4.0 Green roof benefits and costs for the City of Toronto

4.1 Description of approach

The purpose of this study was to determine the environmental costs and benefits of green roofs at the municipal level. Such an exercise requires the compilation of very specific information from many diverse sources. The approach involved the following:

- Identifying the environmental benefits at municipal level;
- quantifying the impact of green roofs for each of the benefits;
- valuing the benefit in monetary terms;
- applying the benefits on a city-wide basis, based on actual distribution of buildings.

4.1.1 Identification of benefits

A literature review on this subject assisted in narrowing down the quantifiable benefits of green roofs at the municipal level. These were related to reduction in water flowing into the stormwater system, the CSO system, to improvements in air quality, mitigation of the urban heat island effect, and reduction in energy consumption due to reduced space heating and cooling needs.

4.1.2 Quantification of impacts

Once the benefits were identified it was necessary to quantify the impacts of green roofs on each of these benefits. For the purpose of this study the impacts were quantified based on research reported to date. As much as possible we relied on local research. For instance, the impact of green roofs on stormwater has been modeled for the Markham branch of Highland Creek. We relied on the results of this work to quantify the impact of stormwater for the rest of the City of Toronto. Another example is the impact of green roofs on air quality. For this we used the work done on the impact of air quality in downtown Toronto. Each is explained in the subsequent sections.

4.1.3 Monetary valuation of benefits

Once the impacts were quantified in terms of their respective benefits (for example, stormwater benefits were measured as reduction in water flow), an economic value needed to be developed for each of the benefits. Some of the work cited earlier had built into it the monetary considerations for each of the benefits. For others we had to develop functions to translate the benefits into monetary terms. Again for this information we relied on local data, such as data from the recently completed study on green roofs by the City of Waterloo.

4.1.4 City of Toronto specific determination of benefits – use of building inventory data

Finally, one goal of this study was to determine benefits taking into account the specific land use in Toronto. This was achieved using a GIS database. This study was based on aggregation of results based on building distribution and land use within each watershed, explained below. Initial consideration was given to determine the impact of different levels of green roofing (for instance, 30%, 60%, and 100% green roofing). However, the models used for stormwater and combined sewer overflow calculations did not readily permit the use of these different scenarios, and therefore the calculations were based only on 100% greening of eligible roofs. It is expected that as this project continues on to its next phase, a method can be developed to allow different scenarios to be constructed.

We have assumed the following about the eligible buildings for green roof applications for the purpose of this report[6]:

- Green roofs are considered on roofs with relatively low slope i.e. "flat" roofs with slopes less than 2%. It is possible to install green roofs on roofs with slopes greater than 2%; Many low-rise residential buildings, which constitute a large percentage of total available roof area, have sloped roofs. However, application of green roofs on sloped surfaces is not very common and the benefits that apply to applications on "flat" roofs do not necessarily apply to sloped surfaces. The reported research on the benefits of green roofing is relevant for construction practices used for flat roofs and cannot easily be extrapolated to green roofs over sloped surfaces. For this reason at this time only low sloped or flat roofs are considered as eligible roofs for greening.
- Green roofs will be installed on buildings that have a roof area of at least 350 sq. m. On buildings with low sloped roofs the roof surfaces are often used for positioning equipment for heating, cooling, and ventilation purposes. Based on empirical evidence, it was determined that on average the roof would have to be at least 350 sq. m. before any significant free area would be available for greening.
- Greenery over underground parking garages or similarly non-conditioned enclosed spaces at grade level is excluded from consideration as green roofs in calculating the benefits in this study. There are three reasons for this assumption. Firstly there was no easy way to identify and measure the number of such spaces in the GIS database. It was not possible to distinguish green areas over underground structures from green areas over regular earth. Secondly the greening of such spaces at grade level is often covered by requirements related to site plan and development or from the need of the

[6] The nature and thickness of the growing medium and components of a green roof affects the amount of stormwater runoff, and the amount of energy transfer through the roof, and the variety of vegetation that can successfully survive on the roof. The models used in the calculation of benefits in this report are based on a minimum performance of green roofs. It is expected that, for stormwater runoff and energy transfer, green roofs with a thickness of 75 mm (3 inches) or more will provide measurable benefits. The minimum threshold for the thickness may however be dictated by the need to be able to use a variety of plants and have them survive for a long term. For this purpose a minimum thickness of 150 mm (6 inches) may be appropriate at the present time. However, the relationship between thickness of green roofs and its performance will become less important with the use of products in the green roof systems that will allow them to perform better at lesser thicknesses.

owners to maintain a certain aesthetic appeal for their property. This situation would not require a separate incentive or policy for more widespread use.

- When installed on a building, green roofs will occupy an area of at least 75% of the roof footprint. The benefits in this study are estimated based on the use of extensive green roof systems with a certain minimum amount of coverage. Use of intensive green roofs, or greening on roofs using planters or greenhouses, will result in benefits that are highly dependent on the nature of design and layout of such systems. The benefits of using these systems in terms of stormwater control and energy usage will be lower than those for a typical extensive roof. This assumption will therefore provide an upper limit for the social and environmental benefit at the municipal level.

Since this report relies very much on existing research it is important for an understanding of this section to also understand the findings reported in the literature review section.