4.2.4 Combined sewers

The combined sewer overflow (CSO) benefit is obtained by estimating the reduction of storage required for the control of CSO in Toronto. The City of Toronto has developed a comprehensive model (the QQS model) to simulate the CSO conditions. Using the QQS model, it was predicted that the total annual CSO volume to Black Creek, Humber River, West Don River, Massey Creek, Lower Don River, Western Beaches, Inner Harbour, Eastern Beaches, and Scarborough Lake would be 10,187,056 m^3. The total CSO drainage area is 9100 ha. The Toronto Wet Weather Study recommends that underground storage of 258,955 m^3 will be required for the whole CSO area.

The QQS is a detailed continuous model which simulates the combined sewer network for the whole city. For planning level analysis of the effect of green roofs on CSO, a simplified approach is used in this study. It is based on analytical probabilistic models, SUDS, which transform the probability density functions of rainfall event characteristics (e.g. volume, duration, and inter-event time) into probability density function of overflow characteristics (Adams and Fabion 2000). These models have been applied to simulate the stormwater and CSO conditions at the 17 Canadian RAP areas (CH2M 1993). SUDS provides continuous analysis of rainfall, runoff, and overflows in urban drainage systems and has been found to provide results in good agreement with continuous simulation models such as STORM and SWMM. SUDS was calibrated with QQS's result and used to estimate the reduction of underground storage.

The method to estimate the reduction of underground storage after the implementation of green roofs is based on the following assumptions:

- The whole CSO area is considered to be one sewershed for modelling purposes.
- The green roof can replace a minimum 5% and a maximum 15% of the total impervious area in the combined sewer area.

With the assistance of the city's modellers, the QQS model was re-run for the 5% and 15% scenarios.

The SUDS model was first calibrated (Table 4.2) to produce a total annual CSO volume of 10,187,056 m^3 (predicted by QQS). Table 4.2 summarizes the input and calibrated data for the SUDS model.

The SUDS model was then used to simulate the following scenarios:

1. Existing CSO condition without green roof;
2. Existing CSO condition with 5% green roof;
3. Existing CSO condition with 15% green roof;

4. Future CSO condition with the Toronto Wet Weather Study's recommended underground storage;

5. Future CSO condition with the Toronto Wet Weather Study's recommended underground storage and 5% green roof;

6. Future CSO condition with the Toronto Wet Weather Study's recommended underground storage and 15% green roof;

The CSO benefit of green roofs is estimated by the reduction of underground storage for the same level of CSO control and a unit cost of $1,340/m^3$ for underground storage (Toronto Wet Weather Study).

Table 4.2
Input and calibrated data for the SUDS model

Input and calibrated data	Value	Details
Total CSO area	9,106 ha.	QQS model input
Depression storage	4 mm.	Assumed parameter
Pervious runoff coefficient	25%	Assumed parameter
% Imperviousness	51%	Calibrated parameter
Effective interceptor capacity	0.152 mm/hr.	Estimated parameter
Existing CSO storage	0.135 mm.	Calibrated parameter
Proposed CSO storage	2.84 mm.	Toronto Wet Weather Study
Unit cost of CSO storage	$1,340/m^3$	Toronto Wet Weather Study

Based on the SUDS model simulation, the existing and future CSO volumetric controls are 17.4% and 59.7% respectively (Table 4.3). With 5% and 15% of potential green roofs, the existing CSO volumetric control can be improved to 17.8% and 18.8%. To achieve the future 59.7% volumetric control, the reduction of underground storage due to 5% and 15% of potential green roofs is estimated to be 11,712 m^3 and 34,752 m^3. The total infrastructure savings for 5% and 15% of potential green roofs are $15.7 million and $46.6 million respectively. If the proposed underground storage is to be built in Toronto, the average annual number of CSOs and the average annual percent of runoff controlled can be improved by 1.3 CSO reductions and 2.3% volumetric reduction respectively. These reductions of CSO can result in additional benefits, such as reduction of beach closures and/or other environmental benefits. The beach closure benefit is based on the number of overflow reductions. In Toronto one CSO/year reduction is expected to result in 3 less days of beach closure during the season when swimming would be possible. The economic impact of extra beach openings is valued at $750,000.

It should be noted that a separate model was used to study the impacts of green roofs on CSO. The 15% potential green roof is close to the 100% green roofing assumption made for the other benefits.

Table 4.3
Analysis of CSO scenarios using the SUDS model

Analysis Scenarios	Average annual number of CSOs (#/year)	Average annual percent of runoff volume controlled (%)
a) Existing conditions without the recommended underground storage	34.1	17.4
b) with 5 % green roofs	34.0	17.8
c) with 15% green roofs	33.5	18.8
d) Future conditions with the recommended underground storage	16.6	59.7
e) with 5% green roofs	16.2	60.8
f) with 15% green roofs	15.3	63.0

Note:

“Existing conditions” refers to the current CSO situation without the Toronto Wet Weather Study’s recommended underground storage.

“Future conditions” refers to the future CSO situation with the Toronto Wet Weather Study’s recommended underground storage.