UBC Social Ecological Economic Development Studies (SEEDS) Student Report

An Investigation into the Applicability of the CIRS Solar Aquatic Wastewater Treatment System at UBC Farm

Noah Joy

Peter Lillos

Steven Lam

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University of British Columbia

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Noah Joy
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Ahmad Chaaban

Faculty: Applied Science
Course: Applied Science 262
Instructor/T.A: Dr. Carla Paterson, Dr. Florence Luo (T2B)
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ABSTRACT

The UBC Farm is currently looking for a sustainable solution to treat storm water, grey water and black water to be used for irrigation, fertigation, toilet flushing, sinks and food preparation purposes. This report assesses the suitability of implementing the Eco-Tek Solar Aquatics System into the UBC Farm so that it becomes a one of a kind regenerative building. The Eco-Tek Solar Aquatics System is evaluated using a triple bottom line assessment, which addressed the environmental, economic and social indicators.

From an economic standpoint, the wastewater treatment system has energy requirements of approximately 200W/m^3 with energy costs of \$0.0177/m^3. The operating and maintenance costs for the system are approximately \$1.00/m^3. The capital investment for the system has been estimated at \$8000/m^3 of reclaimed water. The expected lifespan of the system is greater than 40 years; however the pumps should be replaced after 15 years.

In terms of the environmental indicators, the Eco-Tek Solar Aquatics System must minimize its chemical use with the exception of chlorine and lime (sodium bicarbonate). The system will integrate natural wetlands for use as a storage reservoir for the produced reclaimed water. Also, integrating a UV treatment aspect into the system reduces the risk of eutrophication.

Regarding social indicators, the UBC Farm will provide an educational experience for students and staff by demonstrating how design and construction can improve ecological health. Ultimately, this project promotes sustainable development for household, commercial and institutional applications.

As a result of the triple bottom line assessment, the Eco-Tek Solar Aquatics System proves to be an appropriate system for implementation at UBC Farm. The system meets satisfies contamination requirements and promotes sustainability, proving to be a viable option for the Farm.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

GLOSSARY

Black Water: wastewater containing fecal matter and urine. Also known as brown water, foul water, or sewage

BOD5: Biochemical Demand for Oxygen – it indicates the quantity of oxygen used in five days for the biological decay of the compounds present in water.

Coliform: of, relating to, or being gram-negative rod-shaped bacteria (as E. coli) normally present in the intestine

Drip system: Emitters are installed on low density polyethylene tubing to reduce the flow rate at the emission point to 2 L/hr.

Fixed Capital Cost: the capital necessary for the purchase and installation of equipment, all auxiliaries for complete process operation.

Grey Water: wastewater generated from domestic activities such as laundry, dishwashing, and bathing

Maximum soil water deficit: used to describe the maximum amount of water that can be stored by the soil within the plans rooting depth

Normal Irrigation period: the number of days in the year when irrigation is required due to a climatic moisture deficit occurring during the growing season

NTU: Nephelometric Turbidity Unit – a measure of clarity (turbidity) of water.

Pathogen: a specific causative agent (as a bacterium or virus) of disease

pH: a measure of acidity and alkalinity of a solution that is a number on a scale on which a value of 7 represents neutrality and lower numbers indicate increasing acidity and higher numbers increasing alkalinity

Reclaimed water: former wastewater that is treated to remove solids and impurities, and used in sustainable landscape irrigation

Sprinkler system: Laterals are permanently installed underground or on a trellis

Turbidity: Having sediment or foreign particles stirred up or suspended

1.0 INTRODUCTION

As the UBC Farm progresses towards the designing and constructing of a new farm centre, it's commitment towards sustainable design is being demonstrated by modeling the building as a regenerative living-lab. As part of this design, UBC Farm plans to build a wastewater treatment facility to capture storm water, grey water, and black water for use as a resource in sustainable and organic agriculture applications. One of the available designs includes the CIRS Solar Aquatic wastewater treatment system. This design is to be evaluated using a triple bottom line assessment which addresses economic, ecological, and social factors.

The overall budget for the new UBC Farm Centre is between 15 and 20 million. This budget is to include the costs of the wastewater treatment facility that UBC farm plans to move forward with. Currently there is $52m^2$ of workable land for the project. The wastewater facility is to take up approximately $20\text{-}30m^2$ of land. However, the usage of space within the building may change depending on the building's capacity. Based on these approximations, the triple bottom line assessment will be performed.

In the ecological assessment, the design addresses the health and safety of the end product in agricultural use. This involves addressing the contamination limits for a variety of chemicals within the system. Some of these contaminants may include estrogen levels, salts, endocrine disruptor levels, fecal coliform levels, heavy metal contamination, presence of antibiotics, phosphorous and nitrate levels.

In the social assessment, the design is to exemplify how careful design and construction can improve ecological health. The facility should also serve educational purposes by demonstrating that a Solar Aquatic System can satisfy the needs of an organic agriculture setting.

From an economic standpoint, the design should prove to require little maintenance during its operation. Equipment should be reliable and resilient while keeping capital costs to a minimum.

The following sections of the report address the suitability of the Solar Aquatic System with respect to the environmental, economic, and social factors.

2.0 INVESTIGATION

Prior to addressing the triple bottom line assessment of the solar aquatic wastewater system, it is important to characterize the system on the basis of contaminant regulations, process configuration, and general system requirements.

2.1 Contaminant Regulations

Contaminant regulations in British Columbia are set by the Ministry of Agriculture, Food, and Fisheries. The key effluents and parameters that must be monitored are: pH, BOD, turbidity, coliform, and pathogens. The following table summarizes the permitted usage, along with the treatment, effluent quality and monitoring requirements for Category 1 reclaimed water.

Table 1. Permitted Uses and Standards for Reclaimed Water (Ministry of Agriculture, Food and Fisheries, 2001)

Excerpted from Schedule 2 of the MSR – Permitted Uses and Standards for Reclaimed Water			
Category 1 - Unrestricted Public Access			
Permitted Uses for Irrigation	Treatment Requirements	Effluent Quality Requirements	Monitoring Requirements
Agriculture Food crops eaten raw Orchards and Vineyards Seed Crops Frost Protection Crop Cooling Pasture (no lag time for - animal grazing) **Urban and Landscape** Parks Playgrounds Cemeteries Golf Courses Road Right of Ways School Grounds Residential Lawns Landscape around buildings Greenbelts	Secondary Chemical Addition Filtration Disinfection Emergency Storage	pH = 6 – 9 ≤ 10 mg/L BOD_5 ≤ 2 NTU number of fecal coliform organisms ≤ 2.2/100ml Provider must demonstrate that reclaimed water does not contain pathogens or parasites at levels that are of concern to health authorities. Levels for metal and nutrient concentrations are governed by crop limitations at various growth stages where applicable.	pH – weekly BOD – weekly Turbidity – continuous Coliform - daily

The Eco-Tek system implemented in the CIRS building meets all contaminant regulations set in the "Guide to irrigation system design with reclaimed water." In order to meet the contaminant regulations, small amounts of chlorine are added to the reclaimed water before use. This is to ensure that pathogen levels are below regulated levels. The trace chlorine addition would not affect the UBC Farm in obtaining a certified organic rating (Standards Council of

Canada, 2011). Furthermore, Eco-Tek suggests that UV light is adequate to treat the reclaimed water, eliminating the chlorine addition.

2.2 Irrigation and Storage Requirements

In addition to the contaminant regulations in Section 2.1, there are requirements that pertain to specific irrigation methods. As a Category 1 reclaimed water system, any type of drip or sprinkler system can be used to water crops. Furthermore, there are regulations regarding crop root depth, soil texture, and irrigation requirements, which depend on the crops being planted. These requirements are based on the maximum soil water deficit (MSWD) because the amount of reclaimed water used for irrigation must not exceed the soil limitations. After determining which crops are to be planted, the appropriate requirements can be found on the irrigation factsheet.

In terms of storing reclaimed water, the storage facility should have the capacity to accommodate the design average reclaimed water flow occurring during the normal irrigation period. In the lower mainland the average irrigation period is approximately 140 days per a year. Based on the UBC Farms annual usage during the irrigation period, the storage facility would need to accommodate approximately 6 m^3 of reclaimed water. However, this estimate should be taken as a lower bound, as this does not account for the reclaimed water used by the planned UBC Farm Centre.

2.3 Process Configuration

The system that will be implemented in the UBC Farm will largely incorporate systems that have already been implemented on campus in the CIRS building. However, there are some systems that can be incorporated into the new UBC Farm system as it is being installed in an agricultural application. The farm is unique in that it contains natural wetlands which can be used as a water collection reservoir for irrigation and agricultural purposes.

To assess the functionality of a solar aquatic wastewater system, it is important to delve into a breakdown of the components that should be considered in such a system. This system should not only provide clean drinking water, but also provide irrigation water and the reduction of water consumption. The following flow chart illustrates the process that should be considered; however not every component is necessary for the functioning system.

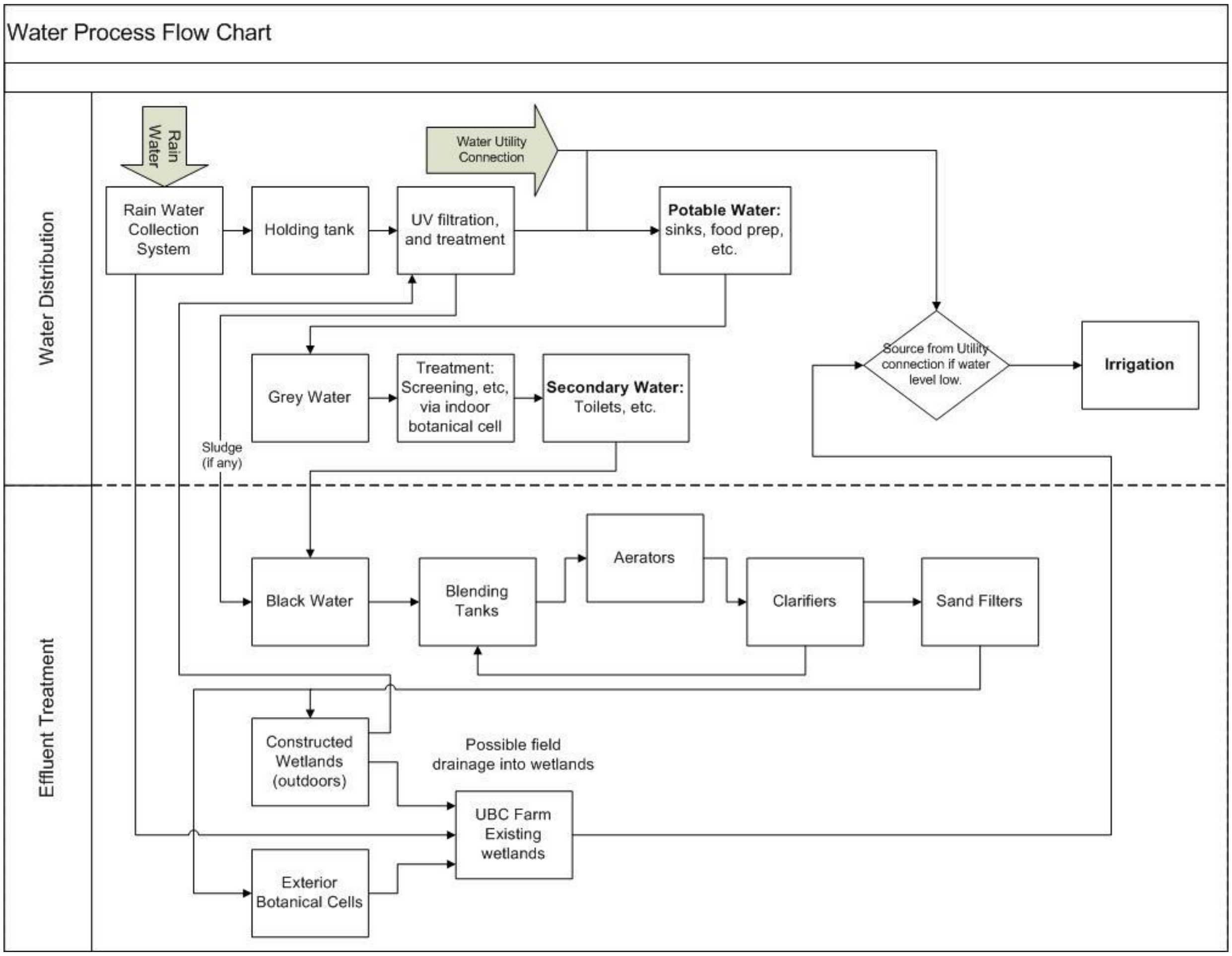

Figure 1. Solar Aquatics System Process Flow Chart

There are some systems which have been included to meet regulation requirements, such as UV filters, and some to reduce consumption from the utility such as the rain water collection. The flow diagram has been reduced into two groups, Water Distribution and Effluent Treatment. Not every component or process in this system requires large installations of equipment. Some may be as simple as piping, but others require holding tanks or other apparatus.

2.3.1 Incoming Water Sources

In a system that utilizes a utility water source, rain water collection, and reclaimed water, there is need for a dual input (source) for the system. In the flow diagram we see two arrows which indicate water coming into the closed loop system. These arrows indicate sources of water. If there is an inadequate amount of water that is reclaimed from the system, then the utility connection must provide water to supplement the source and ensure there is enough potable water to maintain satisfactory operation. In a climate such as Vancouver there is a considerable amount of rainfall during the year. Not every month may provide a sufficient amount of water to completely fulfill the requirements of the UBC Farm building and irrigation system. However as shown below in the annual rainfall from Environment Canada we can see that in the past year the rainfall has been in the range of 19.0 mm to 150.0 mm per month. The opportunity to include what can be deemed as an offset to using the utility water source may reduce the load on the municipal system. Once the area of the building is determined, an accurate calculation may be achieved for how much water can be provided due to rainfall.

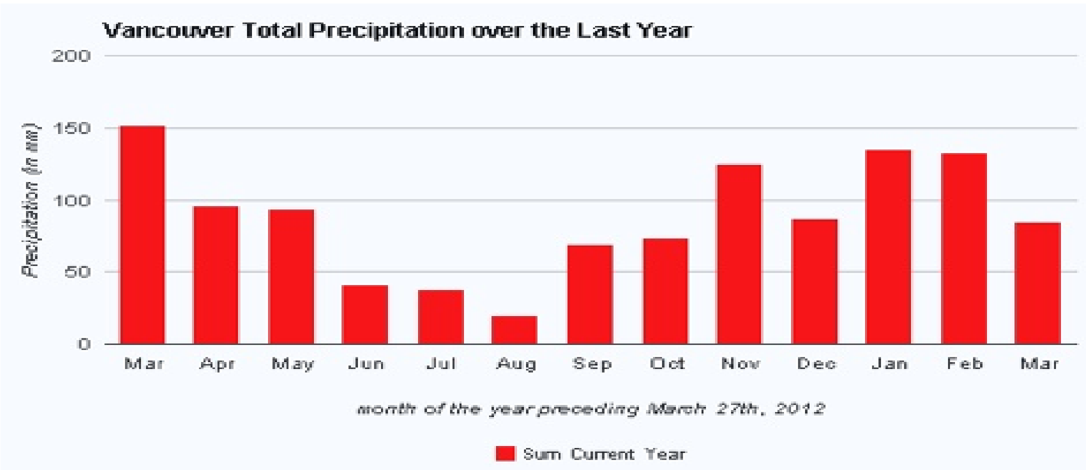

Figure 2. Vancouver Total Precipitation for 2012 (Vancouver Weatherstats, 2012)

There are several rain collection systems on the market. Barr Plastics is a local supplier of rainwater collection systems. One such system can be seen in Figure 3. A rainwater harvesting system consists of collection from the gutters, a holding tank for storage of excess water, a pump to put the water into the distribution system, and an overflow drain for when there is too much water. An accurate cost estimate cannot be determined until system size has been approximated as the system must be designed for a set capacity.

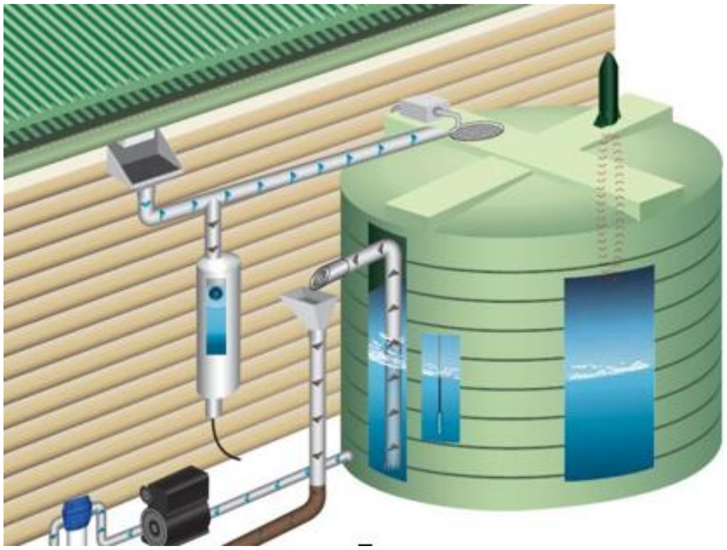

Figure 3. Barr Plastics Rain Water Collection System (Barr Plastics, 2012)

2.3.2 Greywater Use

A key aspect of this system is to reduce water consumption which will help reduce the water that must be processed by the system. To achieve a lower rate of consumption and increase system throughput, utilizing water more than once is a logical decision, but we must also determine the limits of its reuse.

The definition of grey water is water that has been primarily used but not come into contact with high levels of contamination. Common sources of greywater include sinks, showers, and laundry machines. This water may be allowed to be reused in certain applications such as flushing of toilets which has potential to reduce water consumption on average of 1.98 gallons per flush or 7.50 litres per flush (University of Arizona, 2000). Reducing water consumption on this scale will greatly ease the stress on the water system which can be detrimental in some parts of the world where water has a higher scarcity. As set out in the Municipal Sewage Regulations for British Columbia (Government of British Columbia, 1999), a greywater system of this type is defined as a “dual distribution system” where one part is for potable water and the other for non-drinking purposes.

In some parts of the world such as Queensland, Australia and California, USA, greywater systems are being constructed and examined for their benefits as well as their shortcomings. A group based in Oakland, California at the Pacific Institute conducted research into sustainable integration of grey water systems to aid sustainable water management systems. Their research included water from sinks being reused in flushing toilets, and treatment systems for the greywater. Treatment of the greywater in our process flow chart is done in the blackwater system. If there are deemed enough uses for greywater, mild treatment can be done to increase its use before it is put into the blackwater treatment cycle. Water reuse guidelines are on Health Canada's website (Health Canada, 2010) where it is stated that "At present, British Columbia is the only Canadian province to have enacted a reclaimed water standard (Municipal Sewage Regulation) for a variety of applications, including for toilet flushing and irrigation (Government of British Columbia, 1999)" (Health Canada, 2010).

A greywater reuse system may be as simple as distribution piping and a buffer tank to ensure there is an adequate amount for its intended uses, and as complicated as semi-treated water and held in a buffer tank. Costs for these systems vary as water reuse has been slow to be adopted in Canada due to the availability of low cost water sources (Health Canada, 2010).

2.3.3 Black Water

Black Water is defined as waste water containing fecal matter and urine. In our described system, black water is being sent into the effluent treatment system which consists of the reused greywater after having been run tough toilets and urinals. This combined dirty water will have to be run through he treatment process that will be described in the following sections.

2.3.4 Effluent Treatment

The solar wastewater treatment system implemented at the UBC Farm will be based on the ECO-TEK system currently installed in the CIRS building. The following section outlines the key features of the ECO-TEK system, as well as provides a description of the effluent treatment.

2.3.5 Process Description

Stage 1: Collection/Buffer Tank

The wastewater treatment system collects all the wastewater accumulated in the CIRS building. During times of lower occupancy, wastewater is also collected from the campus sewage system.

Stage 2: Blending Tank

Sewage is transferred to a closed tank where the bacterial digestion begins of biological waste. The tank is constantly aerated to increase the contact area between the bacteria and waste. Aeration also contributes to the rapid reduction of odours.

Stage 3: Aeration Tanks

The bacteria along with wastewater is transferred through a series of aeration tanks. These tanks are open-lid and the surface is populated with regionally acclimatized aquatic and terrestrial plants. The plants contribute by absorbing small amounts of nutrients from the sewage as well as the processing of carbon dioxide. However, most of the treatment process is done by bacteria which exist on the root systems below the surface. The roots serve as an ideal habitat for the bacteria. Water in the tank is continuously aerated to promote contact with the bacteria of the root systems. The sewage serves as food for the bacteria to grow and thrive. The aeration process increases the availability of nutrients for reuse. Ammonia content from urine is converted to nitrate and phosphorus becomes more soluble.

Stage 4: Gravity Clarifier

Preceding the aeration tanks, the water is sent to a gravity clarifier which is a cone-shaped tank with no air supply. Here, the bacteria (sludge) settle to the bottom through sedimentation. The water is deemed clarified and the bacteria is recycled to the blending tank at the beginning of the process.

Stage 5: Sand Filter

Clarified water is transferred to the sand filter which serves to remove any tiny particles in the water. This stage is designed to mimic how water filters through a column of soil.

Stage 6: Constructed Wetland

Water travels through a constructed wetland which serves to remove fecal coliform and some metals. This is done via contact with bacteria and plants.

Stage 7: Ultra-Filter

The ultra-filtration system is a system consisting of screens containing micron fibres which serve to filter the water to a very high degree.

Stage 8: Disinfection

The disinfection process is a two-stage process. Water is first exposed to ultra-violet light to kill the remainder of pathogens. Water is then exposed to a residual amount of chlorine.

Stage 9: Storage and Re-use

After the process has completed, reclaimed water is cycled to storage tanks which serve as reservoirs for the CIRS building's clean water supply. The water is used for irrigation and toilet/urinal flushing. Water that has been flushed re-enters the system for treatment.

Stage 10: Compost (future development)

Over the course of water treatment, an accumulation of bacteria (sludge) will colonize within the system. A composting process is to be implemented which will remove and reuse the sludge. The sludge is rich in nutrients and can be absorbed by plants and returned to the biosphere. Currently, the CIRS system is removing their sludge; however, a composting process is likely to be implemented via the collaboration of students and researchers.

The following figure reveals the configuration of the current CIRS Solar Aquatic Wastewater Treatment System:

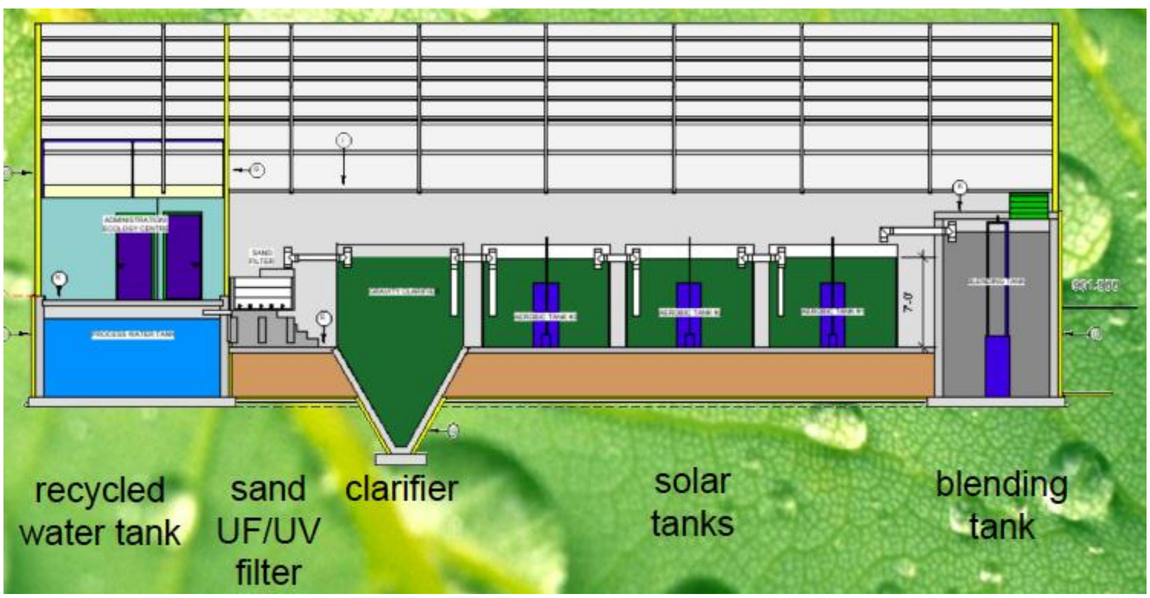

Figure 4. ECO-TEK Process

2.3.6 Botanical Gardens and Constructed Wetlands

After consulting with the CEO of ECO-TEK, Kimron Rink, he revealed that the constructed wetlands component of the system does not have to be contained indoors. The constructed wetlands component may be an adaptation from the naturally existing wetlands surrounding the UBC Farm.

3.0 SYSTEM REQUIREMENTS

The wastewater treatment system has many requirements to which it must meet. These requirements fall under a few main topics including producing the amount of water required per day, ensuring reclaimed water is up to regulations and standards, using and requiring minimal energy and maintenance and being carbon neutral. An analysis of each topic is stated below.

The reclaimed water produced from the system is to be used for toilet flushing, drinking, food preparation, sinks, irrigation, fertigation, struvite extraction and closed-containment fish rearing ponds. The system must produce the sufficient amount of water for the uses stated above. However, the system will include a tap into UBC's main water utility as a last resort when sources are low or in case of emergencies.

The reclaimed water must be up to par with those set by the Government of British Columbia: Ministry of Agriculture, Food and Fisheries which can be found in Table 1. As seen in Table 1, the pH must lie in the range of 6-9 and must contain less than 10 mg/L BOD5 which must be checked weekly and initially proven to health authorities (Ministry of Agriculture, Food and Fisheries, 2001). Also, the treated water must not exceed more than 2.2/100mL of fecal coliform organisms which is checked daily and has to contain less than 2 NTU and must be continuously monitored (Ministry of Agriculture, Food and Fisheries, 2001).

If this system is to be sustainable, it has to consume as little energy as possible. Currently, the Eco-Tek systems operate at $200W/m^3$ or 0.2w/L of reclaimed water with the majority of the energy being consumed in the aeration process. With any system containing mechanical parts, it is going to have to be inspected and maintained frequently to ensure quality and standards are met. To minimize this, the system is kept simple but also utilizes concepts such as storing water in UBC's wastelands as opposed to constructing a holding tank. In terms of replacing equipment, pipes should last over 40 years, pumps around 15 years and holding tanks approximately 25 years. Having staff and students working at the UBC Farm that understand how the entire wastewater treatment system works also helps keep maintenance costs low if something simple needs to be resolved.

A net zero carbon foot print is to be maintained by this system, meaning that all carbon emissions released must be accounted for and an equivalent amount put back into the UBC Farm.

4.0 ECONOMIC INDICATORS

The following section discusses the economic aspects of incorporating the Eco-Tek waste water treatment system at UBC Farm. More specifically, the Eco-Tek system will be assessed based on it's life-cycle financial cost, as well as it's expected system lifespan.

4.1 Total Life-Cycle Financial Costs

The main costs associated with implementing the Eco-Tek system are the capital investment and operating costs. The fixed capital costs include the purchase and installation of all equipment including all auxiliaries for running and maintaining the system. The operating costs consist of the total energy and maintenance costs necessary for implementation. However, by utilizing the Eco-Tek system to reclaim grey and black water, the UBC Farm is able to decrease costs associated with purchasing water from the grid. Table 2 below shows the capital and operating costs of the Eco-Tek system, as well as the cost benefits associated with the water savings. The calculated costs are based on a system requirement of 6 m^3 reclaimed water per day and an annual usage of 500 m^3. The estimated annual usage is based on UBC Farms current irrigation water usage. The annual operating costs and savings are based on current BC Hydro and City of Vancouver rates (City of Vancouver, 2011).

Table 2. Total Life-Cycle Financial Costs.

	Capital Costs ($)	Operating Costs ($) Annual	Savings ($) Annual
Eco-Tek System	$48,000	Electrical: $1770 Maintenance: $500	Water: $440

In the following table on the economic analysis of the waste water system, an estimated savings has been calculated taking into consideration reclaimed water being used in only toilet flushing. The numbers used are from Environment Canada and based upon annual Canadian averages. In our assessment, we examine water usage for an individual as not including laundry or showering and only for eight of the twenty four hour day. As we can see, reduction of flushed water usage by 50% leads to a 33% savings in water consumed from municipal sources.

Table 3. Daily Economic Analysis of Waste Water System Use

Daily Economic analysis of waste water system		
	AMOUNT	
	without reclamation	With Reclamation
Average canadian water consumption per day (litres)	343.00	
Water usage breakdown:		
toilet	30.00%	15.00%
cleaning	5.00%	
laundry	20.00%	
showers	35.00%	
kitchen and drinking	10.00%	
typical municipal water price per litre ($)	$0.0008	
average work day (hrs)	8.0	
estimated canadian business day water consumption (L)	51.45	34.30
size of building (people)	200	
amount of water daily consumed in building (L)	10290	6860
daily cost of building water supply	$8.23	$5.49
Savings	0%	33.33%

Reclamation costs have been considered and estimated based on a 200 person building. Capital cost estimates and energy costs are provided as rough estimates from Eco-Tek. When considering the scalability of Eco-Tek's Solar Aquatic System, Kimron Rink suggests that the costs of the system on a per litre basis will decrease as the size of the system increases. From a financial standpoint this is very positive as the UBC Farm solar aquatic system is likely to be substantially larger than the CIRS Eco-Tek wastewater treatment system. The lifetime of the system varies on different components however for the estimate we will only consider a total system lifetime of 40 years and will not be including O&M costs as they vary in applications. BC Hydro rates were determined from peak rates as given on their website for 2012.

Table 4. Estimated Reclamation Costs

Reclamaition costs (for 200 person building)	
Capital cost of system($/L)	$8.00
Lifetime (years)	40
daily amount of capital cost	$5.6384
energy required per L (W)	0.2
BC hydro commercial rate ($/KWh)	$0.0878
estimated energy cost per litre	$0.000018
estimated cost per person per day	$0.029
estimated cost for reclamaiton per day (including capital cost)	$5.82

4.2 Expected System Lifetime

The Eco-Tek system lifespan is dictated by the equipment lifetime. According to Kimron Rink, CEO and President of Eco-Tek, the main system components that must be replaced are the pumps, tanks, and piping. The tanks and piping are projected to have lifespans of over 40 years, while the pumps require replacement after approximately 15 years. If this system is implemented new pumps can be purchased after the previous pumps have surpassed their useful lifetimes. Futhermore, all systems components are unique entities and can be removed for upgrading or downgrading the system. In the case of component removal, all entities are salvageable and can be used for alternative applications after the system lifetime.

4.3 Economic Conclusion

In Section 4.1**,** the Eco-Tek system was investigated in terms of its life-cycle financial costs and the expected lifespan of the Eco-Tek System. The system has an expected lifespan of over 40 years, but will require the replacement of pumps after approximately 15 years. In consideration of the fixed capital cost as well as the annual operating costs, it is evident that the water savings are not adequate to recover the fixed capital investment. However, by implementing this system, the UBC Farm is able to create a living lab for educational demonstrations, a benefit that cannot be quantified. Furthermore, this system acts to promote sustainable design, and further solidifies UBC's position as a global leader in sustainable developments.

5.0 SOCIAL ASSESSMENT

The social factors in the consideration for a water treatment are critical, as it is the social factors that will determine the success of the system, as well as the embracement of it by users and the public. The indicators studied in this report are the student experience, the public perception, and the adoptability by different market sectors.

5.1 Student Experience

A solar aquatics system is well suited for showcasing to students and visitors to the UBC Farm. The system's simple, linear layout allows the system to either be arranged compactly, or in an easily presentable fashion. Potentially, the system could become wall mounted or contained within a scaffolding structure to reduce the amount of floor space used, while still being able to easily showcase the different unit operations.

The benefits for making a system accessible to students and visitors is to be able to showcase new and sustainable technology to influence or inspire designers, contractors, and investors to incorporate the same or similar systems into their own designs and buildings. Additionally, a successful process with the appropriate documentation can be used by politicians to prove the efficacy of the system, and update current regulation to make implementations of future systems in Vancouver, BC, Canada, or other places in the world easier.

5.2 Public Perception

A study by Dolnicar (2006) found that over half of the public surveyed were not interested in using wastewater-derived reclaimed water in such uses as food preparation and drinking (p. 4). However, a high percentage of people were willing to see reclaimed water used in applications where the water was not in high amounts of contact with the people consuming the water, most notably of which was irrigation. Higgins et al. (2002) found that the primary concerns of water users were microbial and chemical content of the water (p. 5055). Dolnicar's own results identified the primary concerns to be health risks from using reclaimed water.

Survey respondents also expressed the following about the benefits of using reclaimed water. Dolnicar finds that respondents are aware that using reclaimed water was more environmentally friendly and cheaper than using desalinated water (p. 5). Also, the costs of reclaimed water is known to be significantly less than the cost of desalinating water, reduces wastewater release to the environment, and is environmentally responsible (p. 6).

The public perception of recycled water favours usage in situations such as firefighting and irrigation, where the water is not necessarily directly consumed by people. As seen in Figure 5, the public perception favours uses of recycled water that has uses perceived as being less involved with individual contact. Using recycled water in public spaces such as irrigation and firefighting receives greater than 70% approval, but even using water in personal situations such as washing a car brings approval down to 63%. Toilet flushing remains at 77% approval, however, identifying an important use for recycled water. Using recycled water for toilet flushing has the potential to create a closed loop or nearly closed loop system where no or low amounts of external water sources are needed to create water for flushing. When recycled water becomes used for consumption, has the potential for consumption, or has close contact with users, the approval rating drops below 30%.

A solar aquatics system is ideally suited for the UBC Farm because the primary use for reclaimed water is to use it for irrigation purposes. The water can also be used for the secondary purpose of toilet flushing. Provided the solar aquatics system is designed to reduce pathogens to safe levels, the water can also be used for personal usage, at the discretion of the UBC Farm personnel.

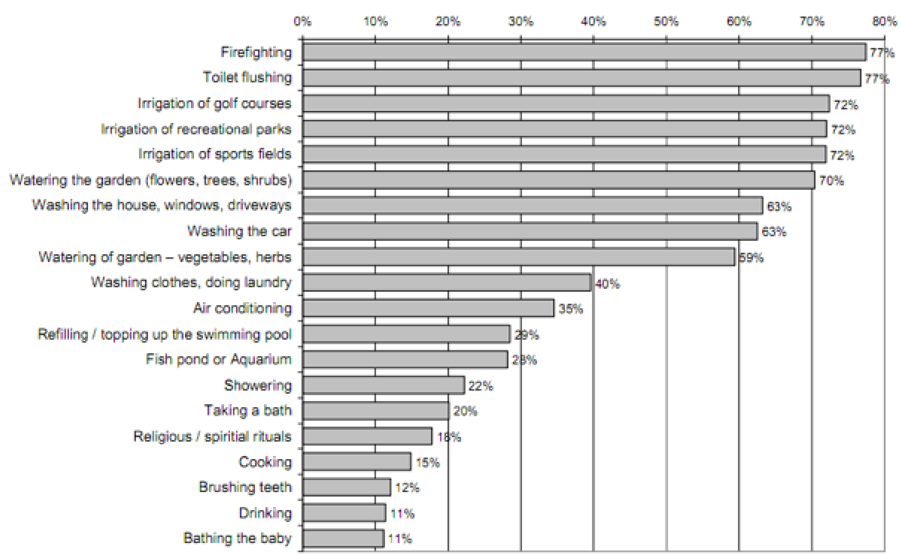

Figure 5. Recycled Water: Comparative Uses (Dolnicar, 2006)

5.3 Residential Adoption

As mentioned in the previous section, the use of reclaimed water in a non-potable setting is more likely to be approved of by users than in potable water usage. Recycled water would face the least opposition for use in non-potable residential settings such as lawn sprinkler systems, and toilet flushing. To minimize cross contamination, the use of a dual-distribution system is recommended, along with a campaign of customer education is recommended (AMMA, 2009, p. 77). New homeowners will be educated at installation and regularly through water bill stuffers, and public education campaigns to consult an expert before making modifications or repairs to their water systems. Further adoption in the residential sector can be improved through public education to improve the image of reclaimed water.

5.4 Commercial Adoption

In commercial settings, water is primarily used for toilet flushing, landscape irrigation, and air conditioning. In these applications, the use of reclaimed water will be beneficial to the sustainability of a building and the environment. Additionally, the construction of the building, particularly the water used to create concrete, can come from reclaimed water sources. The reclaimed water should be marked as such to notify users of the source of the water.

Municipalities may also use the water for landscape irrigation. It is not recommended to use the reclaimed water in a lake or pond, as the high nutrient levels combined with low aeration and high retention times may lead to eutrophication.

5.5 Industrial Adoption

Provided that the water required for an industrial process does not need to be chemically pure, the use of reclaimed water can significantly reduce the amount of natural sources of water used in these processes. The water systems will have to be kept separate from other water sources, and marked as such. The advantage of having reclaimed water in industrial systems is that the water distribution system will likely already be set up in a way that it becomes simple to segregate different water sources, and that industrial systems will likely have the space to implement their own water treatment facilities. Industries will have to assess on a case by case basis whether or not reclaimed water is appropriate for their uses.

Agricultural use of reclaimed water is more beneficial than even that of using fresh water sources, due to the nutrient content of the water. The recycling of the nutrients in the water means that less fertilizer will have to be used by farmers, reducing the risk of highly nutrient-laden water entering natural sources, which may lead to eutrophication.

6.0 ENVIRONMENTAL INDICATORS

There are several impacts to consider when conducting a triple bottom line assessment on adopting the Solar Aquatics System in the UBC farm development.

Currently, potable water is supplied to the UBC campus through the municipal water distributions system. The wastewater from campus is transported through the municipal wastewater distribution system to the Iona Treatment plant prior to disposal in the Straight of Georgia. By incorporating this system, the UBC farm will reduce the demand for potable water from the municipal supply, as recycled rainwater (over 1,100 mm per year) will be used throughout the building. In addition, the wastewater will be treated on site and reused through various applications on the farm, thus minimizing the transportation of waste. The collected wastewater is full of nutrients. The wastewater treatment process will extract these nutrients and redirect them to the plants and generates “clean, nutrient dense water to be used for irrigation”.

The Solar Aquatics design attempts to minimize the use of artificial chemicals and processes’ and integrates existing natural process’s found in the environment to purify the waste water. The wastewater is run through a sand filter to remove some small deposits. This process acts similar to water filtering through a column of soil in a natural environment.

The ideal scenario of incorporating the Solar Aquatics system in the UBC farm would enable the use of the farm wetlands as a storage and filtration medium. The current Solar Aquatics design incorporates a “Constructed Wetland” environment as a natural process to remove fecal coliform and some residual metals. The treated wastewater is rich in nutrients and thus would enable plant growth around the wetlands. The UV treatment would reduce the risk of eutrophication by killing remaining pathogens present in the treated wastewater.

In addition, the Aeration Tanks in the Solar Aquatics system incorporate “acclimatized aquatic and terrestrial plants” to process the wastewater. The plants process the CO2 and consume the nutrients in the waste. However, most of the purification is don’t through the bacteria. The roots of the plants offer ideal living conditions and a habitat for the bacteria. The bacteria absorb the sewage/human waste as a source of food. The procedure offers a chemical free natural process to reuse the nutrients and produce clean water in a self-sustainable, environmentally friendly method.

By integrating the wastewater management system, UBC farm is also able to minimize the environmental impacts of staff, students and visitors in the new building.

7.0 CONCLUSION AND RECOMMENDATIONS

The UBC Farm has the ability to become leaders in sustainable buildings for agricultural practices by implementing a wastewater treatment and reclamation system to treat storm water, grey water, and black water. The system that has been implemented in the CIRS building by Eco-Tek meets many of the criteria set forth by the UBC Farm and meets local and federal regulations regarding water treatment and reuse. It is capable of maintaining a pH level between 6-9, contain less than 10 mg/L of BOD5 and does not exceed more than 2.2/100 mL of fecal coliform organisms. Water reuse by distributing water at various points in its lifecycle and using reclaimed water for toilet and urinal flushing has the capability of providing approximately 33% in water savings from the utility.

Social indicators reveal that while people are generally uneasy regarding the thought of drinking reclaimed water, they embrace the thought of reclaimed water being used in other processes such as toilet flushing and irrigation. A completed system that is used in an educational setting like the one proposed for the UBC Farm is capable of educating not only students but other members of the community as well. Even politicians may wish to modify or create legislation to enable the creation of similar wastewater treatment systems. The experience at the Farm will be enriched by inclusion of such a system.

Economic indicators show the costs of the system will be an estimated $8 per litre of water that is processed. The energy costs are $0.000018 per litre of water processed. The system has an expected lifespan of over 40 years, but will require the replacement of pumps after approximately 15 years. Many factors will help in reducing the capital cost of the system such as building design and equipment selection.

Environmental indicators reveal that the instillation of wastewater treatment facility at UBC farm will reduce the demand for potable water from the municipal supply, as recycled rainwater (over 1,100 mm per year) will be used throughout the building. In addition, the wastewater will be treated on site and reused through various applications on the farm, thus minimizing the transportation of waste. The collected wastewater is full of nutrients which will be directed to plants to create an enriching environment. The Solar Aquatics design minimizes the use of artificial chemicals. The current Solar Aquatics design incorporates a “Constructed Wetland” environment as a natural process to remove fecal coliform and some residual metals. The treated wastewater is rich in nutrients and thus would enable plant growth around the wetlands. The UV treatment as well as natural sunlight would reduce the risk of eutrophication by killing remaining pathogens present in the treated wastewater. The roots of the plants offer ideal living conditions and a habitat for the bacteria. The bacteria absorb the sewage/human waste as a source of food. The procedure offers a chemical free natural process to reuse the nutrients and produce clean water in a self-sustainable, environmentally friendly method.

Recommendations are for the UBC Farm to adopt such a system and make the necessary modifications for reducing water consumption. Inclusion of rain water collection and reclaimed water storage in the form of wetlands will reduce the impact that the UBC Farm has on the municipal water supply and reduce the consumption of chemicals and energy. Upon implementation of this system, the UBC farm should challenge the regulation requirement of using chlorine in order to meet the guidelines provided by the Ministry of Agriculture, Food, and Fisheries as its use will be precautionary and not necessary.

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