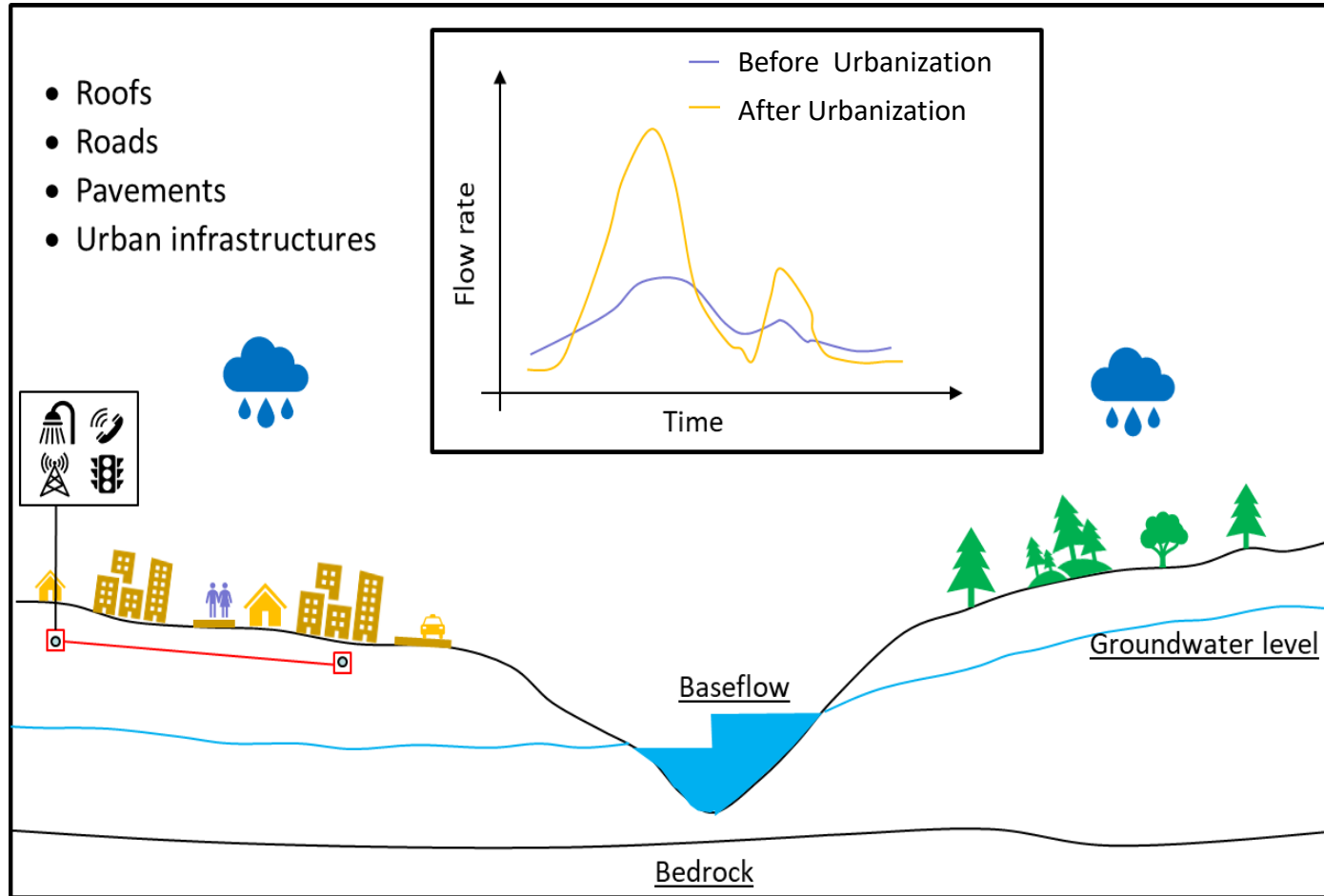# The fate of infiltrated stormwater from infiltration basins to the stream: quantifying the impact of the urban karst

Abolfazl Poozan[a], Andrew Western[a], Meenakshi Arora[a], Matthew James Burns[b], Tim D. Fletcher[b]

[a] *Department of Infrastructure Engineering, University of Melbourne, Victoria 3010, Australia*

[b] *School of Ecosystem and Forest Sciences, University of Melbourne, Victoria 3121, Australia*

Urbanization

- Roofs
- Roads
- Pavements
- Urban infrastructures

Before Urbanization
After Urbanization

Flow rate

Time

Groundwater level

Baseflow

Bedrock

<u>Impacts on hydrology:</u>

- Increased stormwater runoff volumes

- Magnitude and frequency of peak flows

- Less groundwater recharge

- Soil and water pollution

Water Sensitive Urban Design

Infiltration based measures

Rain Gardens

Infiltration Basins

Detention Ponds

Filter Strips

Porous Pavements

Wetlands

Stormwater Control Measures (SCMs)

Aims:

- Reduce runoff volumes

- Recharge groundwater by infiltrating water to the sub-surface

- Reduce pollution discharges to receiving waters

✓ Infiltration basins are one of the most commonly used technologies to achieve those aims.

✓ Infiltration-based measures play a central role in addressing the low-flow impacts of urbanization to streams.

Conceptual model - Questions

- What is the fate of infiltrated stormwater?

- What is the impact of the urban karst on the fate of infiltrated stormwater?

  o Urban infrastructure, such as sewer pipes and telecommunication cables, are usually surrounded by high permeability gravel/sandy trenches collectively known as 'the urban karst'
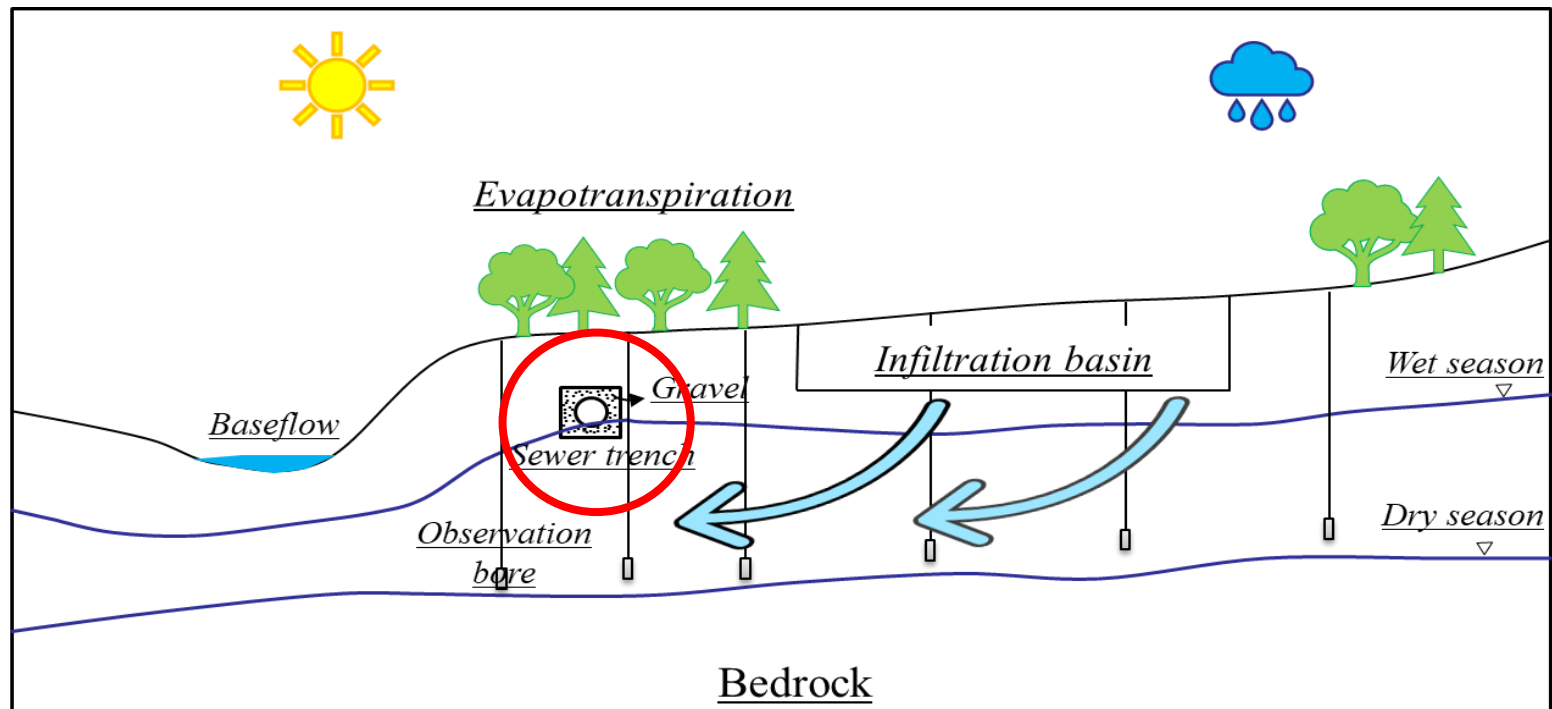
Methodology

- Develop a model for one site, then try to generalize the results

- Modelling the impact of the urban karst on infiltrated stormwater using HYDRUS-3D
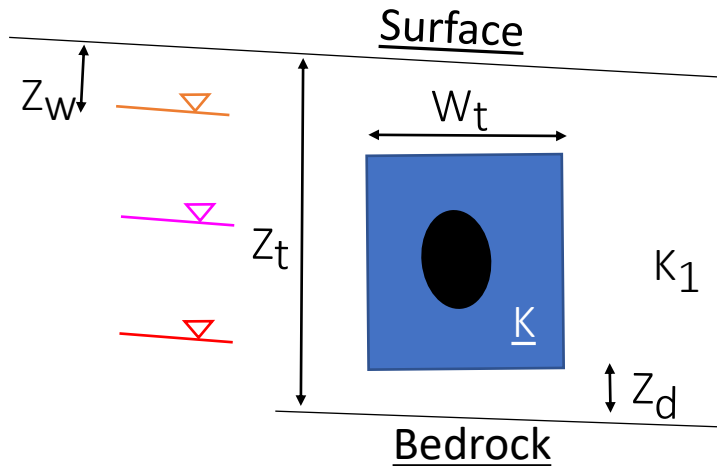

80 m

Outflow

Inflow

18 m. The distance between two observation bores.

Outflow

3 m
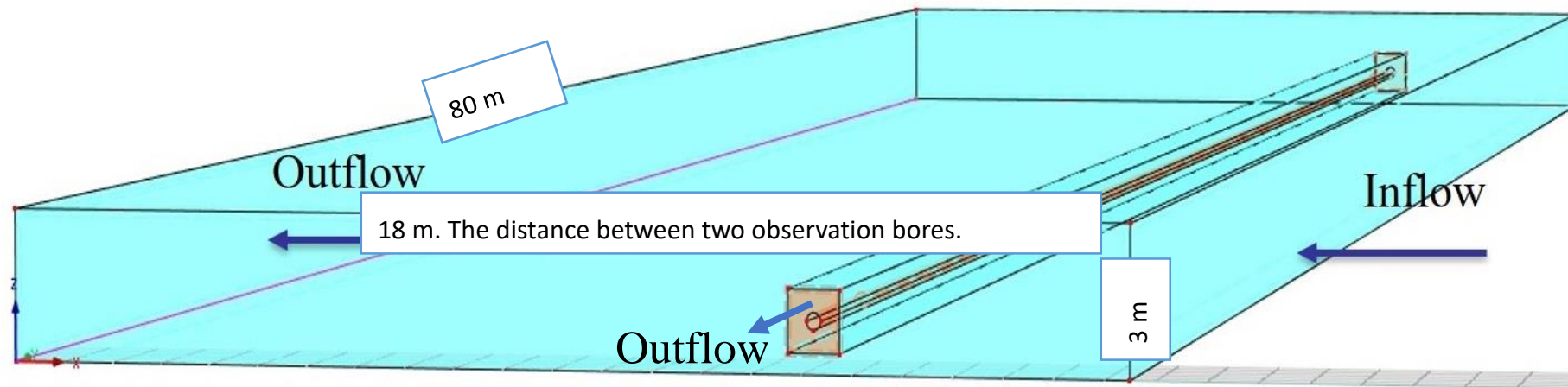
How to generalize the results?

- Propose equations based on groundwater level and the hydraulic conductivities of soil and gravel/sand

$$\circ \quad \frac{K_1}{K}$$

$$\circ \quad 1 - \left(\frac{Z_d}{Z_t - Z_w}\right)$$

$$\circ \quad \text{Ratio} = \frac{(((Z_t - Z_w - Zd) \times W_t) - \pi r^2) \times K \times \tan\alpha}{(Z_t - Z_w) \times W_z \times K_1 \times \tan\beta}$$
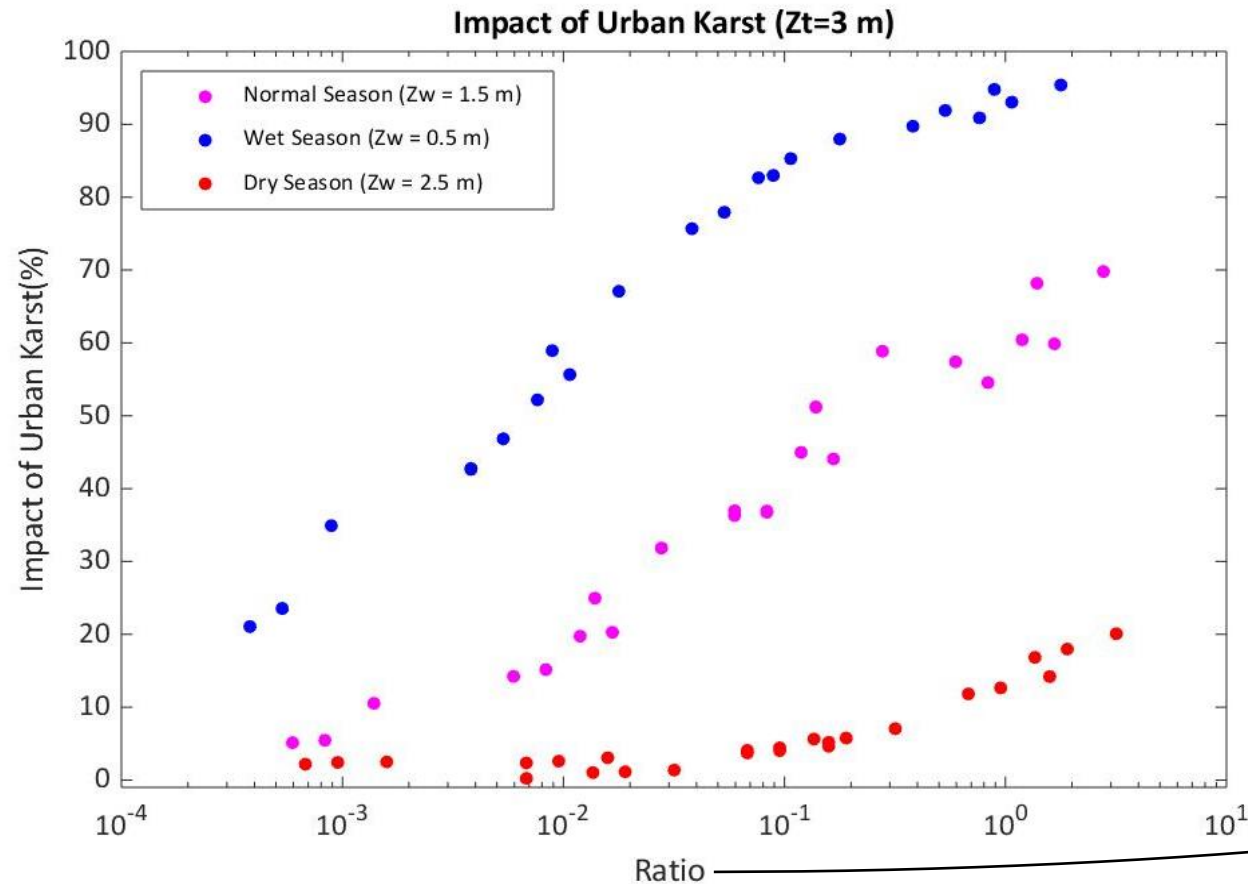
- K: Hydraulic conductivity of gravel/sand
- K_1: Hydraulic conductivity of soil
- Z_w: Groundwater level

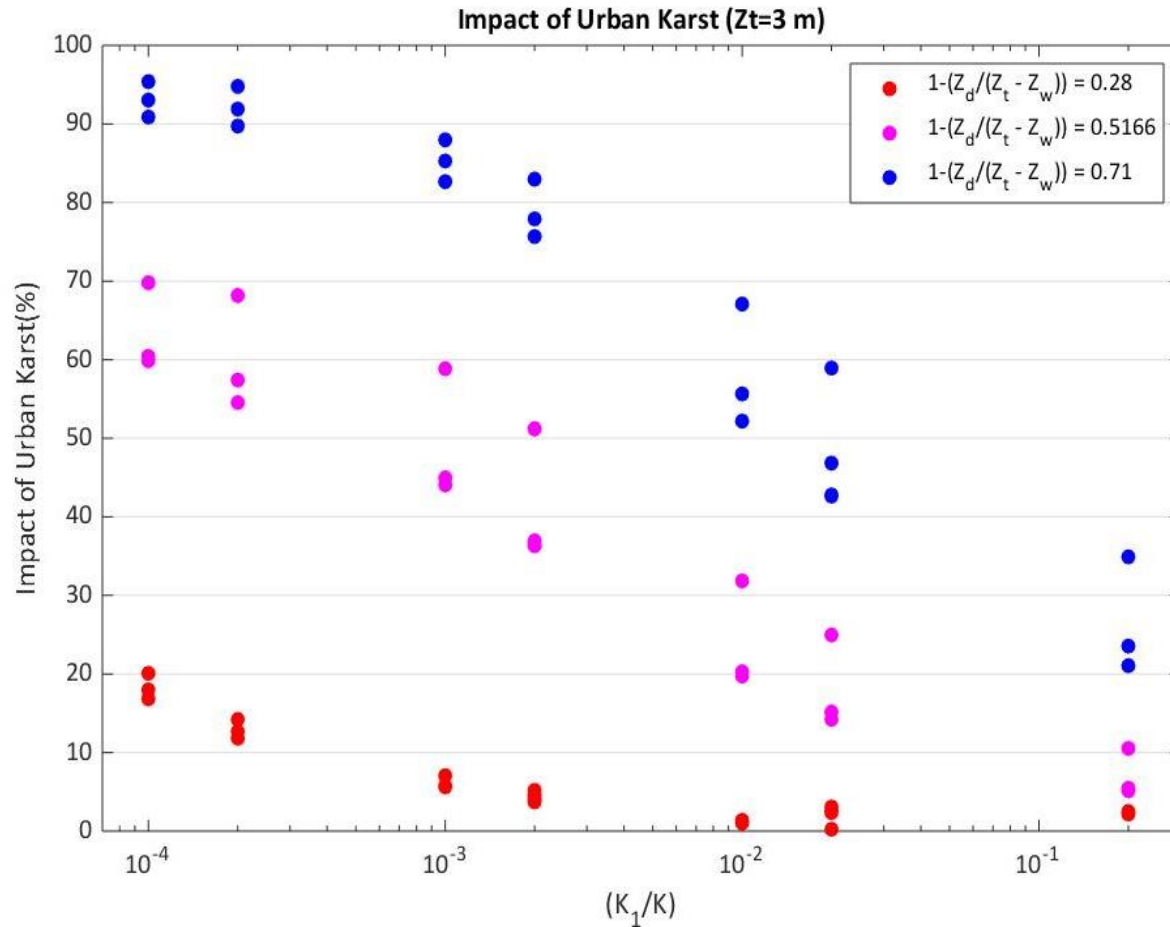|	Variable				Constant			
	Z_w(m)	K_t (m/day)	K_z(m/day)	tanβ	Z_t(m)	W_t(m)	W_z(m)	tanα
Value 1	1.5	20	0.002	0.05	3	0.0825	80	0.0017
Value 2	0.5	10	0.02	0.03				
Value 3	2.5	1	0.2	0.07				

Results

Impact of urban karst= $\dfrac{\text{Inflow to boundary condition (see slide 5)}}{\text{Outflow from urban karst boundary condition (see slide 5)}} \times 100$

Impact of Urban Karst (Zt=3 m)

Legend:
- Normal Season (Zw = 1.5 m)
- Wet Season (Zw = 0.5 m)
- Dry Season (Zw = 2.5 m)

- The higher the groundwater level, the greater the effect of the urban karst on infiltrated stormwater.

$\text{Ratio} = \dfrac{(((Z_t-Z_w-Zd)\times W_t)-\pi r^2)\times K\times \tan\alpha}{(Z_t-Z_w)\times W_z\times K_1\times \tan\beta}$

Results

Impact of Urban Karst (Zt=3 m)

Legend:
- $1-(Z_d/(Z_t - Z_w)) = 0.28$
- $1-(Z_d/(Z_t - Z_w)) = 0.5166$
- $1-(Z_d/(Z_t - Z_w)) = 0.71$

- The greater contrast between hydraulic conductivity of soil and gravel that covers urban infrastructure, the more impact of the urban karst on the infiltrated stormwater.

Conclusion

- Consider impact of the urban karst if goal of infiltration basin is to recharge the baseflow of the stream downslope.

- Basin location is important where urban infrastructure is located between potential infiltration basin sites and downslope stream.

- Impact of the urban karst should be investigated at each specific site before implementing infiltration systems; this study aims to provide simplified representations of impact for design.