Project 2.6: Developing tree-based infiltration systems

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Overall objective

Design *tree*-based *infiltration* systems to:

i) Reduce runoff volumes (*catch and use*)

ii) Reduce stress, improve growth of trees

1. System design

2. Species selection

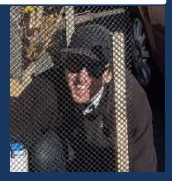
Project deliverables

1. A guidance document (underpinned by experiments and publications):
   - Species selection (1)
     - Suite of species/types depending on system
   - System design (2)
     - Connected versus infiltration, substrate profile and properties, control structures, sediment management

2. A tree-based node for MUSIC
   - System location and integration (3)

Retrofit System Design
[City of Monash]
Chris Szota
Established Trees
Runoff performance
Tree growth & stress

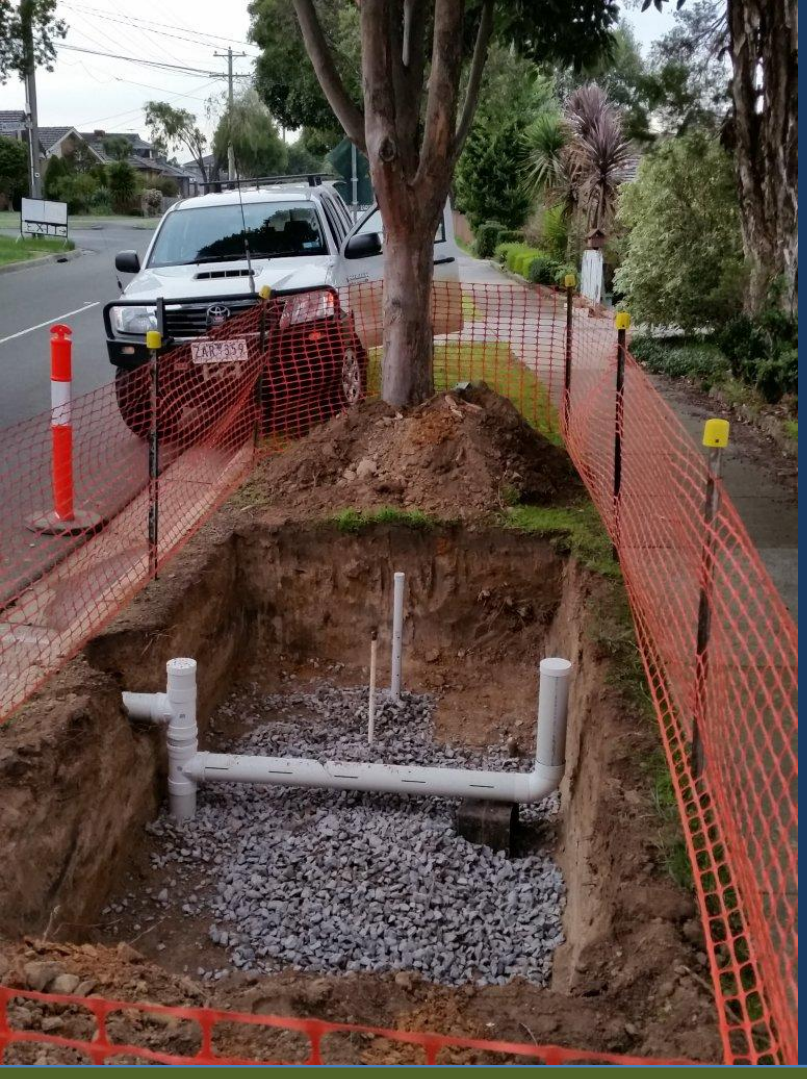
Retrofit System Design
[City of Moreland]
Vaughn Grey
New Trees
Runoff performance
Tree growth & stress



Species selection
Chris Szota
Current/ alternative species
Water use strategies

Retrofit System Design
[City of Monash, City of Moreland]
Established Trees, New Trees
Jasmine Thom
Runoff performance & Evapotranspiration

New System Design
New Trees, New Design
Jasmine Thom
Runoff performance
Evapotranspiration
Tree growth, tree stress



Retrofit System Design

[City of Monash]

Established Trees

Stormwater retention results

Infiltration trench (1500 L storage)

Adjacent to established tree

4 study streets

- 2 soil types
  - sandy clay & clay
- 2 tree functional types
  - evergreen & deciduous
- 2 inlet types at each (lintel and pit)
  - Designed to prevent clogging

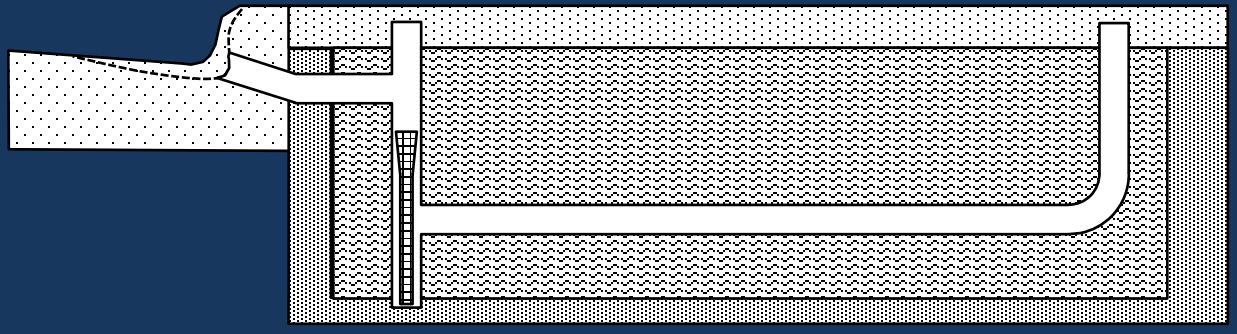
Prevent the trench from clogging

Retrofit System Design

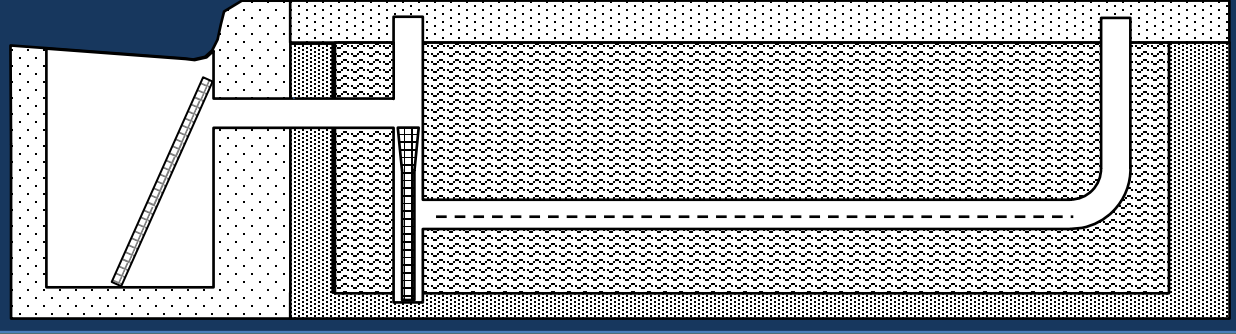
[City of Monash]

Established Trees

Lintel inlet

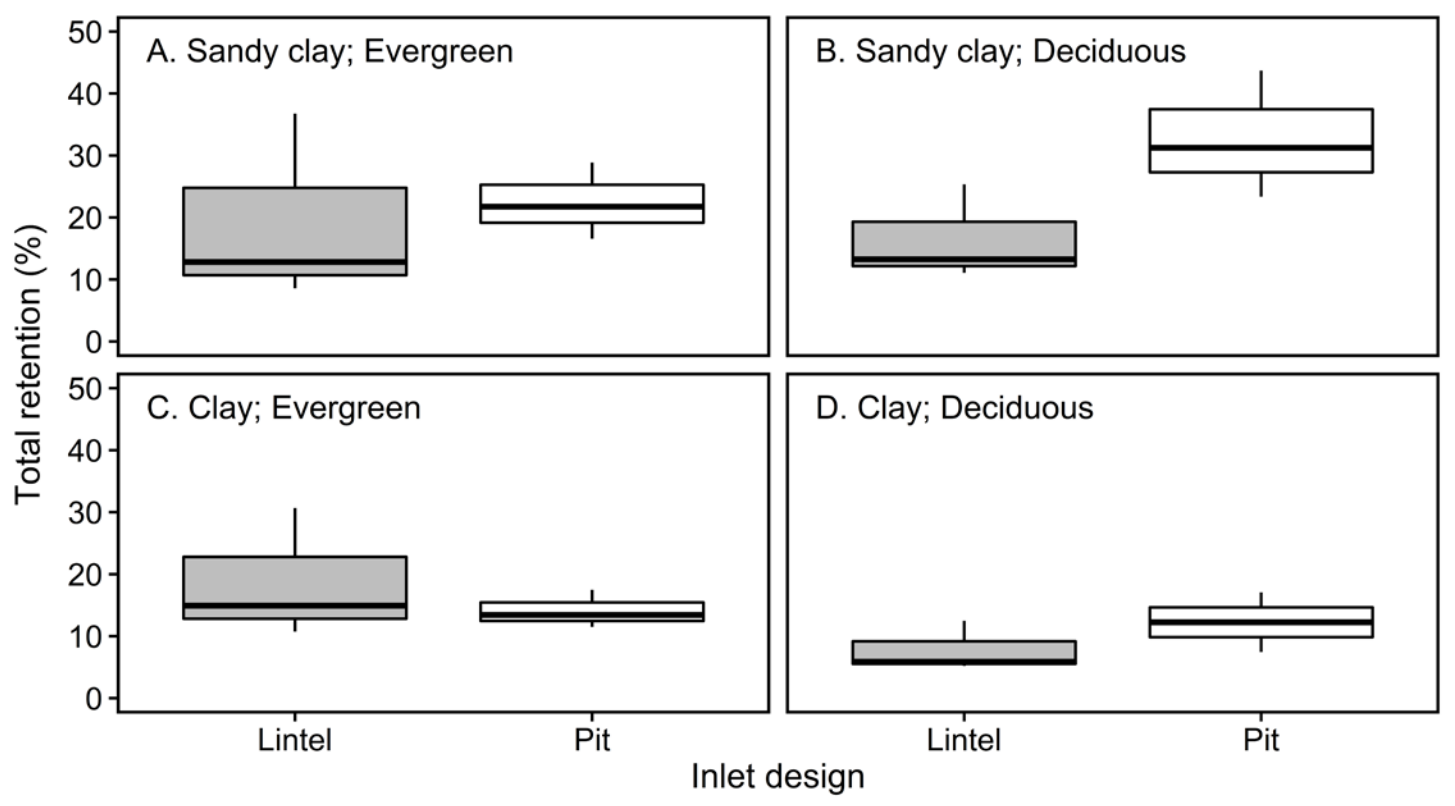


Pit inlet



Total runoff retention (18 months)

Retrofit System Design
[City of Monash]
Established Trees



Retention ~18%

High variability (5 – 44%)

WHY?

Inlets preserved the trench at the cost of retention

Retrofit System Design
[City of Monash]
Established Trees

What next?

- Remove inlet restrictions
  - *Vaughn*
- Quantify evapotranspiration
  - *Jasmine*

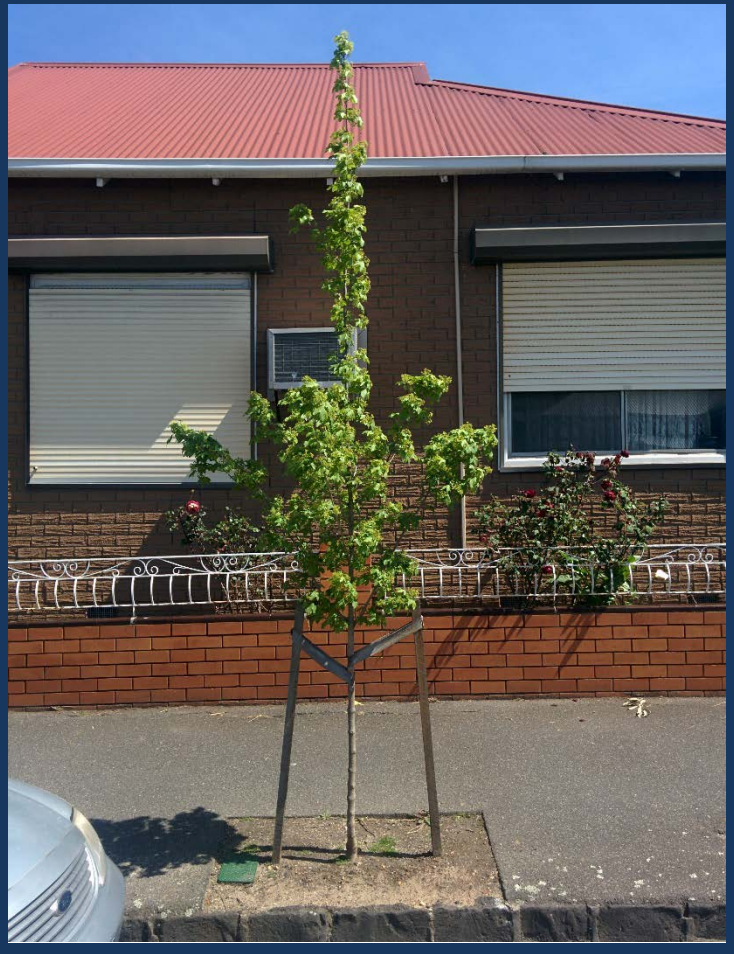
Inlet capacity
(>1 L s^{-1})
[blockages]

Flow velocity
(<2 m s^{-1})
[hydraulics]

Barrow Street field study

New trees

Research Question: Can streetscape tree pits provide solutions to both stormwater quality / quantity and the urban heat island effect?



Treatment 1 – Control

- Standard Council tree planting
- Smallest standard dimensions:
  1200 mm by 600 mm

Treatment 2 – Drained

- Standard WSUD tree pit configuration
- Saturated zone
- Underdrain connected to stormwater system

Treatment 3 – Infiltration (sand)

- Similar to standard WSUD tree pit but no underdrain
- Same WSUD layers
- Relying on exfiltration to surrounding soil only

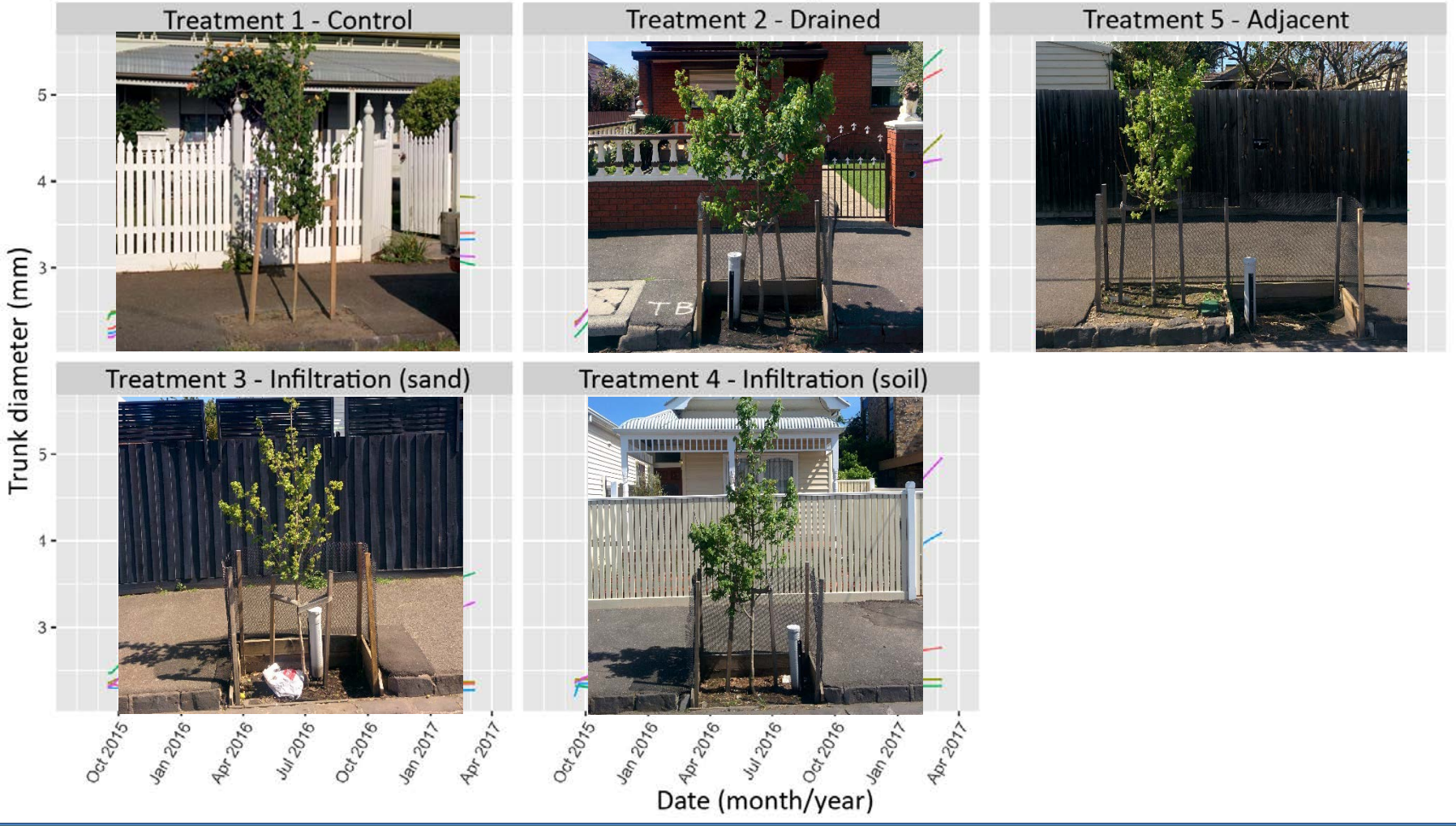
Treatment 4 – Infiltration (soil)

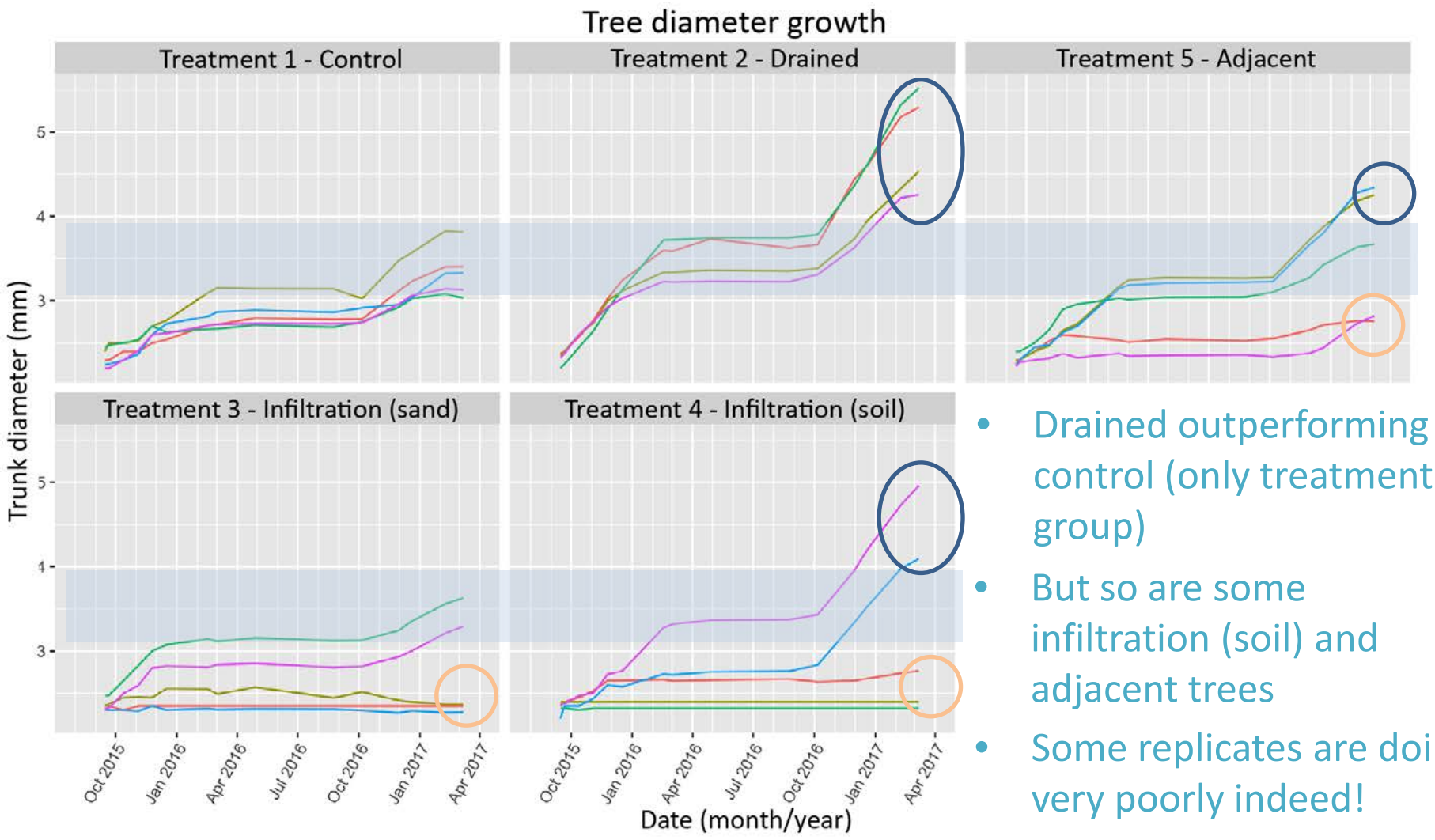
- Same inlet and extended detention zone
- No WSUD layers using in-situ soil (clay) only
- No underdrain connected to stormwater system
- Relying on exfiltration to surrounding soil only

Treatment 5 – Adjacent

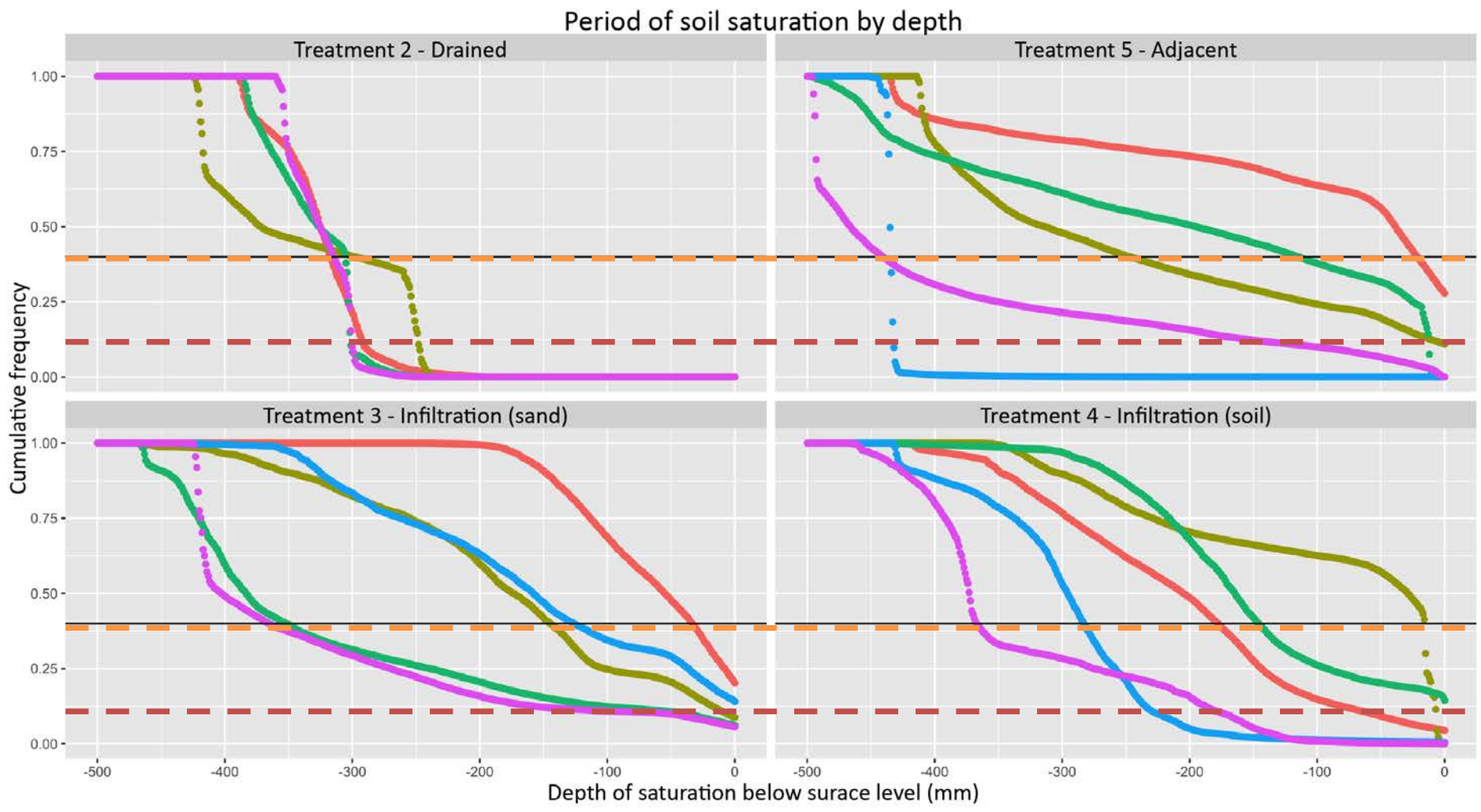
- Standard Council tree planting next to an infiltration (sand) pit
- Water directed into pit next to tree rather than directly to root ball
- No underdrain
- Relying on exfiltration to surrounding soil only

Tree diameter growth

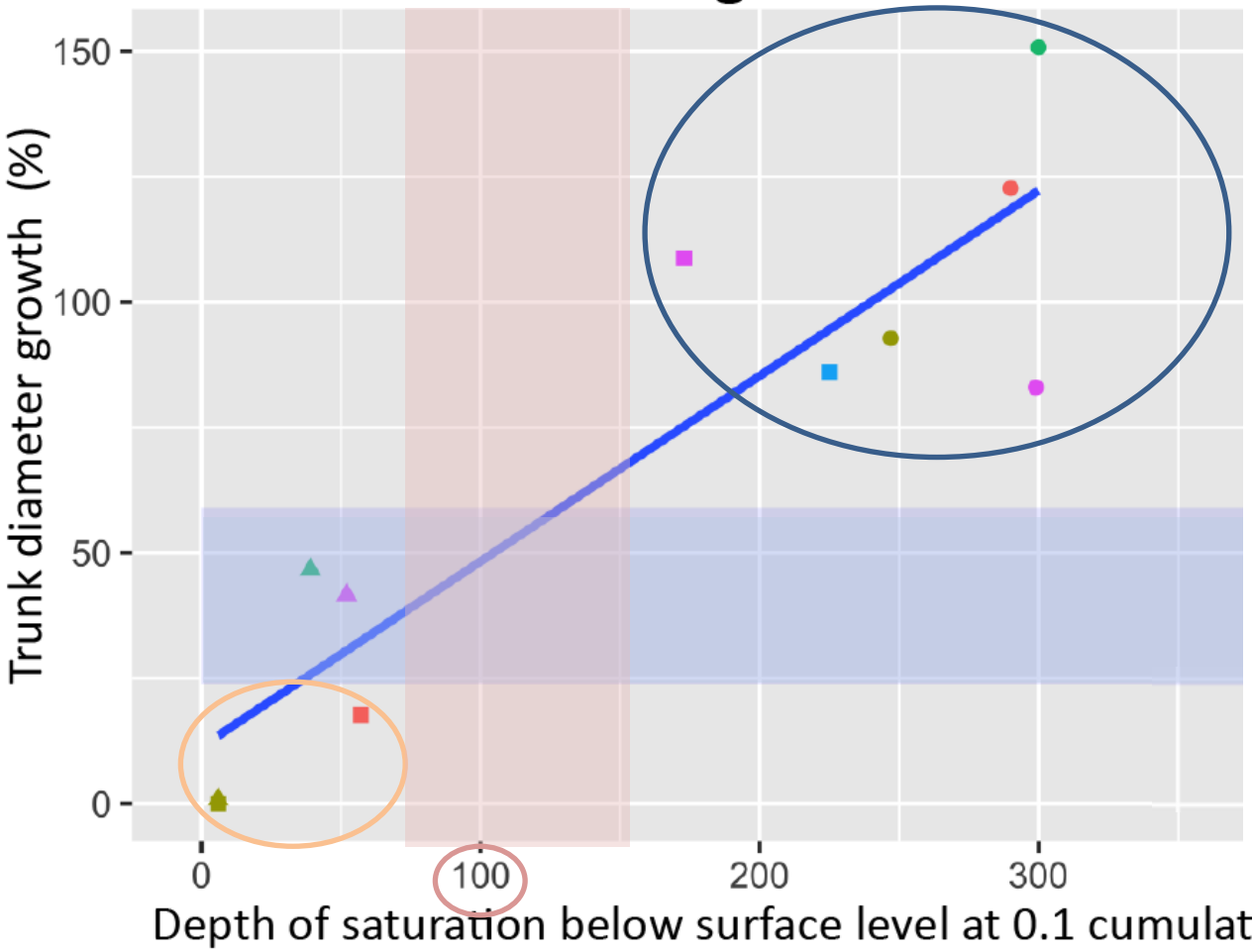




- Drained outperforming control (only treatment group)
- But so are some infiltration (soil) and adjacent trees
- Some replicates are doing very poorly indeed!


Period of soil saturation by depth
Treatment 2 - Drained
Treatment 5 - Adjacent
Treatment 3 - Infiltration (sand)
Treatment 4 - Infiltration (soil)
Cumulative frequency
1.00
0.75
0.50
0.25
0.00
-500
-400
-300
-200
-100
0
Depth of saturation below surace level (mm)

Tree diameter growth vs saturation depth



- Can **double** growth (and associated benefits)
- Under-drained pits
- Infiltration pits with avoiding saturation in top 150 mm
- Poor performance where saturation in top 75 mm of soil

Where to from here?

1. Need more quantitative data about how trees function in infiltration systems
   i. Runoff reduction
   ii. Tree growth and health
   iii. Tree water use
2. Need to understand what species, water-use strategy, substrates, design for which climates
3. Need user-friendly decision-making tools to aid species selection and system design

Where to from here

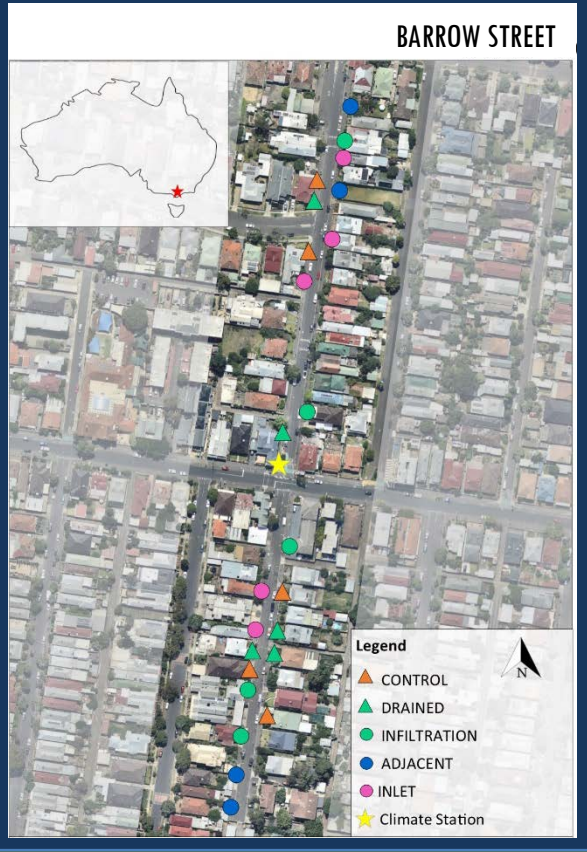
Field-based functioning

Tree-based infiltration modelling

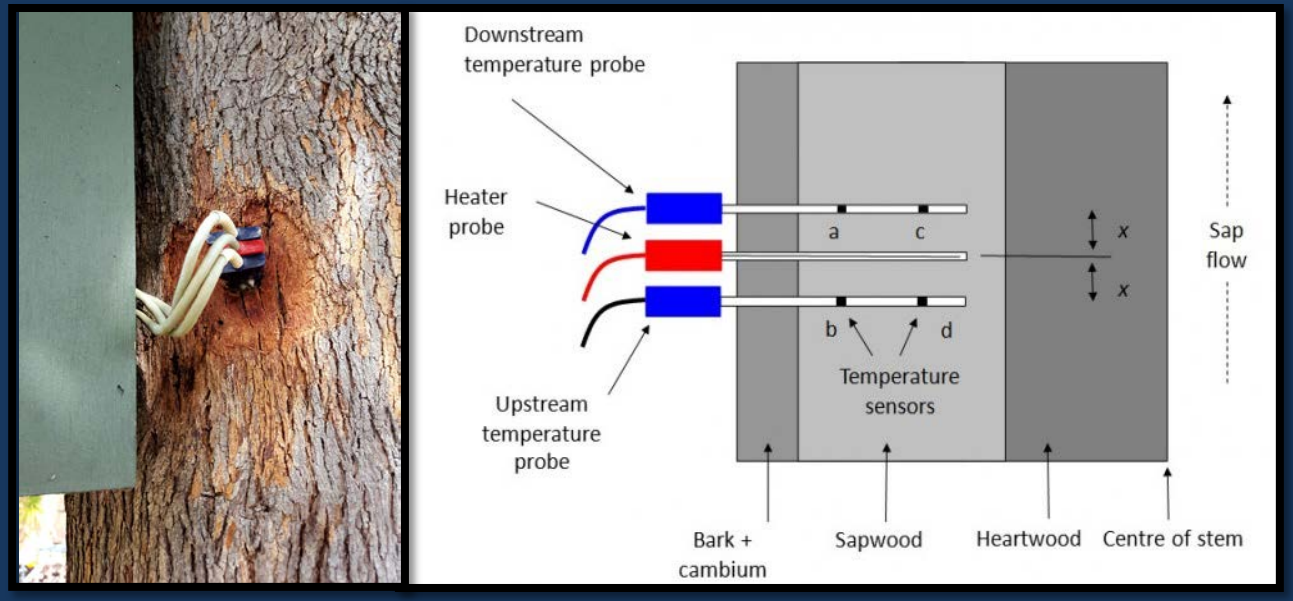
Nursery-based plant selection

Field-based functioning

1. Newly-planted *Acer campestre* in four infiltration system designs
2. Mature *Lophostemon confertus* with adjacent infiltration system designs and two inlet designs
3. Monitoring tree water use over spring-summer-autumn conditions

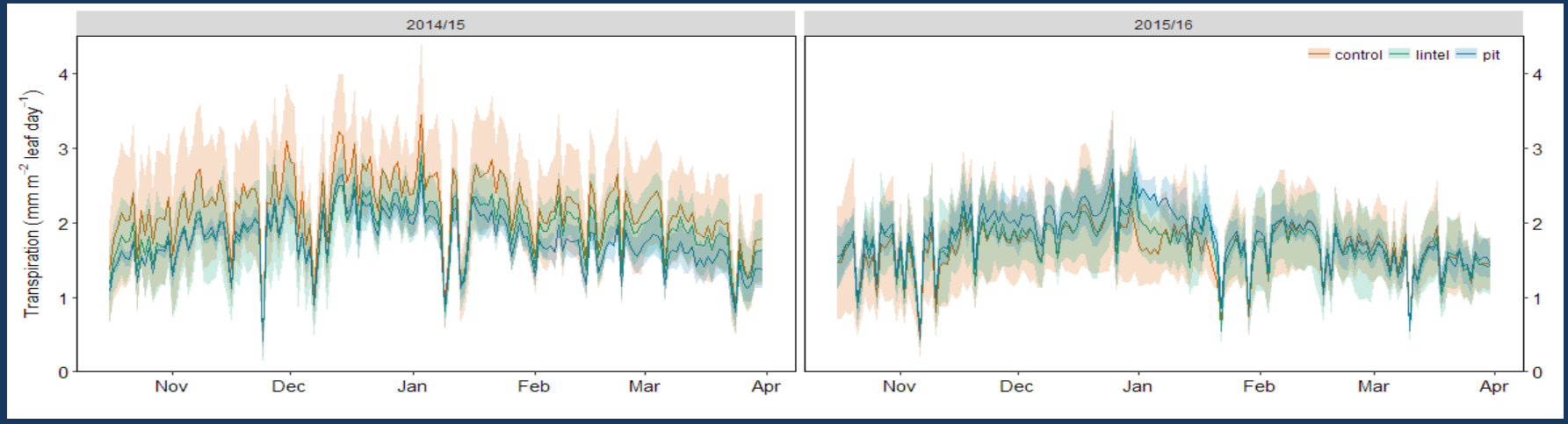


Measuring the use of stormwater resources



Tree water use measured by sapflow sensors using the heat ratio method

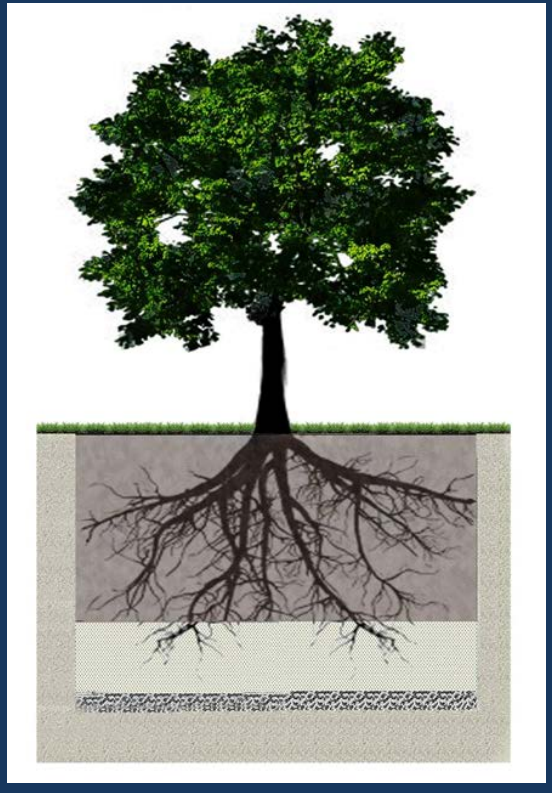
Measuring the use of stormwater resources



- Control trees reduced water use in second period
- Pit treatments all increased water use
- Lintel treatments were varied

Tree-based infiltration modelling

- Nursery experiments to inform plant selection, and modelling of water use based on tree characteristics
- Species responses grouped by
  - Deciduous/Evergreen
  - Maximum transpiration
  - Water-use strategy



Project deliverables

1. Guidance document
    i. Lessons from Barrow Street
    ii. Lessons from Monash
    iii. Lessons from the glasshouse

1. MUSIC node
    i. Optimising design
    ii. Quantifying benefits from tree-based infiltration