# Green Infrastructure Placement Strategy in Urban Stormwater Network

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## INTRODUCTION

Green infrastructure (GI) reduces runoff to storm sewer by locally infiltrating the stormwater. However, existing GI projects are often planned and managed at a site-scale. Our goal is to connect the GI projects' patterns to stormwater network structures, and to assess their performance under different rainfall scenarios on a watershed scale.

*Q1. Network Structure:*

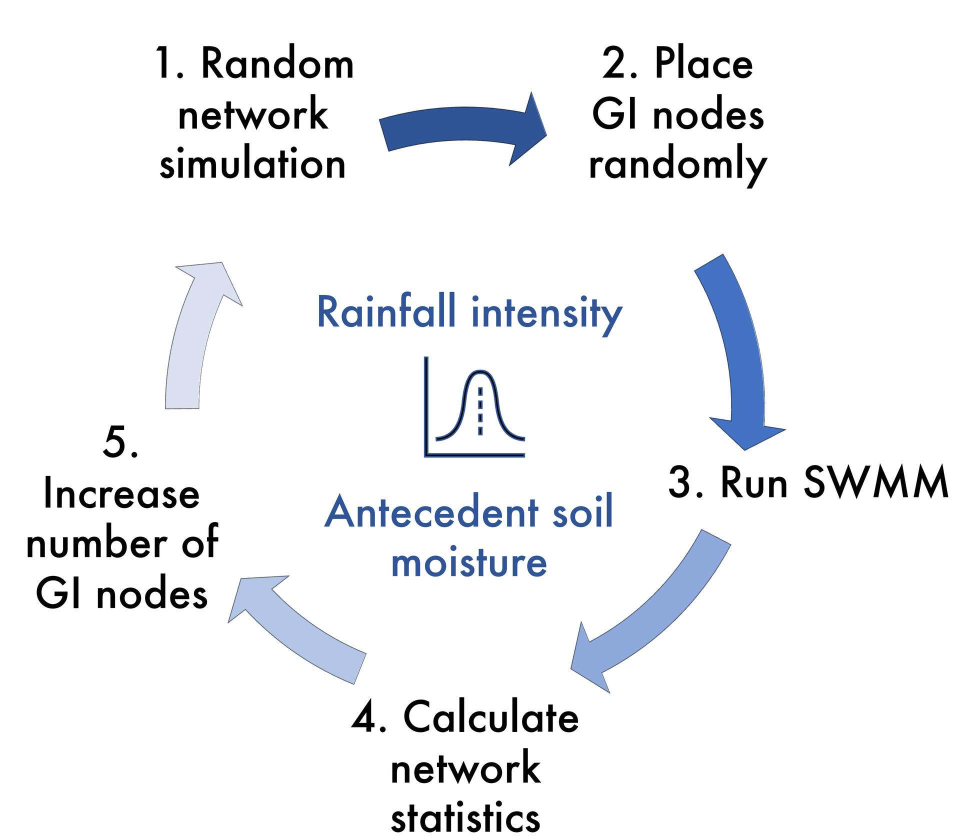
*On a watershed scale, how do green infrastructures change the travel time in a stormwater network?*

*Q2. Rainfall Scenarios:*

*Where to plan for green infrastructures when we expect more intense and more frequent rainfall?*

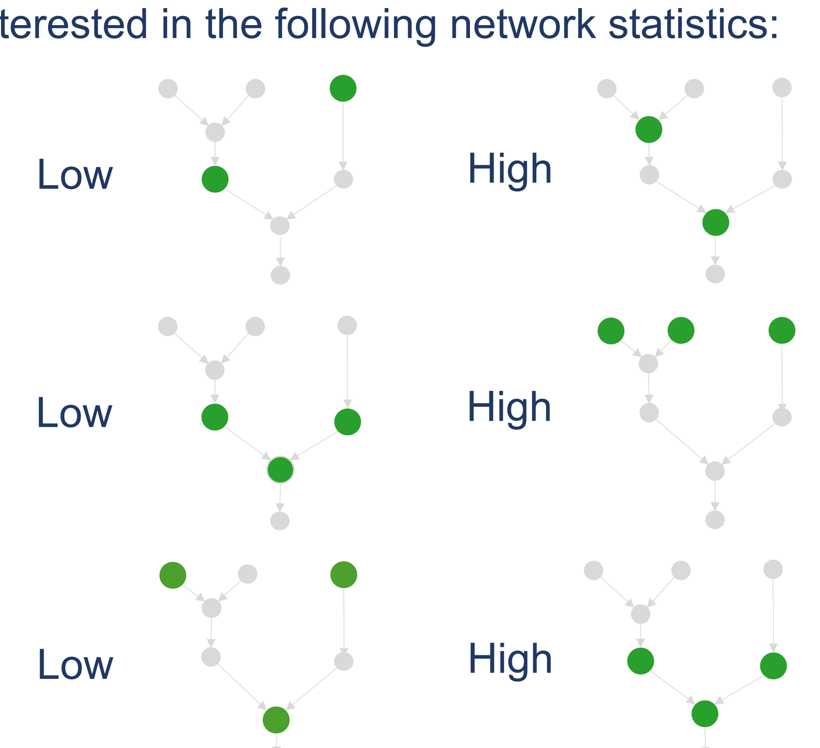
## METHOD

Our method examines how the GIs perform when placed in different urban development patterns and climate scenarios and provides metrics on how they are connected.




Mainly, we are interested in the following network statistics:

- Mean neighbor count of GI nodes
- Mean distance from GI nodes to outlet
- Clustering of GI nodes




## NETWORK SIMULATION

The urban stormwater network development pattern is modeled by different degrees of sinuosity. This is calculated by the difference between the length of actual path to outlet (following the current graph) and length of the shortest path to outlet (following the complete graph).

The degree of sinuosity and path difference can be modeled by the Gibbs distribution with sinuosity parameter $\beta$.

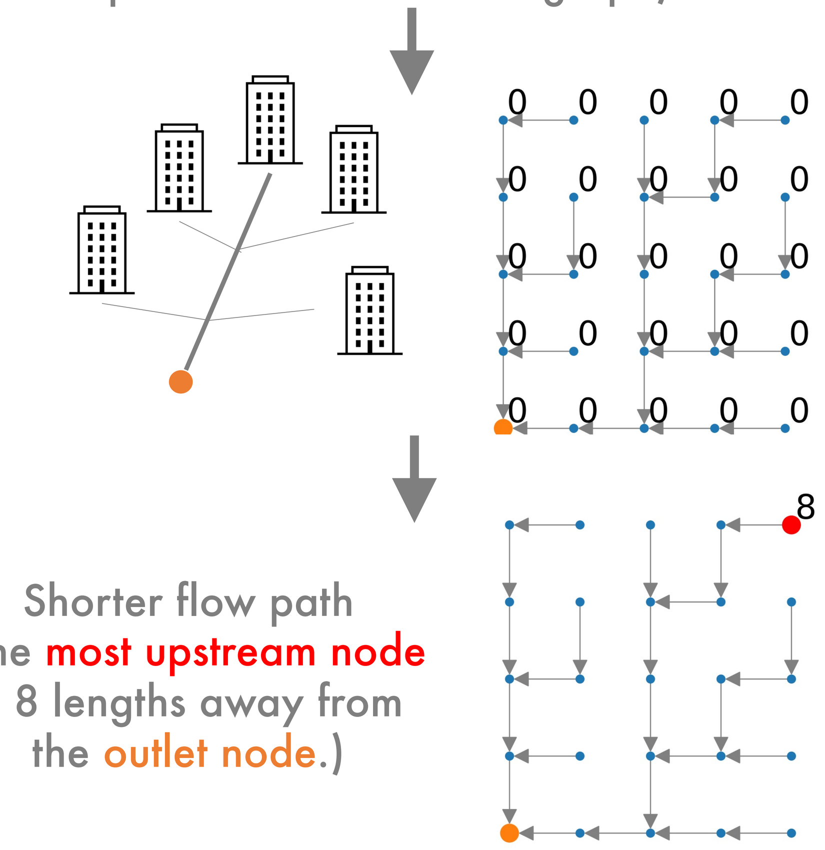
$$P_\beta\{s\} = [C(\beta)]^{-1} e^{-\beta H(s)}$$

where $C(\beta)$ is the normalizing coefficient, and the path difference is $H(s)$.

**"High-Density Development" Case**

Larger β → shorter travel time

(actual paths follow shortest paths, shown as 0 path difference on the graph)

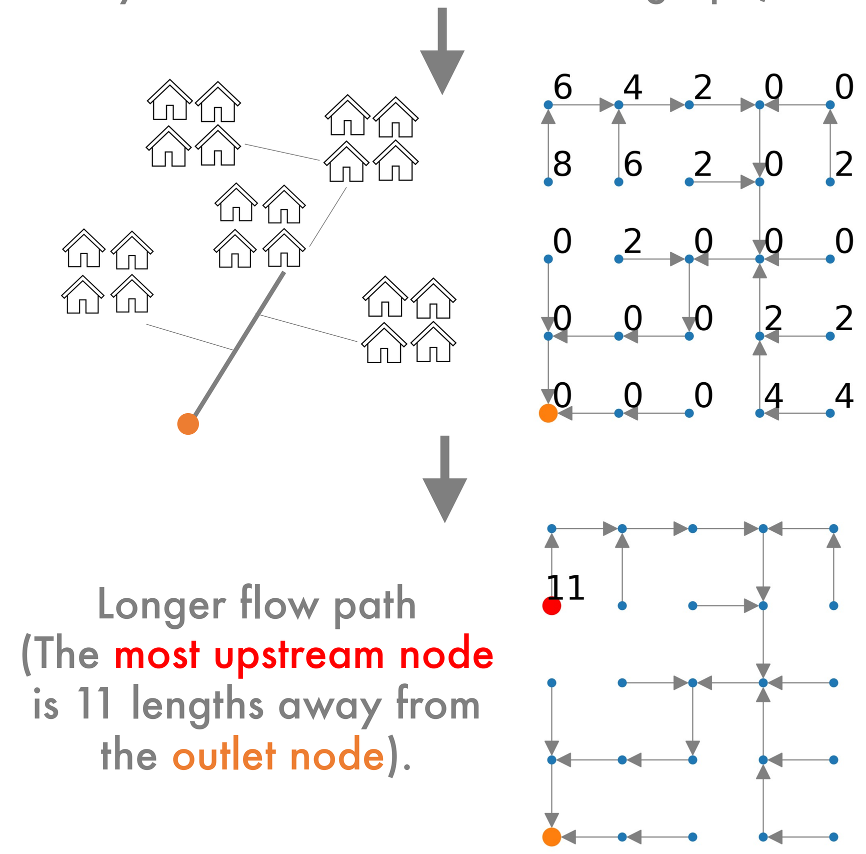


Shorter flow path (The most upstream node is 8 lengths away from the outlet node.)

**"Urban Sprawl" Case**

Smaller β → longer travel time

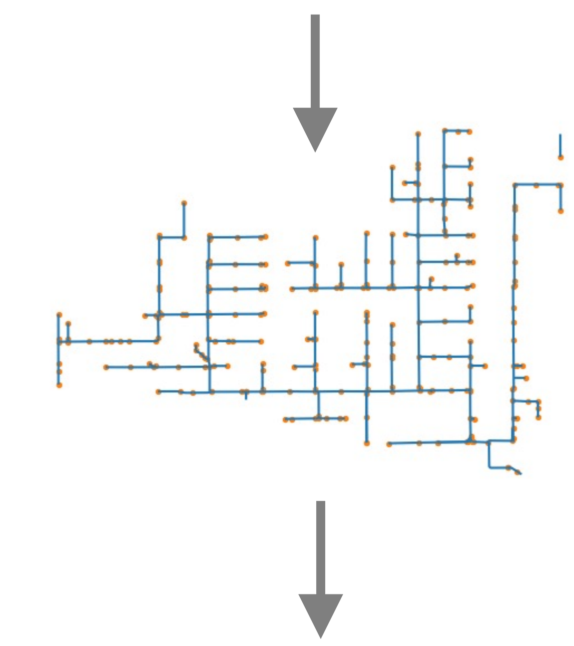
(actual path is longer than the shortest path, by the amount shown on the graph)



Longer flow path (The most upstream node is 11 lengths away from the outlet node).

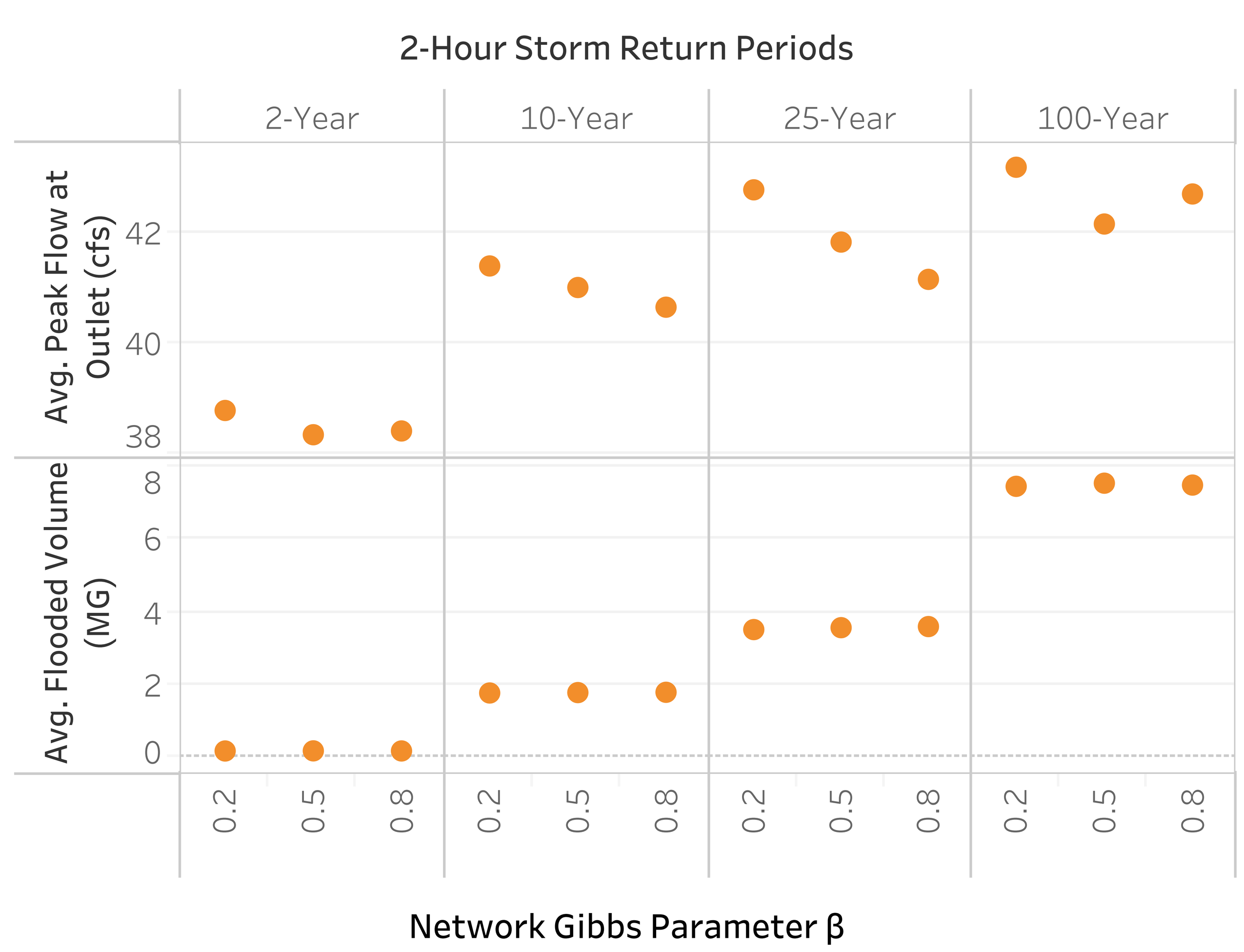
**Real Case**

β varies

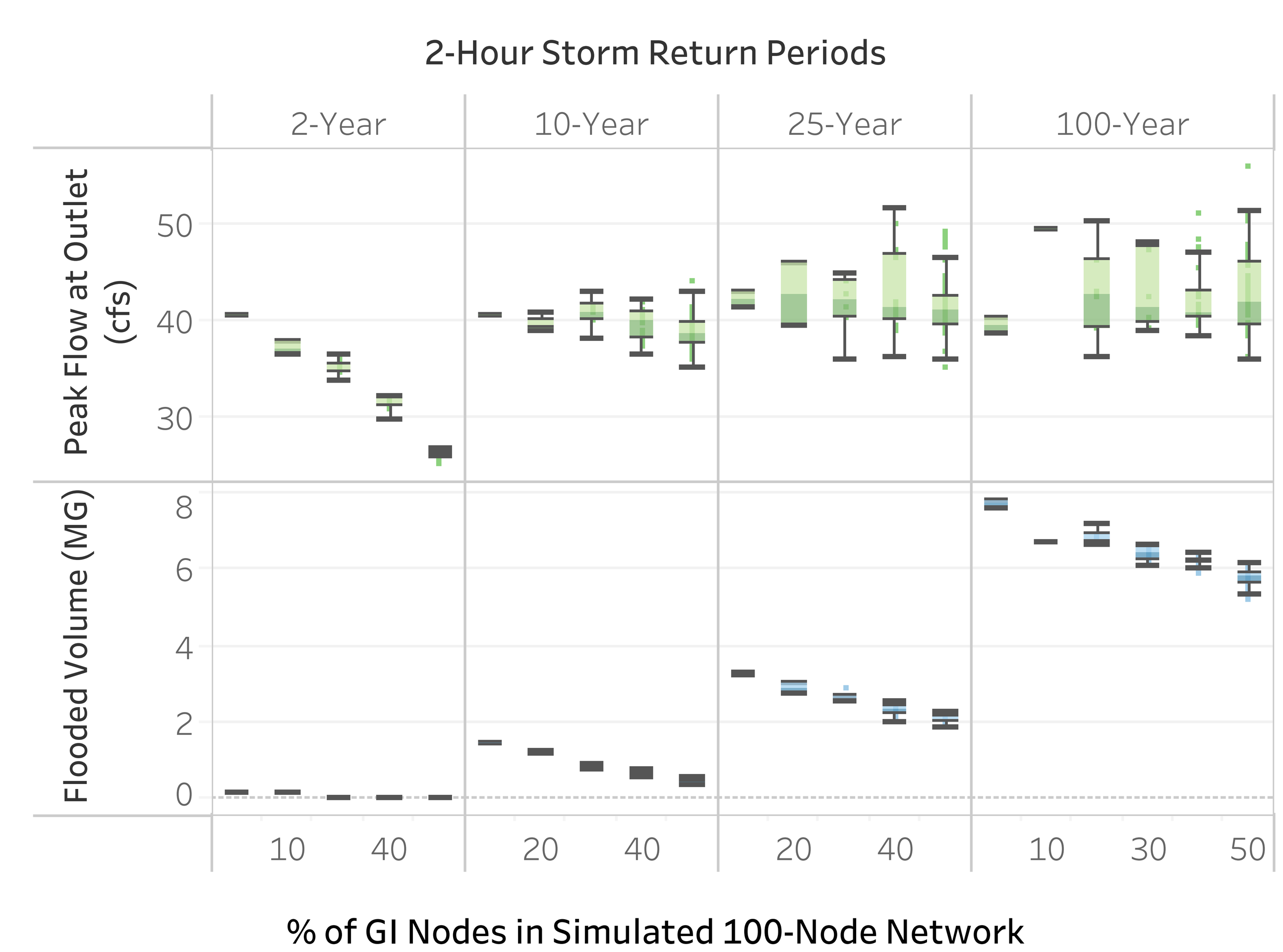


In order to estimate β, shapefiles of stormwater network will be fitted on lattice graphs.

## PRELIMINARY RESULTS




*Each point represents the mean value of all data points after Monte Carlo simulations.




* In SWMM, each GI occupies 5% of a subcatchment

**Q1 Network Structure**

The peak flow rate decreases with increasing network sinuosity β. The decrease is more significant at higher rainfall frequency.

This counterintuitive result may be due to the confounding effects of pipe network sizing, which will be further investigated.

**Q2 Rainfall Scenarios**

Higher number of GI nodes lowers peak flow rate and flooded volume. But its effect on lowering peak flow rate diminishes as rainfall intensity increases. On the other hand, GI nodes can more effectively reduce total flooded volume as rainfall intensity increases.

## FUTURE DIRECTIONS

Green infrastructure planning should be a collective municipal effort beyond site-only planning. We see a need to investigate the following areas in future projects to further understand the system and improve our model:

- Vary the scale of GIs from bioswales to parks.
- Differentiate between permeable covers and vegetative covers.
- Model GIs' effects on the network's runoff water qualities.

## ACKNOWLEDGEMENT

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Image credit: www.salamandaart.com