# Impacts of Land Use and Climate Change on the Drainage of the Davis Creek Subwatershed

Jun Wang Dr. Yiping Guo (McMaster University) *June 27th, 2017* *Project 4-3*

## 1. Introduction

### Background

-Urbanization and Climate Change have significant impacts on urban catchments. It is important to evaluate the hydrological responses of urban catchments to land use and climate changes.

### Objective

- Develop and calibrate a hydrologic model for a typical urban catchment.
- Evaluate the effectiveness of stormwater detention ponds on flood control under the existing and future land use conditions.
- Estimate the effects of future climate change on urban drainage infrastructures and explore effective stormwater management measures to reduce climate change impacts.

## 2. Study Area

### Site Description

- Davis Creek subwatershed is a large part of the Red Hill Creek watershed. It is Divided into the upper and lower portions by Niagara Escarpment and outlets to Lake Ontario.

Table 1. Characteristics of the Davis Creek subwatershed

| Subwatershed | Total Area (ha) | Pervious Area (ha) | Impervious Area (ha) | Impervious (%) | Slope (%) |
|---|---|---|---|---|---|
| Lower Davis Creek | 245.8 | 163.6 | 82.2 | 33.44 | 0.99 |
| Upper Davis Creek | 922.5 | 721.0 | 201.5 | 21.84 | 0.94 |

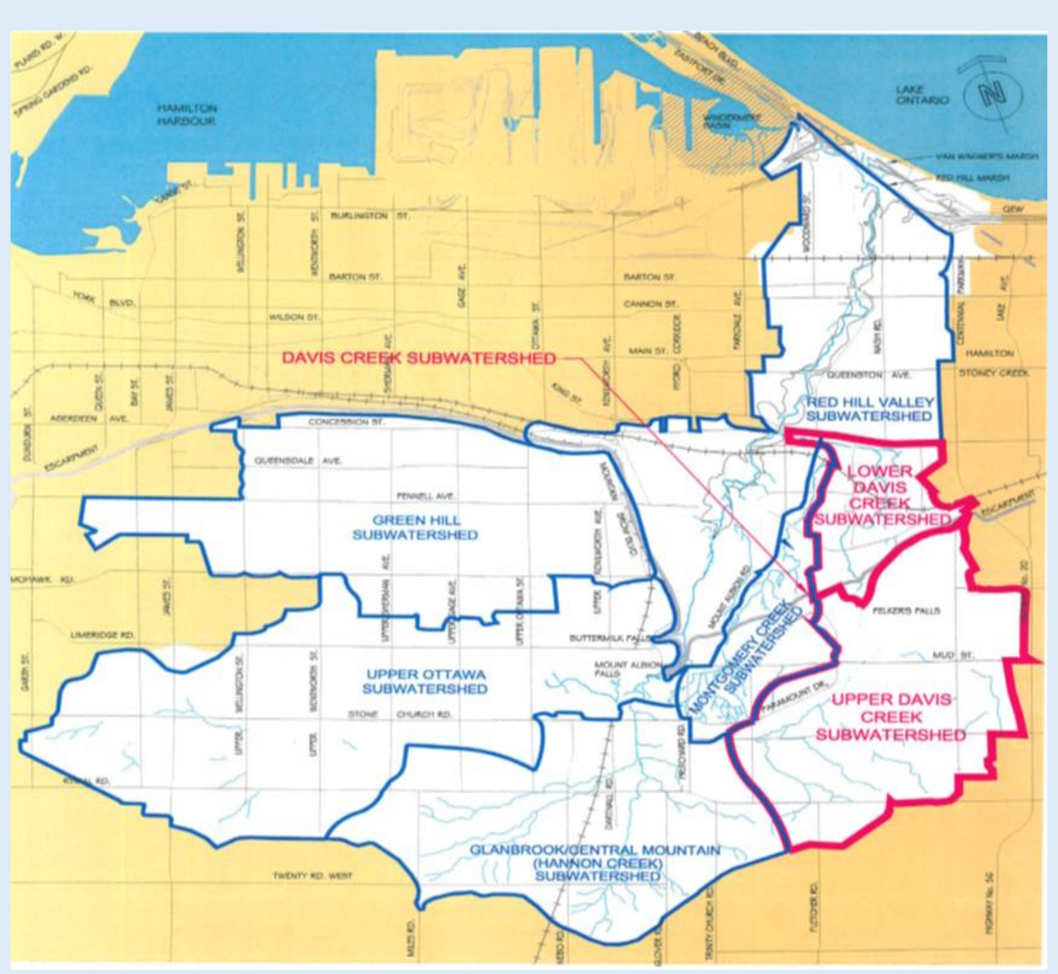



Figure 1. Location of the Davis Creek Watershed

## 3. SWMM Model

### Existing Land Properties

### Future Land Properties

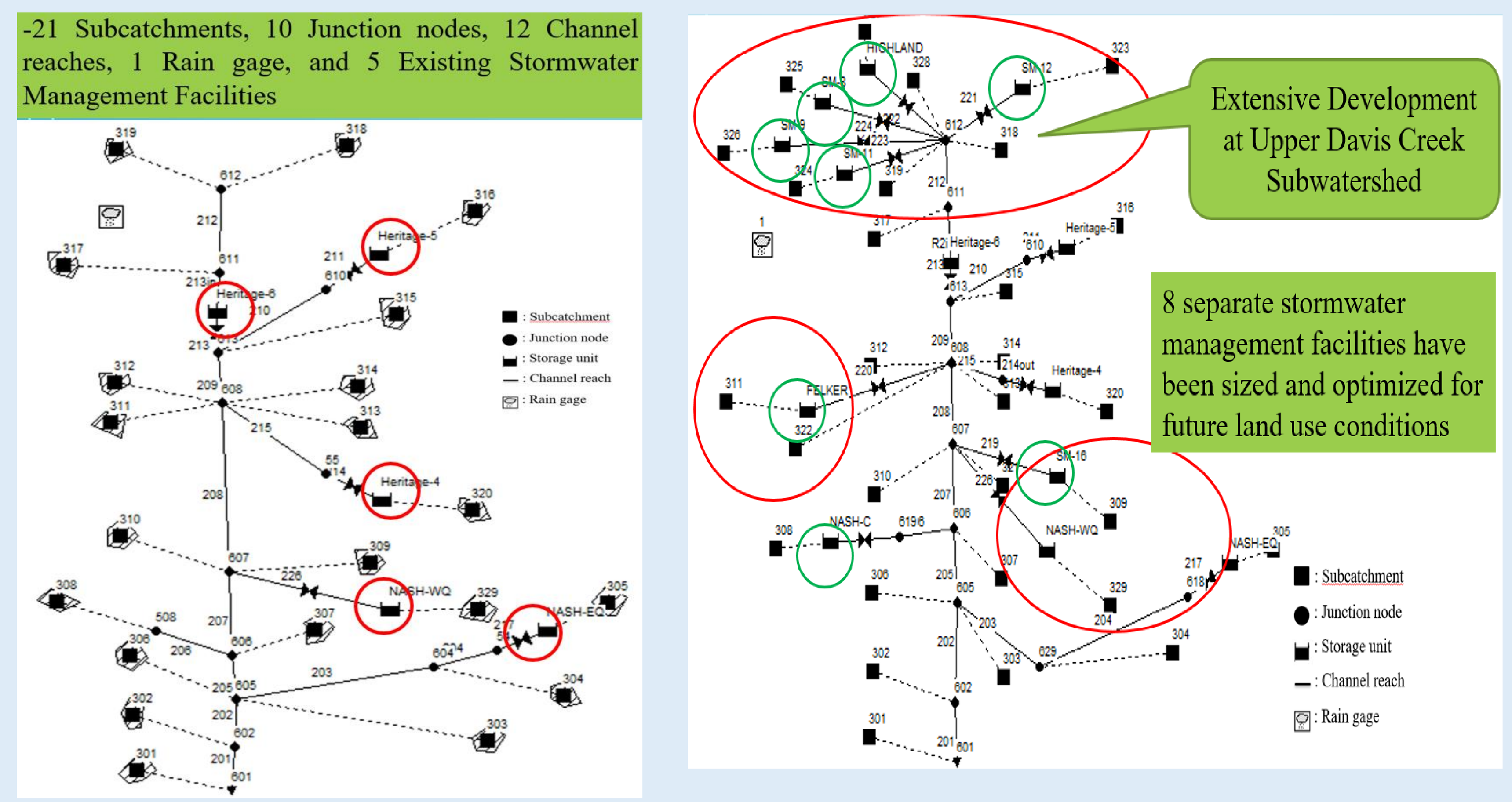



Figure 2. Diagram of the Subwatershed Land Use Conditions in SWMM

### Model Calibration

Parameters selected for calibration:

- Overland Flow Length ($L_m$)
- Manning's *n* for pervious and impervious land segment (n-p, n- imp)
- Maximum infiltration capacity (*$f_0$*)

Selected Measures: Root Mean Square Error (RMSE) and Nash-Sutcliffe Coefficient

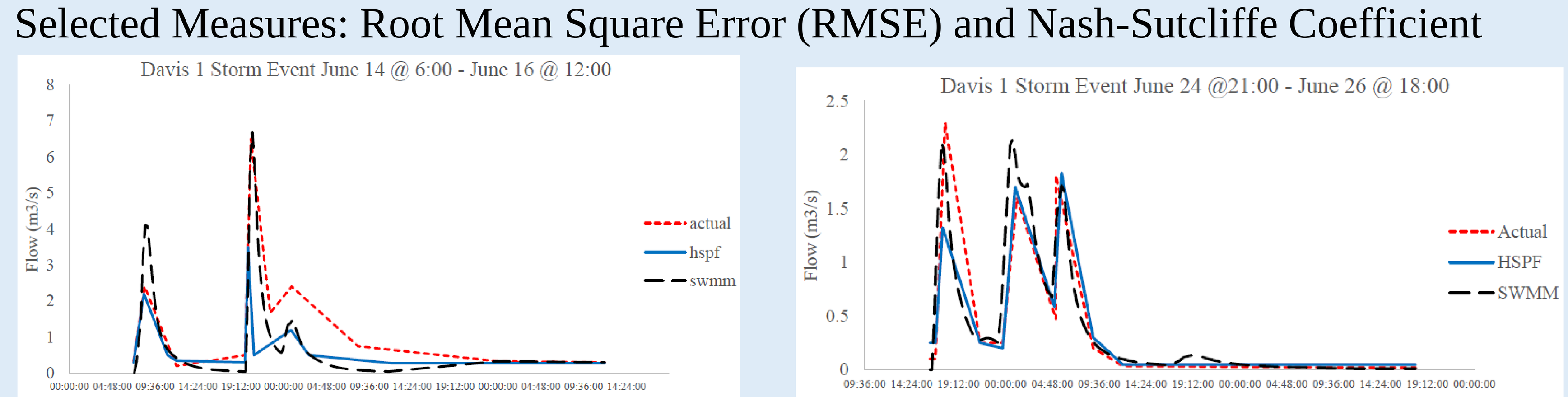
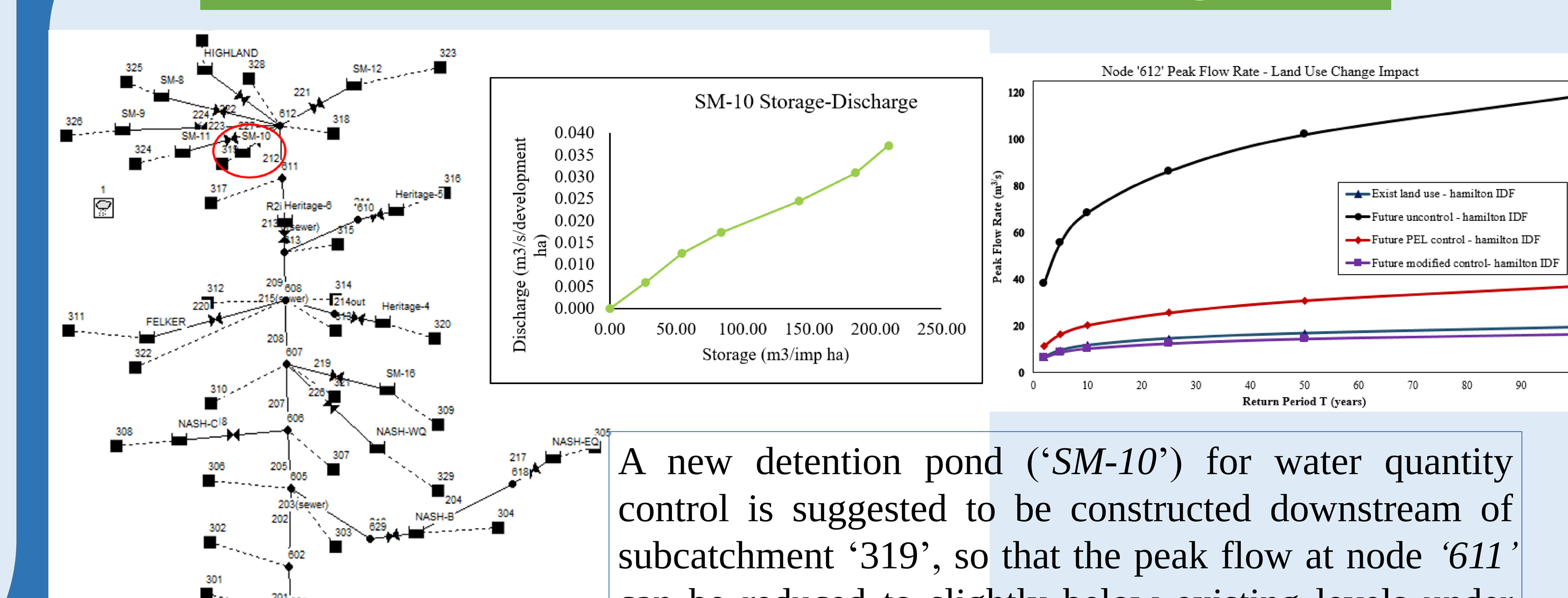



Figure 3. Calibration Results for Daily Storm Events

- RMSE (Root Mean Squared Error) = 0.451 $m^3/s$
- Nash-Sutcliffe model efficiency coefficient = 0.8

## 4. Impacts of Land Use Change




A new detention pond ('*SM-10*') for water quantity control is suggested to be constructed downstream of subcatchment '319', so that the peak flow at node *'611'* can be reduced to slightly below existing levels under the future land use condition.

Figure 4. Peak Flow Rates Dynamics under Different Land Use Conditions

## 5. Impacts of Future Climate Change

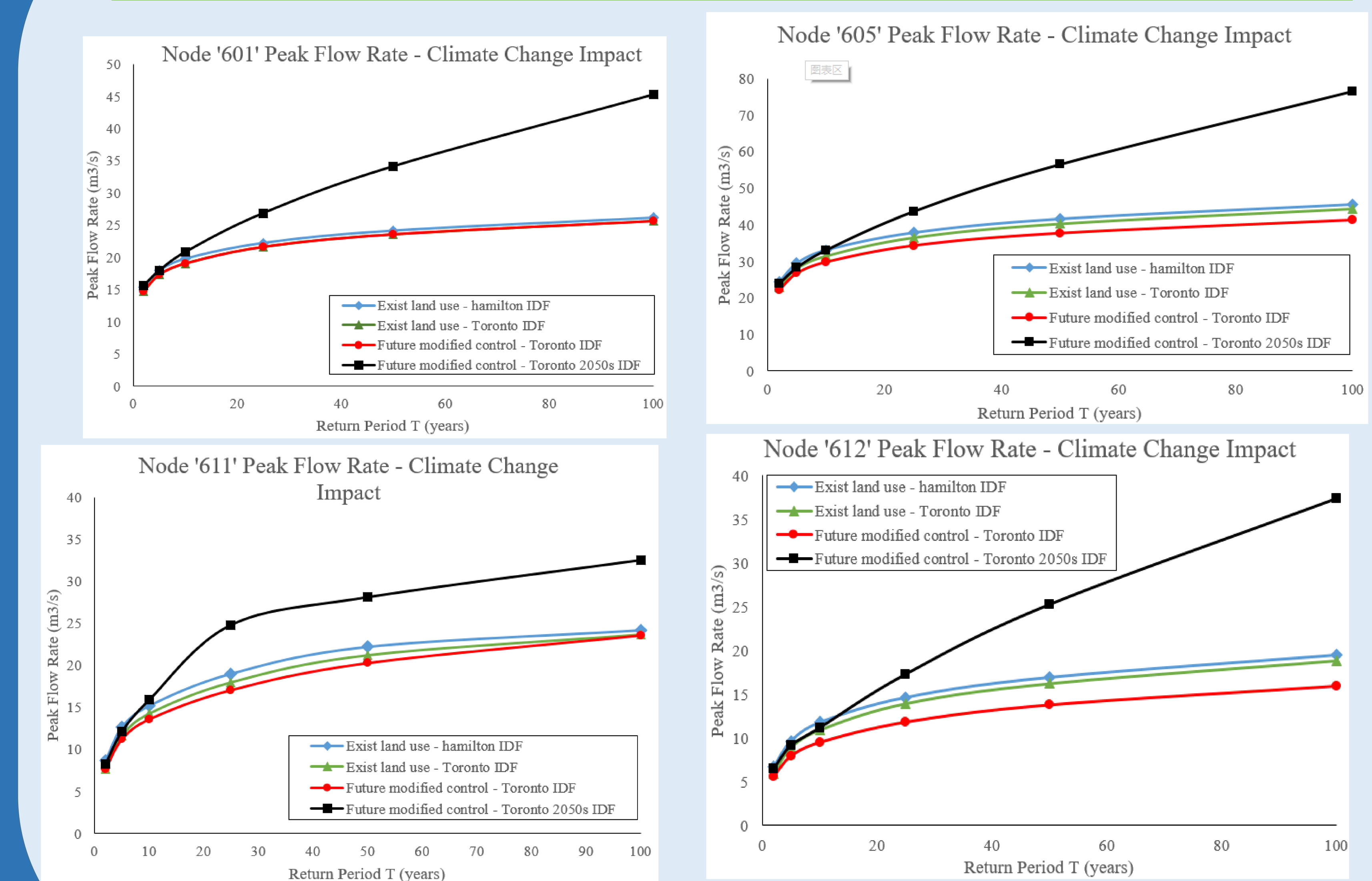



Figure 5. Comparison of Peak Flow Rates at Different Nodes under Climate Change

## 6. Stormwater Control Practices

### Construct Additional Ponds

A new detention pond should be added with approximately 160 m3/ha storage volume in average.

### Enlarge the Size of Existing Ponds

Existing detention pond 'NASH-EQ' controlling runoff from subcatchment '305' needs to be 12.4 times larger than the previous design (from 104.95 m3/ha to 1406.70 m3/ha) so that the 100-year return period flood peaks can be kept at existing levels.

### Expansion of Sewer Pipe Size

The increase of a fraction of α in rainfall intensity would require an enlargement of a fraction of $\sqrt{1+\alpha}-1$ for the diameter of the sewer pipe.

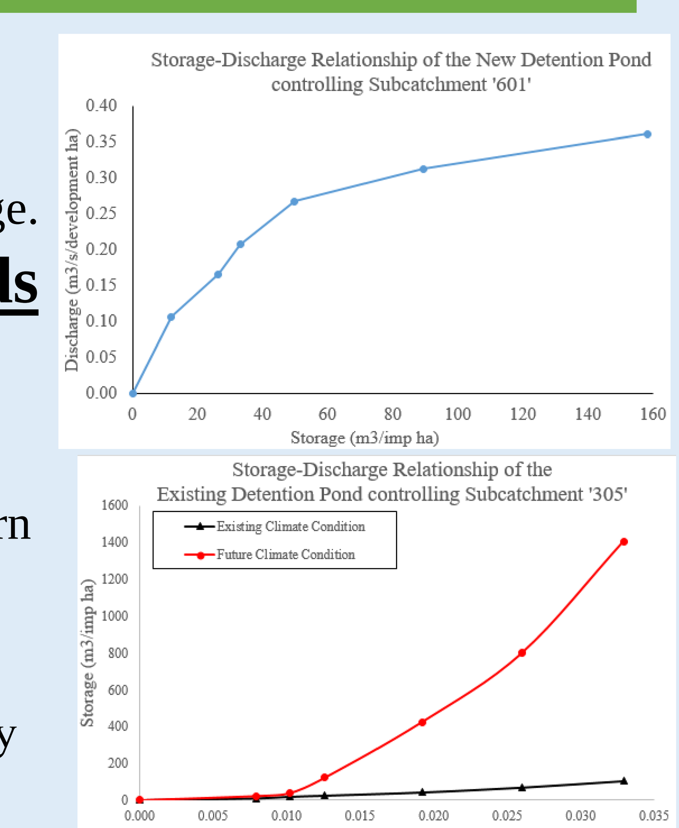



Figure 6. Storage-Discharge Relationships of Modified Existing and New Ponds

## 7. Summary

- The SWMM model is suitable for hydrological simulation of urban catchments; the calibration results are considered to be within the acceptable range.
- A new detention pond 'SM-10' for flow quantity control may be added downstream of subcatchment '319' due to increased peak flow under land use condition in future.
- In order to mitigate peak flow rates at the evaluated junction nodes under future climate, for subcatchments discharging directly to the junction nodes without any control, an average storage of 160 $m^3$/ha is required to control, while existing detention ponds need to be enlarged by 12.4 times.
- The diameters of sewer pipes in the Davis Creek subwatershed are suggested to increase by 23.87% in maximum and 7.46% on average for 50-year design storm with duration from 5 min to 24 hr.