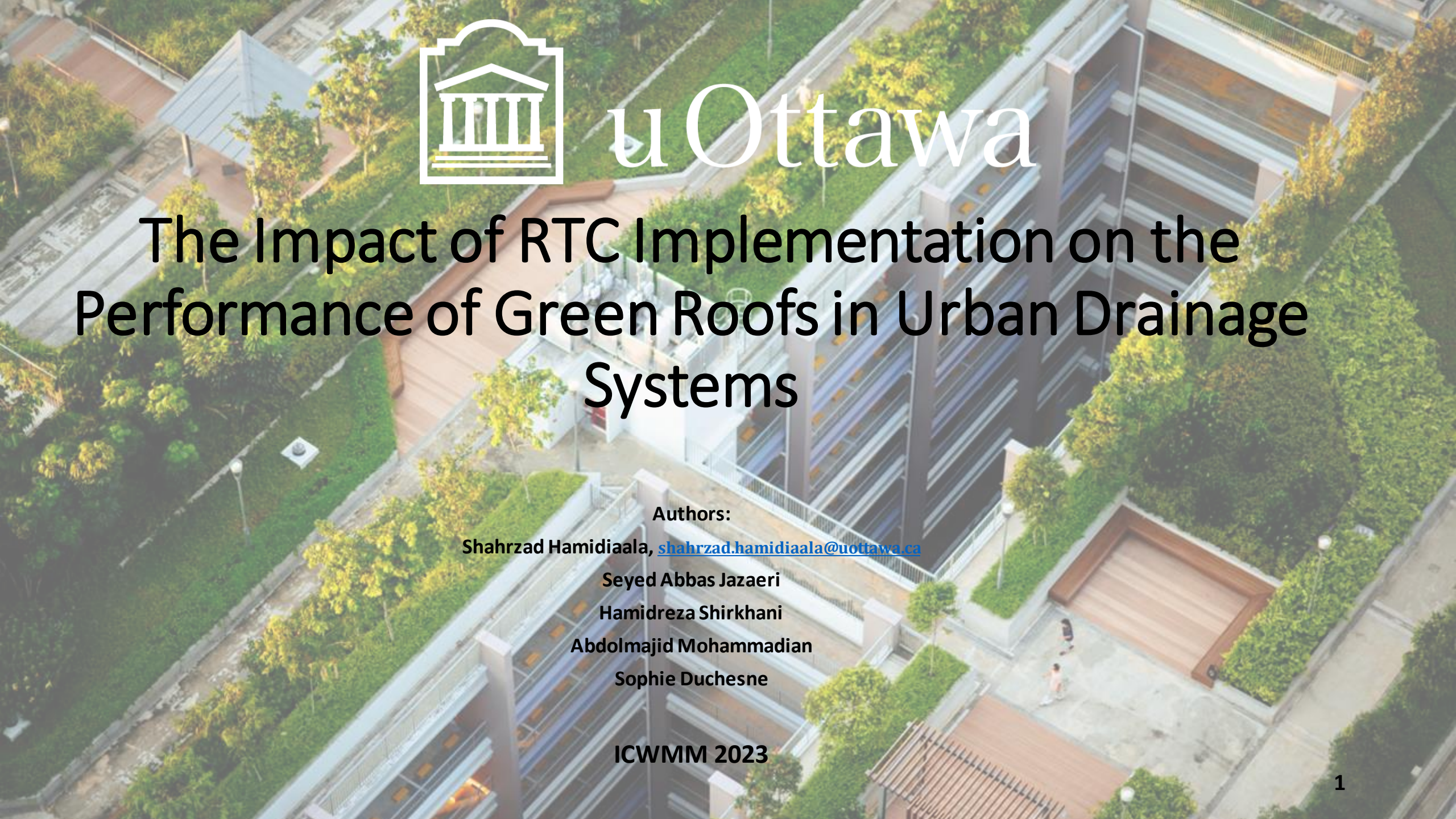

The Impact of RTC Implementation on the Performance of Green Roofs in Urban Drainage Systems

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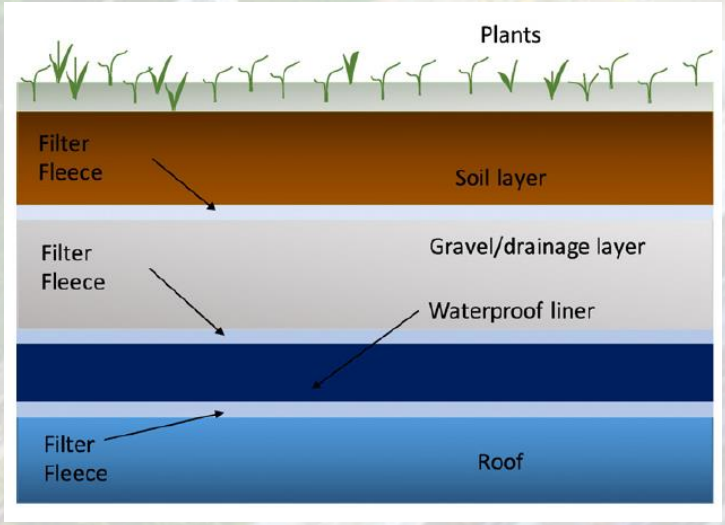
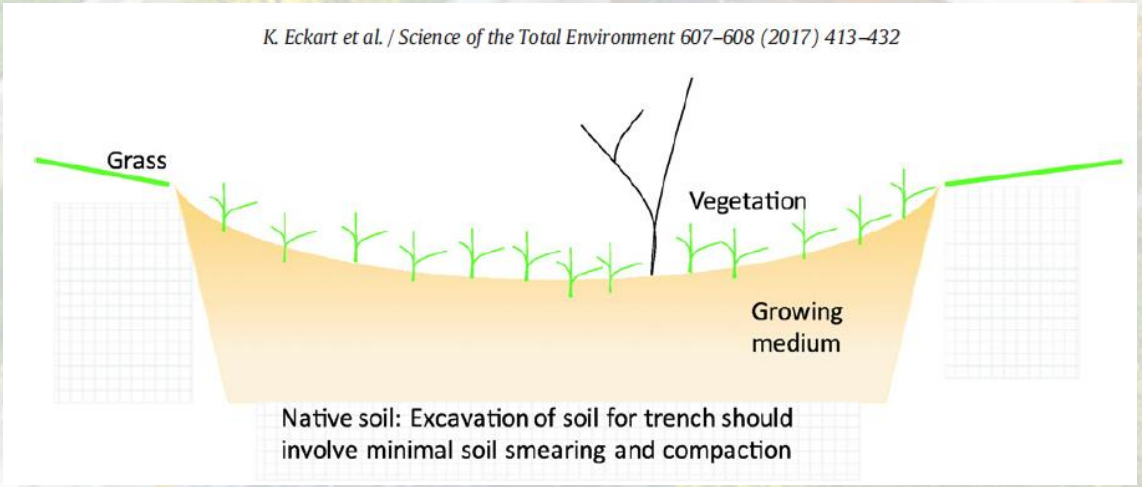
Introduction

Literature review

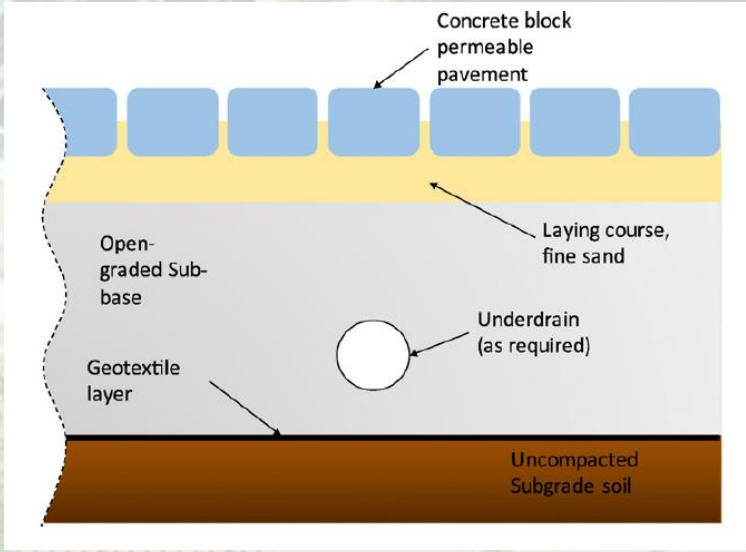
- **Stormwater Management Terminology**
- **LID Classifications**
  1. **Infiltration-based**
  2. **Retention-based**



cross section of a typical LID green roof (Drake et al., 2014)



vegetation-filled swale cross section (Drake et al., 2014)



cross section of pervious pavement (Drake et al., 2014)

Green Roof

- Curb the impacts of stormwater in urban areas
- Improve sustainability
- Implementing nature-based or nature-involved practices in cities
- Improve the runoff quality

Optimization Problems

A prosperous stormwater management system is one that properly integrates all different types of controls in order to achieve its objectives through optimization.

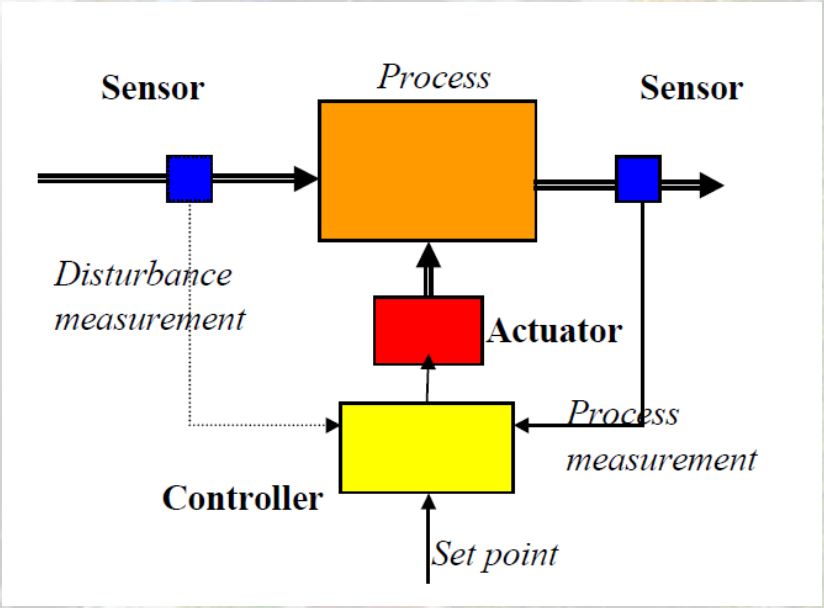
Designing an implementation of such system require both public and municipal co-operation to ensure a that the network functions sustainably. There are two bases for optimization approaches:

- Static
- Dynamic (RTC)

Real Time Control (RTC)

- RTC Definition

- RTC classification based on complexity level:
  1. Local Reactive Control
  2. Extended Reactive Control
  3. Predictive Global Optimal Control (GO RTC)
- Typical types of RTC used in UDSs:
  1. Model-based Predictive Control (MPC)
  2. Rule-based Control (RBC)



The flow of information is shown with single arrows, and the double arrows represent hydrodynamic processes. Hardware parts of the system is written in bold letters and italic style shows variables. (Schütze et al., 2003)

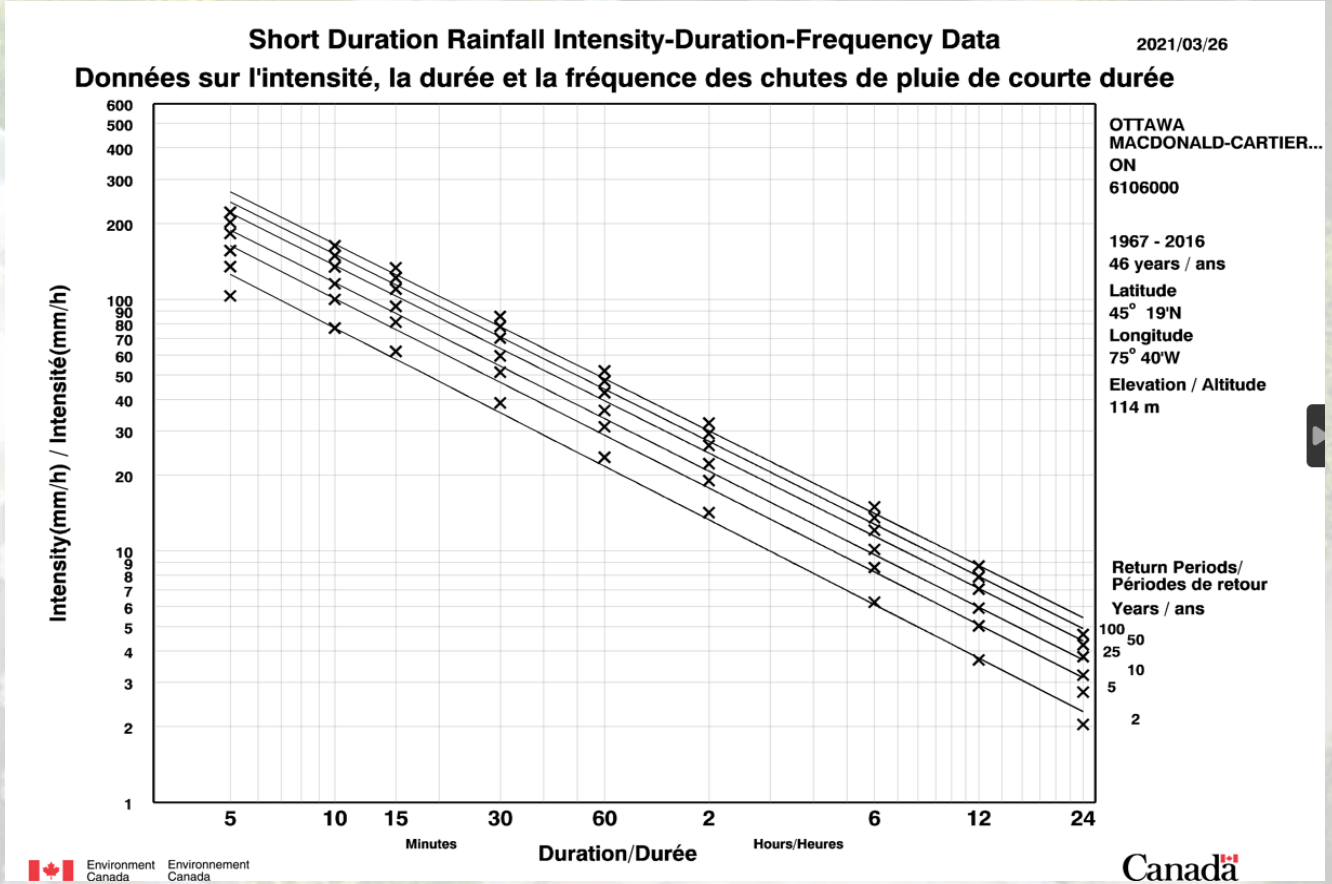
Scenarios

- Three green-based models:
  1. A green roof
  2. A green roof connected to a storage tank
  3. A roof top, half green roof and half a simple grey roof

- Each of them has been simulated once without any control rules, and once with (a) heuristic control(s).

Rainfall Data

- Synthetic rainstorm
  - ✓Ottawa, ON
  - ✓Chicago Design Storm method
  - ✓5-year return period
  - ✓6-hour duration
  - ✓Peak intensity occurs at after around 175 minutes



IDF (Intensity Duration Frequency) Curves for McDonald Cartier Station, Ottawa, ON derived from Environment Canada

First Model: Green Roof

The entire sub-catchment is covered with the SWMM-LID green roof.

Area: 1 Hectare (10,000 m^2)

Width: 500 m^2

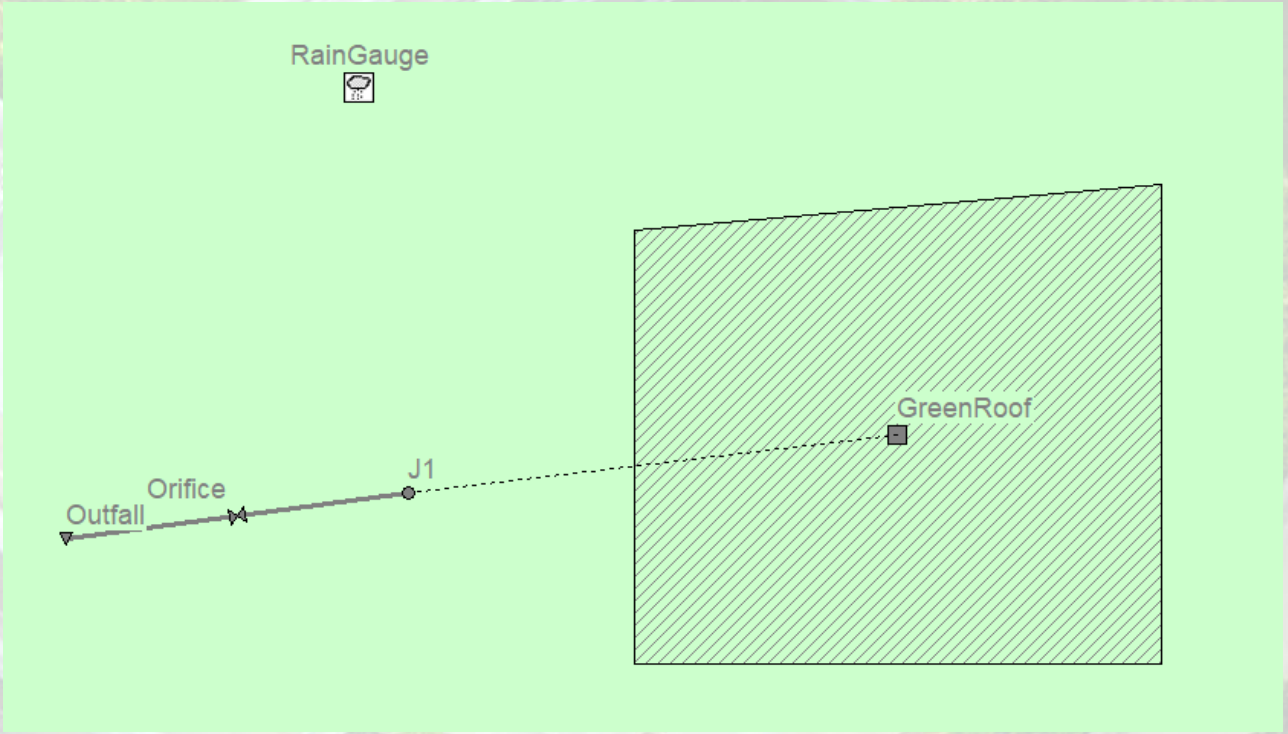
Slope: 0.5 %

Imperviousness: 100%

Berm Height: 2 mm

Soil Thickness: 30 mm

Drainage Mat Thickness: 15 mm

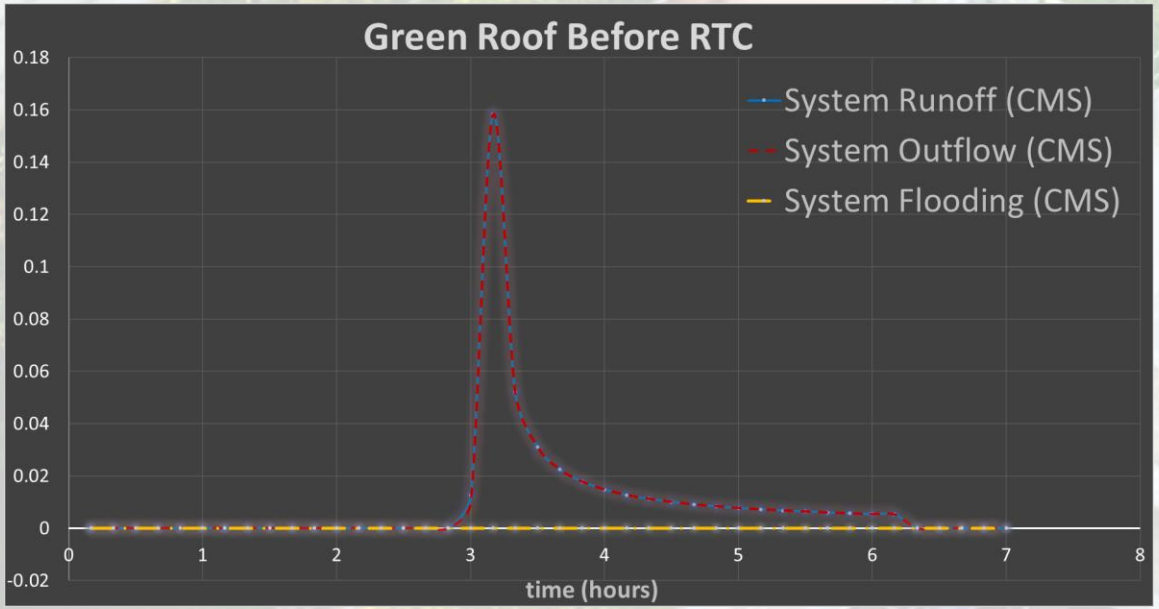


Schematic design of the first model, green roof, in SWMM

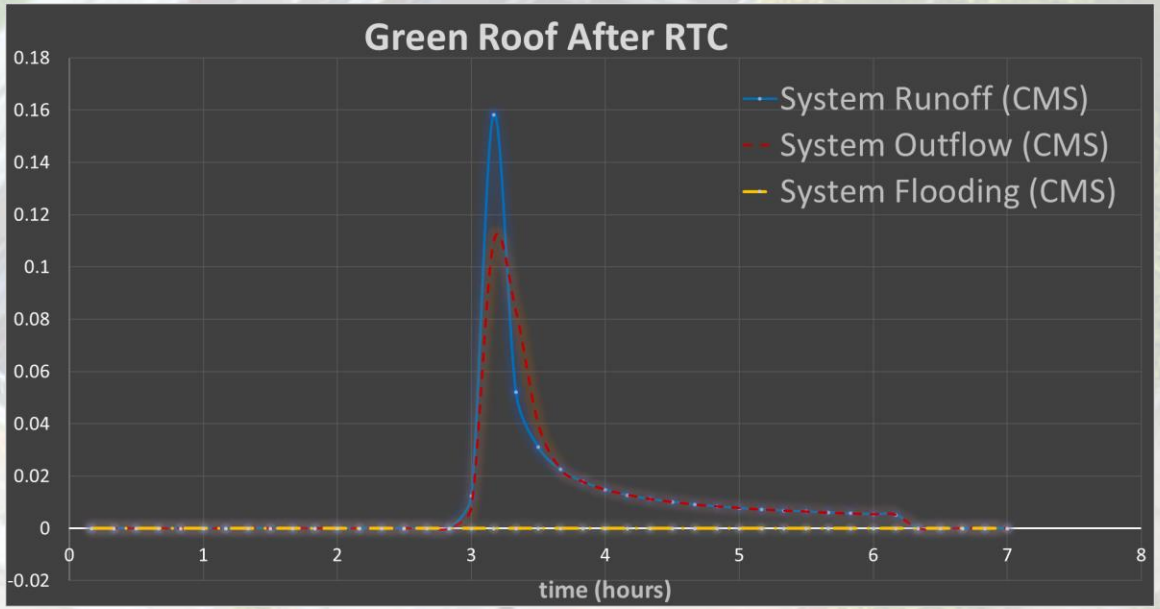
Heuristic Control

- A heuristic if-then statement has been set as the controller according to the depth in node J1 .
- This simple condition is controlling the opening fraction of the orifice.

Results Before and After RTC Application



Overlaid graphs of system runoff, outflow, and flooding (CMS)



Overlaid graphs of system runoff, outflow, and flooding (CMS) after RTC application

Second Model: Green Roof And Storage Unit

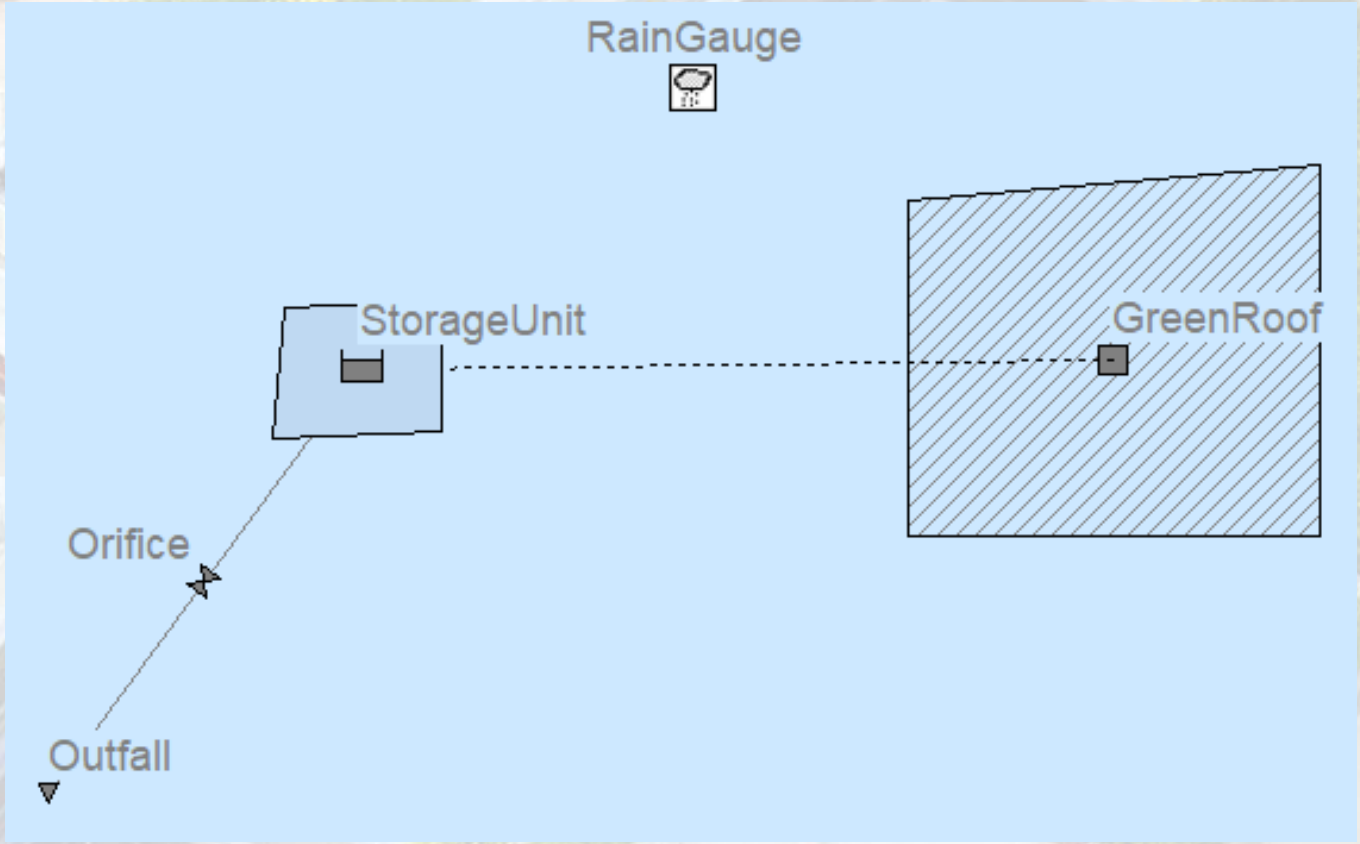
Area: 1 Hectare (10,000 m^2)

Width: 500 m^2

Imperviousness: 100%

Maximum Depth: 0.5 m

Volume: 150 m^3

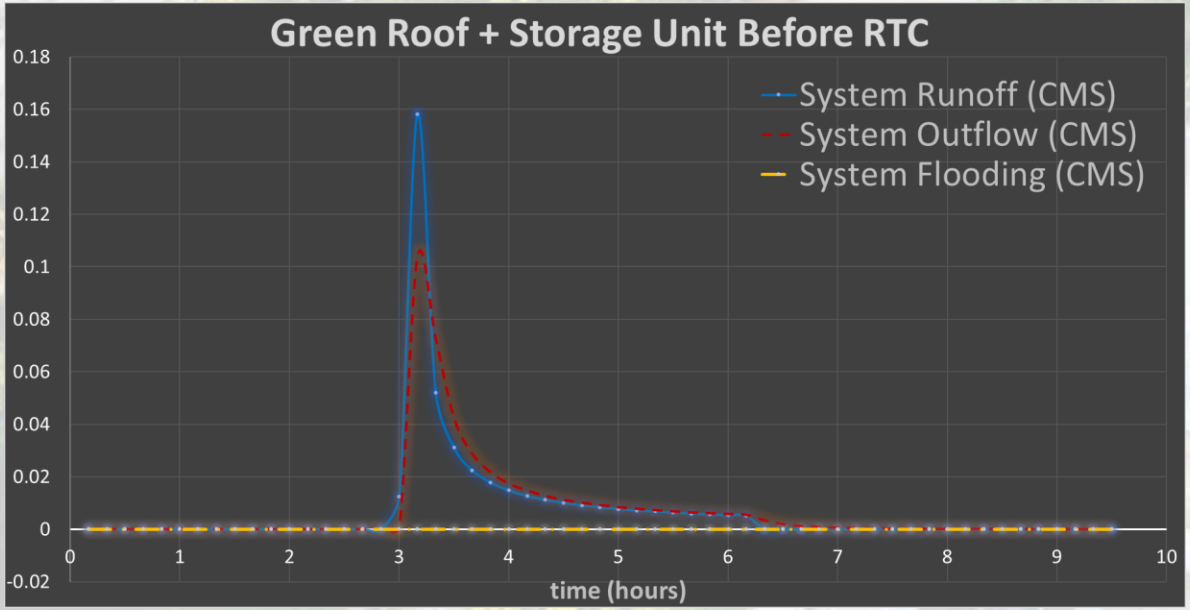


Schematic design of the second model, green roof and storage unit, in SWMM

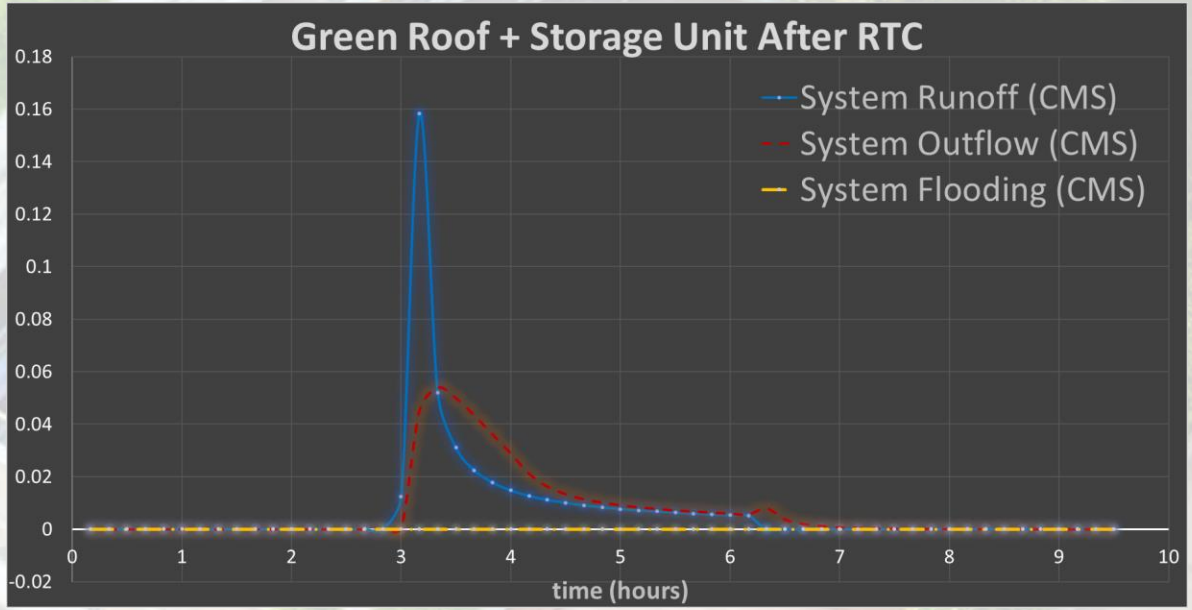
Heuristic Control

- Similar to the first model, a heuristic if-then statement has been set as the controller according to the depth in storage unit .
- This simple condition is controlling the opening fraction of the orifice.

Results Before and After RTC Application



Overlaid graphs of system runoff, outflow, and flooding (CMS)

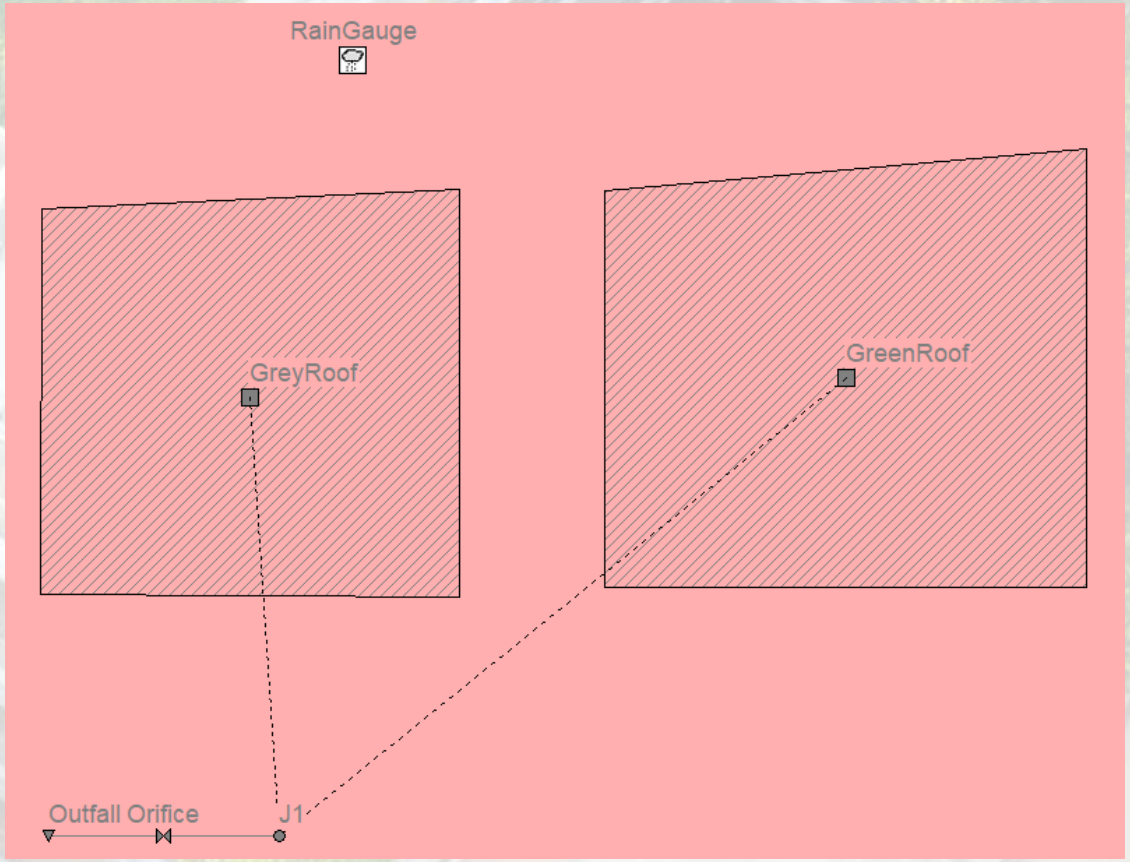


Overlaid graphs of system runoff, outflow, and flooding (CMS) after RTC application

Third Model: Green Roof And Grey Roof

Area (Green Roof): 0.5 Hectare (5,000 m^2)
Area (Grey Roof): 0.5 Hectare (5,000 m^2)
Width: 500 m^2
Imperviousness for both: 100%

- The sub-catchment is divided in half.
- First section is allocated to a green roof using the SWMM-LID module.
- Second section is a simple impervious grey roof.

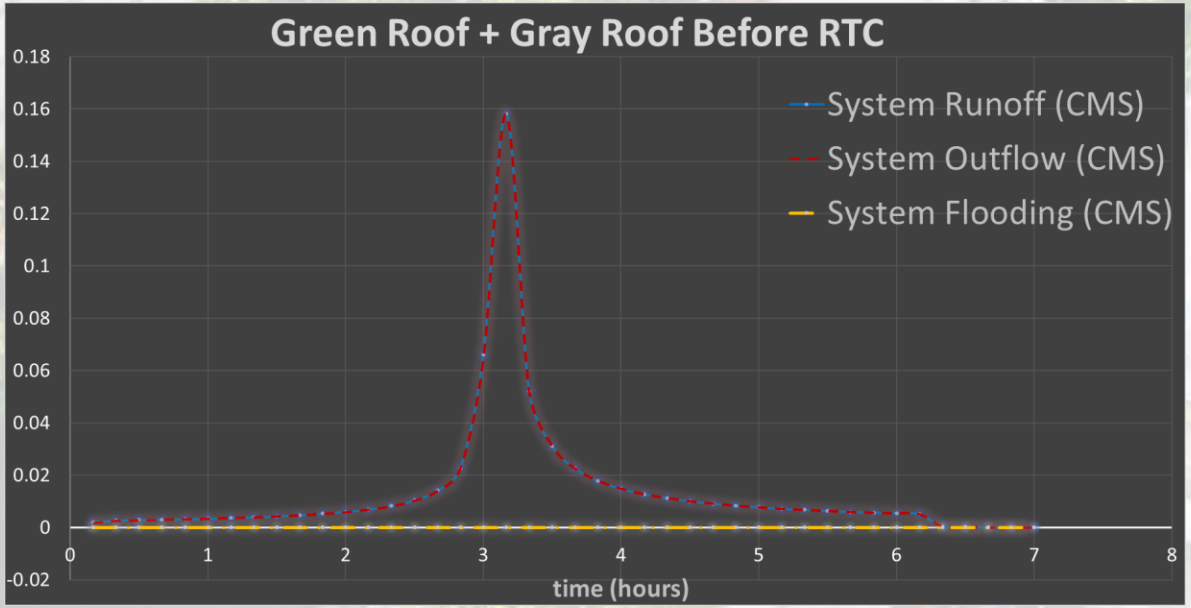


Schematic design of the third model, green roof and grey roof, in SWMM

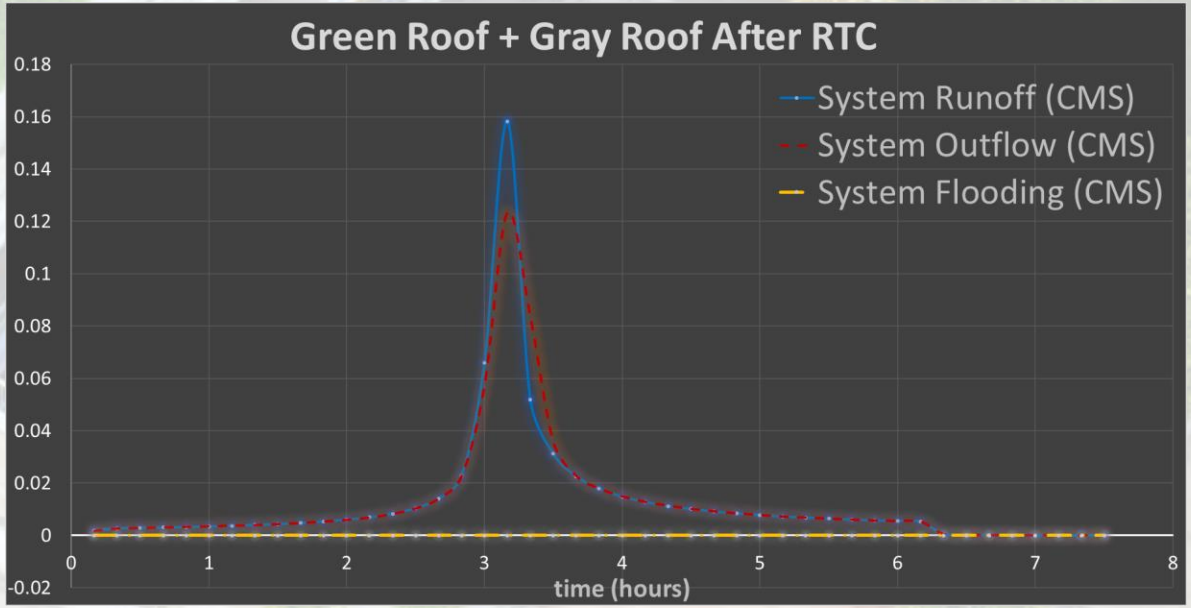
Heuristic Control

- Similar to the previous models, a heuristic if-then statement has been set as the controller according to the depth in node J1.
- This simple condition is controlling the opening fraction of the orifice.

Results Before and After RTC Application



Overlaid graphs of system runoff, outflow, and flooding (CMS)



Overlaid graphs of system runoff, outflow, and flooding (CMS) after RTC application

Conclusion

- These heuristic rule-based controls have illustrated the capability of RTC of improving the performance of the already superior green roof in stormwater management.
- RTC addition to these three models have been able to attenuate the peaks in the outflow of the systems, and subsequently, the runoff.
- With RTC application, it has also been shown that the peaks in these systems' runoff occur over a slightly larger period and is not instantaneous.

Future Work

- Devising more complex RTC rules, in addition to heuristic controls, can be investigated to compare the attenuation of peaks in the system runoff.
- Besides, based on the scale of the catchment, involving numerous control rules in different components, can potentially expand the room to maneuver and achieve the best optimization solution.
- RTC implementation in a real catchment can be examined to observe its performance under authentic and unpredicted conditions.

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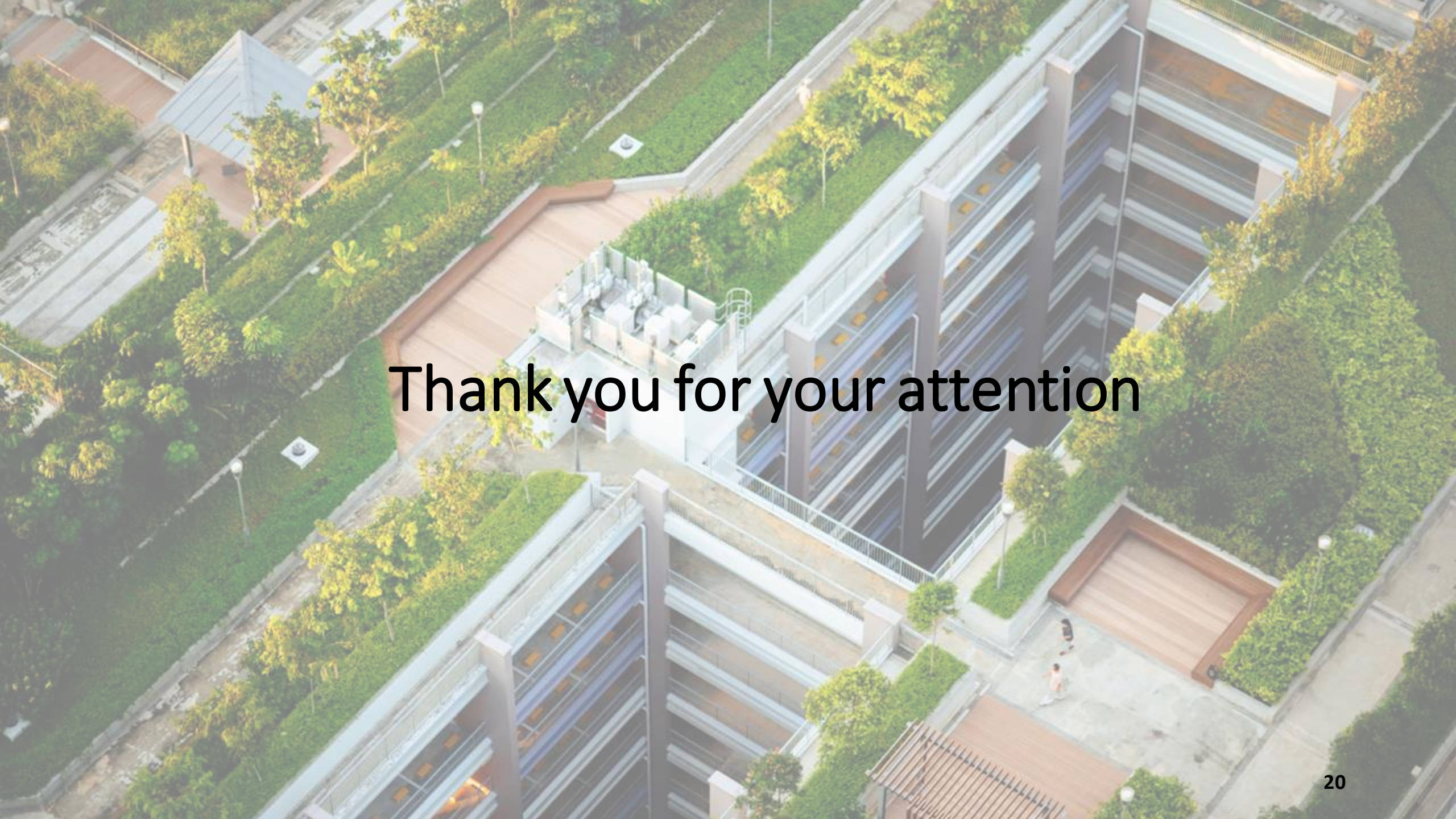
Thank you for your attention