Stormwater for urban forests: Is it a good fit?

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Stormwater Vic – 5 June 2019

G&M Connellan Consultants

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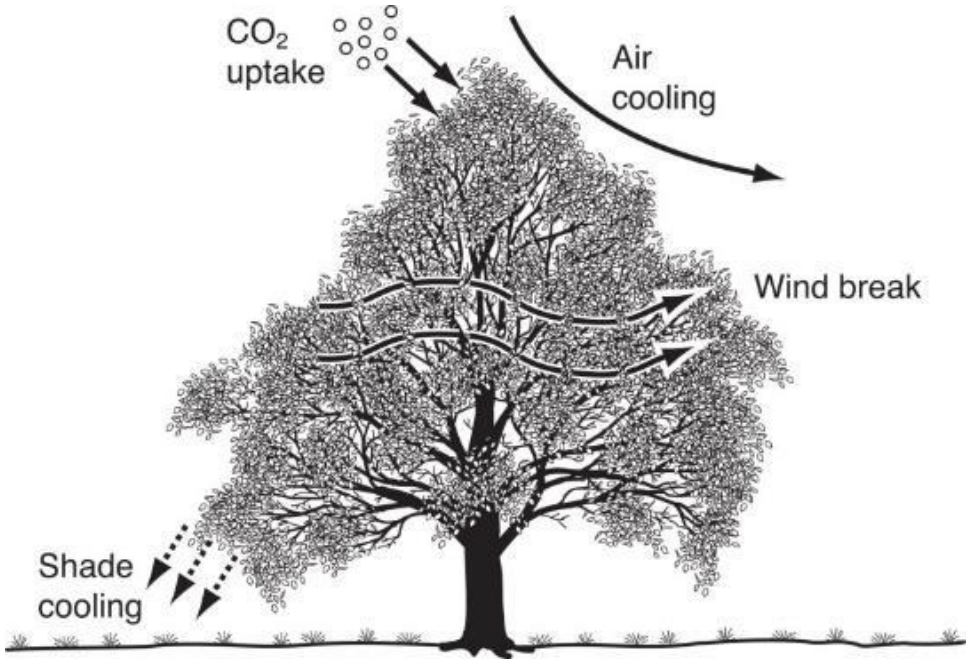
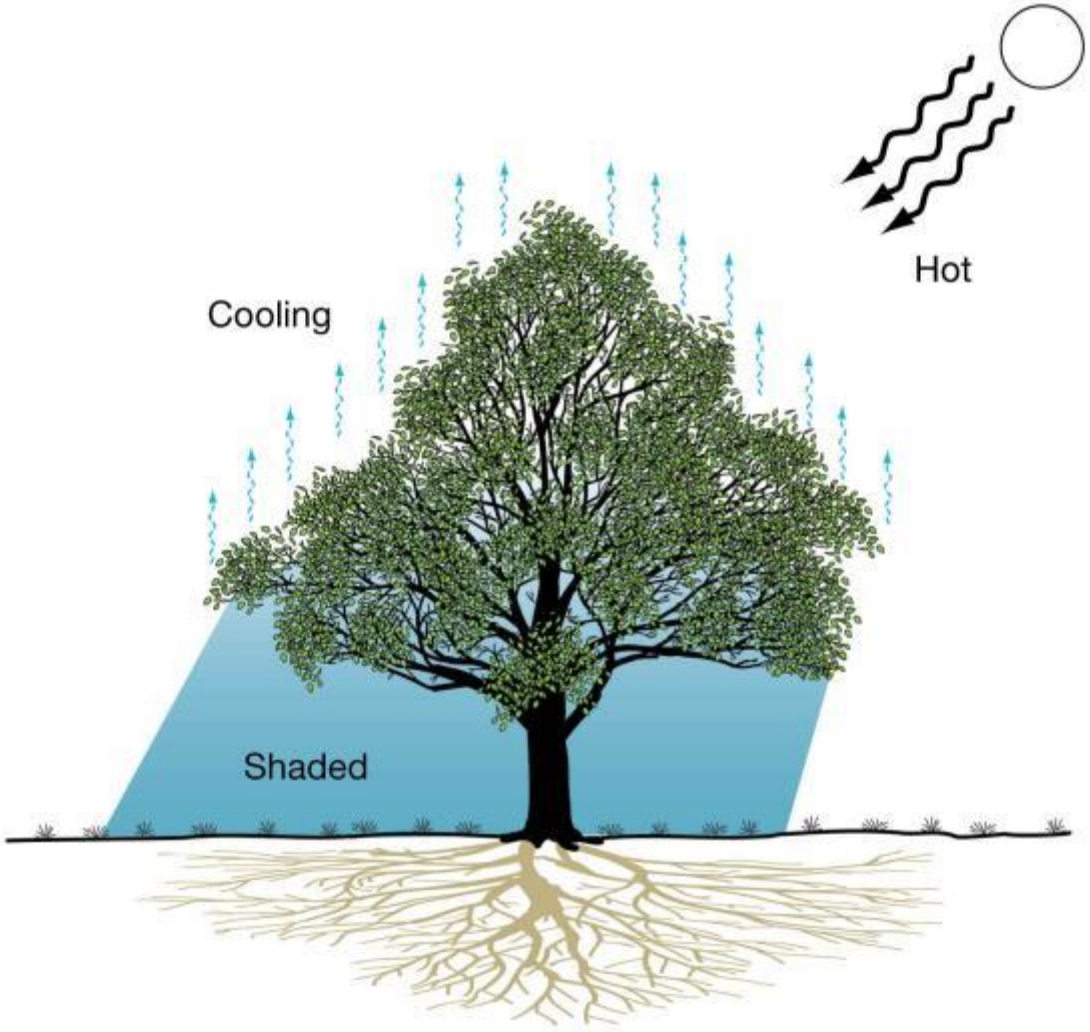
The main tree benefit categories:

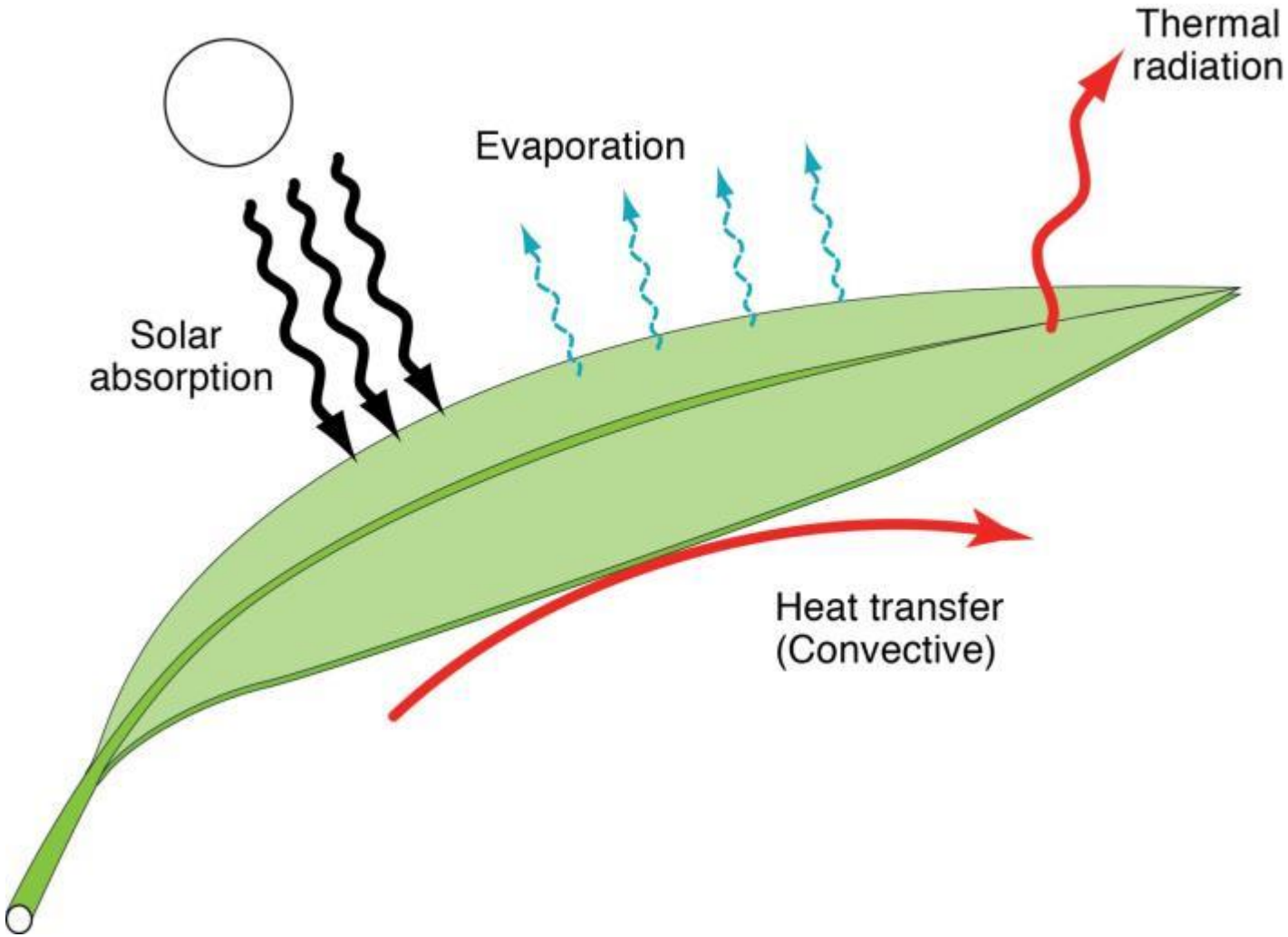
1. Carbon storage
2. Microclimate modification – cooling & shade
3. Modification of urban water cycle
4. Aesthetics



The Tree – Thermal (Energy) Modifier

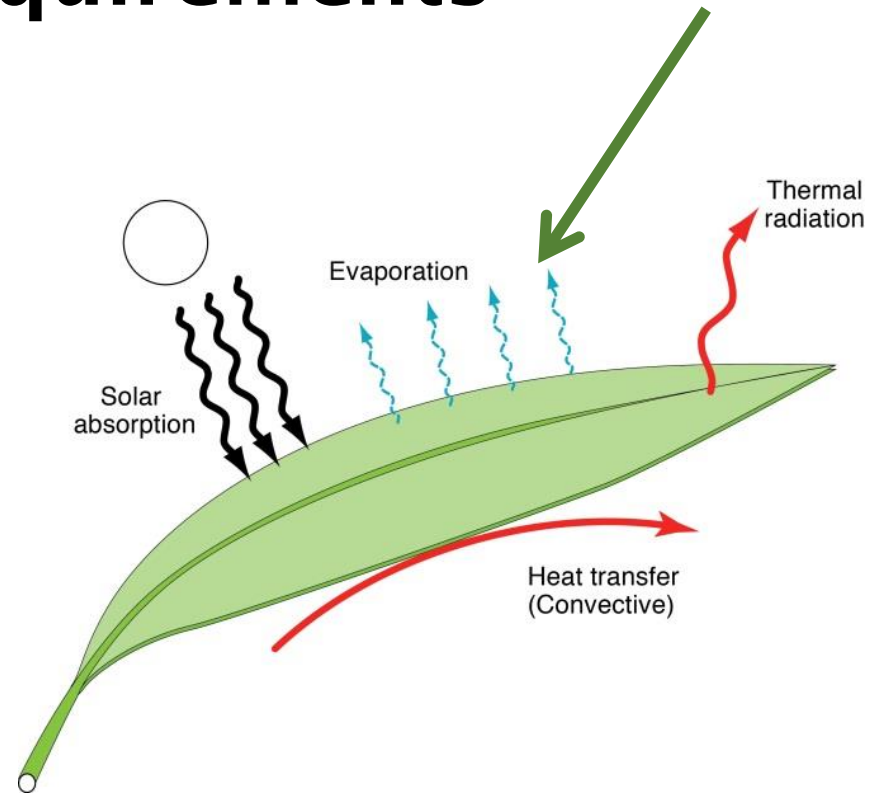


The energy transformation power of a leaf!



Cooling – Water requirements

Hot, sunny day



Solar radiation: 800 W/m²

Evaporation (Latent heat): 600 W/m²

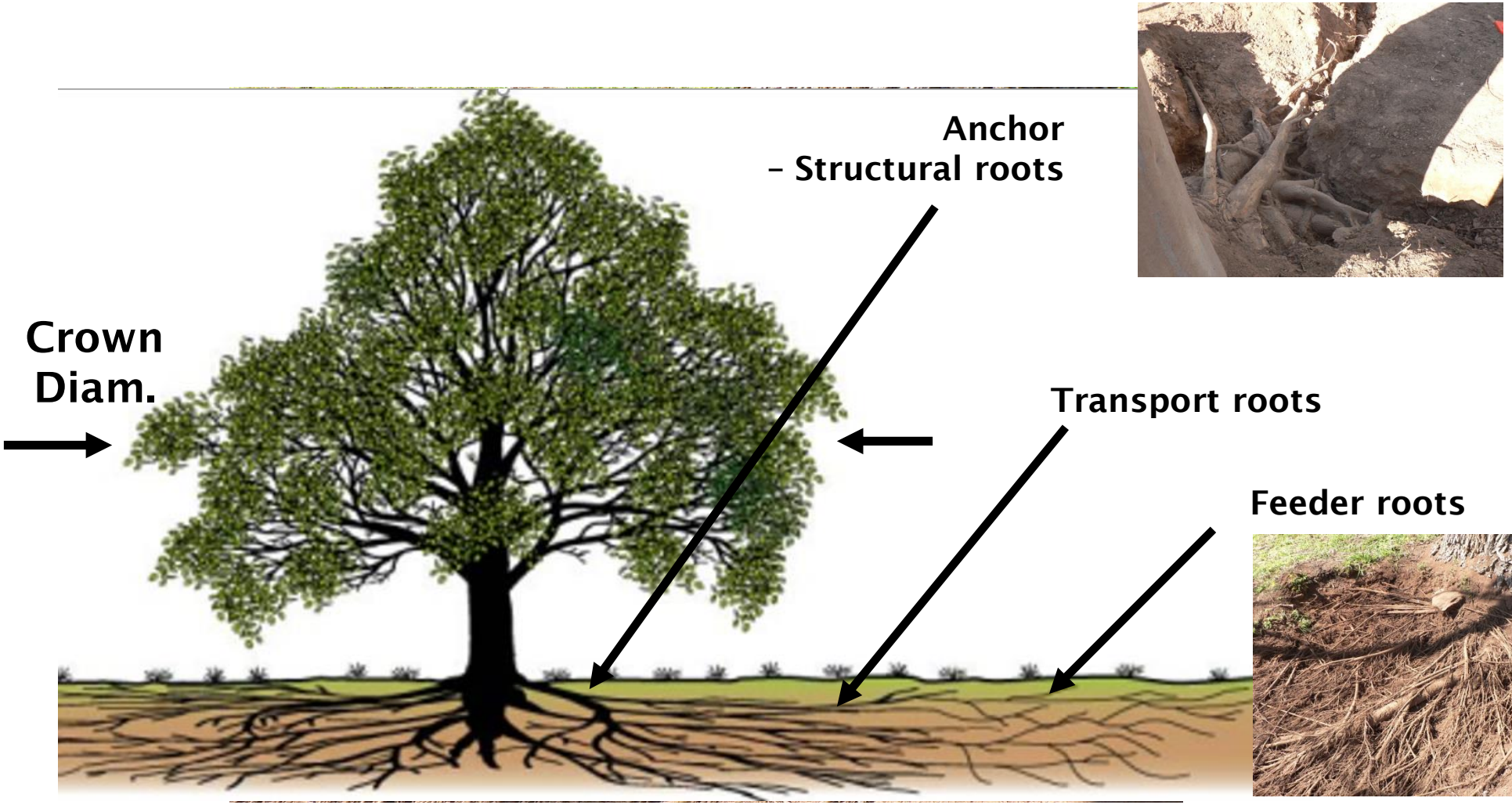
Water transpired: 0.5 L/m²/h

For a tree 10 m Crown diameter: Represents approx. 1,600 Litres per week.

The Large Tree

To deliver required Urban Forest Outcomes, trees need to be large and healthy.

Tree terminology – Structure and Roots



Tree Roots

Key comments/statements

1. Trees in the natural environment, unconstrained root development, tree roots extend 2 times the height of the tree.

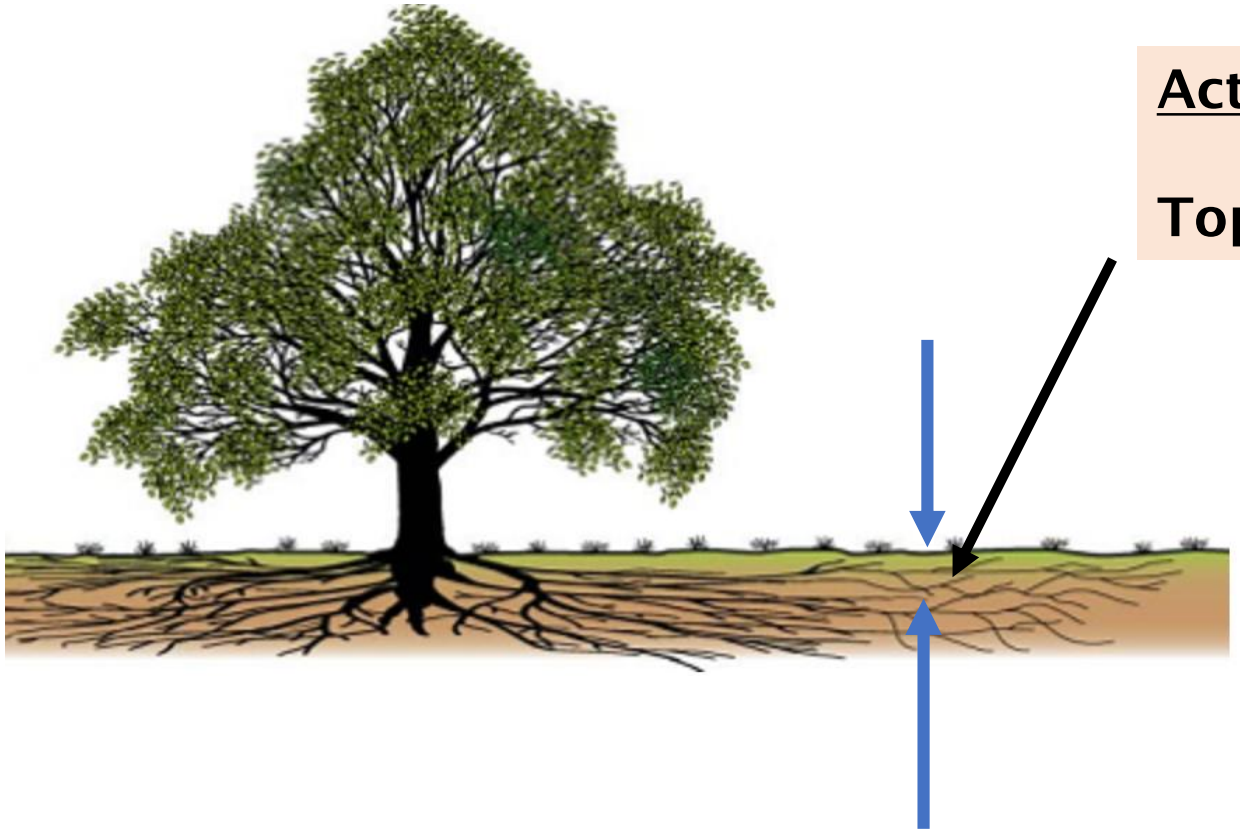
2. Roots are opportunistic.

If soil conditions are suitable, roots systems will develop and extend.

3. Tree growth and development to maturity requires access to significant resources including: oxygen, nutrients, micro-organisms and water.

4. The top soil layer, 300 mm to 400 mm, is the source of the majority of resources available to the tree.

Tree root zone properties



<u>Active</u> root zone

Top 400 mm/500 mm

Tree Roots

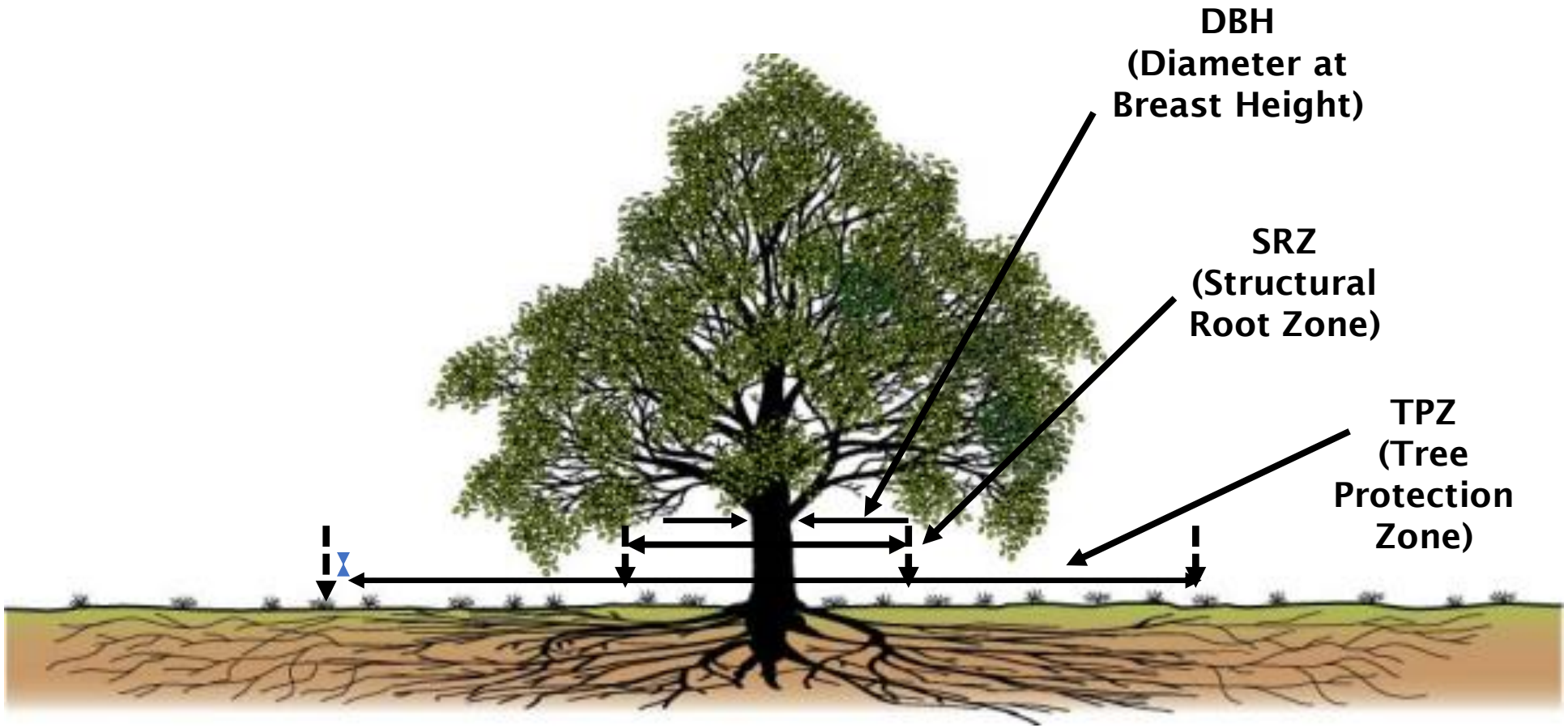
Some common misunderstandings

1) Roots do not seek out water.

2) Tap roots are not pathways to water for majority of urban trees.

3) If water is applied to dry soil, in vicinity of the tree, there is not necessarily any water uptake by root system. Active feeder roots need to be present to allow uptake.

Tree Terminology & Protection Zones



*** Protection Zones are very important when retrofitting stormwater infrastructure.**

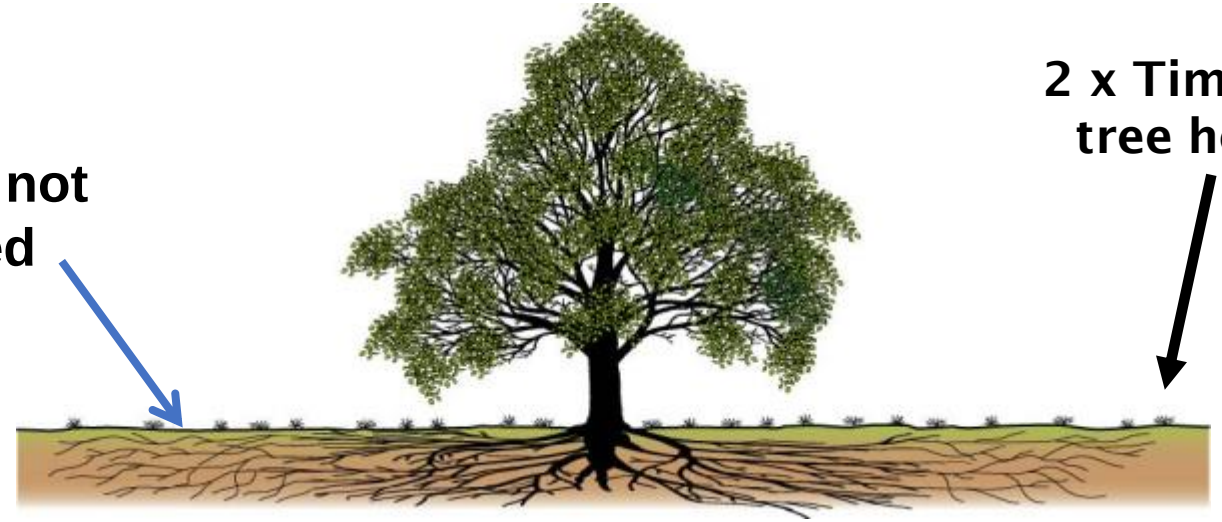
How much soil volume?

- Enough to ensure that the soil resources can maintain the tree in a healthy condition.
- Soil water reservoir to support tree for extended period.
- Nutrients and micro-organism resources.
- Provide anchorage.

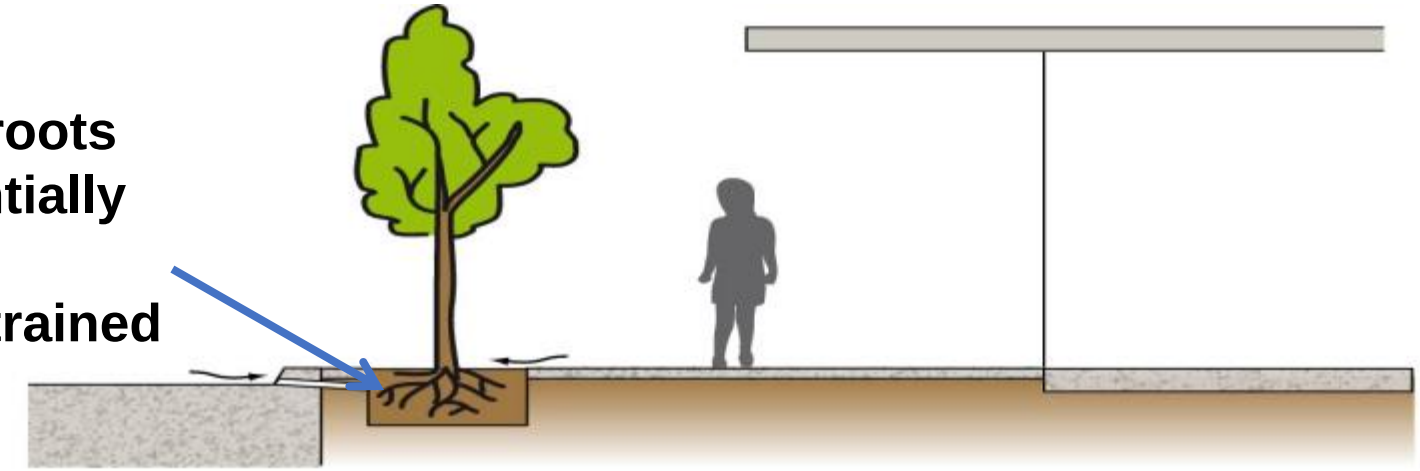
Tree Soil Volumes

Tree roots not constrained

2 x Times the tree height

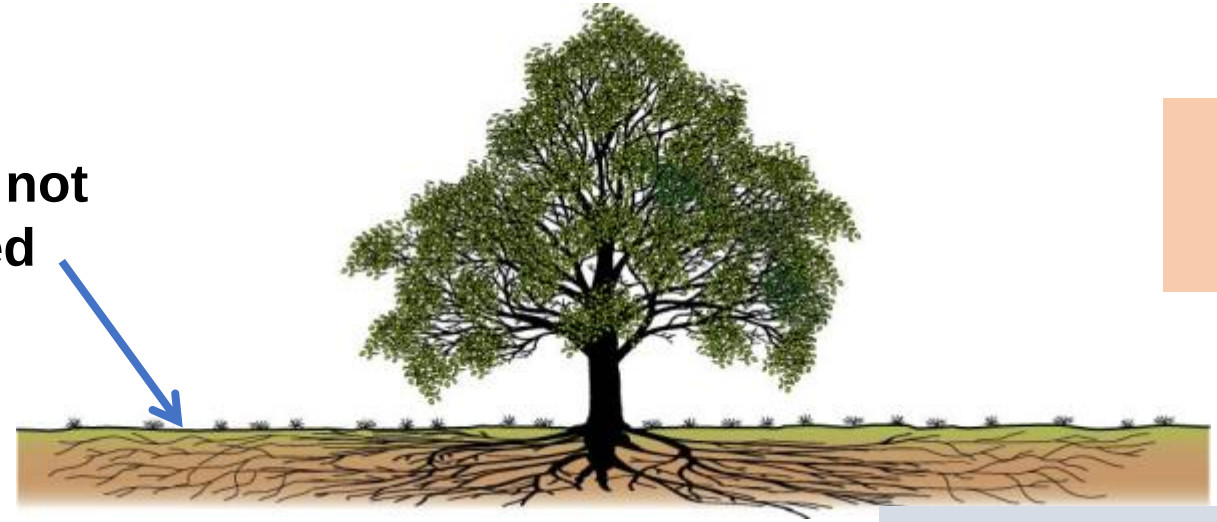


Tree roots potentially very constrained



Tree Soil Volumes and Water Storage

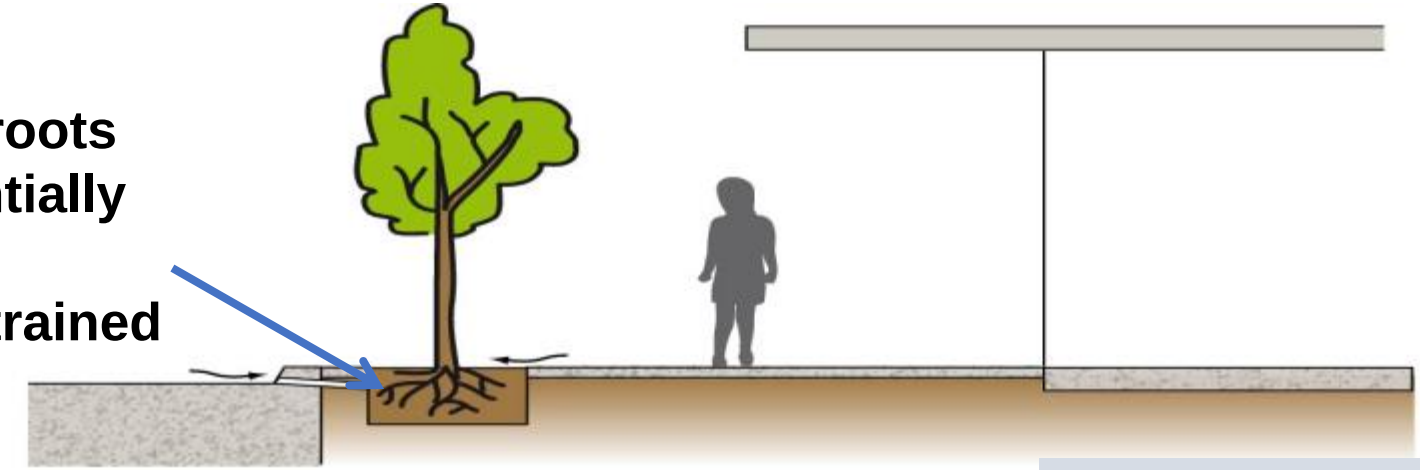
Tree roots not constrained



Soil volume
5 to 10 m^3
per m^2 of crown

Days of storage: > 100

Tree roots potentially very constrained



Days of storage: e.g. 7

Soil Volume for Healthy, Large crown trees

How much soil volume is needed?

<u>Guidelines</u>:

0.6 m^3 per m^2 of Crown area.

***Reference Lindsey & Bassuk (1991)**

0.39 m^3 per m^2 of Crown area.

***Reference Urban (2008)**

Resource: Better Best Practice Note – Sizing Tree Pits

LOCI
Environment & Place

Example - Soil volume for trees

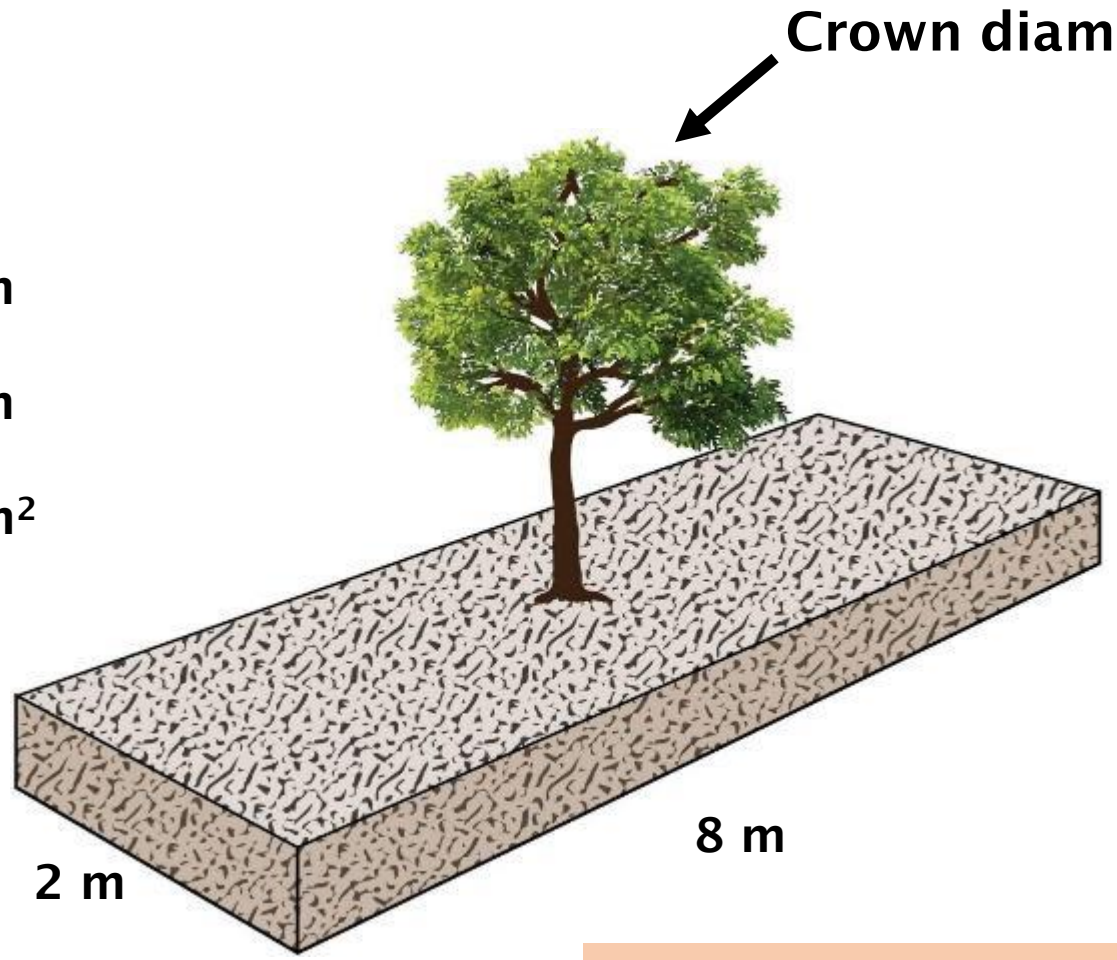
Example

Medium size tree

Tree height: 8 m

Crown diam.: 6 m

Crown area: 28 m²



Soil volume: 16.8 m³

Tree Development and Size - Soil volume and Irrigation

Tree size including height, trunk diameter and crown diameter is dependent on:

1) Soil volume

2) Soil moisture conditions – irrigation.

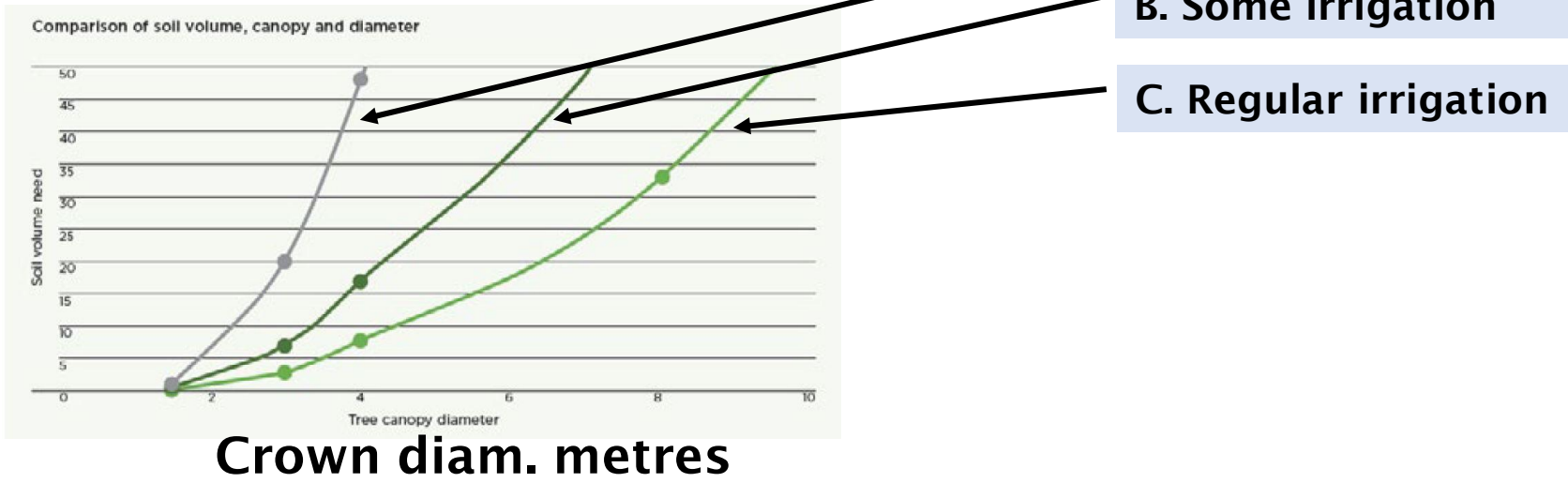


Figure: Comparison of required soil volume to achieve the desired tree canopy in containerised environments under varying irrigation conditions in Melbourne (Source: Hitchmough, 1994)

Tree Development and Size - Soil volume and Irrigation

Tree size including height, trunk diameter and crown diameter is dependent on:

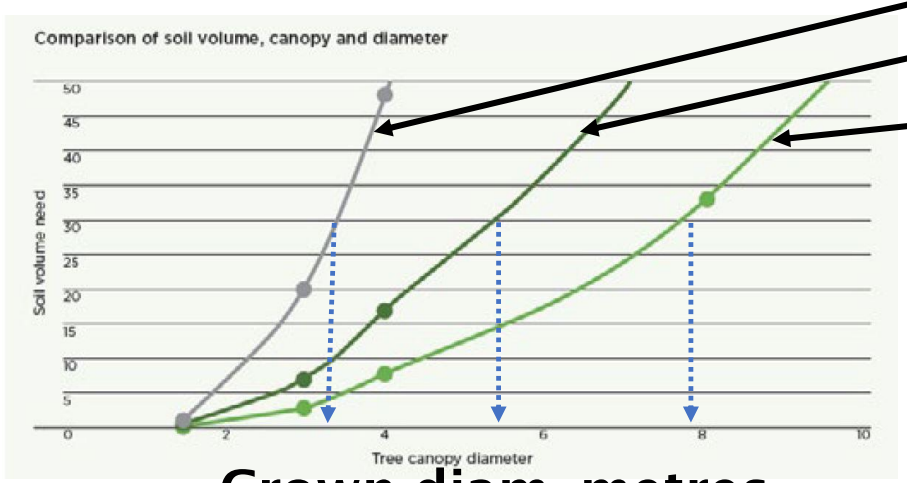
1) Soil volume

2) Soil moisture conditions – irrigation.

A. No irrigation

B. Some irrigation

C. Regular irrigation



Soil Volume m^3

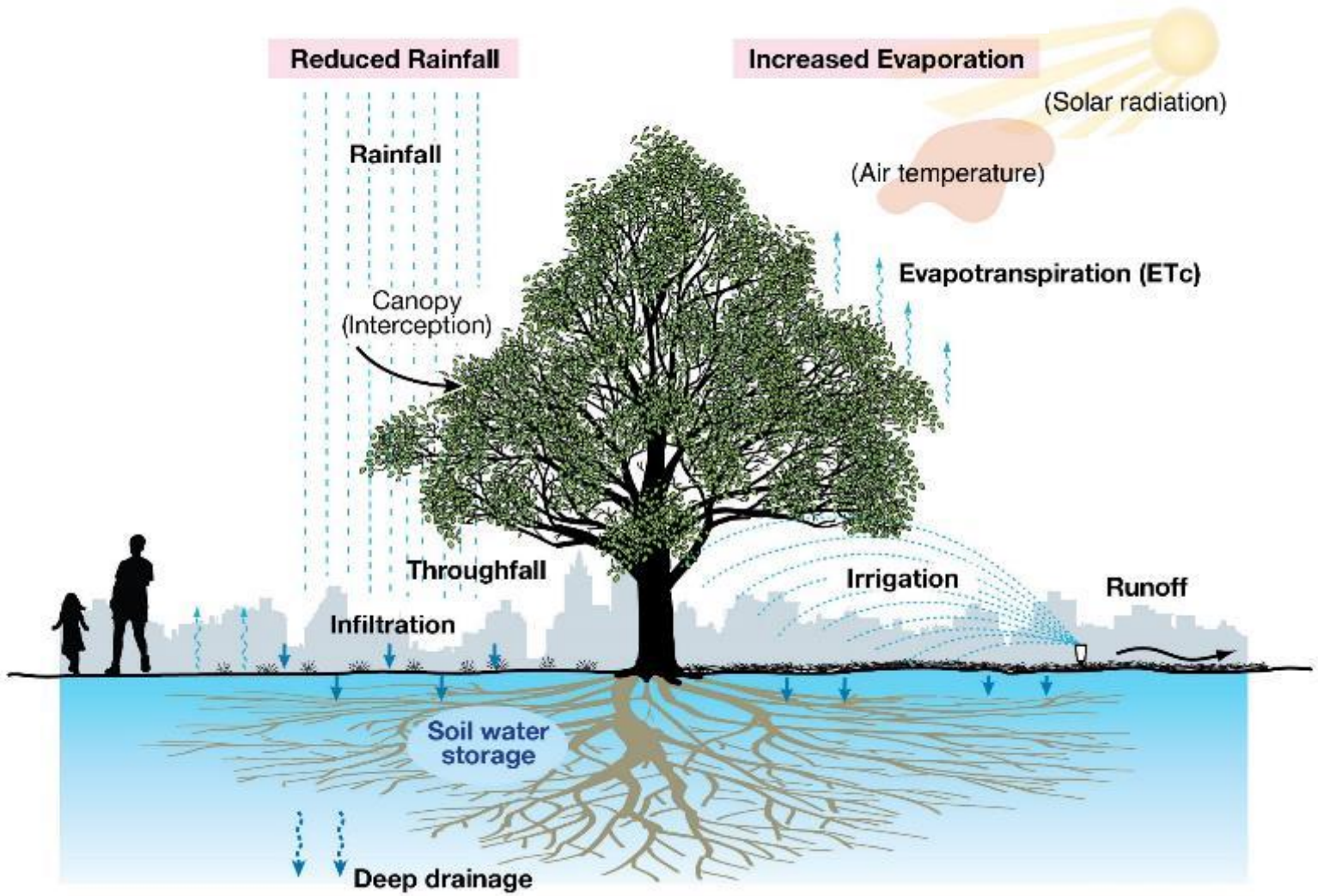
Crown diam. metres

Tree crown diameter
- Assuming 30 m^3 of soil

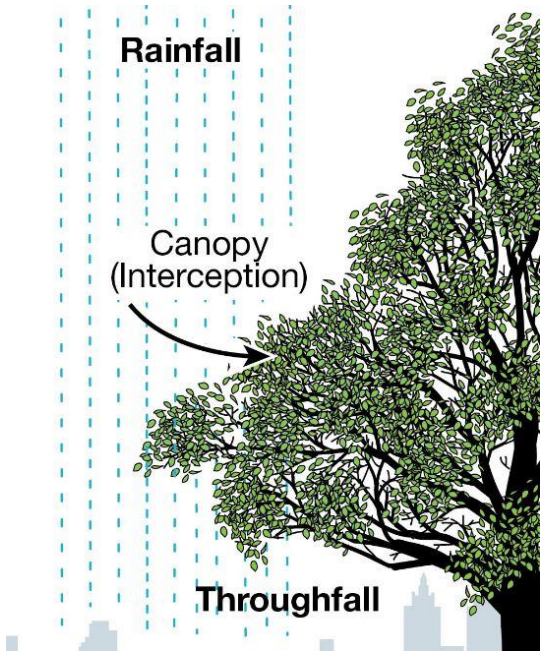
A. (None)	**3.0 m**
B. (Some)	**5.5 m**
C. (Regular)	**7.5 m**

Figure: (Source: Hitchmough, 1994)

Urban Tree Water Cycle



Interception and Effective Rainfall

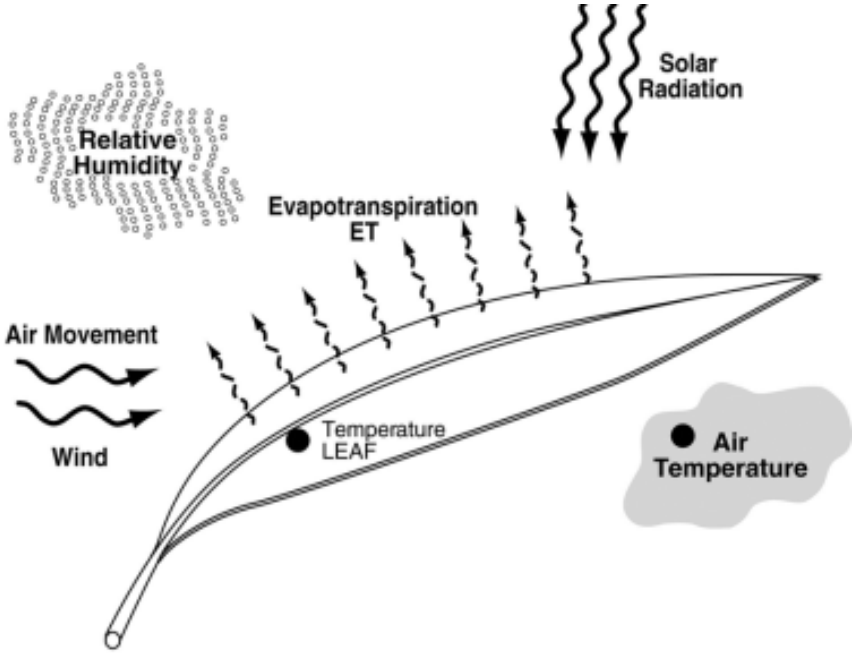


Troughs – Measuring apparatus

Up to 60% of rainfall can be intercepted per month

Source: Dunkerley D (2011) Geo.Research Abstracts Vo 13, EGU2011-4016

Urban Tree Water Demand



Major influencing factors:

- Plant species
- Plant performance and condition
- Tree health and stage of development
- Site microclimate and planting density
- Soil conditions – Soil moisture available

Estimating Tree/Plant Water Demand

$$ET_L = K_L \times ETo$$

ET_L – Evapotranspiration rate of plant/tree

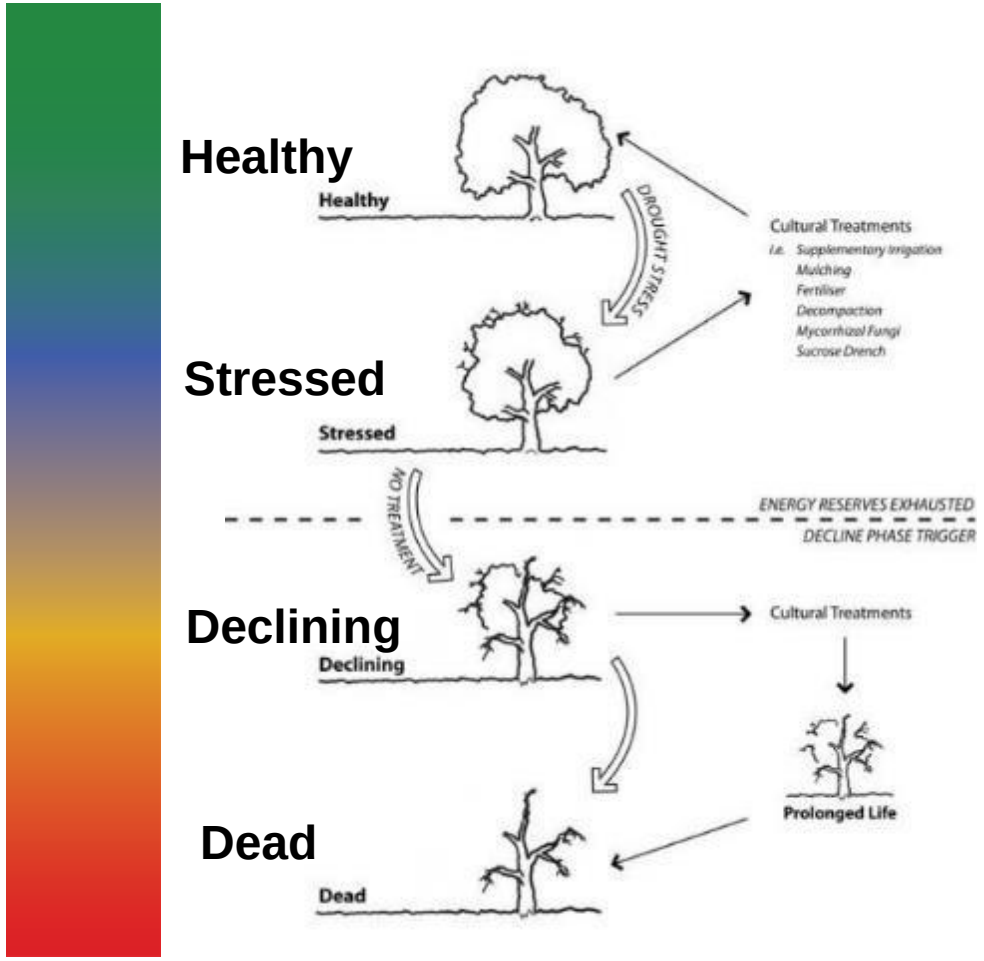
K_L – Landscape/Crop coefficient

ETo – Reference evapotranspiration

Tree Condition and Water Demand

More available water, increased growth

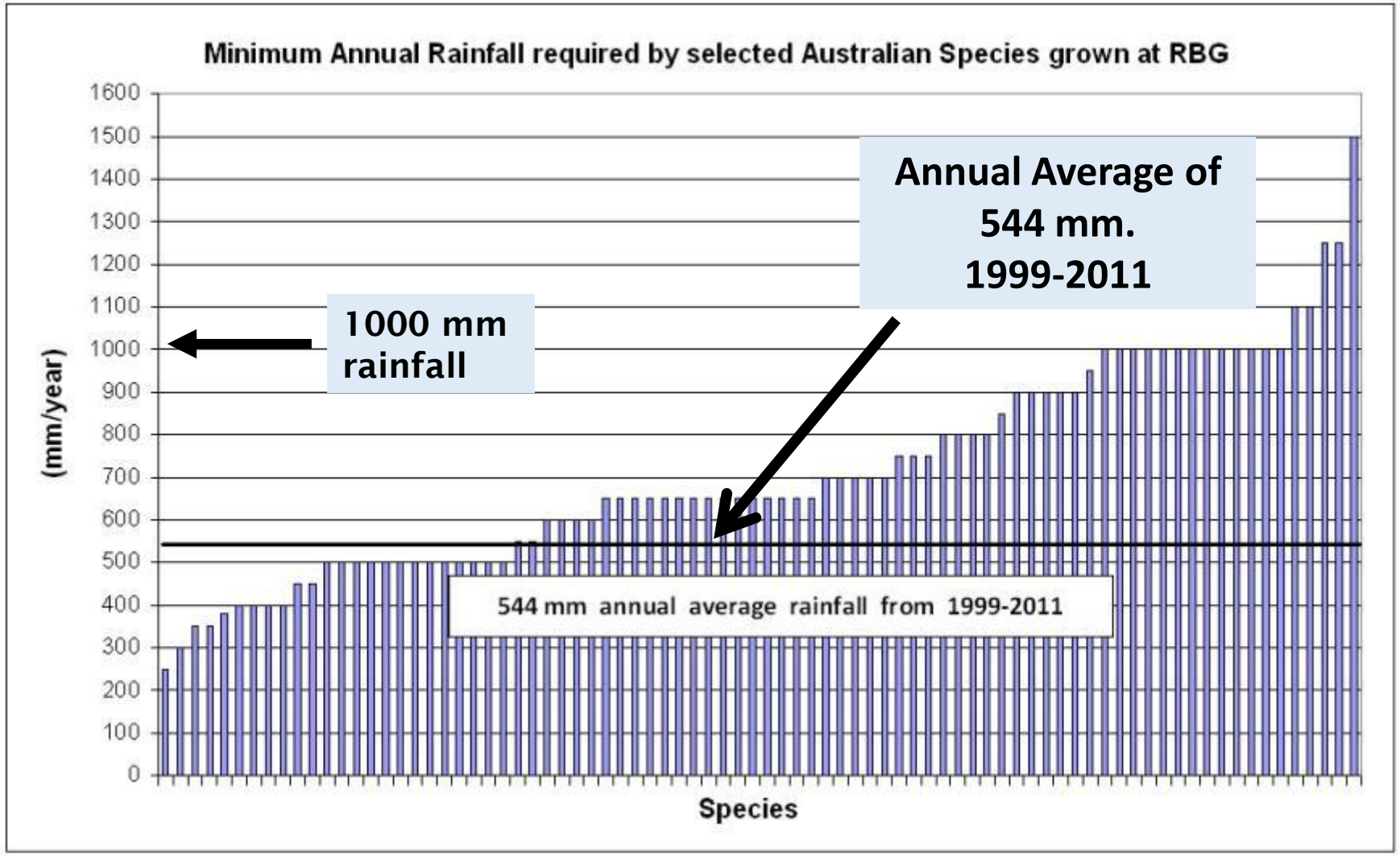
Tree Health Ladder – City of Melbourne



Ref: I. Shears, Urban Landscapes, City Melbourne.

Healthy > Stressed > Declining > Dead!

Selected Australian native species growing at RBG Melbourne



Water for Urban Forests

Example

Suburb: 10 km^2

Canopy Target: Increase from 15% to 25%, by 2040

Actual canopy area increase: 1,000,000 m^2

Estimated total water demand: 500 to 1000 ML (1.0 GL)!

Rainfall contribution: 500 ML

Supplementary water: 500 ML
(Stormwater, recycled and potable)

Planning for significant water supplies for urban forests!


CLIMATE CHANGE

Projections – Tree water impact

Scenario to 2070 **NB: Tree life 50 to 100 years**

Species risk: With 3ºC increase, 20% of current species in City of Melbourne region at risk.

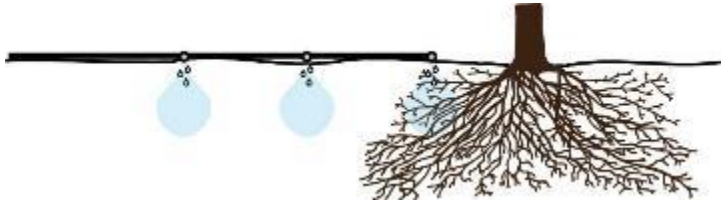
E.g. Beeches, birch, Dutch elm

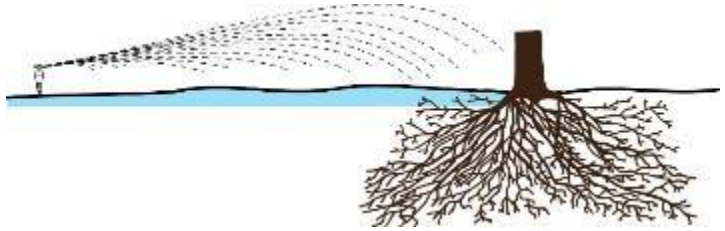
Ref: Dr D Kendal, University of Tasmania

Water

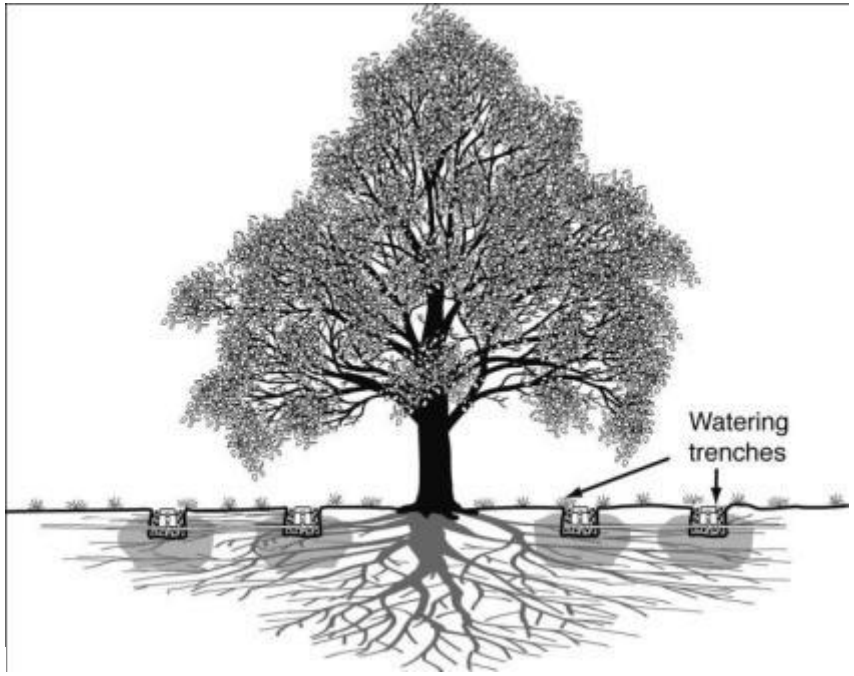
- **Summer rainfall: 10% reduction (Annual)**
- **Evaporation: 9% increase**
- **Potential deficit (Evaporation - Rainfall) increase: 19% (Supplementary water)**
- **Summer catchment harvesting reduction: 21%**

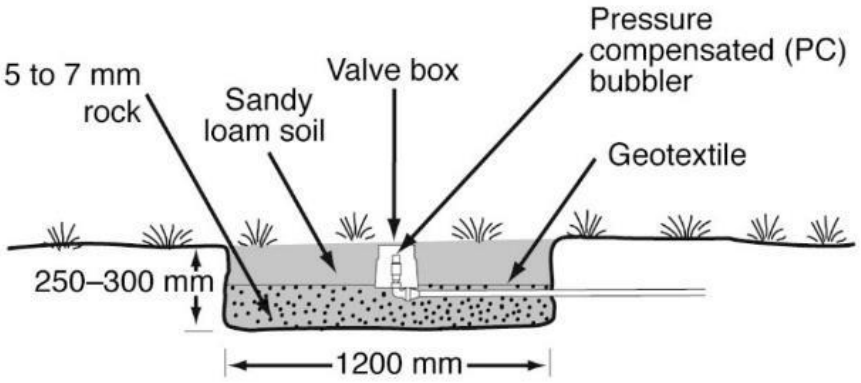
Water delivery to trees - Active irrigation





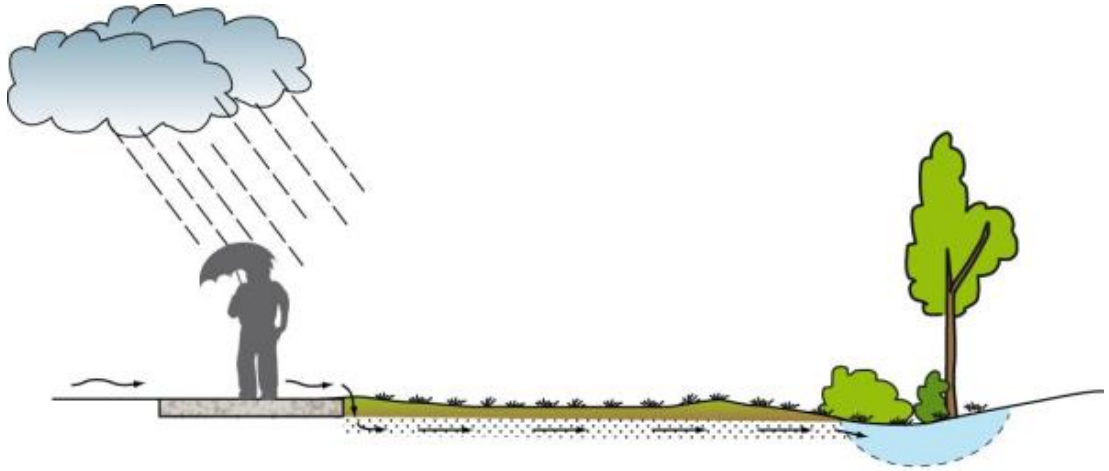
Constrained root systems – Watering trenches – Royal Pde., Melbourne





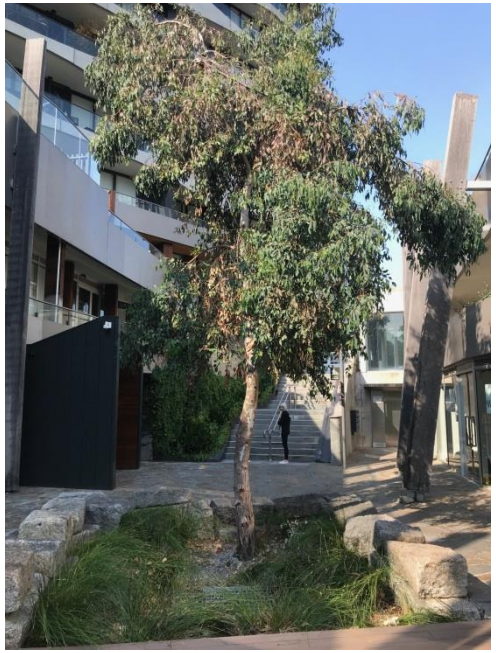
Ref: City Melb.

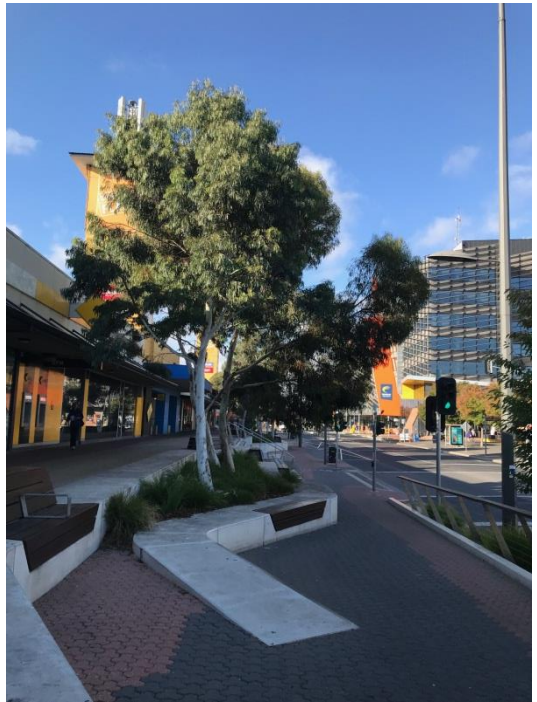
Stormwater – Water source



*Stormwater has the potential to provide significant amounts of water to the soil environment of urban trees.

Passive irrigation
Stormwater for trees – Many options





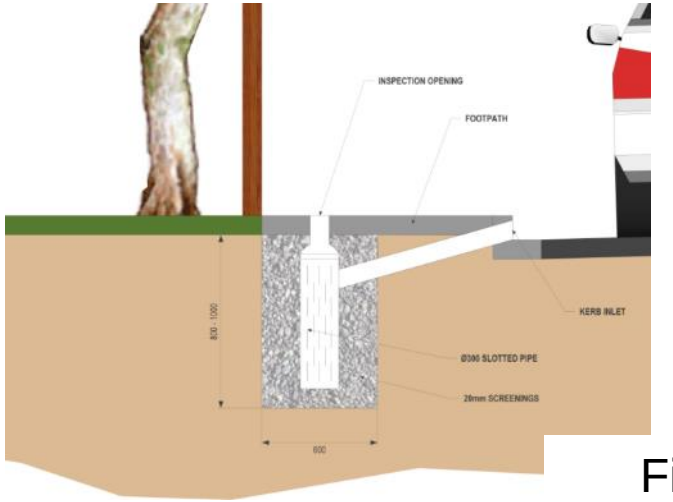


Figure: Designflow

(1) Stormwater harvesting opportunity – Street tree example

Locality: North west of Melbourne

Roadway/pavement width: 7 m. Crowned road surface

Tree spacing: 12 m (House block width)

Climate data: Tullamarine

Climate period	Rainfall	(< 50 m^2) 40 m^2	(> 50 m^2) 80 m^2
Annual - Average	535 mm	**7,704 L**	14,380 L
Annual - Decile 1	393 mm	**5,659 L**	11,318 L
Monthly Summer - Jan. Average	41 mm	**590 L**	1,103 L
Monthly Summer - Jan. Decile 1	14 mm	**201 L**	403 L
Note: Runoff Coefficient: 0.90. Tree water use effectiveness: 0.40			

Stormwater supply and tree size

Annual water demand

Tree Species – Water use	Crown diam. 3 m	Crown diam. 5 m	Crown diam. 7 m	Crown diam. 9 m
High	**6.7 kL**	19.2 kL	36.5 kL	61.5 kL
Medium	**4.8 kL**	13.7 kL	26.1 kL	43.9 kL
Low	**2.9 kL**	**8.2 kL**	15.7 kL	26.4 kL

Stormwater available – Annual basis: 7.7 kL

Tree supported: ***Crown 3 to 5 m diameter.**
***Low to Medium water use species.**

NB: This assessment based on annual data.

(2) Amount of water diverted?

a) Inlet design
- Hydraulic conditions, fall, flow direction, turbulence

b) Opening – area, height, width

c) Degree of blockage

Treenet inlet diversion

Accepted 30% of flow at 5 L/s
(0% to 1.5 % Slope)

Accepted 10% of flow (2.5% slope)

Treenet Inlet
(Ref: IPWEA P. Levett, June 2014)

Diversions from roadways - Examples

Kerb inlets

Images:
Designflow, Moonee Valley City Council
& Monash City Council

Tree site storage – Volume and layout

Factors

a) Space available at the site – Nature strip width, services

b) Dimensions - Depth, width and length

c) Storage volume relative to tree demand

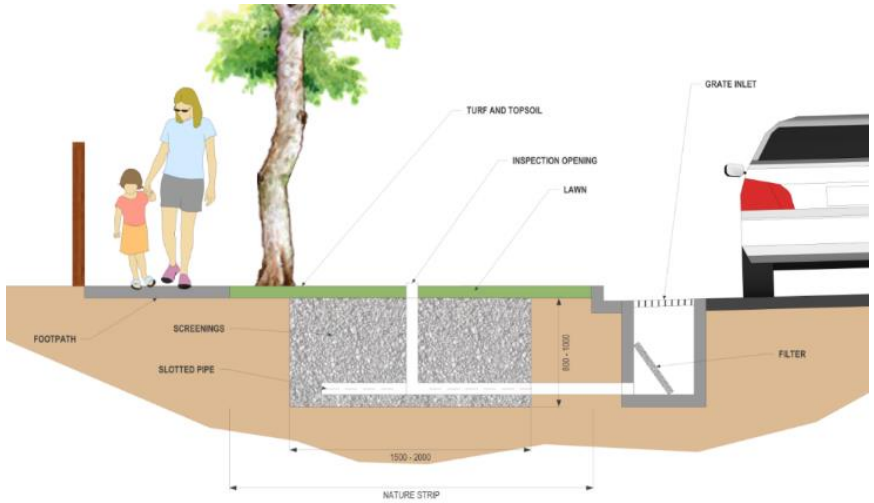


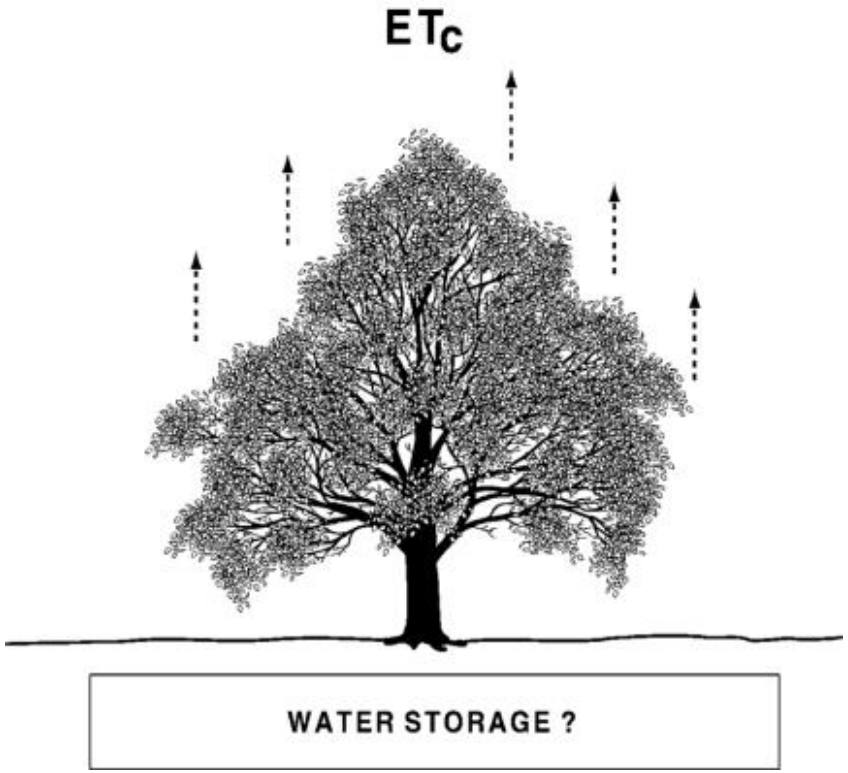
Image: Designflow

(3 & 4) Water used beneficially by the tree

How much water is;

a) Absorbed by the soil and

b) Taken up by the root system?



<u>Tree lessons/studies – data</u>
***Manningham City Council**

***Moreland City Council**

***Monash City Council**

Summary Comments & Messages

1. Large functional trees, growing in physically constrained sites, require large volumes of supplementary water.

2. Stormwater should ideally be available to the upper soil layers.

*Shallower and wider rather than deeper storages and delivery systems.

3. Water application should achieve significant coverage of the tree root zone.

*Point delivery systems are very limiting in the lateral spread of water that can be achieved.

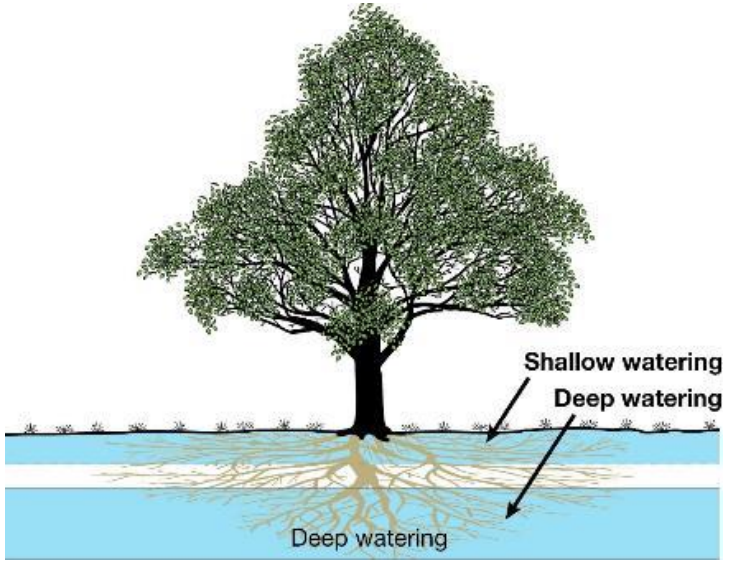
Summary Comments & Messages

4. Stormwater can be used to charge the soil/subsoil over winter/spring period.

***Soil water banking can be utilised.**

5. Maintaining soil moisture over summer months is critical to the overall growth and performance of the tree.

***If stormwater not available, then active irrigation is required.**



New Kerb Inlet and Tree Watering System

- Melton City Council
- Woodlea Developments
- Alluvium
- Spiire
- G&M Connellan Consultants