Industrial Rainwater Harvesting Design for Guelph Area

Laura Doody, Lana Kwan, and Christopher Colvin

Abstract. This paper presents a rainwater harvesting system to reduce CAMTAC Linamar’s municipal potted water costs. The principle behind the design is to channel the rainwater collected from the plant’s roof into a piping system. Through multiple filters, including first flush, basket, UV, and reverse osmosis, the water will then enter the site’s storage tank. Using an automated system, the design will allow continual supply of water by either rain or main lines. The design was simulated using EPA SWMM 5 and the results used to optimize pipe length and cistern size for collection and cost efficiency.

Key words: backflow prevention, industrial, rainwater harvesting, SWMM 5

1 Introduction

CAMTAC Linamar, located in Guelph, Ontario, uses approximately 1,300 m²/month of water, with 90% used for manufacturing processes. Currently, water is purchased from the city of Guelph at approximately $2,000/month [1]. A rainwater harvesting system was to be designed to reduce water costs. Rainwater harvesting is the collection, storage, and use of rainwater for domestic or industrial purposes.

Numerous constraints and criteria are placed on this design. Major constraints include: the quality of the water must meet the site’s requirements, and the design must be safe and meet all appropriate national and municipal safety requirements. The following criteria were placed on the design: maximize the rainwater collected and minimize the payback period. CAMTAC’s roof was assumed to allow for proper drainage and limited pooling.

Many rainwater harvesting solutions exist for both domestic and industrial use. The typical system consists of piping directing water to a storage tank, or cistern. Water is pumped from the cistern as needed. Water purifying equipment such as UV lights, filters, and distillers can be added to purify the collected water to the required water quality.

This system presented is the most suitable for CAMTAC since it is innovative yet simple and cost-effective. The site’s roof is flat with an area of 220,000 ft² and 35 drainpipes distributed equally across this area. The site uses a mezzanine level within the plant for water storage.

The major stages throughout the design process were: gathering data and information on the site through constant contact with on-site sources; researching existing rainwater systems and regulations; and generating and optimizing potential solutions. The final system was designed to meet all constraints and criteria and provide the site with detailed drawings, analyzes, and cost benefits.

2 Design Overview

The design uses a portion of CAMTAC’s roof area to collect rainwater. Rain is conveyed through the rainwater harvesting system by 8 vertical drainage pipes from the roof. Each drainpipe is covered by a dome filter to remove large debris. Rainwater passes through a first flush filter in each pipe before being integrated into a piping network (Figure 1). The piping network runs parallel to the roof at a slight angle and combines into a single 6” pipe that directs rain through a basket strainer and into the rainwater cisterns, located on the site’s mezzanine level.

![Fig. 1. Piping network directing water from the roof to the cistern.](image)

From the cistern, rainwater is pumped through a UV sterilizer and into the site’s reverse osmosis (RO) filter. Figure 2 shows a diagram of the system components from the rainwater cistern to the RO filter, all located on the mezzanine level. From the RO filter, the water is sent to a collection tank and then pumped to the site’s manufacturing equipment. A float switch and relay set-up is used to switch on and off the harvesting system components. The rainwater line will be connected to the city’s water line so water is continuously available to the RO unit. Switching between the lines is accomplished using a solenoid valve. A backflow prevention device prevents contamination of the potable water line by rainwater.
3 Design Specifics

3.1 Piping Network

The downspouts from the roof of the plant are 4” PVC pipes. Eight of these pipes will be diverted. A first flush filter system will be installed on each downspout to remove the most contaminated rainfall at the start of each rain event. A collection network of pipes, which has been optimized to limit the required piping length, was found to require about 653ft. This is shown in Figure 1. The system was modeled in EPA SWMM 5 to determine the optimal pipe diameter for the various components.

3.2 Cistern

Three water storage tanks were chosen for the system: a 2,500 gallon polyethylene tank that is currently in place at the CAMTAC plant and thus has no capital cost, and two 3,000 gallon polyethylene tanks. The 2,500 gallon tank is outfitted with a 1” copper outlet pipe at the bottom of the tank and an overflow pipe at the top directs excess water to the storm sewers. Rainwater enters the cistern through a vertical pipe at the top of the tank. All three tanks are connected by bridge connections.

3.3 System Control

The rainwater harvesting system is fully automated to provide a constant flow of water to the RO unit. Control of the rainwater system is carried out via a relay connected to two water level switches. When the RO tank is full the first switch turns off the RO filter and opens the relay. The second input is a horizontal float switch within the rainwater tank, 8” from the tank’s bottom. If water drops below this point, the float switch opens the relay. The relay is powered by a transformer to spiking voltage that can destroy the float switch. The relay switches on and off the power to the rainwater pump, UV sterilizer, and mains line solenoid valve. The pump transports rainwater through the 1” diameter pipes at a rate of 5gpm and 70psi pressure. Water passes through a UV sterilizer before heading to the RO unit. From here, the current water delivery system used by CAMTAC takes over. Controlling the switching between the rainwater and mains line is a two port electronic solenoid valve. In accordance with the CSA B128.2, a backflow prevention device must be used when there is a risk of contamination of potable water by rainwater. A reduced pressure zone backflow prevention assembly was chosen as per regulations.

4 Discussion

All components of the system were narrowed down to specific types based on the constraints and criteria. A fully functional system had to be designed before considering the optimal component sizes, layout, and ideal control system. In design optimization, EPA SWMM 5 simulated the system using 50 years worth of daily rain data from Station: 6143090 GUELPH TURFGRASS. This program allowed varying pipe diameters, layouts, and cistern sizes to be inputted and modeled. It provided data corresponding to flow rates and water collection in the system. This allowed the minimal filter to be chosen, as well as the determination of the required cistern sizes, if all the rainwater were kept.

The most critical constraint after determining all the necessary components and sizes was to minimize cost. Ideally, a ROI of less than one year should be achieved. To minimize cost, the smallest size of all components required through modeling were chosen. Numerous suppliers were contacted for the price of system components. An estimate of the overall component cost of the system is $9,720 and $2,978 in labour. Based on system modeling, the design is estimated to save the Linamar site approximately $5,286/year. This results in an ROI of 65%. Prior to implementing this design, the system should be reviewed by certified engineering, electrical, and plumbing personnel.

Acknowledgement

We would like to acknowledge the contributions of CAMTAC Linamar’s Engineering Manager, Mike Minogue.

References

1. ENGG*3100 Website [http://courselink.uoguelph.ca](http://courselink.uoguelph.ca) Updated 26 December 2008.