street tree design guidelines

For Landcom Projects

LANDCOM

street trees

contents

introduction

1.1 Purpose and reason for this document

The Landcom Street Tree Guidelines have been prepared as one of a suite of documents providing specialist information to aid Development Managers achieve best industry practice outcomes in Landcom developments. While the documents are primarily for Landcom Development Managers, they may also be used in discussions with Councils, Joint Venture Partners and Consultants to define Landcom's objectives and practice.

The Street Tree Guidelines propose a methodology for making successful street trees species selection. The methodology provided is intended to form a coherent link between design considerations and implementation by setting out the optimum characteristics of street trees, options for layout within streets, critical considerations in the selection process and best practice techniques for implementation.

1.2 Background

Trees in streets are essential for a high quality streetscape. This concept is stated as a guiding principle in Landcom's Street Design Guidelines 2006. The Street Tree Guidelines enlarge on this concept providing more detailed technical information.

Healthy, established urban trees provide a long term legacy for the community. Many of the most memorable streets and localities can attribute their noteworthy status to the presence of large healthy trees. At the regional scale street trees contribute to the overall percentage canopy cover which in turn delivers a variety of environmental benefits.

Recent experience has shown that simply the planting of street trees with all good intention is not sufficient to achieve a high quality streetscape. To achieve successful streetscapes critical factors such as selection of the most appropriate tree species, quality of the plant stock and planning for and providing adequate soil and water are essential. These guidelines address these matters.

Grand Drive, Centennial Park

1.3 How to use this document

The information in the guidelines leads the reader sequentially through the process of planning, installing and establishing street trees.

Part 2 highlights the **Key Principles** behind the document.

Part 3 Selection Considerations addresses consideration of the design intent for streetscapes; the function of the streets; underlying environmental conditions, and horticultural considerations.

Part 4 Technical outlines planning for the fundamental physical requirements of planting street trees.

Part 5 Sourcing and Plant Procurement discusses the impacts of plant procurement and construction method on the realisation of the streetscape.

Part 6 Details graphically describes options for layout and construction.

Part 7 summarises in diagram format the minimum **Establishment Maintenance** requirements of street trees.

Part 8 Recommended Street Tree List provides a guide for selection of species, along with the critical limiting factors pertinent to each species to ensure their successful use as street trees.

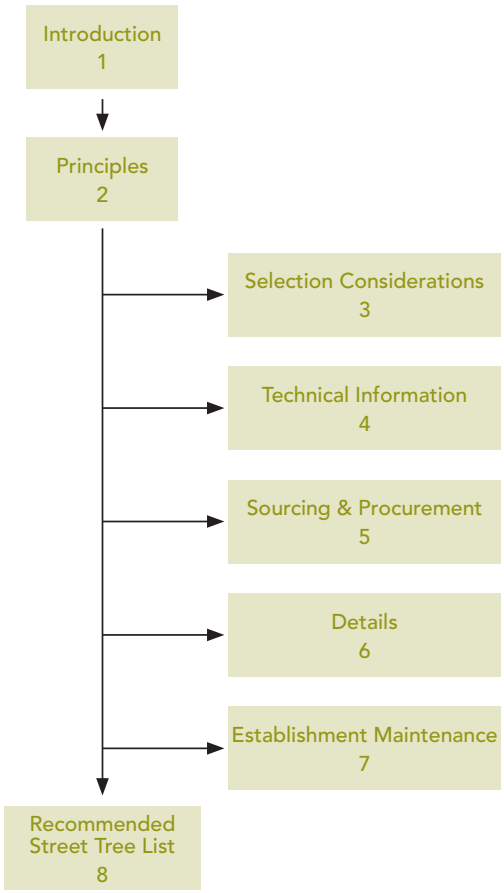


Fig 1 How to use these guidelines

Street trees contribute to the unity of the streetscape enhancing the character of the neighbourhood.

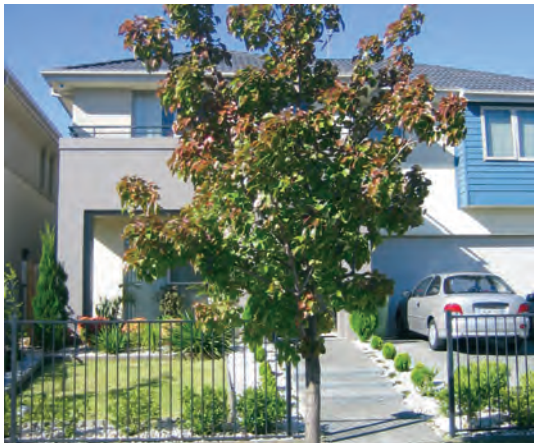
part 2

principles

There are seven key principles that guide the landscape design of streetscapes.

- Street trees are a legacy for the community. Maximise planting of trees in all streets and retain existing trees wherever possible.
- Street trees should contribute to the overall unity of the streetscape, through their layout, scale and character. Careful selection of the tree species will provide scale and visual cohesion to the street. Beyond this generic design intent for the street trees, trees can also form landmarks, contribute to both contextural character and the general amenity of a place.
- Select the most appropriate tree species to satisfy the design intent and the physical conditions of the site both natural and man made. Respond to other functional requirements such as solar access, vehicle clearances etc.
- Optimise soil conditions for trees. Locate trees to maximise available soil volume. Ensure that there is a sufficient quantity and quality of soil within the anticipated root zone to support the intended mature tree and that adequate moisture is provided to that zone.
- Street trees need adequate water to flourish. Street tree location and design should optimise passive watering of all street trees.
- Minimise infrastructure and functional conflicts. Locate trees and utility services to minimise potential conflicts between street elements and functions, such as streetlights being blocked by the tree canopy, or car doors being opened into tree trunks.
- Where appropriate integrate water sensitive urban design (WSUD) initiatives with the provision of street trees.





part 3

selection considerations

FOR ALL TREE TYPES

Selection considerations

The advantages of urban trees are extremely broad; from environmental to sociological benefits such as reducing crime, domestic violence and ADHD symptoms (see references Landscape & Human Health Laboratory), to quality of life and visual amenity improvements. This document accepts these benefits as a given and addresses the specifics of how to select longer living trees with appropriate characteristics for planting in streets.

3.1 Character

i. Historic

The layout of street trees and species selected may reflect previous land use or be species used historically in association with a particular location or period of landscape design, for example, the use of Norfolk Island Pines along the foreshore.

Where there is an existing streetscape pattern and species used, any infill planting should reinforce the existing character.

ii. Cultural

Trees in general and street trees in particular often represent the community's preferences or aspirations and can landmark important community or urban elements. Some species have special associations with a particular cultural group such as Olives, flowering trees etcetera.

The community often exhibits extremes of attitude in regard to trees in their environment. Trees are a community asset and involvement of the community is imperative to ensure the success of any new street tree planting.

Trees with a distinctive form or appearance can be used to create gateways or landmarks. Commercial areas, community buildings and other focal areas may be given better legibility through the use of street trees whose character contrasts to that of those in adjacent streets.

iii. Natural

Street trees may be used to extend or reinforce the natural character of the area, particularly where neighbourhood character is drawn from or has a strong association with its natural context, local native vegetation type, a local landform or feature.

Palms at Fox Studios are a distinctive form for the urban environment.

Norfolk Island Pines seen here along Grand Parade, Sans Souci are a commonly used tree along the foreshore.

3.2 Aesthetics

i. Tree Form

Selected species must have predictable growth habit and form to function as a successful street tree. A street tree should have a single straight trunk (to minimise conflicts with pedestrian and vehicular traffic) and stable branch structure (to minimise hazards created by inherent defects) with a clear trunk height (free of lateral branches) for not less than 3 metres from ground level.

The tree canopy (foliage and branches) should be broad domed or umbrageous in form (see Fig 2). The traditional ideal of the avenue includes regularly spaced broad domed trees with canopies that interlock to provide a leafy ceiling to the street. In some situations strong vertical forms may be appropriate as a landmark (see Fig 3).

Ideally species selection should aim for consistency and visual uniformity providing streets with a recognisable character. This generally dictates the use of a single species within a street. Street plantings with a multiplicity of different species (with disparate forms) can add interest to the streetscape but often detract from the overall amenity of the street and the primary design character intent of giving the street unity.

Pistachio Tree has an umbrageous form suited to the streetscape.

Species with low branching habits, such as some conifers, trees with pendulous branching habits or those with multiple trunks and low horizontal branch development, are not generally suitable as street trees.

Where possible the scale of the tree should be related to its greater context as well as the adjacent dwelling. For example larger trees should be planted along streets on ridgelines in order that the trees provide the silhouette against the sky rather than the dwellings (Fig 4).

The selection of a street tree should also consider seasonal features that help the community experience their changing environment and add interest such as leaf colour variations (pink leaves in spring, autumnal leaf colour), flowers, or attractive bark that alters through the year. This creates an important dimension to the neighbourhood landscape.

In certain situations it may be beneficial to use more than one species in a street, where multiple species are used, however, they should be compatible (in form) and laid out so as to work together to achieve the overall unity of the streetscape. An additional benefit of the use of multiple species is the potential reduction of the impact of debilitating pests and diseases that have historically affected monocultures.

Fig 2 Umbrageous or umbrella like form

Fig 3 Strong vertical forms

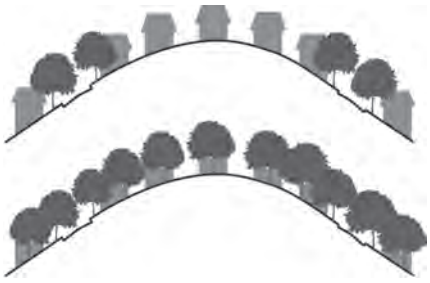


Fig 4 Trees provide a more sympathetic silhouette than buildings.

ii. Planting Configurations

Unity or the perception of visual consistency is primarily achieved in street tree planting by symmetry (identical planting on both sides of the road) and repetition (of the same form). When considering the broad options for the required visual character or "look" of the streetscape the first clear decision to be made is whether the planting will be symmetrical, asymmetrical or a pattern (see 6.1 for diagrams).

Some layout options to consider are:

- **Formal avenues** Single species symmetrically spaced.
- **Informal avenues** Asymmetrically arranged single species.
- **Patterned planting** Multiple species in a patterned avenue or patterned grouped planting.
- **Focal / landmark areas** Street trees used to highlight presence of an entry, community focus or precinct by use of contrasting species.

Traditionally street tree plantings are of a single species, evenly spaced. This is seen as the ultimate expression of the boulevard. Notable examples are Ocean Street in Woollahra, Burns Road in Wahroonga and Anzac Parade at Moore Park. These successful avenues create a grand scale with trees of umbrageous form, interlocking overhead canopies and regularly spaced trunks.

Australian native species, particularly Eucalypts, for instance, are inherently asymmetrical in form with more open canopies and give the street a very different character to an avenue of exotic species even when planted symmetrically.

Considering the variety of challenging urban conditions that are commonly found today in local streets, such as difficult soil conditions, smaller lot sizes and competition with utility services, it is advisable to broaden the options for tree layouts considered for use in streetscapes.

Jacarandas provide seasonal colour in the street

Ocean Street, Woollahra

3.3 Climate

Sydney has a warm temperate climate, however there is considerable variation in average temperatures and rainfall patterns between coastal areas, inland areas of the Cumberland Plain and the foothills of the Blue Mountains. Species that perform well in the cooler elevated areas of Sydney's Northern Suburbs, for example, will not perform satisfactorily in warmer, drier areas of the south-western plains. Only those species that have a proven performance record within the locality should be selected for use as street trees in the corresponding geographical area.

Different species have different microclimatic preferences and tolerances depending on the natural habitat. Some species are tolerant of full exposure to sunlight, whereas others prefer semi-shaded positions. Exposure to prevailing winds, salt laden winds, tolerance or sensitivity to frost and other environmental variables must be considered in both selection and placement within the site.

3.4 Soils & drainage

Soil conditions throughout the Sydney basin are variable, ranging from disturbed landscapes, to shallow sandy impoverished soils derived from Hawkesbury Sandstone to more fertile soils derived from Shales or alluviums. The selection of street tree species must take account the soil types both within the locality and the geographical region. Whilst some species are adaptable to a range of soil conditions, others prefer particular soil depth, fertility and moisture content to perform satisfactorily.

The site hydrology will also be a limiting factor in the selection of tree species. Low lying areas along drainage lines are typically poorly drained and may be suitable to species that will tolerate periodic inundation or waterlogged soils. Higher areas on side slopes or ridges are more typically well drained and species that prefer well drained soil conditions should be selected for these areas.

The root system provides the essential functions of anchorage (structural stability), absorption of water and nutrients and storage of vital food reserves. The mature size of a tree will be limited by the volume of soil suitable for root growth and development. Most tree roots are contained in the top metre or so of soil, but may extend 2 to 3 times beyond the extent of the drip-line (extent of the canopy projected to the ground plane). For trees to achieve their optimum mature dimensions, they must have adequate below ground space for the growth and development of the root system.

Soil conditions within an urban environment, particularly streetscapes, are far from natural. Soil profiles are often inverted, disturbed, paved, compacted and contain a variety of underground structures and utility services. Satisfactory growth and performance of street trees relies heavily on an effective root system. Root growth is limited by available soil oxygen, soil strength, permeability and moisture holding capacity. Whilst some species will tolerate poor soil conditions, ideally improved soil conditions should be provided to ensure satisfactory root growth.

A healthy root system is essential for tree success in the streetscape.

3.5 Water

Adequate soil moisture is essential for street trees to flourish in the challenging urban environment. Traditionally the local Council would be responsible for the watering of street trees alternatively their fate is dependent on the benevolence of the weather or the local community.

There are a number of means by which street trees may be watered including irrigation systems however these means tend to be unreliable or costly. Alternative means of watering should be investigated, the discussion of these means is outlined in Section 4.2 of this document.

3.6 Services & public infrastructure

The size and position of underground utility services may limit effective root growth therefore limiting the optimum size, growth and performance of street trees. Likewise, tree roots may cause damage to underground services by direct pressure on conduits as roots grow and expand in diameter, or by entry to hydraulic services such as sewer and stormwater lines causing damage and blockage. Tree roots and underground services do not mix. Where possible tree planting areas and below ground service corridors should be separated.

Species that have large and vigorous root systems may result in significant damage to public infrastructure, including roads, kerbs, footpaths, paved areas and underground services. These types of trees should be avoided.

Where overhead power or communication lines occur, the size and/or types of trees suitable to be grown beneath are limited due to their branching habit and tolerance to severe pruning.

Where trees share the road verge with aerial utility services large trees suffer severe lopping that compromises the trees form and health. Tree selection should consider these constraints.

Trees with vigorous root systems may damage road infrastructure.

3.7 Native or exotic

There is considerable divergence of opinion within the general community in regard to the use of native or exotic tree species in our urban environment. However, the origin of a tree is of lesser importance than it's ability to tolerate the modified urban environment and its appropriateness to the site conditions. Ultimately, it is critical that the species selected will be sustainable in the landscape, that is, it will grow to maturity and perform satisfactorily for an extended period in the street environment with a minimum of care and maintenance. A combination of tree types may best suit the specific site situation. There are broadly three different species options to consider:

i. Locally native species

These trees are generally best suited to the soils and climate of their particular area, they also promote biodiversity and habitat linkages, one such species is the Cheese Tree *(Glochidion ferdinandii)* (Photo Page 12). Many local government areas actively support the use of locally native species within urban development. However, the constraints posed by the urban environment may not allow these species to flourish causing them to be more susceptible to pests and disease when under environmental stress. Many of these species have not been extensively trialled in urban situations and their performance is not readily predictable.

ii. Species native to Australia

Native trees are widely used in the landscape industry having both the required form and ability to perform well in the urban environment. Many native species have been extensively used in amenity horticulture and their performance can be predicted under known environmental conditions. The industry is extending the number of species trialled, investigating a range of NSW east coast natives largely from drier rainforest vegetation types that are particularly well suited to the poorly drained and aerated, shady urban conditions.

iii. Exotic species

Traditionally many of our street trees are exotic species and in some cases the species have been bred specifically for amenity horticultural purposes therefore being hardy and having a suitable form for use in the urban environment.

Many of the exotic species commonly used are deciduous giving the benefit of affording solar access in winter. The option of using deciduous native trees species is extremely limited as there are very few true deciduous native species, most being semi-deciduous associated with their flowering cycle such as the Illawara Flame Tree rather than in the winter period as is desirable in the urban environment.

The success of some exotic species and lack of predators in the Australian environment has resulted in these species becoming environmental weeds. An effort should be made to exclude species that have become environmental weeds particularly in areas close to bushland.

Australian Native Lemon Scented Gum are widely grown throughout the country.

Liquidambers are exotic to Australia originating in North America.

3.8 Biodiversity & habitat

Where appropriate, consideration should be given to planting trees which provide a linkage between open space or other vegetated areas and natural stands of vegetation or bushland to assist in the movement of wildlife (fauna and birdlife) between those areas. These species should contain some benefits to wildlife including the physical benefits of protection, shelter, nesting sites and food sources.

Species that are locally indigenous to an area are likely to provide the most benefit to local wildlife, however these species are not always successful when planted in a highly urbanised situation. In some situations exotic species can provide similar attributes, such as habitat and linkages, for wildlife.

3.9 Weeds, nuisances & pests

Some exotic and native species are known to be, or have the potential to be, serious environmental weeds due to their ability to self-propagate and invade bushland areas, competing with locally indigenous species. These species should be avoided as street trees particularly in proximity to bushland.

The selected species must have an acceptable level of nuisance created by the shedding of leaves and fruit for a street environment. Whilst all trees have some leaf / flower / fruit drop, those with large or heavy seed pods, excessive leaf drop, fleshy fruit or flowers, or hard spherical seeds which may lead to slip hazards on pavements should be avoided. Trees with other nuisance factors, such as plants that produce known allergens producing such conditions as asthma or skin irritants, spikes or thorns should also be avoided.

Pollen is a known hay fever and asthma trigger. Some trees particularly deciduous trees produce abundant amounts of pollen however not as much as grasses which are the primary source of pollen. The most problematic species (Plane Trees, Birch, Cypress) have been excluded from the recommended species list. Some deciduous species are listed in recognition of the other functions they perform in the streetscape.

Selected tree species should be resistant to disease and significant pest infestations. The control of pest problems in large trees using chemical methods is both impractical and inappropriate in urban areas. Species that have known susceptibility to debilitating pest or disease infestations should be avoided.

The use of a diversity of species within a neighbourhood or region is also important in reducing the impact of devastating diseases (such as Dutch Elm Disease) on specific tree species and species with similar genetic make-up. Consider the use of a broad mix of species and family groups within a street tree population (not necessarily within the same street) to minimise this risk.

Locally native trees such as the Cheese Tree promote biodiversity and habitat linkages.

Tree species planted in monocultures such as these bottle-brushes are often subject to pests and diseases.

3.10 Tree size, spacing, life span & maintenance

i. Tree Size

Species should be selected such that the ultimate mature size is in scale with the relevant street, taking into consideration the site constraints, such as verge widths, overhead powerlines, building setbacks and vehicle clearances. The optimum size range should not be so small that it does not make a contribution to the amenity of the street, and not so large as to dominate and cause significant problems (damage & nuisance). In some instances the constraints imposed by the street environment will limit the ultimate size of street trees or even restrict tree planting altogether.

Where site constraints limit the ultimate size of street plantings and the visual impact of a larger tree is essential for legibility, consideration may be given to mechanisms that minimise or remove the impact of these constraints. These could include for example, replacing overhead powerlines with Aerial Bundle Conductors (ABC's) or underground power conduits, planting trees within a median or carriageway (where verges are narrow and streets are sufficiently wide) and increasing the root zone soil volume by use of structural soils or similar technologies.

For Landcom's roads (see Landcom Street Design Guidelines 2006) it is recommended that the following sizes of trees be planted depending on specific design and physical conditions:

Small trees:
6-8m height with a 5m crown spread

Medium trees:
10-12m height with a 8m crown spread

Large trees:
16-20m height with a 16m crown spread

ii. Tree Spacing

Throughout NSW Council requirements vary as to the distance of street trees from the back of the kerb which is generally between 900mm and 1.5m in a standard 3.5m verge. A 900mm minimum setback generally allows garbage trucks to operate along the street without causing too much damage to the trees. At minimum these trees would be spaced to give a consistent visual presentation, the optimum would be a size and spacing to achieve interlocking canopies both along and over the road reserve.

Street trees linear spacing ranges from 5m to 15m depending on tree size to achieve the previously stated design intent but in detail will depend on the planting layout, mature size and road verge width. Generally spacing should be:

Small trees at 5-7m centres

Medium trees at 7-10m centres

Large trees at 10-15m centres

When locating trees in detail consideration should also be given to the proximity to driveways, light poles, kerb inlet pits and services. Refer Section 6.2 Construction Details.

Crepe Myrtle , small tree

Tuckeroo, medium tree

iii) Life Span & Maintenance

The procurement, planting and establishment maintenance of street trees is a significant investment of time and resources, therefore species selected should be long lived, say not less than 20 years. While the majority of tree species are reputed to be long lived in their natural habitat it is common industry knowledge that many species experience a reduced lifespan in the urban environment.

Street trees typically do not receive the same level of care as those in residential gardens or parks and must be tolerant of drought, general neglect and atmospheric pollutants. Trees that are sensitive to disturbance or require high levels of maintenance such as regular removal of deadwood, pruning or pest and disease control should be avoided.

Tree species selected should require a minimum of maintenance following the establishment period. Species should also be adaptable to pruning and shaping where required to achieve clearances and appropriate form.

To achieve the best outcome for environmental benefits and design intent the tree population should be managed through a life cycle management approach with a mix of tree age classes maintained in order to spread recurrent expenditure and management actions.

Post establishment, trees should be inspected annually to monitor tree health and identify preventative actions such as formative pruning. Street cleaning to remove detritus such a leaves, flowers and fruit drop may need to be carried out, the magnitude and frequency of this activity will depend on the tree species selected.

Lace Bark, large tree

Trees are often planted for their aesthetic benefits however long term management requirements of large trees in small verges are often not considered

part 4

technical

FOR ALL TREE TYPES

4.1 Soil volume & type

The ultimate size of a tree is governed by its genetic make-up and influenced by the prevailing environmental conditions and the quality and quantity of growing media (natural or artificial soil) available for root growth and development.

Current research indicates that typically in clay loam type soils, the root system of a mature tree may extend up to two to three times the spread of the crown (extent of the foliage and branches), but usually extends no deeper than one metre from the surface level. Tree roots are opportunistic, that is, they will flourish wherever soil conditions are favourable. Conversely, however, they will not grow where soil conditions are unfavourable. Three things limit root growth and development; available soil oxygen (necessary for root function and respiration), available moisture, and the resistance of the soil to root penetration (degree of soil compaction). Beyond the requirements for normal tree growth, root development is also critical for the anchorage and stability of the tree (refer to Fig 5). A tree can be sustained on a very small volume of soil (in a nursery container for example) provided that frequent and adequate water is provided. However, in a street situation, where the tree must rely on the infiltration of natural rainfall to the root zone, tree growth and development is limited by the volume and moisture holding capacity of the soil.

There are many methodologies for calculating the required soil volumes for trees in a street situation, however the results are extremely variable. Most suggest a minimum volume as of:

- Between 5 and 15 cubic metres for a small tree.
- Between 20 and 40 cubic metres for a medium sized tree and
- Between 50 and 80 cubic metres for a large tree.

These volumes represent the unobstructed soil volume required by the tree i.e. where the roots can spread to, not the improved soil planting hole (see Fig 6a & 6b). The improved soils area is defined in the standard details in Section 6.2 - Fig 15.

As root growth is limited by available soil oxygen, and this oxygen depletes with depth, there is no benefit in increasing soil volume by increasing the depth of the planting zone beyond a depth of 1.0m. The greater benefit is in increasing the soil volume laterally (refer to Fig 6a & 6b).

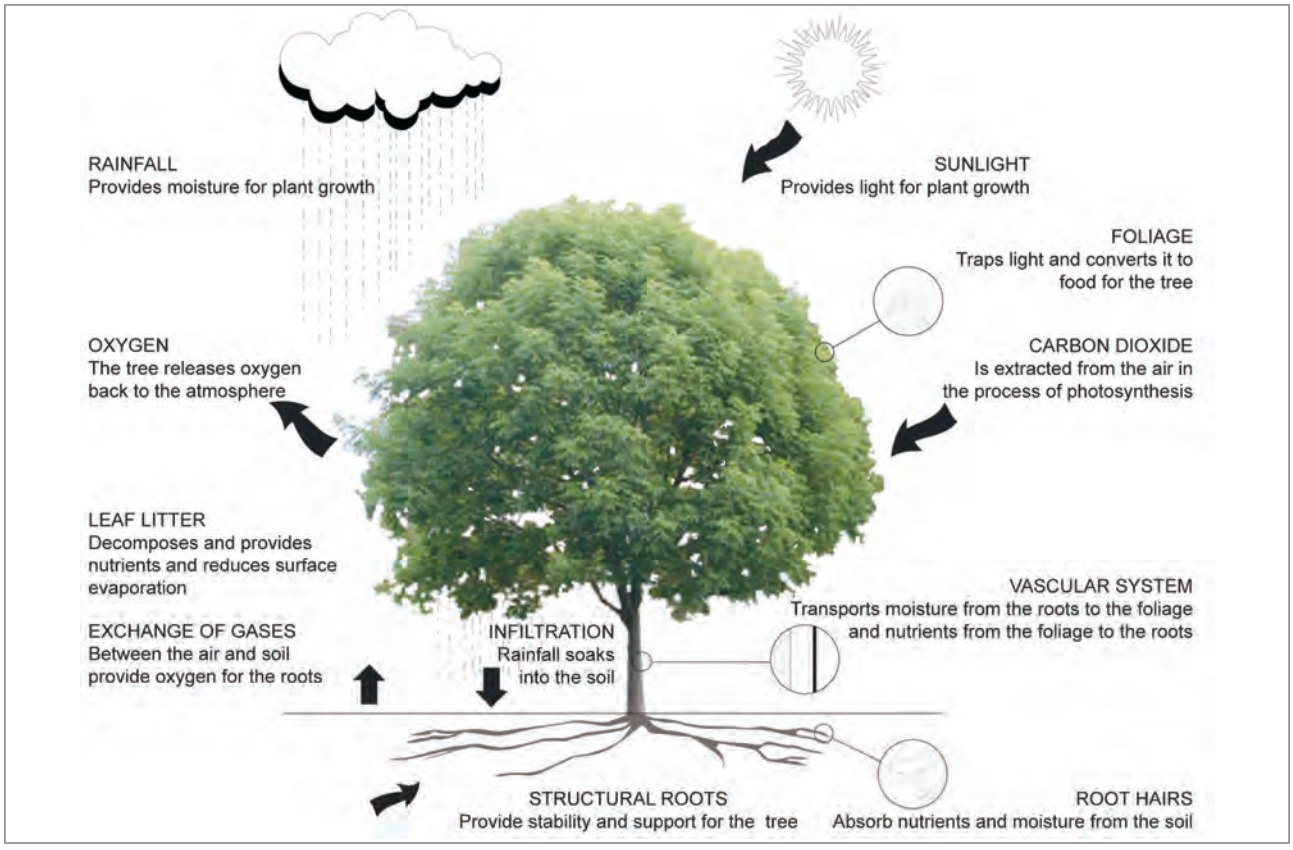


Fig 5 Tree structure and needs

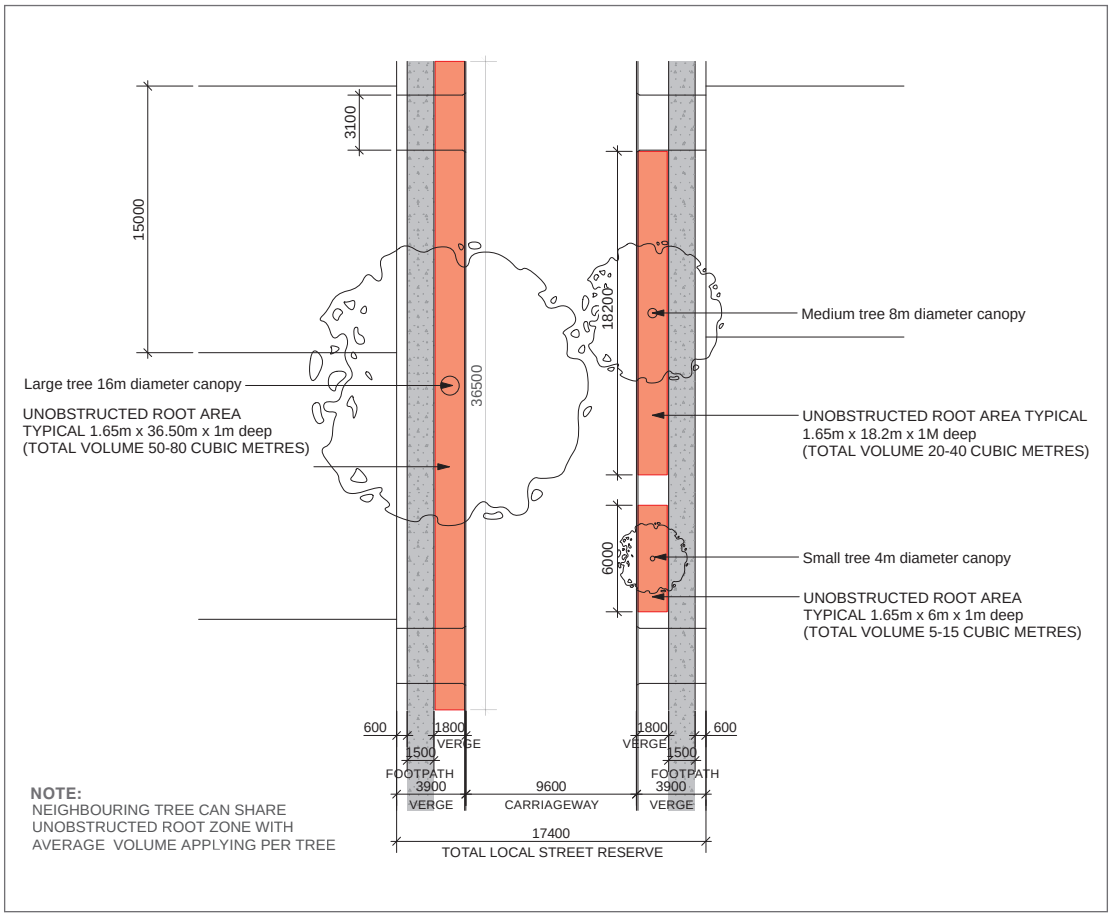


Fig 6a Available unobstructed root area for Local Street (planting in verge)

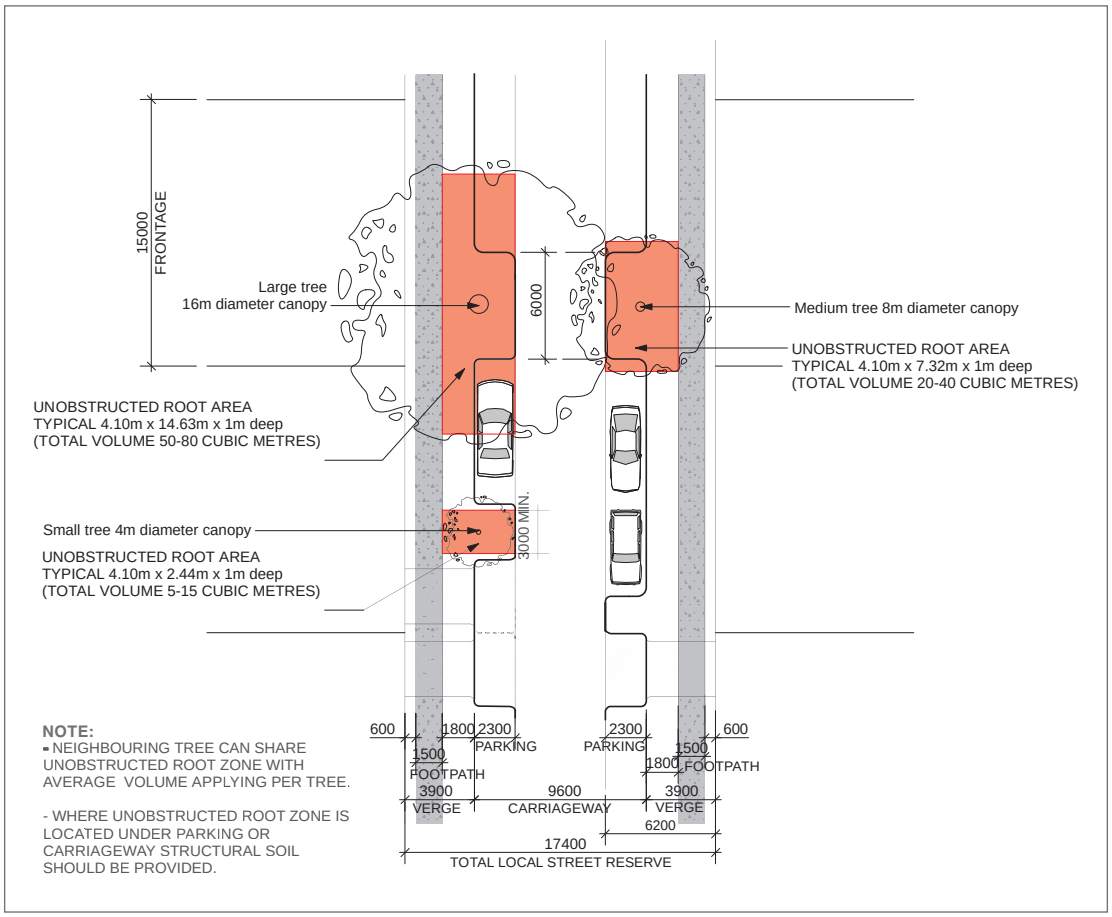


Fig 6b Available unobstructed root area for Local Street (planting in carriageway)

In order to provide reasonable conditions for tree growth and enable trees to reach their optimum ultimate dimensions, some compromise is necessary between the conflicting needs of the street tree and urban infrastructure. Various innovations have been developed that reduce the potential conflict in requirements between trees and urban infrastructure. These include:

- Porous and permeable pavements and sub-base materials
- Skeletal (structural) soils (providing load bearing sub-base for pavements and parking bays)
- Drainage technologies
- Interconnected tree pits
- Separation from service corridors
- Modifications to kerb alignments to increase soil volumes through introduction of blisters, medians and the like.

4.2 Designing for passive watering

Access to moisture is a fundamental requirement for tree health. The configuration of the traditional road verge is not designed to maximise stormwater flow to street trees rather stormwater is rapidly collected in the gutters which feed this water to the piped drainage system. Passive watering entails the redirection of 'low flow' road stormwater to water street trees while allowing any greater flows to be collected in the stormwater collection system. The benefit of accommodating street tree watering as part function of the road drainage system is to promote more successful street trees and reduce the need to use potable or town water for tree watering.

The tree may be located in the road carriage way within a blister or in a depressed planting area in the verge as illustrated in Fig 7.

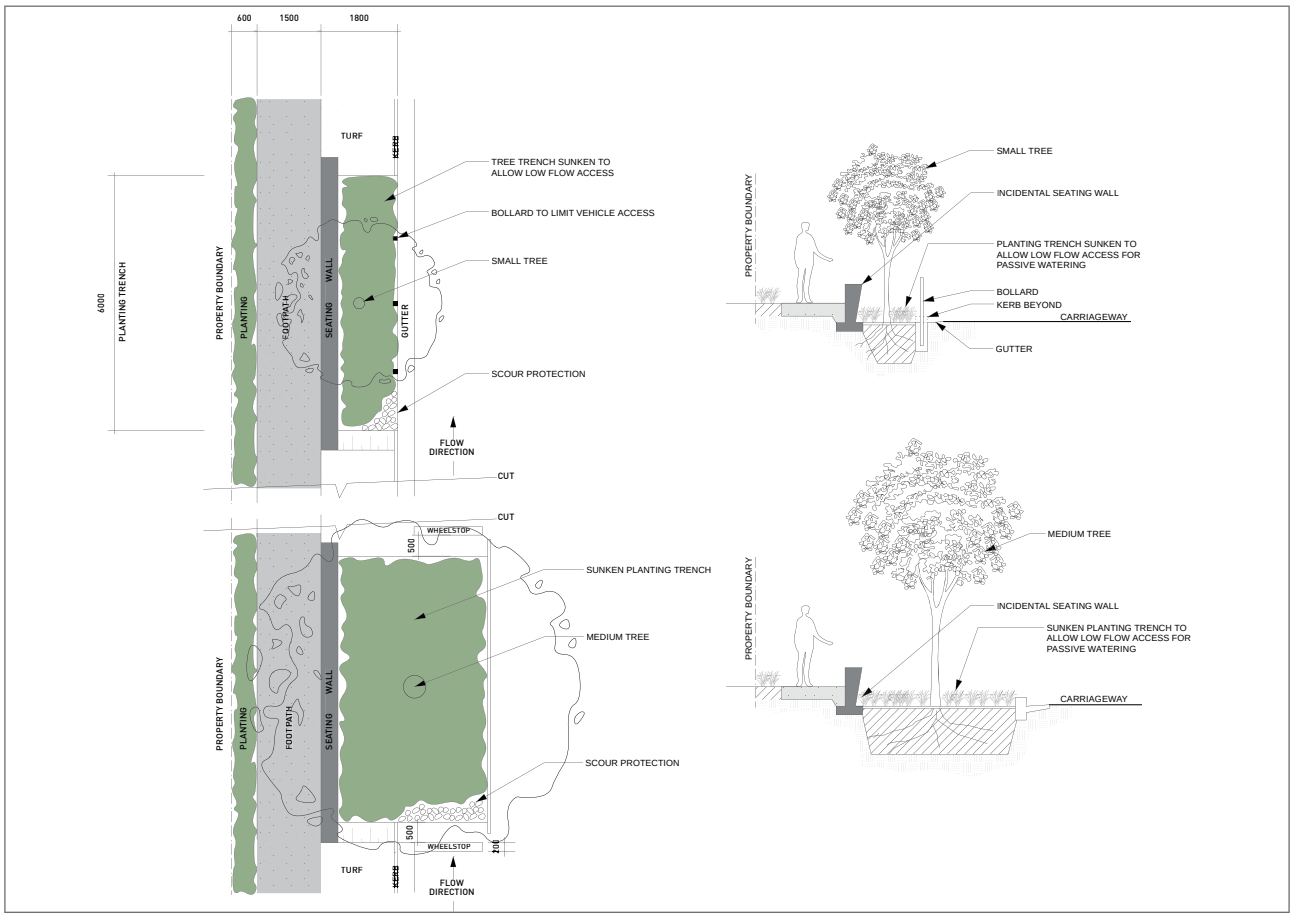


Fig 7 Designing for passive watering. Top diagrams show street tree in verge while bottom diagrams show street tree in blister in carraigeway.

4.3 Water sensitive urban design

Raingarden Street Trees

Raingarden tree pits are essentially bioretention cells located at kerbside containing a street tree with groundcover vegetation around the base. Stormwater runoff enters the tree pit through a break in a standard road kerb and is filtered through the soil media within the cell. Treated stormwater is then collected via a perforated drainage layer at the base of the cell before being discharged into conventional stormwater pipes that also act as an overflow. Fig 8 below illustrates the flow of stormwater from surrounding impervious areas, onto the surface of the street tree before percolating down through the filter media and being collected in the drainage pipes before being discharged to conventional stormwater pipes.

Street trees designed in this way provide streetscape amenity and stormwater treatment. An additional benefit is that the passive irrigation from stormwater reduces the demand for irrigation from other sources such as potable water.

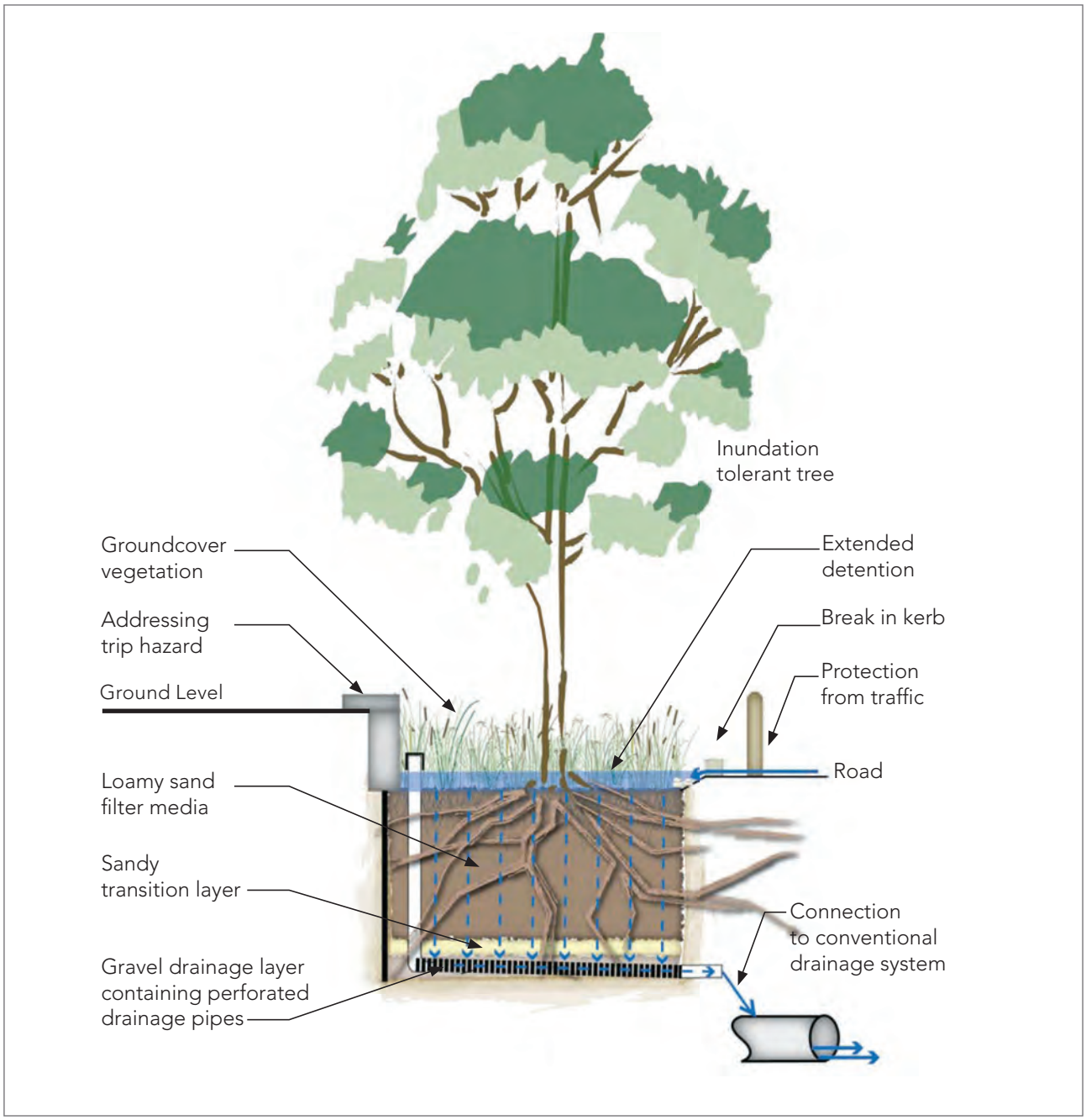


Fig 8 Typical raingarden tree pits (NTS) showing the stormwater flow path.

Things to consider:

Connection to conventional stormwater system

As the inclusion of tree pits into the drainage system does not affect other conventional drainage elements, stormwater discharge exceeding the capacity of the tree pit may continue down the kerb and is collected in a conventional side entry pit, as illustrated in Fig 9.

Set down

The surface of the filter media (growing media) of a raingarden tree pit must be set down from the surrounding surface to allow for ponding of water across the surface (extended detention). As a result there may be a need to address any tripping hazard created by the set down of the filter media. This may be done in a number of ways including the provision of bollards or seats or the provision of a custom designed tree grate as illustrated in Figs 10a & 10b.

Groundcover vegetation

The inclusion of ground cover vegetation around the base of the tree reduces the likelihood of clogging at the surface of the tree pit. Raingarden street trees can be designed without groundcover vegetation, as illustrated in Figs 10a & 10b, however there is an expected increase in maintenance with this type of design to ensure the surface of the filter media maintains its porosity.

Filter media and drainage pipes

The design of a street tree as a raingarden to treat stormwater means that the tree essentially has a much larger catchment than would have previously been the case. As a result it is important that the correct filter media and drainage pipes are specified to ensure that stormwater can efficiently move through the system and then be discharged back into the conventional stormwater drainage system.

Tree species selection

The tree species need to be relatively hardy (tolerant of freely draining sandy soils and regular inundation). The soil (filter media) into which the trees are planted has a specified hydraulic conductivity (often between 100 – 200 mm/hr).

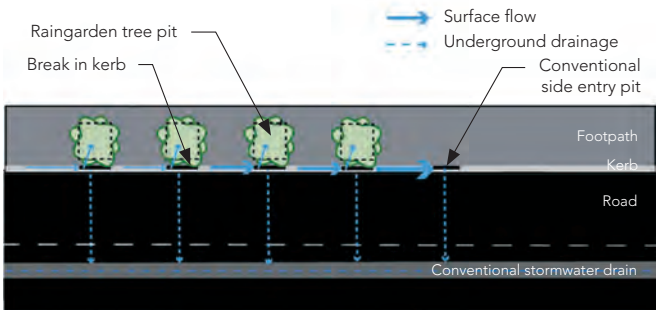


Fig 9 Raingarden tree pits - Typical plan view (NTS) showing stormwater flow into and out of a row of raingarden street trees.

Fig 10a Typical design of a raingarden street tree with customised grate and overflow grate located along the kerb.

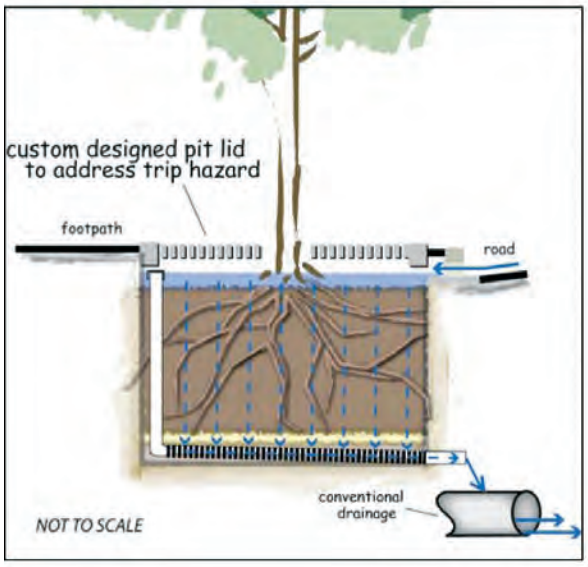


Fig 10b Customised grate for raingarden street tree.

4.4 Tree hardware

i) Tree Guards

Tree guards are sometimes used to protect trees from accidental damage or vandalism in urban areas. A considerable variety of styles and designs are commercially available plus options for custom made types. If tree guards are required, the design should allow for easy removal of the guard once the tree is of sufficient size to no longer require protection. Segmented types that can be disassembled from around the tree are preferable to single piece structures. A minimum intrusion into the ground plane should also be considered as footing for tree guards can form an obstruction to root growth and displace valuable root volume.

ii) Root Barriers

Tree roots are opportunistic and will grow wherever the soil conditions are favourable. Roots require acceptable levels of oxygen moisture and growing media to grow successfully. Where conditions are unfavourable, they will not grow. As roots are limited by available soil oxygen, they will often grow close to the soil surface, and in moist aerated materials such as pavement sand bedding layers. As roots grow, they gradually expand in diameter and can exert considerable pressure on structures and pavements, causing them to lift, crack and displace.

Root barriers are sometimes used in new planting situations, particularly planting pits in pavements or adjacent to kerbs, to deflect roots away from structures and avoid future damage. A range of products and materials are commercially available. However, to minimise potential conflicts and reduce the potential for damage to structures, adequate soil volume and quality needs to be considered as a priority as root control devices appear to be the least effective method of containment where poor soil aeration and compaction encourages shallow root growth. The installation of a root barrier is not a guarantee of protection of infrastructure and requires specialist knowledge in design, installation and maintenance.

Tree guards can provide a variety of uses such as protection and landmarking, they also need to accommodate tree growth and be easily removed.

Root barriers installed to protect public utility and road assets however a better solution is providing trees with adequate soil volume.

iii) Plant Stakes & Ties

Industry best practice is for plant stock not to require staking for support. Where the supply plant stock is of a prescribed quality as specified in the Natspec guide, plant stock should be "self-supporting" that is, not requiring stakes and ties or other artificial means of support during establishment. This is because the plants are grown with an acceptable ratio between the container volume, trunk calliper and tree height.

Stakes and ties are sometimes used to provide artificial support to trees during establishment of the root system, however, incorrectly installed stakes and ties can cause damage to young trees and should generally be avoided. Trees that become reliant on stakes for support develop weak stems that do not strengthen naturally under normal weather conditions, leading them to bend or snap once the stakes are removed.

Where stakes are installed there should be sufficient flexibility in the ties to allow some movement of the stem, which will promote increase in stem calliper and strengthening of the trunk

Stakes as markers.

Urban tree guard and grate.

part 5

sourcing & procurement

FOR ALL TREE TYPES

Sourcing & procurement

Beyond the selection of an appropriate species for planting consideration needs to be given to the availability of plant stock in terms of pot size, quantities and quality.

5.1. Availability

In Australia, plant stock is normally grown in containers and sourced from commercial nurseries. The container type, shape and size may vary depending on the size of the stock and the grower. Some plant stock is also grown in the ground (field grown) and transplanted to containers prior to delivery (sometimes referred to as "Balled and Burlapped" stock). A limited number of tree species are grown by commercial nurseries, depending on their popularity and ultimately their commercial viability. Where unusual plant material or large tree stock is required, pre-ordering several years in advance may be required to ensure the most appropriate plant stock can be sourced for the project, particularly where local provenance or large numbers of stock are required.

Local provenance species are tree species that are indigenous to a specific local area. Planting local provenance species may be important in proximity to areas of natural vegetation or re-vegetation of disturbed roadside areas adjacent bushland to preserve genetic integrity of the natural vegetation. Where local provenance species are required, procurement should be undertaken several years in advance so that local provenance seed can be collected and grown on as plant stock. A number of companies specialise in seed collection and growing-on of local provenance stock.

Container grown plant stock is available in standard sizes and a variety of species.

5.2 Quality

The quality of plant stock grown by commercial nurseries is extremely variable. To provide greater consistency and quality of plant stock, Natspec has produced a useful guideline titled "Specifying Trees – a Guide to Assessment of Tree Quality". This guideline provides a basis for specifying and assessing tree stock quality in line with current best practice in the nursery industry. Trees to be used as street trees require a clear stem without low branching. This requires specialist pruning in the nursery. Specifications for supply of tree stock should preferably be derived from this guideline and prepared by a qualified professional.

In addition to the general health of the stock, the branching structure and root formation of tree stock is especially critical for the long term success of trees in the landscape. Poor branching structure may result in longer term problems such as structural defects and weaknesses that lead to hazards. Poor root development impedes establishment and may lead to long term problems such as tree failure and windthrow (overturning under adverse weather conditions). Container grown stock is especially prone to poor root formation unless the stock is grown in accordance with best practice principles.

Plant stock in Australia is grown in one of two main methods, in containers of various shapes and sizes or in the field (sold as "Balled and Burlapped" or "bare-rooted" stock). Field grown stock is normally reserved for deciduous trees and conifers that can tolerate root pruning and transplanting when dormant. The greater majority of plant stock is grown in containers by wholesale and retail nurseries.

Larger size plant stock is available from a limited number of commercial nurseries.

5.3 Procurement alternatives

There are currently two main options for procurement of plant stock in Australia:-

Open Market

Contract Growing

The procurement method selected will generally depend on the normal commercial availability of the stock specified and the quantities required. Small quantities of commonly grown stock can be sourced relatively easily from the open market, however large quantities, large sizes, unusual or local provenance species may need to be sourced by Contract Supply options.

i) Open Market

The open market can only supply a limited range of commercially viable stock, suitable to the local climatic conditions of an area. The market availability of various species will depend on current industry trends as well as supply and demand. Many large Commercial Nurseries act as brokers to obtain all of the stock they can from more specialist growers to fill an order. There are many good reasons for this, including the fact that most buyers prefer to deal with one supplier rather than a large number of nurseries to obtain all the required plant stock for a project. Specialist growers may also have the expertise and climatic conditions or facilities to grow various species more successfully and cost effectively than larger nurseries.

ii) Contract Growing

Contract Growing is an agreement between a grower and a buyer to grow a defined quantity of stock to the clients' specification and requirements (including for example, a specified time frame for delivery or pruned to suit a street tree function). Contract growing is a fairly reliable and cost effective procurement method for large quantities of particular species, assuming sufficient lead time is available for production of the stock. The client and grower normally share the risks associated with supply from the outset, as the stock is grown for a particular project and purpose and would not be saleable to another client.

Healthy trees with the required branching structure and root formation result in a more successful streetscape.

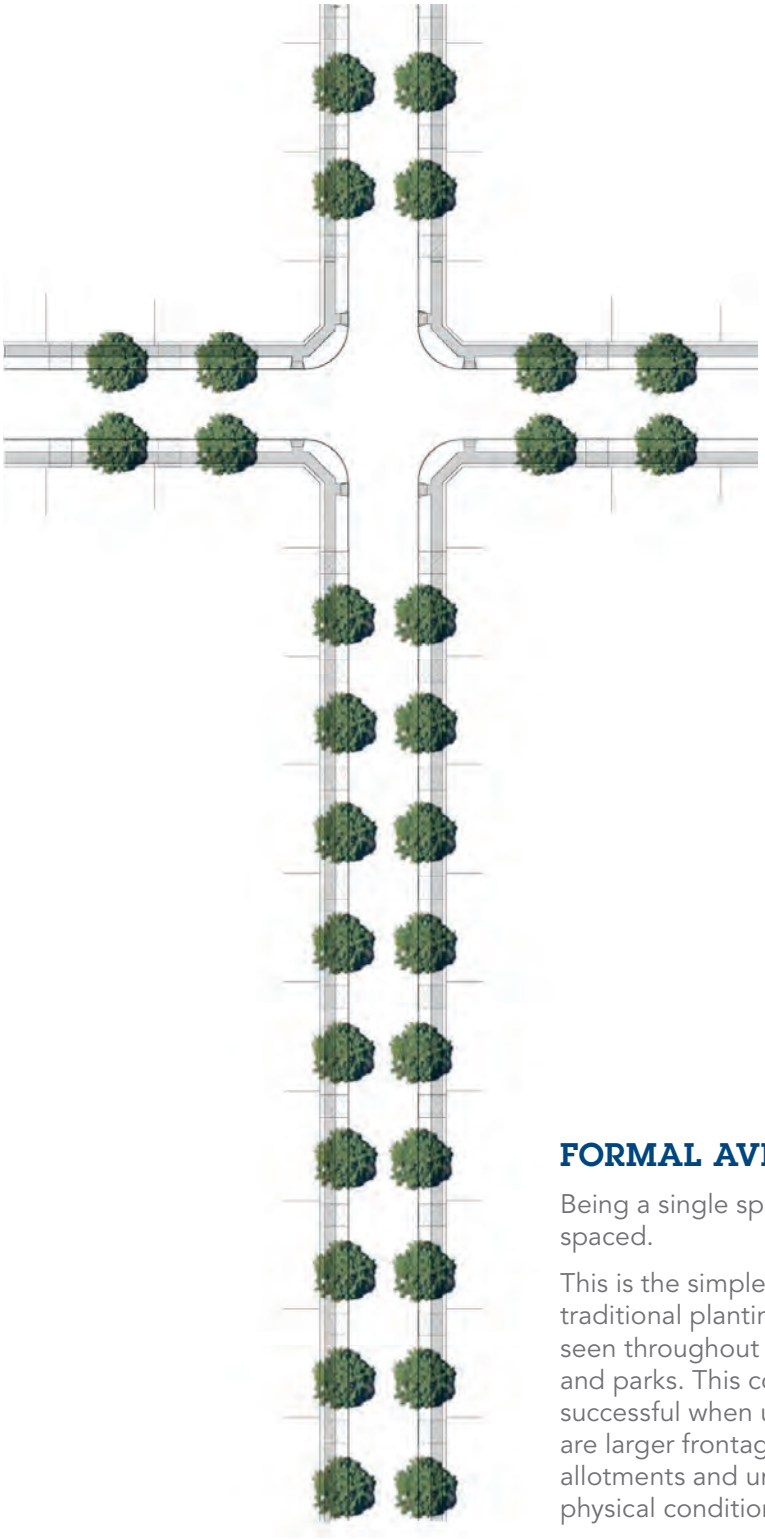
part 6

details

FOR ALL TREE TYPES

6.1 Planting configurations

For the purposes of this document the focus for consideration are the streets defined as Local, Minor Local and Laneways in Landcom's Street Design Guidelines. The technical considerations for choosing the right tree species for these locations have been outlined in Parts 3 & 4 addressing both the spatial and environmental requirements of three generalised tree sizes.

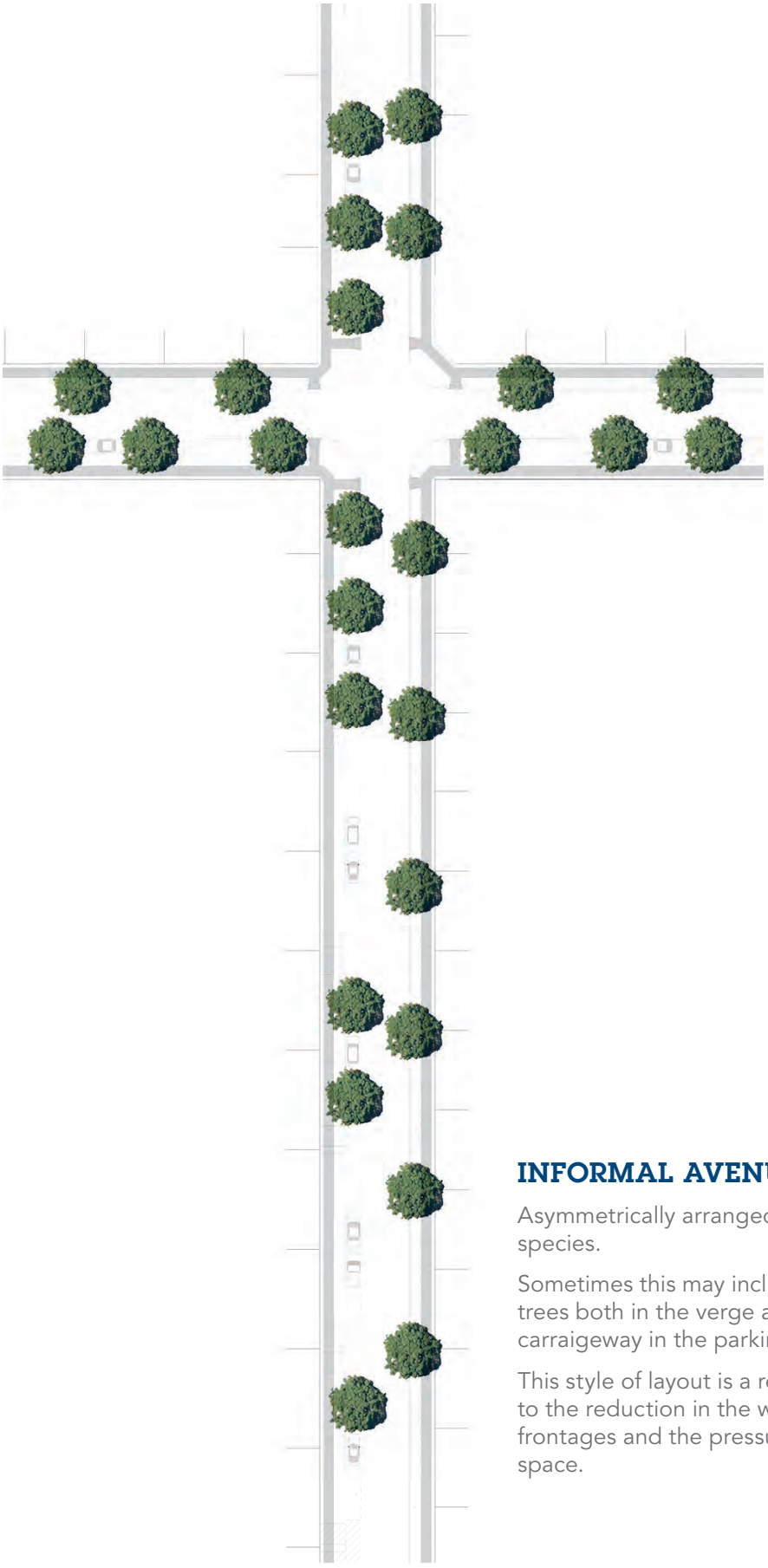


FORMAL AVENUES

Being a single species symmetrically spaced.

This is the simplest and most traditional planting configuration seen throughout the world in streets and parks. This configuration is most successful when used where there are larger frontages to residential allotments and uniform street and physical conditions.

Fig 11 Formal Avenue



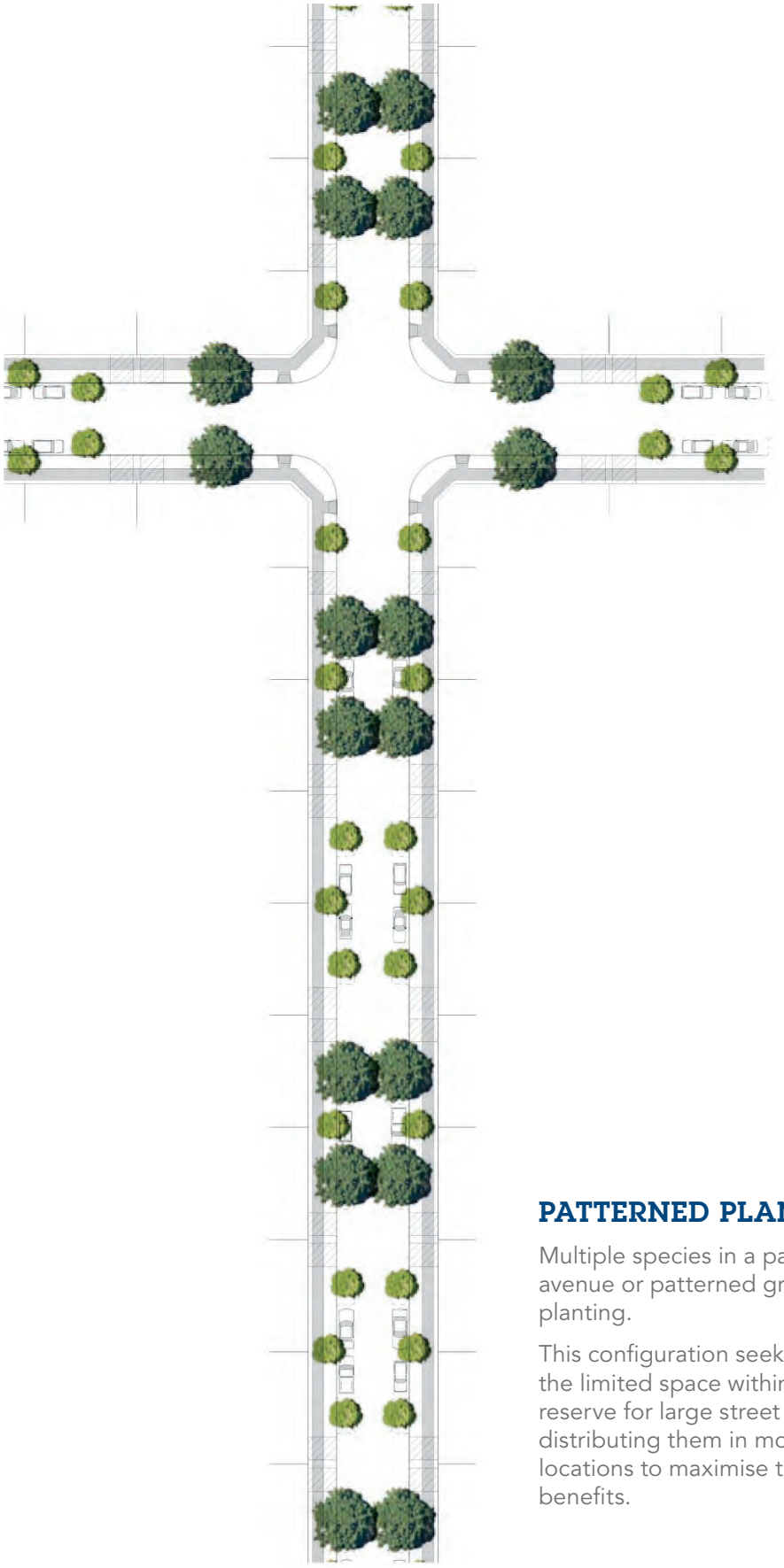
INFORMAL AVENUES

Asymmetrically arranged single species.

Sometimes this may include trees both in the verge and the carraigeway in the parking lane.

This style of layout is a response to the reduction in the width of frontages and the pressure for space.

Fig 12 Informal Avenue

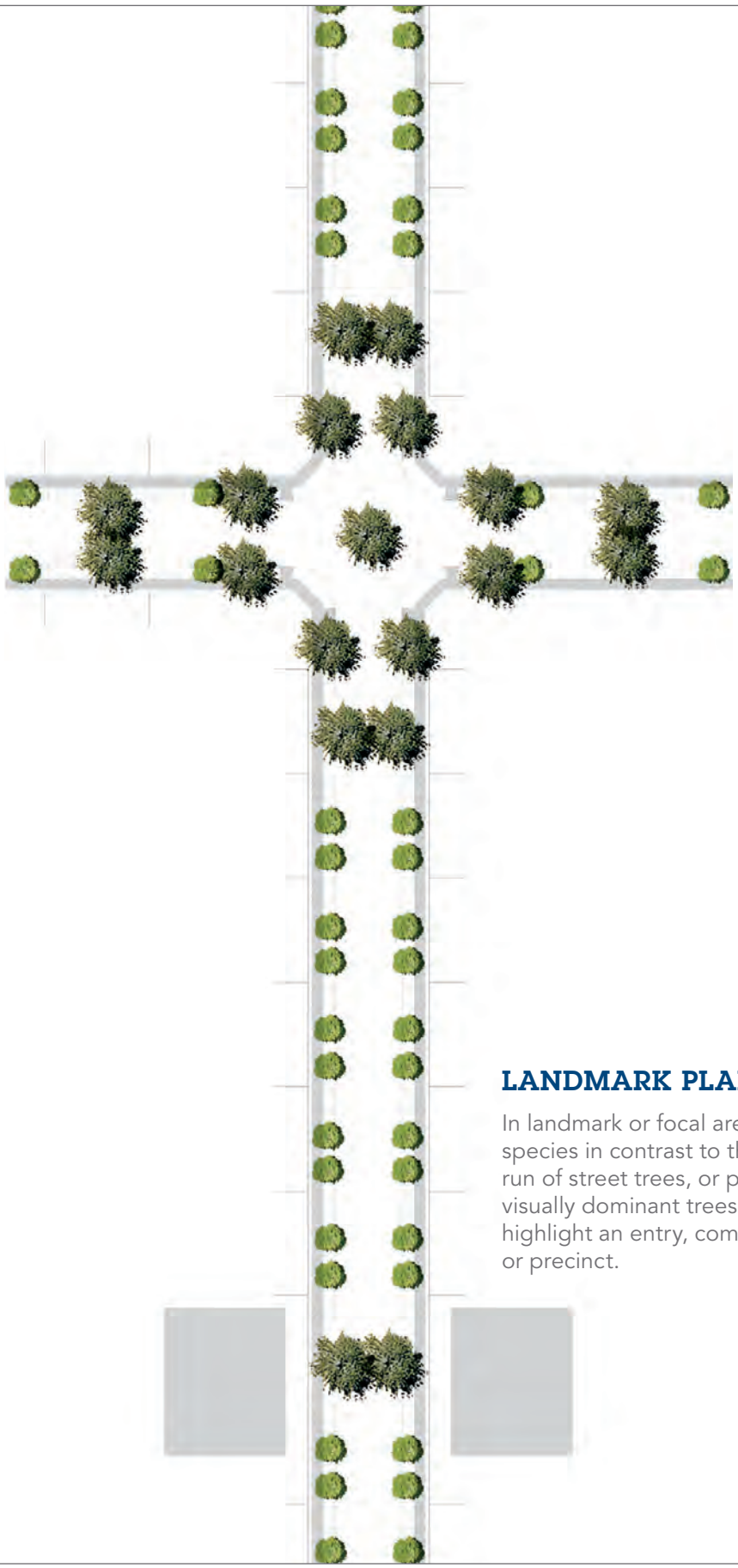


PATTERNED PLANTING

Multiple species in a patterned avenue or patterned grouped planting.

This configuration seeks to optimise the limited space within the road reserve for large street trees by distributing them in more critical locations to maximise the visual benefits.

Fig 13 Patterned Planting



LANDMARK PLANTING

In landmark or focal areas a species in contrast to the main run of street trees, or particularly visually dominant trees, are used to highlight an entry, community focus or precinct.

Fig 14 Landmark Planting

6.2 Construction details

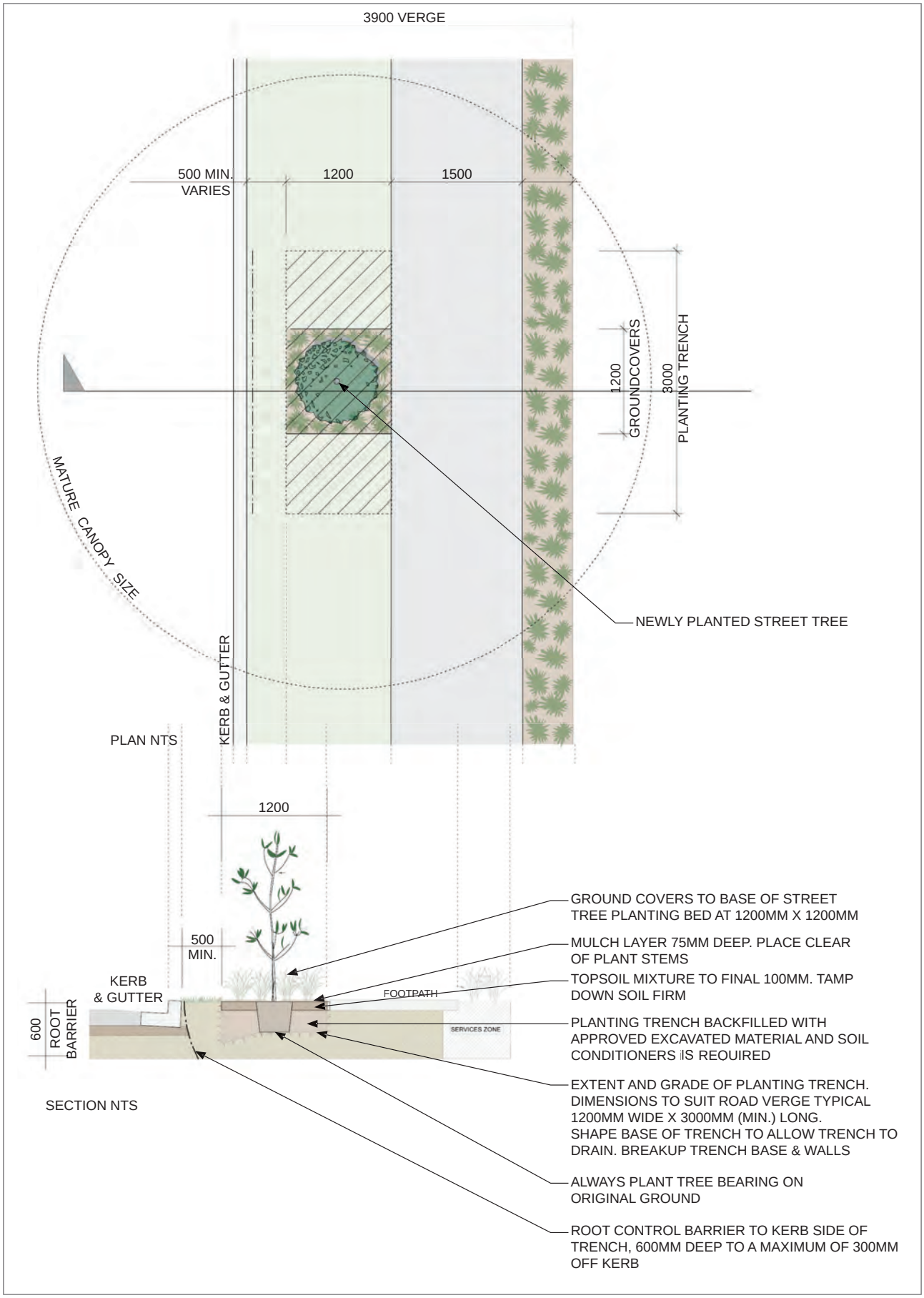
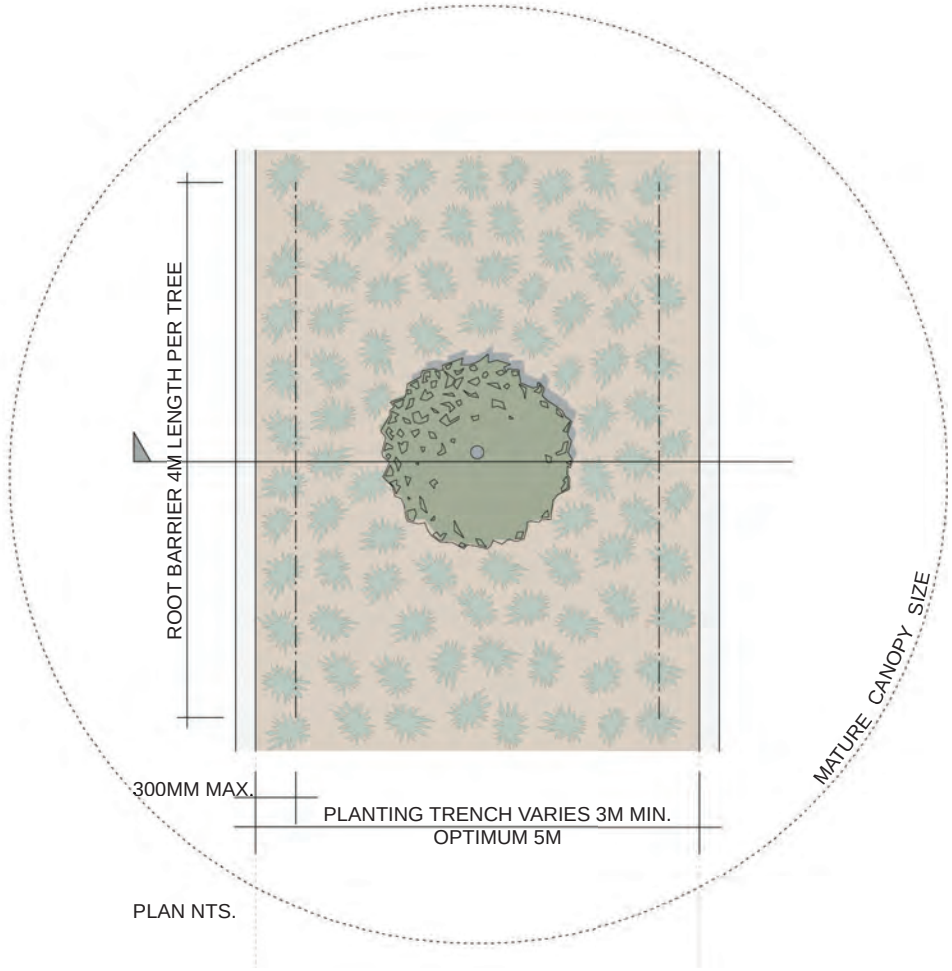


Fig 15 Typical street tree in Landcom Local Street in verge



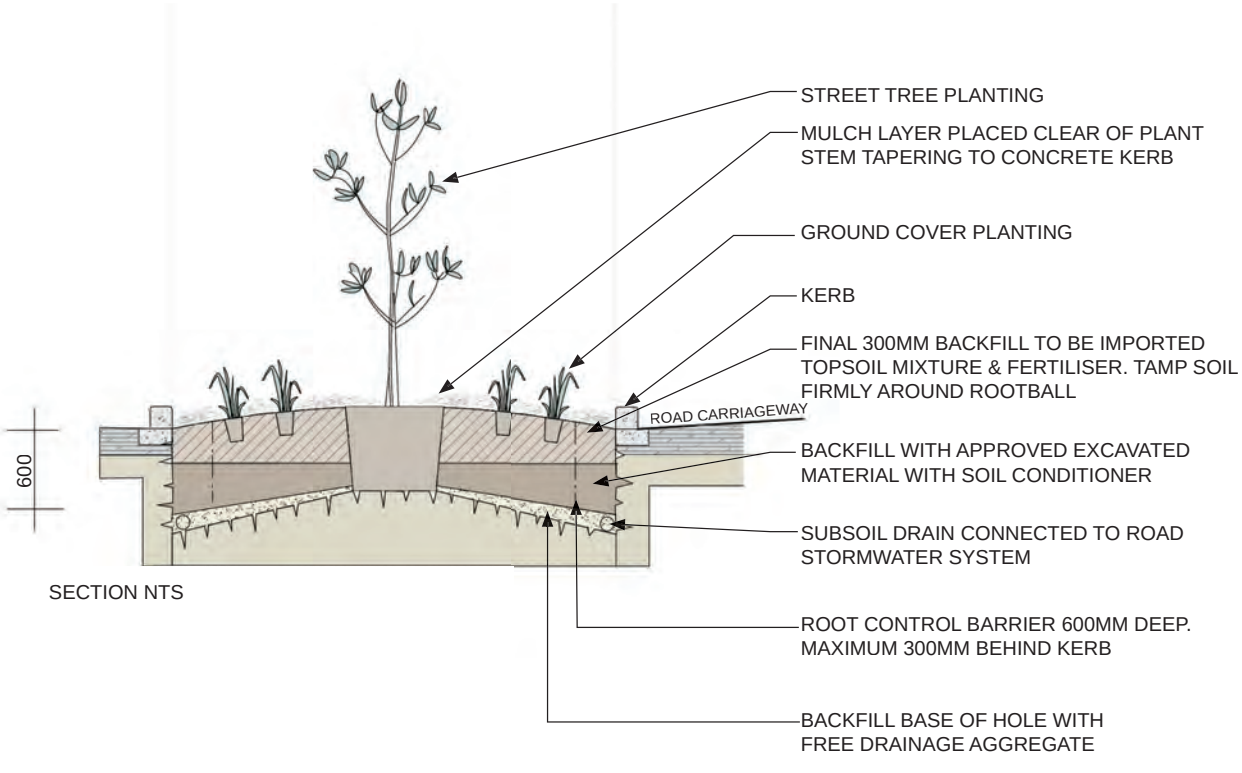


Fig 16 Typical street tree in Blister or Median

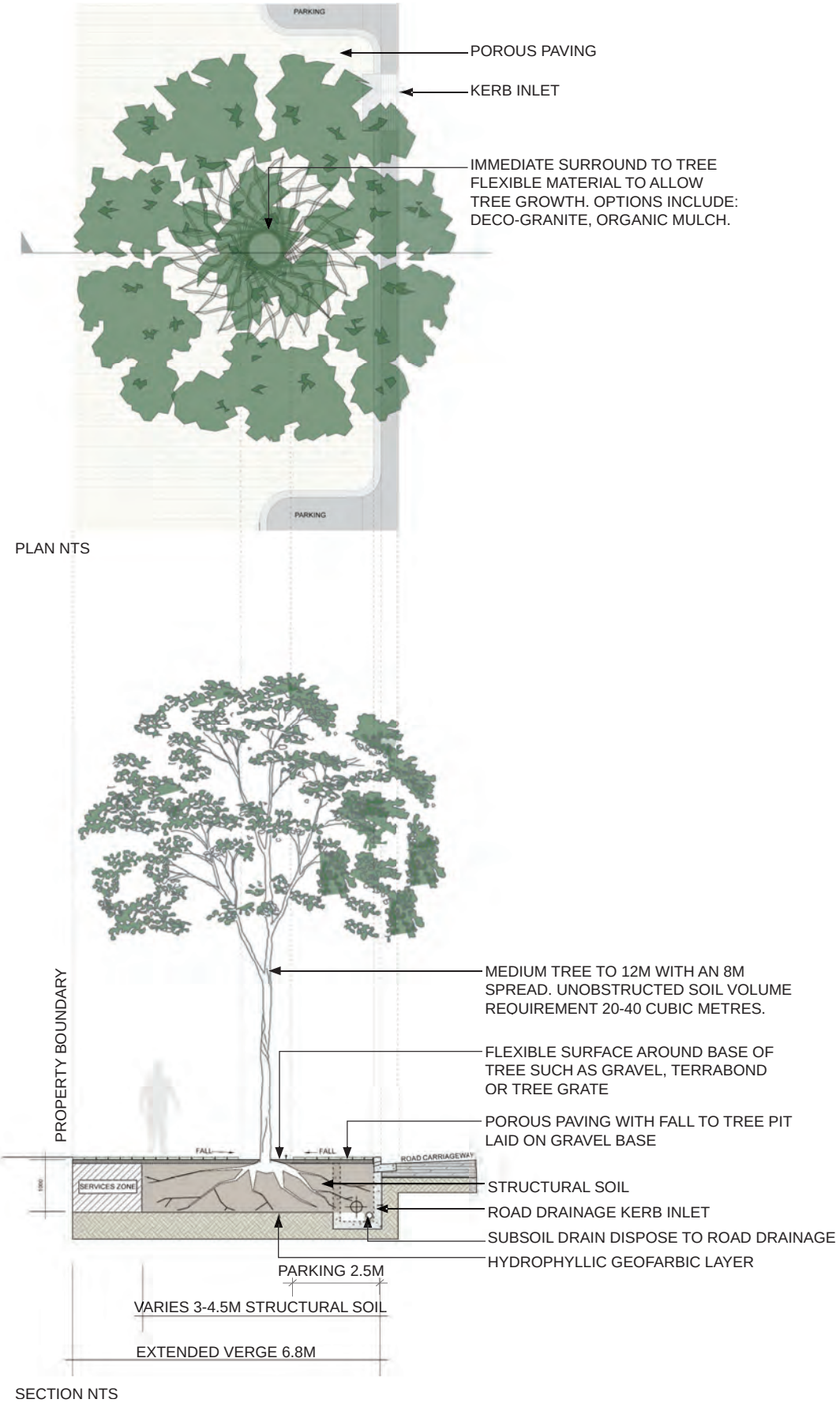


Fig 17 Typical street tree in paving with structural soil

part 7

establishment maintenance

FOR ALL TREE TYPES

Establishment maintenance

To ensure the best possible outcome new trees should have a high level of maintenance for the first two growing seasons to ensure optimum future shape and correct tree form. During this period trees would need to be regularly watered, monitored for pests and diseases and may need formative pruning. A general establishment specification can be found in Appendix B (included on CD-ROM included in inside back cover) of this document outlining the activities that should be undertaken during this period. These activities are also summarised in the Fig 19 below.

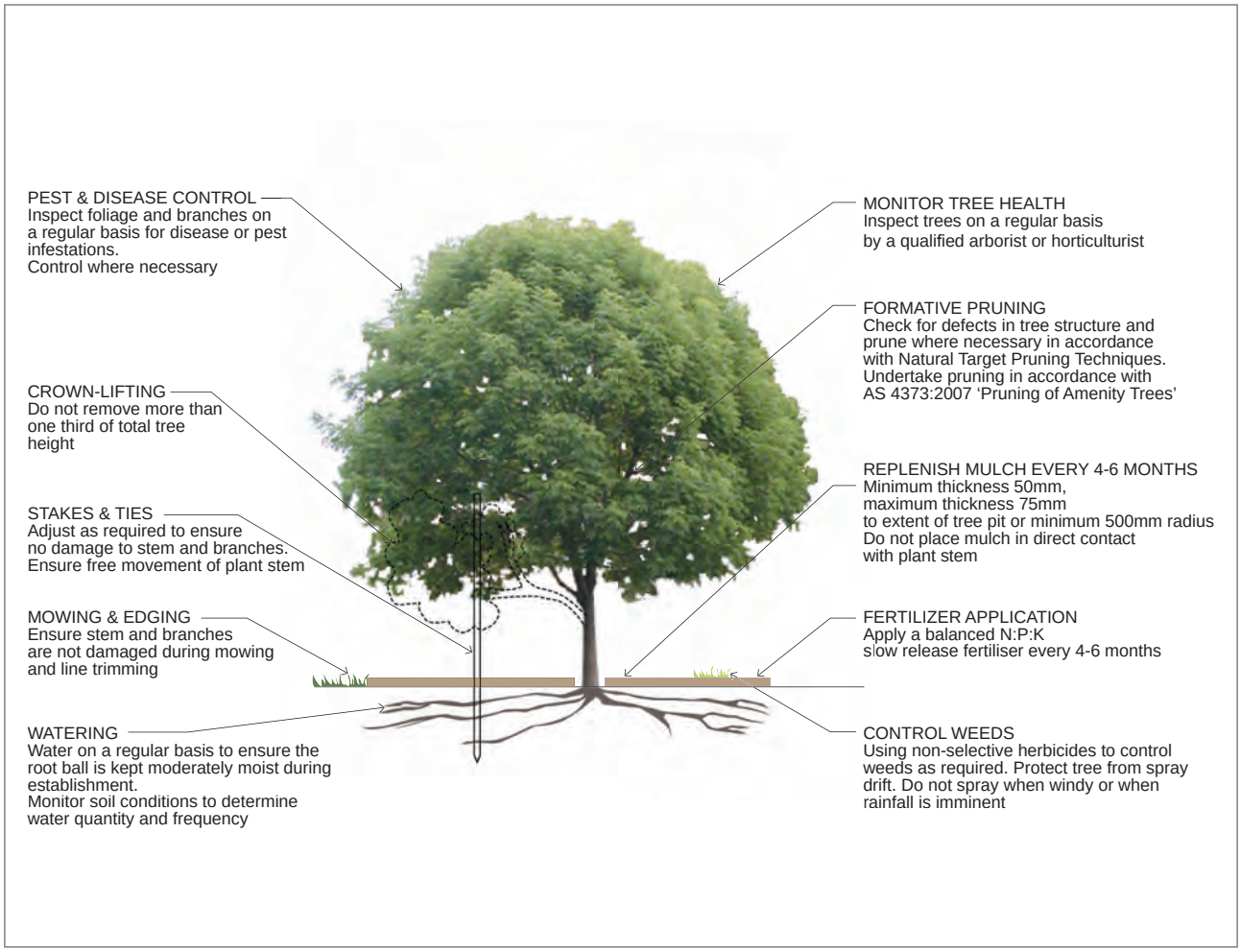


Fig 19 Essential establishment maintenance activities

part 8

recommended street tree list

FOR ALL TREE TYPES

SYDNEY South-West & North-West Region

Small Trees Height 6-8 m x Spread 4-5 m

Botanical Name	Common Name	Origin		Soil Conditions				Drainage Requirements			*Data Sheet
		Deciduous (D) / Evergreen (E)		Shale	Sandstone	Transitional	Alluvium	Good	Average	Poor	
Elaeocarpus reticulatus	Blueberry Ash	E	Native	✔	✔	✔	✔	✔	✔	X	1
Syzygium leuhmannii	Small-leaf Lillypilly	E	Native	✔	✔	✔	✔	✔	✔	X	2
Buckinghamia celsissima	Ivory Curl Flower	E	Native	✔	X	✔	✔	✔	✔	X	3
Backhousia citriodora	Lemon-scented Verbena	E	Native	✔	✔	✔	✔	✔	✔	X	4
Callistemon viminalis	Weeping Bottlebrush	E	Native	✔	✔	✔	✔	✔	✔	✔	5
Magnolia 'Little Gem'	Little Gem Magnolia	E	Exotic	✔	X	✔	✔	✔	✔	X	6
Arbutus unedo	Irish Strawberry Tree	E	Exotic	✔	X	✔	✔	✔	✔	X	7
Franklinia axillaris	Gordonia	E	Exotic	✔	✔	✔	✔	✔	✔	X	8
Tibouchina granulosa	Lasiandra	E	Exotic	✔	X	✔	✔	✔	✔	X	9
Tibouchina macrantha	Lasiandra	E	Exotic	✔	X	✔	✔	✔	✔	X	10
Fraxinus griffithii	Evergreen Ash	E	Exotic	✔	X	✔	✔	✔	✔	X	11
Melaleuca decora	White Feather Honey Myrtle	E	Local	✔	X	✔	✔	✔	✔	✔	12
Melaleuca linariifolia	Narrow-leaved Paperbark	E	Local	✔	✔	✔	✔	✔	✔	✔	13
Prunus campanulata	Taiwan Cherry	D	Exotic	✔	X	✔	✔	✔	✔	X	14
Lagerstroemia indica	Crepe Myrtle	D	Exotic	✔	✔	✔	✔	✔	✔	X	15

* Data sheets are included on CD-Rom included on back page of these guidelines.

SYDNEY South-West & North-West Region

Medium Trees Height 10-12 m x Spread 8-9 m

Botanical Name	Common Name	Origin		Soil Conditions				Drainage Requirements			*Data Sheet
		Deciduous (D) / Evergreen (E)		Shale	Sandstone	Transitional	Alluvium	Good	Average	Poor	
Brachychiton populneum	Kurrajong	E	Native	✔	X	✔	✔	✔	X	X	16
Banksia integrifolia	Coast Banksia	E	Native	✔	✔	✔	✔	✔	X	X	17
Cupaniopsis anacardioides	Tuckeroo	E	Native	✔	✔	✔	✔	✔	✔	X	18
Harpulia pendula	Tulipwood	E	Native	✔	X	✔	✔	✔	✔	X	19
Tristaniopsis laurina	Water Gum	E	Native	✔	✔	✔	✔	✔	✔	✔	20
Pittosporum rhombifolium	Queensland Pittosporum	E	Native	✔	X	✔	✔	✔	✔	X	21
Corymbia eximia	Yellow Bloodwood	E	Native	X	✔	✔	X	✔	X	X	22
Angophora bakeri	Narrow-leaf Rough-barked Apple	E	Native	X	✔	✔	X	✔	X	X	23
Acmena smithii	Lillypilly	E	Native	✔	X	✔	✔	✔	✔	X	24
Syzygium paniculatum	Magenta Cherry	E	Native	✔	X	✔	✔	✔	✔	X	25
Magnolia grandiflora	Bullbay Magnolia	E	Exotic	✔	X	✔	✔	✔	✔	X	26
Quercus suber	Cork Oak	E	Exotic	✔	X	✔	✔	✔	✔	X	27
Fraxinus oxycarpa	Desert Ash	D	Exotic	✔	X	✔	✔	✔	✔	X	28
Jacaranda mimosifolia	Jacaranda	D	Exotic	✔	X	✔	✔	✔	✔	X	29
Pyrus calleryana 'Chanticleer'	Callery Pear	D	Exotic	✔	X	✔	✔	✔	✔	X	30
Acer buergeranum	Trident Maple	D	Exotic	✔	✔	✔	✔	✔	✔	X	31
Sapium sebiferum	Chinese Tallow Tree	D	Exotic	✔	X	✔	✔	✔	✔	X	32
Malus floribunda	Japanese Crabapple	D	Exotic	✔	X	✔	✔	✔	✔	X	33
Zelkova serrata	Japanese Zelkova	D	Exotic	✔	X	✔	✔	✔	✔	X	34
Pistachia chinensis	Chinese Pistachio	D	Exotic	✔	✔	✔	✔	✔	✔	✔	35
Melaleuca styphelioides	Prickly-leaved Paperbark	E	Local	✔	✔	✔	✔	✔	✔	✔	36

* Data sheets are included on CD-Rom included on back page of these guidelines.

SYDNEY South-West & North-West Region

Large Trees Height 16-20 m x Spread 16 m

Botanical Name	Common Name	Origin		Soil Conditions				Drainage Requirements			*Data Sheet
		Deciduous (D) / Evergreen (E)		Shale	Sandstone	Transitional	Alluvium	Good	Average	Poor	
Eucalyptus tereticornis	Forest Red Gum	E	Local	✔	✔	✔	✔	✔	X	X	37
Eucalyptus fibrosa	Broad-leaved Ironbark	E	Local	✔	X	✔	✔	✔	X	X	38
Eucalyptus crebra	Narrow-leaved Ironbark	E	Local	✔	X	✔	✔	✔	✔	X	39
Angophora floribunda	Rough-barked Apple	E	Local	✔	✔	✔	✔	✔	✔	✔	40
Corymbia maculata	Spotted Gum	E	Local	✔	X	✔	✔	✔	✔	X	41
Eucalyptus sideroxylon	Mugga Ironbark	E	Native	✔	X	✔	✔	✔	X	X	42
Syncarpia glomulifera	Turpentine	E	Native	✔	✔	✔	✔	✔	✔	X	43
Brachychiton discolor	Queensland Lacebark	D	Native	✔	X	✔	✔	✔	✔	X	44
Flindersia australis	Australian Teak	E	Native	✔	X	✔	✔	✔	✔	X	45
Lophostemon confertus	Brushbox	E	Native	✔	X	✔	✔	✔	✔	X	46
Quercus palustris	Pin Oak	D	Exotic	✔	X	✔	✔	✔	✔	X	47
Quercus rubra	Red Oak	D	Exotic	✔	X	✔	✔	✔	✔	X	48
Carya illinoinensis	Pecan	D	Exotic	✔	X	✔	✔	✔	✔	X	49
Ulmus parvifolia	Chinese Elm	D	Exotic	✔	X	✔	✔	✔	✔	X	50
Liquidambar styraciflua 'Parasol'	American Sweet Gum	D	Exotic	✔	X	✔	✔	✔	✔	✔	51
Nyssa sylvatica	Tupelo	D	Exotic	✔	X	X	✔	✔	✔	✔	52
Paulownia tomentosa	Princess Tree	D	Exotic	✔	X	X	✔	✔	✔	X	53
Quercus ilex	Holm Oak	E	Exotic	✔	X	✔	✔	✔	✔	X	54
Afrocarpus falcatus	Yellowwood	E	Exotic	✔	X	✔	✔	✔	✔	X	55

* Data sheets are included on CD-Rom included on back page of these guidelines.

part 9

glossary & references

FOR ALL TREE TYPES

Glossary

This section contains descriptions of the meanings of terms and phrases used in the Guidelines.

Aerial Bundle Conductor (ABC)
A type of overhead low voltage electrical cable. Insulated cables are wrapped around a steel cable strung between overhead poles. This minimises the risk of open conductors touching and reduces the clearances for pruning around trees.

Balled and Burlapped
Type of nursery stock in which the plant is excavated from a field grown position with the surrounding soil and roots ('root ball') then wrapped with protective material ('Burlap').

Bioretention
Bioretention is an up-land water quality and water quantity control practice that uses the chemical, biological and physical properties of plants, microbes and soils for removal of pollutants from storm water runoff.

Canopy
The crown of a tree, comprising of all the foliage and small branches.

Central leader
The main stem of a tree.

Clear stem height
The distance between the ground and the lowest branch of a tree.

Deciduous
A plant that sheds all of its leaves at one time during the year.

Drip-line
Outer edge of tree canopy, the extent of the crown of a tree projected to the ground plane.

Environmental Weed
An invasive introduced plant species, which is capable of establishing, self-sustaining and expanding populations in natural and semi-natural habitats.

Exotic
Any introduced plant species that is not native to Australia.

Filter media
In bioretention systems, the media that captures and separates solid pollutants from stormwater.

Form
The overall shape of a tree canopy.

Formative Pruning
The selective pruning of a young tree to promote good form and branching structure typical of the natural growth habit of the species. The main aim of formative pruning is to identify and remove any growth defects or other structural problems that may have long term implications early in the development of the tree.

Groundcover vegetation
Any vegetation that grows low to the ground or may be prostrate in habit.

Habit
The nature and appearance of the branching framework of a tree or plant.

Hydraulic conductivity
The ease with which water can move through pore spaces or fractures in a growing media or filter media.

Local provenance
Genetic variability of a species influenced by the local soil and climatic conditions of a particular area or situation.

Locally-indigenous
Plant species that originally occurred in a particular local area.

Micro-climate
The immediate climatic conditions of a location influenced by aspect, sun, shade, reflected heat, wind exposure, water bodies and so on.

Moisture Holding Capacity
The capability of a soil material or growing media to hold moisture in pore space against the effects of gravity.

Mulch
Any material that is spread over the surface of the soil to prevent erosion, reduce weed growth & retain soil moisture.

Passive Watering
Redirection of 'low flow' road stormwater to water street trees.

Permeable pavement
Modular or monolithic pavement materials that allow water to percolate through the pavement profile.

Planting trench
Area of site soil excavated then mixed with or replaced by improved topsoil for the planting of trees.

Procurement
The process of acquiring (purchasing) goods or services.

Root Control Barrier or Device
A material (usually in sheet form) inserted vertically through the soil profile to deflect root growth.

Root Plate
The conglomerate of structural (woody) and fibrous roots that radiate out from the tree trunk, often extending beyond the drip-line and usually confined to the top metre of soil (i.e. a relatively shallow but broad 'plate').

Soil volume
The total amount of soil material or growing media available for unobstructed root growth.

Stem Caliper
Diameter of the stem or trunk.

Structural Soil
A growing media for plants consisting of a mixture of materials designed to provide load bearing capacity for pavements whilst also providing basic requirements for root growth (aeration, moisture holding capacity & nutrients).

Unobstructed Soil Area
Area able to be accessed by tree roots without impediments such as utility services and compaction by road traffic including both existing and improved soils.

Windthrow
Over-turning of a tree due to wind force or failure of the root plate.

References

A number of references have been sourced for the preparation of this document. These may assist Development Managers and designers to gain a greater understanding of the principles and research influencing these guidelines.

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