
Report on the Environmental Benefits and Costs of Green Roof Technology for the City of Toronto

1.0 About the study

1.1 Study objectives

This study is part of a project undertaken by Ryerson University through funding provided by the Ontario Centres of Excellence-Earth and Environmental Technologies (OCE-ETech) and matched by the City of Toronto as the major partner. Other partners include Trow Associates and 401 Richmond. This document reports on the first part of the project and deals with the municipal level benefits of Green Roof Technology.

Individual building owners are driving construction of green roofs; the City of Toronto is investigating the development of programs to promote green roofs and the required standards for their implementation.

In order to develop appropriate actions, the City of Toronto identified a need to determine the social and environmental benefits of green roofs on a city-wide level. The City of Toronto needs to have an understanding of:

- the types of green roof technology;
- the measureable benefits of green roofs to the city's environment;
- potential monetary savings to the municipality;
- minimum threshold points for the City of Toronto to provide incentives to make significant cost savings.

This study conducted by Ryerson University and as reported here will be used to inform the City of Toronto in developing programs to promote the use of green roof technology. The social and environmental benefits of this technology are of primary importance. It is expected that the information in this report will assist the City of Toronto to formulate the appropriate types of government programs or incentives to encourage private investment in green roofs and thus reap the social benefits. The public costs of these programs or incentives are as yet to be determined and not part of this project.

Beyond this study for the City of Toronto, the overall objective of the project is to build on the knowledge gained in order to formulate a model and useable technology that will allow individual building owners and other municipalities to measure the benefits of green roof technology.

1.2 Context and background of green roof related activity in Toronto

Green roof activities have been ongoing in Toronto for almost a decade. Promotion of green roofs in Toronto can be traced back to a small number of dedicated volunteers under the umbrella of the Rooftop Garden Resource Group. Their activity was enhanced with the involvement of an association that is today known as Green Roofs for Healthy Cities (GRHC).

The City of Toronto's formal involvement in green roofs is rooted in the recommendations of the Environmental Plan (2001). The Plan was the first to formally identify the need for a strategy to encourage green roofs and rooftop gardens. The Natural Environment policy within the City's new Official Plan further supports green roofs calling for "the development of innovative green spaces such as green roofs, and designs that will reduce the urban heat island effect."

Another place where green roofs have found a potential is in the Wet Weather Flow Management Master Plan for the City of Toronto completed in 2000. It examined ways to improve the water quality of local rivers and Lake Ontario by strengthening mechanisms to prevent and reduce stormwater runoff. Green roofs may appear in future stormwater planning policies that discuss best management practices; however, the policies have not been drafted at this point.

The following subsections deal with specific activities that have been undertaken to promote green roofs in the City of Toronto.

1.2.1 Green Roof Demonstration Project

In Fall 2000, Green Roofs for Healthy Cities, the Toronto Atmospheric Fund, the Federal Government and the City of Toronto partnered to initiate a Green Roof Demonstration Project.

Two demonstration green roofs were constructed as part of the project:

- eight plots covering more than 300 square metres on the podium roof of Toronto's City Hall building;
- a 465 square metre green roof on the Eastview Neighbourhood Community Centre.

For the first two years, the City of Toronto and Green Roofs for Healthy Cities managed the demonstration roofs jointly. After that period, the City assumed the management of the project.

The objectives of this million dollar, three-year project, were to find solutions to overcome technical, financial and information barriers to the widespread adoption of green roof infrastructure in the marketplace by:

- generating reliable technical data on green roof performance in areas such as energy efficiency, stormwater retention, the extension of roof membrane life span and plant survival in the Toronto climatic context;
- conducting research on city-wide cooling benefits of green roofs in the summer and the potential spin-off from greenhouse gas reduction, smog reduction and energy efficiency gains from reducing cooling loads in buildings;
- evaluating the costs and benefits of future public-private investments in green roofs;
- increasing awareness of the benefits of green roof technology by giving professionals the opportunity to visit a working demonstration site with multiple applications.

The City Hall podium green roof has been used to study the different plants that can be used for green roofs in Toronto.

The Eastview Neighbourhood Community Centre green roof is an extensive green roof built beside a regular membrane finished flat roof. It has been extensively instrumented, and results from the measurements have been published. The results to date have been encouraging.

1.2.2 Sustainable Technologies Consortium – York University Roof Monitoring Program

The Sustainable Technologies Consortium was formed in order to address the growing need for research to support the implementation of technologies promoting sustainable development. The Consortium is a public partnership between the Toronto and Region Conservation Authority (TRCA), Seneca College, the University of Guelph and Ryerson University. The multi-disciplinary nature of the Consortium's members was intended to reflect the nature of sustainable technology research, which integrates various disciplines and research interests. The mandate of the consortium is two-fold:

- to pursue scientifically defensible research in sustainable development;
- to quantify the potential benefits of technologies relating to stormwater management, water and energy conservation, and air pollution.

The impetus for the Sustainable Technologies Consortium can be traced to the International Joint Commission, which in 1987 identified Toronto as one of 42 regions of concern bordering the shorelines of the Great Lakes. It developed a Remedial Action Plan to restore polluted drainage networks and water bodies located in the city or along the shorelines of Lake Ontario. Some of the goals and actions recommended by the Remedial Action Plan can be achieved using green roof technology.

In 2003, a research site was established on the York University Computer Science Building. A green roof was designed during building construction and has been monitored by the TRCA. Unlike the Eastview Neighbourhood Community Centre building which was a retrofit the York University green roof was installed over a new building.

Measurements of climate, soil and runoff have been taken to quantify the stormwater quality and quantity benefit of the green roof. The monitoring devices have been linked to a single logger and network server that statistically calculates and communicates measured data via the internet. The internet connection also provides real-time measurements of activities (e.g. rainfall) that can be accessed from anywhere in the world.

Initial results from the monitoring of the effects of green roof technology on stormwater runoff control have been positive.

In addition to the monitoring, a hydrological modeling analysis of Highland Creek was undertaken using the monitored data. This data has been used in this study.

1.2.3 City of Toronto, FCM and OCE-ETech partnership

The encouraging results from the green roofs on the Eastview Neighbourhood Community Centre, Toronto City Hall and the York University Computer Science Building have provided positive impetus for ongoing promotion of green roofs. City planners started to examine the possibility of developing programs to promote green roofs. City of Toronto staff explored the possibility of seeking funding from Federation of Canadian Municipalities (FCM) to carry out research that would inform the development of programs and policies to promote green roofs.

The City of Toronto was successful in procuring funds from FCM for further studies to examine the municipal level social and environmental costs and benefits of green roofs. FCM has been the national voice of municipal government since 1901 and is dedicated to improving the quality of life in all communities by promoting strong, effective, and accountable municipal government. Recently, the Government of Canada endowed the FCM with \$250 million to establish the Green Municipal Funds and support municipal government action to cut pollution, reduce greenhouse gas emissions, and improve quality of life.

The City of Toronto approached OCE-ETech, who organized a green roof think tank in November, 2003. OCE-ETech is a division of the Ontario Centres of Excellence and helps Ontario organizations grow by finding solutions for their innovation challenges. It engages clients and academic partners in various market driven strategic clusters of activities, including sustainable infrastructure and energy solutions. Research into the municipal level costs and benefits of green roofs was identified as an area of research.

Based on the City of Toronto's interest and FCM support, OCE-ETech put out an expression of interest (EOI) in the winter 2004. Teams from Ryerson and other universities participated in the EOI. In spring, 2004 a team from Ryerson and two teams from other universities were shortlisted to submit a detailed proposal. Ryerson submitted a proposal with the City of Toronto as the major partner. In Fall, 2004 Ryerson was selected to carry out the project related to the costs and benefits of green roofs.

As indicated earlier the project has multiple parts. The first part, which resulted in this report, was to examine the social and environmental benefits of green roofs at the municipal level for the City of Toronto.

1.3 Other FCM sponsored studies of GRT

In the past, FCM has supported work specific to green roof technology at two other municipalities: the City of Waterloo and the City of Winnipeg. The following sections provide a brief description of these studies.

1.3.1 City of Winnipeg study

Funded by the FCM grant, the City of Winnipeg explored the feasibility of developing a green roof strategy for flat-topped buildings in its downtown area. Such a strategy could help alleviate stormwater management problems in Winnipeg's downtown. The City felt that a green roof strategy could be incorporated into the Combined Sewer Overflow (CSO) control model to reduce runoff effects and provide other environmental benefits.

The Assiniboine district was the focus of this study due to its high concentration of flat-topped buildings. The area is also the most prone to overflows from the combined sewer system. Recent aerial photographs and visual inspections indicated that an area of 218,773 square metres (almost 20% of the total area of the district) could be used for green roof development.

Control-system models were created to simulate rainfall and runoff during a typical year. Various scenarios were examined to determine whether a green roof strategy could reduce not only the number of overflows in a year, but also their volume and the volume of wastewater going to the water pollution control centre.

In this study plant species were also evaluated for their carbon-fixation and sequestering potential.

Data collected during the stormwater modelling process indicated that the number of overflows could be reduced by 16%, if 100% of the potential roof space in the district were used. The volume of the overflow could also be reduced by approximately 48%, which in turn would cut the volume of flow to the water pollution control centres.

In terms of the carbon fixation it was found that if 100% of the potential green roof space were developed, 24.5 tonnes of carbon would be fixed (removed) annually.

1.3.2 City of Waterloo study

As part of its Environment First Policy, the City of Waterloo developed an Environmental Strategic Plan, which was adopted by Council in 2002. Green roofs fit into the Environmental Strategic Plan in all important areas.

In 2003, the City of Waterloo received a grant of \$25,000 from FCM for a "Green Roofs Feasibility Study." As a condition of the grant, a green roof demonstration site was to be constructed on a city-owned building.

A multidisciplinary steering committee was formed to guide the study. It included 12 professionals from various agencies, levels of government and community interests. Totten Sims Hubicki, Enermodal Engineering and Elevated Landscape Technologies were retained to complete the above study on behalf of the City of Waterloo.

The purpose of the Green Roofs Feasibility Study was to identify a city-wide green roofs implementation plan for municipally owned buildings in the City of Waterloo, including identification of potential costs and associated maintenance. It would also, through the selection process, identify a preferred location for a green roof demonstration site in the City of Waterloo. The function of the demonstration site would be to raise public and industry awareness and to provide an educational forum to display the benefits of green roofs. A business plan for the green roof demonstration site, including an analysis of performance, benefits, and costs, was to be generated as part of the feasibility study.

The study, which was completed in February, 2005, identified a mechanism for selecting a site for implementing green roof technology. The green roof has recently been constructed on the City Hall building.