Rainwater Harvesting System for a Commercial Building in Guelph

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Abstract. Rainwater harvesting is an effective way to reduce the cost associated with water drawn from a municipal supply by replacing municipal water with collected rainwater. An optimum rainwater harvesting system was designed for a 220,000 ft\(^2\) manufacturing plant in Guelph for this purpose. The system was chosen using sensitivity analysis to find the shortest return period, which was determined to be 6.5 years. This system collects rainwater by individually tying into the pre-existing roof downspouts from 25% of the roof, piping the collected water to two 5,000 gallon cisterns for storage, and then pumping the water through a treatment unit. The total cost associated with the system is $22,000.

Key words: Cistern design, Commercial applications of rainwater, Rainwater harvesting

1 Introduction

Rainwater is a valuable and useful source of water as it naturally soft, has a near neutral pH and is free of salts, minerals and man-made contaminants [2]. With increased concern regarding reduction in groundwater levels and the increasing cost of municipally supplied water, many residents, institutions and corporations are considering rainwater harvesting as a viable solution for water supply. In the case of the client, a 220,000 ft\(^2\) manufacturing plant that uses an average of 6,454 gal/day of municipally supplied water, the potential cost savings from an effective rainwater harvesting system could be significant.

2 Design Process And Analysis

The design process was conducted over a 12 week period in which the optimum system was designed to give the shortest return period for the project. To do this, a sensitivity analysis was conducted to determine how the size of the cistern and the collection area are related to the return period on investment. The costs of the system are broken down into three parts, the rainwater treatment system, the cistern cost, and the piping and associated material cost. The costs of the the treatment system and the different sized cisterns were priced out and thus known; however, the piping costs were estimated based on the size of the collection area being tested. At this stage it was deemed reasonable to approximate the piping costs, determine the optimal system configuration and calculate the actual piping cost and payback period later. The system savings are broken down into two components, the amount of money saved due to reduced water consumption from the city, and the amount of money saved on water softening costs. The amount of potential water that could be collected from the system is determined in the sensitivity analysis which utilized meteorological data from the Guelph Turfgrass Institute [1] for 56 years. The results of this sensitivity analysis are shown in Figure 1.

From this analysis it was determined that the optimum size of cistern was 10,000 gallons with a corresponding utilized roof area of 55,000 ft\(^2\). As seen in Figure 1, this system will give the project an estimated payback period of close to 4 years.

Once the optimal system configuration was determined, the exact system cost was calculated and the actual payback period was found to be 6.5 years. Because the actual payback period was significantly higher than the 4 years predicted with the estimated piping costs, additional testing was done to ensure this was in fact the best system configuration. It was found that increasing the initial piping cost estimate increased the payback period of all system configurations fairly uniformly. Therefore, even though the payback period was inaccurate, the final design configuration selected was in fact the optimal one.
3 Final Design

To collect the rainwater, 9 of the existing 35 downspout pipes will be cut into and fitted with additional 4 inch PVC pipes that divert the water to a main installed near the ceiling. The main is initially 4 inches in diameter but will increase to 6 inches and ultimately 8 inches as it approaches the cistern so as to be able to handle the rainwater from all 9 downspouts. An 8 inch main is sufficient for the expected flow from all 9 downspouts based on the current plant roof drainage system which consists of four 8 inch mains below the plant four, each fed by 9 downspouts. This water diversion system can be seen in Figure 2.

The water main will feed the collected rainwater to two 5,000 gal polypropylene cisterns for storage. Two cisterns were chosen instead of one 10,000 gal cistern due to space limitations and also because it was cheaper to buy two 5,000 gal tanks instead of one 10,000 gal cistern. An overflow line has been attached to each cistern which connects back up to the existing storm water line beneath the plant floor. An automated float switch connected to the municipal water supply maintains a minimum water level in the cisterns during periods of no rain. This ensures that the water treatment unit, especially the UV light, are not run dry as recommended by the supplier of the treatment unit.

Water treatment equipment is necessary to ensure that the rainwater is of an acceptable quality to be fed into the in-house 5 gpm Reverse Osmosis treatment system. The treatment system includes two filters of different pore sizes, a 20 µm to remove coarse particles in series with a 5 µm to remove fine particles. The filtered water is then treated with a UV light to remove biological contaminants. This treatment system is a self contained unit where filters can easily be replaced when required. Furthermore, it should be noted that the high level of treatment afforded by the treatment unit potentially could allow removal of the RO unit saving the plant even more money. Of course this would have to be properly investigated but it might prove fruitful. An overview of the overall system is displayed in Figure 3.

4 Conclusion

The total cost of the entire system (not including installation labour) was calculated to be $22,000. Taking into consideration the savings, this represents a payback period of 6.5 years. While not an ideal return period, the return on investment was calculated to be 20.1% for an estimated life of 20 years. Therefore, despite the undesirable return period, this system is still an economically advantageous design and should be implemented. Further benefits may include government tax exemptions and RO machine redundancy which potentially could significantly improve the financial benefits of the design.

Acknowledgements

Blue Sky Consulting would like to personally thank the staff and employees at Linamar’s CAMTAC plant for their cooperation especially Mike Minogue, CAMTAC’s supervising engineer, for all information and data essential for this design. Special thanks also go to Professors Lubitz and Moussa for their help and patience.

References