	% of occupants have showers >>	80	people		

Potable Water	8934 L/day	1.1 L/day.pers
Black Water produced	80934 L/day	10.1 L/day.pers

Correction Factors

Potable Water treatment

15 % Loss due to potable water treatment

Rainwater collection

20 % Evaporation Losses

10 % Downpipe Filter

Blackwater treatment

25 % Loss due to filtration

50 % Reduction summer occupancy (June-July-August)

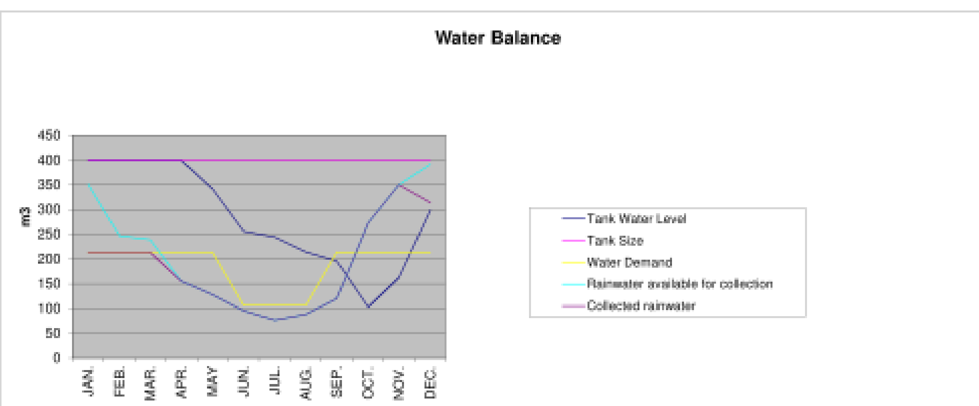
RESULTS SUMMARY (FOR TYPICAL WEEKDAY)

• Daily Potable water consumption	9,254	L	2,445	gallons
• Daily Treated water consumption for flushing	73,350	L	19,377	gallons
• Daily Total Treated Black water	82,604	L	21,822	gallons
• Daily Treated black water available for reuse	61,953	L	16,366	gallons
• Daily Treated black water available (balance)	(11,397)	L	(3,011)	gallons

** note: more treated black water used than available but collection from weekends are able to make up the difference

PLANT SIZING

• Potable Water Storage Tank Size:	400	m3	105,669	gallons	133 m^2	Tank footprint area (3.5 m depth)
• Rainwater Catchment Area:	2,300	m^2				



SUB Water Balance Spreadsheet

Element	L / use	Uses / person / day	People / Weekday	People / Weekend	L / weekday	L / weekend	L /month
AMS Offices							
Toilets - 1/2 Flush	3.0	2.0	56	11	338	68	7,290
Toilets - Full Flush	6.0	1.0	113	23	675	135	14,580
Urinals - Low Flow	3.0	2.0	56	11	338	68	7,290
Showers	17.0	1.0	6	1	107	23	2,330
Lavatories	0.5	4.0	113	23	213	43	4,599
Student Space							
Toilets - 1/2 Flush	3.0	1.0	4000	0	12000	0	240,000
Toilets - Full Flush	6.0	1.0	8000	0	48000	0	960,000
Urinals - Low Flow	3.0	1.0	4000	0	12000	0	240,000
Showers	17.0	1.0	80	0	1363	0	27,255
Lavatories	0.5	2.0	8000	0	7571	0	151,416

BLACKWATER TOTAL	L / weekday	L / weekend	L /month
Toilets - 1/2 Flush	12338	68	247,290
Toilets - Full Flush	48675	135	974,580
Urinals - Low Flow	12338	68	247,290
Showers	1470	23	29,585
Lavatories	7784	43	156,015
Washing/Cooking/Cleaning	0	0	0
TOTAL	**82604**	**336**	**1,654,760**

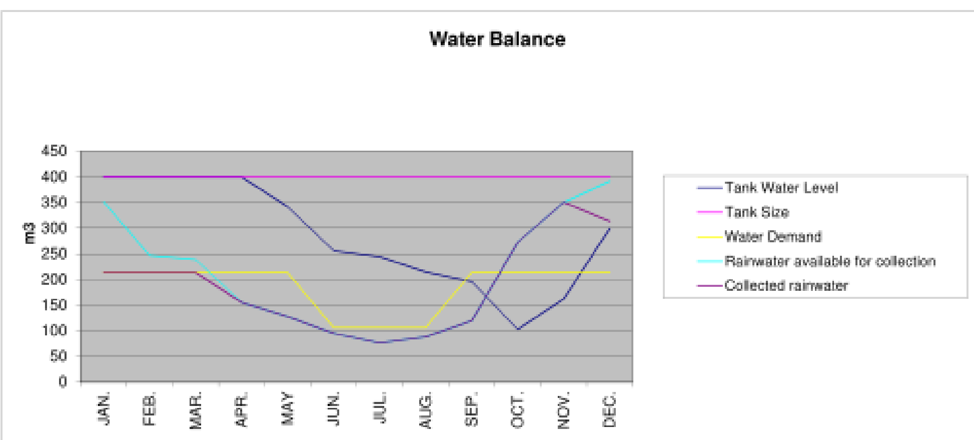
TREATED WATER FOR FLUSHING	L / weekday	L / weekend	L /month
Toilets - 1/2 Flush	12338	68	247,290
Toilets - Full Flush	48675	135	974,580
Urinals - Low Flow	12338	68	247,290
TOTAL	**73350**	**270**	**1,469,160**

POTABLE REQUIREMENT	L / weekday	L / weekend	L /month
Showers	1470	23	29,585
Lavatories	7784	43	156,015
Washing/Cooking/Cleaning	0	0	0
Coffee Making	0	0	0
TOTAL	**9254**	**66**	**185,600**

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.		TOTAL
Potable Water consumption (m3/month)	186	186	186	186	186	186	186	186	186	186	186	186		
Corrected Water consumption (Filtration)	213	213	213	213	213	213	213	213	213	213	213	213		
Corrected Water consumption (Summer Reduced	213	213	213	213	213	107	107	107	213	213	213	213		
Cumulative Water consumption (m^3)	213	427	640	854	1067	1281	1494	1708	1921	2134	2348	2561		2561
Average rainfall (mm/m^2)	0.218	0.153	0.148	0.096	0.079	0.059	0.048	0.055	0.075	0.169	0.218	0.243		
Average water collection available/month	502	353	341	222	183	136	110	126	172	390	500	560		
Corrected Collection (losses)	351	247	239	155	128	95	77	88	120	273	350	392		2516
Average Cumulative Rainwater (m^3)	351	598	837	993	1120	1216	1292	1381	1501	1774	2124	2516		
Effective Water collection area	2300 m^2													
Balance Rainfall - Water demand (m^3)	138	171	197	139	53	-65	-202	-327	-420	-361	-224	-45		
Effective Tank water storage (m^3)	400 m^3													
Tank water storage level (m^3)	400	400	400	400	397	350	324	340	386	400	400	400		

Collectable rainwater	187													

Tank Water Level	400	400	400	400	342	256	245	215	196	103	162	299		
Tank Size	400	400	400	400	400	400	400	400	400	400	400	400		
Water Demand	213	213	213	213	213	107	107	107	213	213	213	213		
Rainwater available for collection	351	247	239	155	128	95	77	88	120	273	350	392		
Collected rainwater	213	213	213	155	128	95	77	88	120	273	350	314		



Greater Vancouver Sewerage and Drainage District
Yearly Rainfall Summary
Station VA13 Stanley Park

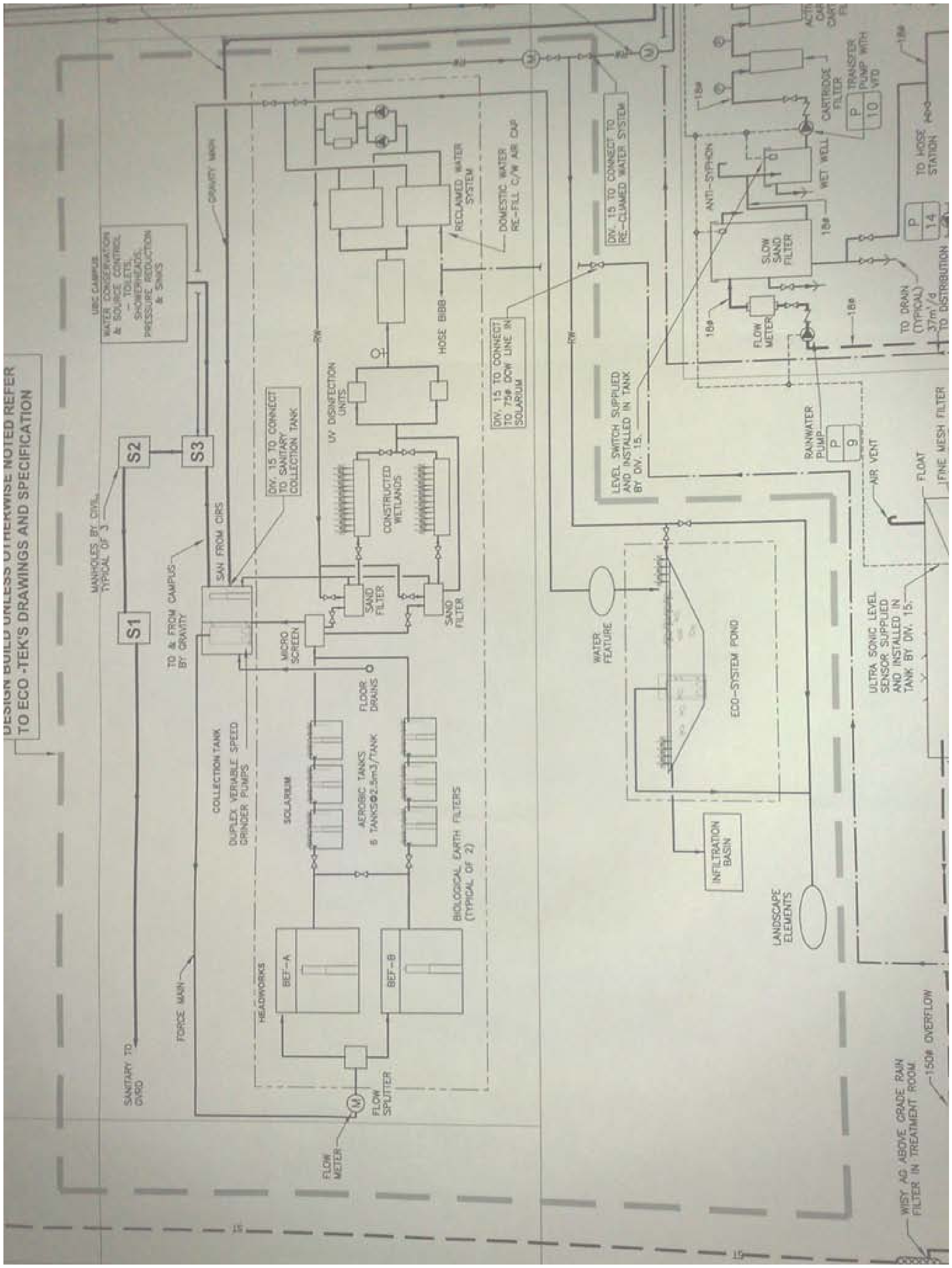
YEAR	RAINFALL (mm)												
	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1959	181.4	165.1	183.9	83.1	63.8	85.1	29.2	20.6	167.4	110.2	186.4	195.1	1471.2
1960	180.3	166.6	124.0	78.5	120.1	48.8	0.8	100.3	49.8	238.5	168.4	133.6	1409.7
1961	304.8	350.8	138.7	64.8	71.9	32.0	30.5	62.5	61.2	189.7	197.1	237.5	1741.4
1962	181.4	57.4	84.3	97.0	63.2	34.8	28.2	113.0	63.5	105.4	199.1	291.6	1319.0
1963	42.4	153.2	91.7	86.6	27.2	50.8	68.6	17.3	34.3	153.4	207.5	281.2	1214.1
1964	273.8	103.6	150.4	70.6	79.0	66.3	82.0	52.8	167.6	76.7	213.4	135.1	1471.4
1965	252.2	239.3	51.8	55.6	61.5	16.5	13.7	46.5	15.5	197.6	148.1	176.0	1274.3
1966	184.4	108.0	117.9	36.8	63.5	61.2	86.4	37.8	70.6	187.7	226.1	368.6	1548.9
1967	272.3	152.4	145.3	82.0	29.7	23.4	32.0	7.4	72.4	468.1	128.3	220.7	1634.0
1968	370.1	155.2	196.6	74.4	53.3	77.0	35.3	73.2	143.3	236.7	211.3	235.5	1861.8
1969	234.7	88.9	126.7	154.4	45.0	32.0	26.7	63.5	184.2	148.3	132.6	198.9	1435.9
1970	149.1	89.7	94.0	146.6	60.5	26.4	56.6	16.3	117.6	116.3	149.9	248.2	1271.0
1971	227.6	208.5	210.6	71.9	35.8	88.4	18.0	32.0	108.5	241.6	264.4	243.3	1750.6
1972	145.0	192.5	262.9	162.3	36.6	73.4	135.6	46.0	109.0	55.1	208.3	438.2	1864.9
1973	256.0	110.0	114.8	23.6	81.8	105.2	29.7	55.1	59.2	160.5	258.1	319.3	1573.3
1974	269.7	198.6	260.1	161.5	182.9	30.7	112.0	2.0	28.2	60.2	242.1	283.5	1831.6
1975	196.1	165.6	143.5	50.3	55.4	39.9	12.2	128.8	1.0	378.0	229.6	262.4	1662.7
1976	236.0	173.7	149.9	103.9	119.6	98.8	31.2	106.2	65.8	115.1	86.1	188.7	1475.0
1977	114.3	120.7	94.0	69.1	118.4	23.6	78.5	28.2	90.2	108.7	268.0	205.7	1319.3
1978	124.7	126.2	109.7	105.4	99.1	26.7	15.0	116.8	112.0	46.2	118.1	92.5	1092.5
1979	60.5	220.5	79.5	71.6	52.6	42.4	32.3	14.5	86.4	102.4	79.5	316.0	1158.0
1982	304.5	296.2	92.7	162.3	19.1	30.2	105.2	58.2	52.1	174.8	215.9	167.1	1678.2
1988	114.6	130.6	183.6	133.6	150.6	58.4	26.2	47.5	98.0	126.0	284.2	216.7	1570.0
1989	201.2	93.5	147.3	61.0	134.9	41.7	52.3	68.6	13.2	179.8	255.5	131.8	1380.7
1990	341.4	81.5	105.7	99.3	80.8	117.1	17.3	37.6	32.0	179.1	390.4	275.8	1757.9
1991	201.4	208.3	125.5	156.7	83.8	86.9	43.4	252.0	13.5	25.1	354.3	315.7	1866.6
1993	180.1	11.4	183.9	115.3	61.7	59.4	80.8	13.5	5.1	75.7	138.2	308.9	1233.9
1994	NA	186.7	151.9	77.2	39.6	78.2	56.1	8.9	83.3	145.5	261.9	286.0	***
1995	281.4	199.9	143.8	58.7	28.4	20.3	57.2	6.9	31.5	226.1	372.6	281.4	1708.2
1996	252.0	132.6	94.4	238.0	102.9	35.3	26.8	33.2	94.0	331.4	232.4	252.7	1825.6
1997	355.8	137.6	530.6	146.0	104.0	115.2	75.0	36.2	136.0	216.0	185.8	216.6	2254.8
1998	270.6	148.2	113.0	34.0	154.2	42.6	95.0	24.0	9.6	196.0	413.6	257.8	1758.6
1999	305.8	283.6	153.8	72.6	103.4	110.2	31.0	***	***	165.0	287.0	272.2	1784.6
2000	188.4	78.6	159.4	40.0	118.0	99.2	0.0	5.4	99.6	177.0	102.2	173.4	1241.2
2001	168.2	31.8	78.8	131.0	75.6	90.6	48.2	130.8	64.0	216.6	199.2	294.2	1529.0
AV.	**218.3**	**153.3**	**148.4**	**96.5**	**79.4**	**59.1**	**47.7**	**54.8**	**74.7**	**169.4**	**217.6**	**243.5**	**1557.9**

NOTE:
Rainfall for April 1970, December 1988, October and November 1989, February 1996, March 1996, June, July, August and December 1997 are taken from West Vancouver Municipal Hall Station.

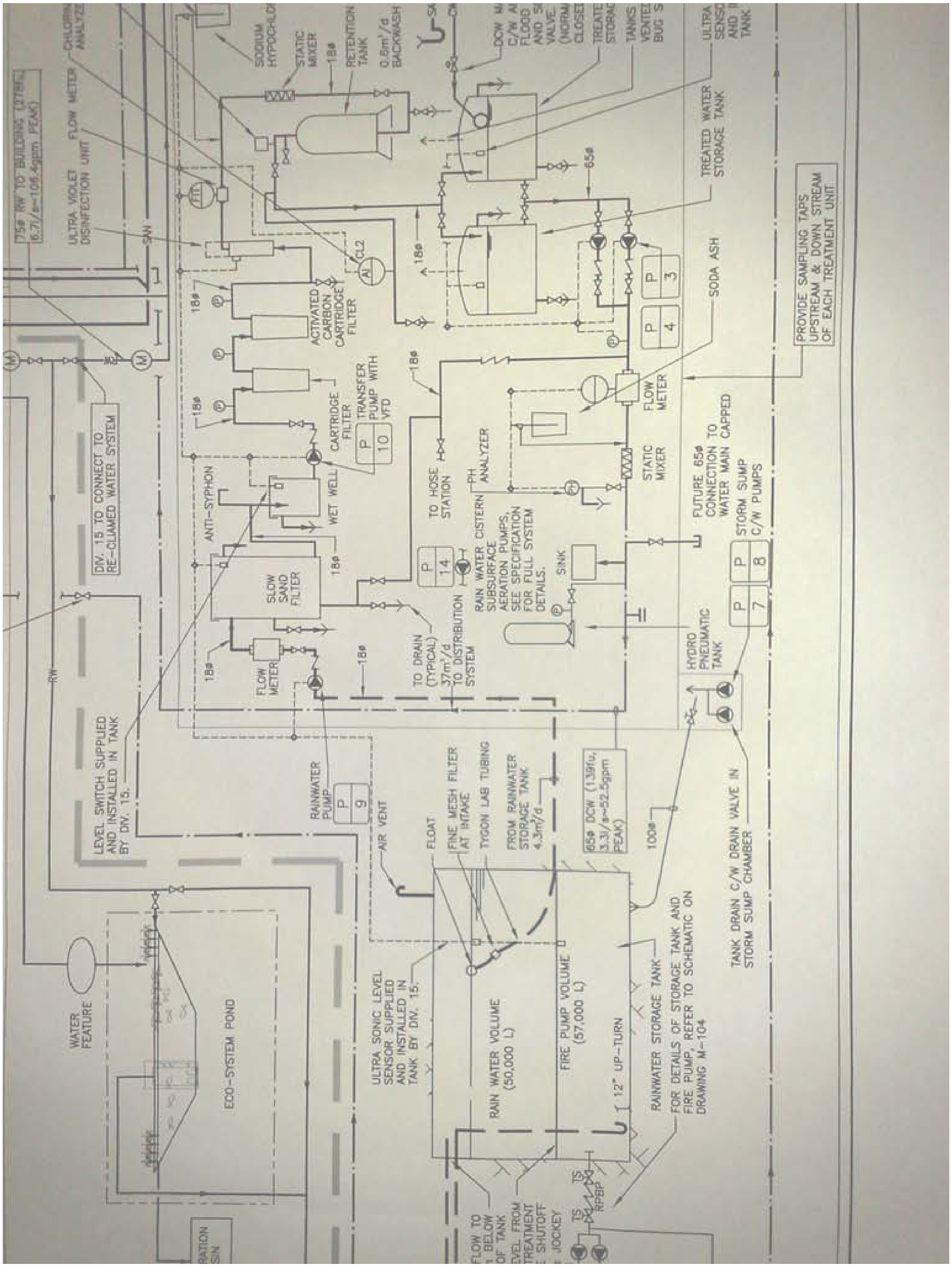
NA = Data not available

Appendix B – Schematic

B-1 Eco-Tek's Solarium System



B-2 Rainwater Collecion and Filtration System



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