Rainwater Harvesting - Replacement to Municipal City Water

Hina Tariq, Angelin Satgunarajah, and Amna Tariq

Abstract. The rainwater harvesting system designed for Linamar Corporation provides 38 m^3 of water per day and reduces the city water consumption. Sensitivity analysis was performed using the tank cost and the daily consumption which is affected by the amount of area used. The optimum range was between 30 m^3 to 40 m^3 and a 38m^3 tank was selected to meet high demands for some months. The system meets 66% of the total demand while the remaining is fulfilled by City water. Budget for this project is kept under 30K, which provides a payback period of 2 years and a return on investment of 61% in the first year. Various cost savings in this project includes reduction in water bills, softening costs and storm water discharge costs.. . .

Key words: Biocide, Catchment Area, Centrifugal Pumps, Filtration, First Flush, Optimization, RainCycle,Rainwater Harvesting, Reverse Osmosis, Storm Water,

1 Introduction

A Rainwater Harvesting System is designed to replace costly city water supply with rainwater. Automotive part producing factory, Linamar CAMTAC has provided us with a problem of reducing their utility bills by showing interest in a Rainwater Harvesting System. Linamar CAMTAC has constrained the design to deliver 975 m^3/month or atleast a significant amount for the manufacturing purposes. The budget for the entire project must not exceed $30, 000 CAD. Water Consumption data provided for year 2006 and 2007 is used to represent the coming years because it is current and best represents the usage trends. Also to keep the project cost effective, the optimized tank size and the selection of major components were analyzed for the environmental and economical factors. Strict by-laws are to be followed, therefore, fixtures such as solenoid valve, backflow preventers, excavation permits are considered (By Law Number (2000) - 16352). Rainwater harvesting is needed to meet the high demand for water in industrial use. Linamar Corporation has provided a constraint of limiting utility costs for water and for discharging waste water into the storm water sewer. The solution to this problem collects rainwater from the existing roof of 200,000 m^2 of area and drains through internal pipes from where it is filtered stored and distributed. Since rainwater is naturally soft and Guelph water is hard, softening cost will be reduced by this system. The rainwater will be collected at the four discharge points that lead to the storm water sewer.

2 Conceptual Design/Methodology

The basic approach to carry out this design includes the use of the existing roof as the catchment area to capture as much rain as possible. The rainwater is carried through internal pipes located within the plant and sent to bypass a first flush unit to eliminate initial rain contaminants. The 300 gallon First Flush unit directs the water to a 38 m^3 concrete tank installed underground. The tank uses a centrifugal pump to move the water through the RO unit to meet the water quality standards. The analysis performed does a hydraulic and financial assessment on the system taking into account all the parameters and components mentioned in this design. Concrete tanks are the ideal option for underground installation since they are reliable, durable and come in various sizes. Unit Precast provides CSA approved concrete tanks in varying sizes [2]. The optimized tank size of 38 m^3 is to be used to meet the daily consumption of 32 m^3. These concrete tanks are maintained at CSA B66- 05 standard, required by Ontario building code [3]

2.1 Overall Design

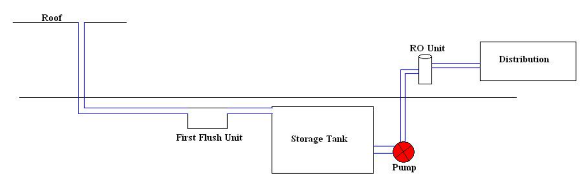

Fig. 1. Design Components

3 Design Components

Catchment Area: precipitation collection point.
Storage Tank: Design uses a 38 m^3 underground concrete storage tank to meet daily consumption of 32 m^3. From the sensitivity analysis, the optimum tank size ranges from 30 m^3 to 40 m^3 and since demand is highest in March of 37 m^3 a 38 m^3 tank should be ideal Concrete tanks are durable, inexpensive and recommended for industrial use. Storage tanks are best suitable when installed underground because the freezing factor can be omitted when installed atleast 5 feet undergound.
Centrifugal Pump: ideal for rainwater harvesting because they provide a wide ranges of heads and flow rates.

Pedrollo pumps can be purchased for $500.00, which provides 18 GPM at 65 feet maximum.
First Flush Unit: Filtration component that treats the first 15 minutes of rain event, which carries debris, bird droppings and other contaminants present at the roof surface.
Floating Suction Fine Filter: pumps water from the surface to avoid sediments.
Automatic Switching: between city water and the rainwater. When the tank reaches a minimum level, city water can be triggered to fulfill the remaining demand.
Calmed Inlet: Prevents disturbance of settled sedimentation layer and therefore helps provide clean water out of the floating intake.
Solenoid Valve: a direct lift solenoid valve is used. To open orifice, it receives an electrical signal and allows fluid to bypass and to close orifice, valve is de-energized.
Double Check Valves: backflow prevention device, used for avoiding city water contamination.

4 Discussion

The total precipitation that can be collected is 14292.35 m^3/ year, which is greater than the yearly consumption of 11695.57 m^3. But losses need to be considered, which can be due to the material of the catchment area producing runoff and losses the filtering process. The catchment area is made of gravel, rock and tar, which produces a large amount of runoff. It can be assumed that the runoff coefficient would be in the lower range of 0.60-0.90 [1]. Therefore, it is safe to assume that the runoff coefficient will be 0.60. This means that only 60% of the precipitation will be collected through the internal pipes and the remaining 40% is lost due to evaporation.

After the losses are accounted for, the total amount of precipitation that can be collected reduces to 8575.40 m^3/year. The second loss factor being filtration, it may not be a major cause of loss but can be significant for larger (industrial) systems. 0.90 is a safe value to assume for the filter coefficient, which means that 90 % of 8575.40 m^3/year enters the storage tank. Ultimately, 643.16 m^3 of precipitation is collected per month after all the losses have been taken into account. Having calculated the total demand of 11695.57 m^3/yr and total amount of precipitation provided of 7717.90 m^3/yr, the calculated efficiency results in 66%. Therefore, the efficiency interprets that 66 percent of the demand can be met through this design.

The total cost of the design is approximately $22, 000, excluding the maintenances costs over the following years. Linamar CAMTAC pays for the municipal city water supply, which requires softening. Rainwater harvesting overcomes the need for softening, reducing their utility bills. Currently, the charges for city water supply are $1.72/$m^3$, which results in $20, 200 per year for City Water. And city water requires softening which is an estimated cost of $1000/month as stated by Linamar, totaling to $12, 000 per year. The resulting payback period is of 2 years, which interprets that 2 years are required for the return on the investment (Rainwater Harvesting System) to ”repay” the sum of the original investment of $25, 000.

5 Conclusion

The designed outlined in this report is very simple and under the budget limit of $30, 000 CAD, which makes it cost effective. The rainwater harvesting system is designed using all the basic components: catchment area, storage tank, first flush unit, PVC pipelines, and centrifugal pumps to capture, filter and distribute the rainwater. The system meets 66% of the overall demand, thereby reducing the utility bills of municipal city water supply and completely omitting the need for softening. The return on investment is calculated to be within 2 year. The critical parameter in this design is precipitation and errors regarding this parameter can have significant impact on the system performance. It is recommended to use daily precipitation data to provide more accurate results. The sensitivity analysis was used to decide an optimum tank size of 38 m^3, which from selected from an optimum range of 30 m^3 to 40 m^3. The selection was based on the daily consumption, which is highest in March of 37 m^3 and lowest in December of 25 m^3.

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