

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

## **Prepared For**

*City of Toronto and  
Ontario Centres of Excellence –  
Earth and Environmental Technologies (OCE-ETech)*

## **Prepared By**

*Ryerson University*

### **Professors:**

*Dr. Doug Banting*

*Professor Hitesh Doshi*

*Dr. James Li*

*Dr. Paul Missios*

### **Students:**

*Angela Au*

*Beth Anne Currie*

*Michael Verrati*

**October 31, 2005**

### **Project Contact:**

**Hitesh Doshi**

**Dept. of Architectural Science, Ryerson University**

**350 Victoria Street, Toronto, Ontario , M5B 2K3**

**Phone: 416 979 5000 x6502**

**E-mail: [hdoshi@ryerson.ca](mailto:hdoshi@ryerson.ca)**

# **Executive Summary**

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

Toronto has been at the forefront of organized green roof activity over the last several years. In early 1990's volunteers under the Rooftop Garden Resource Group (RGRG) started to promote green roof development in the city. This has been taken over by Toronto-based Green Roofs for Healthy Cities, a not for profit organization, which carries out world-wide education on green roofs.

The City of Toronto has been an active participant in studying wider use of green roofs as a sustainable alternative to meet many of the urban environmental challenges. In the past few years the City has shown leadership in promoting green roofs. In order to inform its actions, the City in partnership with OCE-ETech and the Federation of Canadian Municipalities, engaged a team of Ryerson researchers to develop further understanding of: the types of available green roof technology, the measurable benefits of green roofs to the city's environment, potential monetary savings to the municipality through use of green roofs, and minimum thresholds of green roofs that could be used for part of any incentives or programs.

This report presents the findings on the municipal level benefits of implementing green roof technology in the City of Toronto. Beyond this report, which addresses the immediate needs of the City of Toronto in assisting them to formulate appropriate programs and policies, the Ryerson team has been charged by OCE-ETech to develop a generic technological solution that can be used to predict the costs and benefits related to green roofs. This work is ongoing and is not reported here.

For this report, the Ryerson team conducted an extensive literature review to determine the benefits related to green roofs and, in particular, the quantification of these benefits. It also collected information on the types of buildings in Toronto and their geographic distribution. The information collected was modeled as a GIS database and used for aggregating the benefits on a city-wide basis. The Ryerson team also developed a method to compute the monetary value of the benefits. A survey of the existing green roof technologies and standards was carried out to inform the development of minimum requirements for green roofs.

The findings of the work are presented in the following sections of the report: Section 1, about the study, provides historical background related to this work; Section 2, survey of research related to green roofs, provides the findings of the literature review on benefits of green roofs; Section 3, survey of types of green roofs and their standards, provides information on the different green roof technologies currently available and the performance standards pertaining to green roofs; Section 4, green roof benefits and costs for the City of Toronto, provides the details of the quantification of benefits of city-wide implementation of

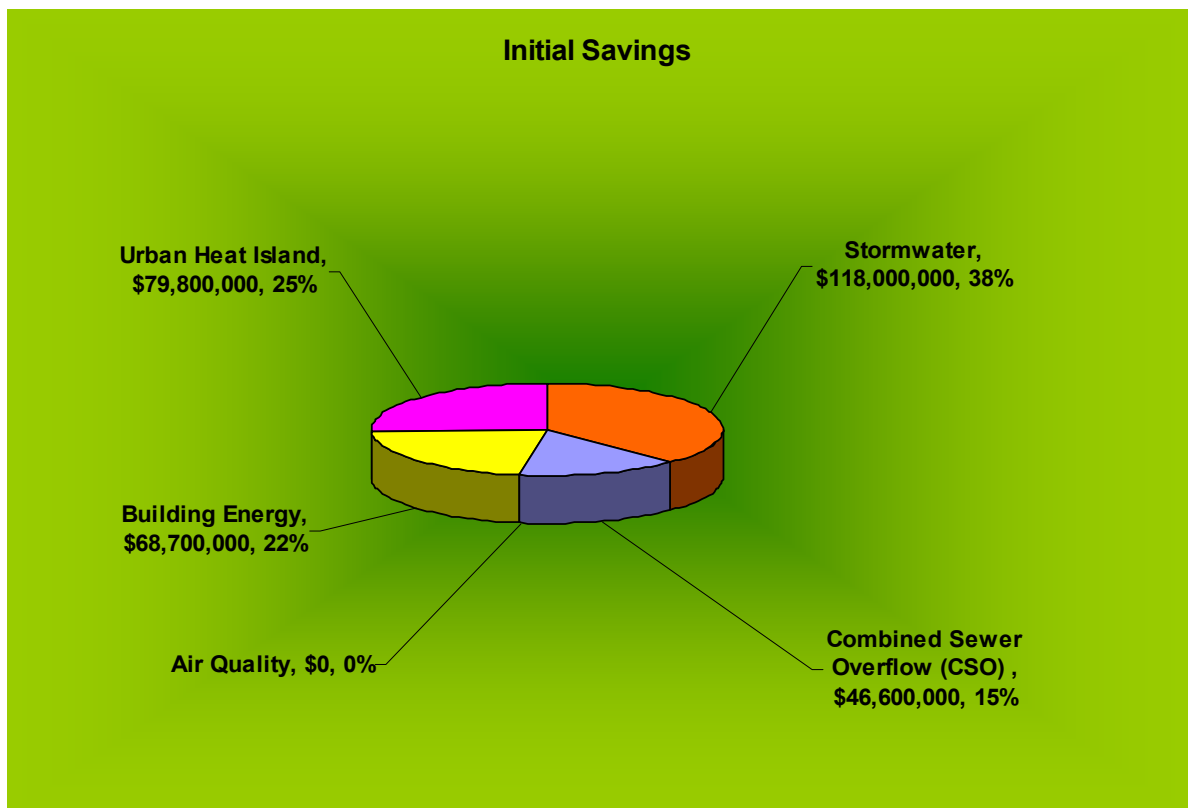
green roofs. The report ends with a summary and recommendation, in Section 5, which provides the recommendations, the minimum thresholds and guidance for further work.

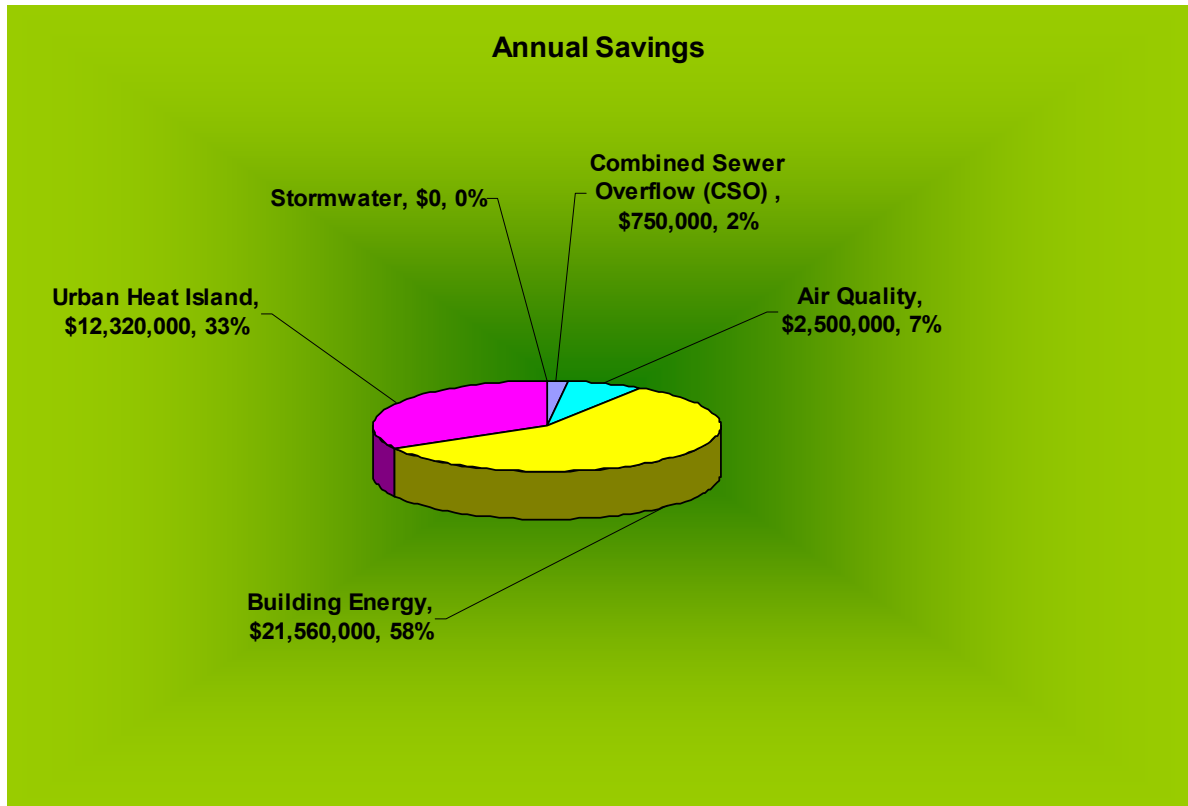
Of the many benefits of green roofs reported in the study, the ones that had the most quantifiable monetary value based on currently available research data are: benefit from stormwater flow reduction including impact on combined sewer overflow (CSO), improvement in air quality, reduction in direct energy use, and reduction in urban heat island effect.

The literature review indicated other benefits that could not be quantified in this report. These benefits included: aesthetic improvement of urban landscape, increase in property values, benefits resulting from green roofs used as amenity spaces, use of green roof for food production, and increased biodiversity. Further work is needed to quantify these benefits.

The benefits on a city-wide basis were calculated based on the assumption that 100% of available green roof area be used. The available green roof area included flat roofs on buildings with more than 350 sq. m. of roof area, and assuming at least 75% of the roof area would be greened. The total available green roof area city-wide was determined to be 5,000 hectares (50 million sq. m.).

The benefits were determined as initial cost saving related to capital costs or an amount of annually recurring cost saving. These are shown in the following charts and table.





Category of benefit	Initial cost saving	Annual cost saving
Stormwater	\$118,000,000	
Combined Sewer Overflow (CSO)	\$46,600,000	\$750,000
Air Quality		\$2,500,000
Building Energy	\$68,700,000	\$21,560,000
Urban Heat Island	\$79,800,000	\$12,320,000
<b>Total</b>	<b>\$313,100,000</b>	<b>\$37,130,000</b>

The report also presents the minimum considerations for the type of green roof to achieve the stated benefits. The key considerations include that: the roof system be of the type known as an extensive roof system, that it cover a significant portion of the roof, have a maximum runoff coefficient of 50%, and have at least a 150 mm. depth where structural loads permit. Green roofs with less depth could be used on roofs where structural loading does not permit the 150 mm. depth.

The benefits quantified in this report show that there is a case for development of public programs and the promotion of green roofs. The City of Toronto may wish to use this information to embark on consideration of programs that will give further impetus to the construction of green roofs.

Green roof technology is an emerging technology and many questions need further exploration. Although this study has made several advances in predicting benefits of green roofs, and it has provided information for the City of Toronto to move further on programs and policies pertaining to green roofs, there are several areas that will require further work. Questions remain to be answered regarding the uncertainty of the benefits, impact of less than 100% green roof coverage, impact of building specific constraints, the quantification of program costs leading to a complete cost benefit analysis, quantification of other social benefits and consideration of the effect of alternative technologies that may be able to perform one or more of the functions of a green roof. These questions are important and will need to be considered in further studies. Some of these will be explored in the continuing work by the Ryerson team. In the meantime, policy decisions regarding green roofs will need to consider the potential impact of these questions

