ARBORICULTURAL IMPACT ASSESSMENT & TREE PROTECTION MANAGEMENT PLAN

Project

Storage Shed Build

Site Address

2 Bloodwood Road
Ingleside, NSW 2101

Assessment Date

December 2024

Project Consulting Arborist

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Acknowledgement of Country

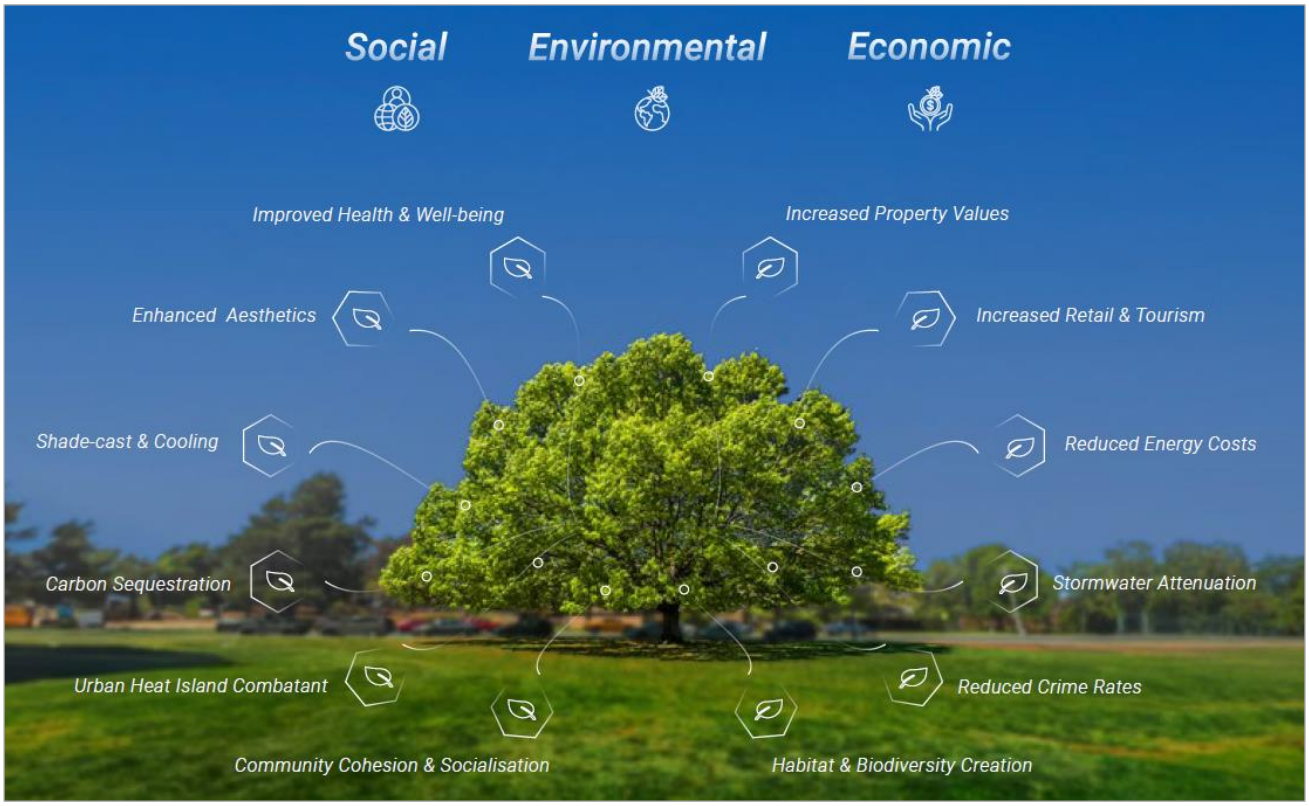
We acknowledge Aboriginal and Torres Strait Islander peoples as the Traditional Custodians of this land – Australia, and pay tribute to elders past, present and emerging. In particular we would like to acknowledge the traditional custodians of this area and recognise their continued connection to the land and their primary custodial care obligations.

Preface

The planting of trees in urbanised areas for their nutritional, aesthetic and spiritual value has been commonplace for centuries. Historical documents show that trees were planted for their known benefits along the main thoroughfares of Egypt approximately 4000 years ago, and in the communal areas of China during the Qin Dynasty, 221-206 B.C. (Gerhold. 2007). Closer to home, trees in n Australia have always been and will continue to be celebrated. Especially for the Aboriginal peoples as trees represent significant connections to Country, their ancestry and lore (Long. 2008).

Nowadays the benefits of urban forests are considered to span environmental, economic, cultural and socio-political domains alike. Hence communities around the world regard trees as critical urban infrastructure, with this 'Green Infrastructure' considered to be as important to the day-to-day functionality of an urban locale as its 'Grey Infrastructure' (human engineered roads, structures, utilities, etc). However, trees grow in a delicate balance with their environment and any changes to that balance must be minimized if the tree is to remain healthy and fulfil its potential. Therefore, tree protection is essential and this protection is even more important when it comes to development and possible root impact. Whereby tree roots not only physically anchor the tree to the ground but are the critical supply lines of water and minerals essential for both carbohydrate storage and hormonal signalling. This facilitating tree bio-functionality, vigour and longevity.

Therefore, the aim of this Arboricultural Report is to provide 'tree sensitive' options to pragmatically guide the proposed development works around any retained tree(s) so arboricultural impact is minimised. This through evidence-based arboricultural methodologies and the implementation of the accompanying site-specific Tree Protection Management Plan.



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Proposed location for a Storage Shed Build: 2 Bloodwood Road, Ingleside 2101

1 Executive Summary

Active Green Services Pty Ltd (AGS) has been engaged to author an Arboricultural Impact Assessment (AIA) and a site-specific Tree Protection Management Plan (TPMP) per *AS4970-2009 Protection of trees on developments sites*. This regarding any tree that is likely to be impacted upon during the construction of a Storage Shed that is to be built at 2 Bloodwood Road, Ingleside 2101. Hence on the 15th of December 2024 individual Visual Tree Assessments (VTA) were carried out on the trees that are within close proximity to the proposed construction footprint by a Consulting Arborist from AGS.

The following arboricultural recommendations in this Report are based on the VTA data. This includes the trees biometrics, pedology, useful life expectancy, vitality, ecophysiology, biomechanics, and landscape significance *in situ*. In addition, all of the subject trees were further assessed with regards to their calculated Tree Protection Zones[1] (TPZ) and the specified development works per the supplied scope of works and the projects design plans. This so arboricultural impact could be calculated, plausible tree viability determined post-development, and a site-specific TPMP formulated for any retained trees. On review, eleven (11) trees were visually assessed, whereby it was calculated that:

- One (1) tree has a TPZ encroachment that is calculated as *Major*[2], however the encroachment does not extend into the subject trees Structural Root Zone[3] (SRZ). Therefore, with a pre-adopted tree sensitive ideology it is foreseeable that this tree will remain viable post-development and therefore can be retained. This ideology is to include initial Non-Destructive Root Exploration (NDRE) and practicable Tree Sensitive Urban Design (TSUD).

  Please note: To expedite the Development Application process NDRE was carried out on by two (2) Consulting Arborists on the tree assessment day per *AS4970-2009 Protection of trees on development sites*. On review no significant roots where visibly present within the proposed construction footprint. Therefore, it is demonstrated that the subject tree will remain viable post-development.

- Ten (10) trees have no or minimal arboricultural impact that is foreseeable. As these encroachments are catergorised as *Minor*[4], these trees are to be retained (unless otherwise stated) and afforded protection per the site-specific TPMP.

Therefore, it is of a reasonable arboricultural belief that with strict adherence to the TPMP, the build can be completed with the subject trees remaining viable. The details supporting this summary follow.

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[1] *AS4970-2009: Tree Protection Zone* (TPZ): *"A specified area above and below ground and at a given distance from the trunk set aside for the protection of a tree's roots and crown to provide for the viability and stability of a tree to be retained where it is potentially subject to damage by development".*

[2] *AS4970-2009: Major (>10%): "If the proposed encroachment is greater than 10% of the TPZ or inside the SRZ the project arborist must demonstrate that the tree(s) would remain viable. The area lost to this encroachment should be compensated for elsewhere and contiguous with the TPZ. This may require root investigation by non-destructive methods and consideration of relevant factors listed. Tree sensitive construction techniques may be used for minor works within this area providing no structural roots are likely to be impacted, and the project arborist can demonstrate that the tree(s) will remain viable".*

[3] *AS4970-2009: "SRZ is the area of the root system used for stability, mechanical support, and anchorage of the tree. Severance of structural roots (>50mm in diameter) within the SRZ is not recommended as it may lead to the destabilisation and/or serious decline of the tree".*

[4] *AS 4970-2009: Minor encroachment (<10%): "If the proposed encroachment is less than 10% (total area) of the TPZ, and outside of the SRZ, detailed root investigations should not be required. The area lost to this encroachment should be compensated for elsewhere and be contiguous with the TPZ".*

2 Introduction

2.1 Overview

i. AGS has been engaged to author an AIA and a site-specific TPMP per *AS4970-2009 Protection of trees on development sites*. This regarding trees and the construction of a new storage shed at 2 Bloodwood Road, Ingleside. Thereby, this Report is authored per *AS4970-2009 Protection of trees on development sites* and includes the following arboricultural elements:

- The geo-location and visual assessment of any tree that is growing within the proposed works footprint and/or is within close proximity of any infrastructure works associated with the project.
- The calculated encroachment level of the proposed works on the assessed tree. This so tree viability can be objectively determined post-development.
- A site-specific Tree Protection Management Plan authored per *AS4970-2009 Protection of trees on development sites.* This outlining the tree sensitive methodology needed to mitigate the likelihood of foreseeable arboricultural impact to identified trees during the abovementioned works.

2.2 Objective

i. The purpose of this Report is to provide all parties with standing an objective and unbiased arboricultural assessment of the trees within the proposed development area per *AS4970-2009 Protection of trees on development sites.* This so prior to the commencement of works, practicable tree sensitive design modifications and/or installations can be candidly considered, pragmatic tree retention or tree removal ascertained, and a site-specific TPMP formulated for practicable enactment.

2.3 Limitations

i. All arboricultural reasonings that have been discussed and provided are based on extensive empirical arboricultural knowledge, the internationally recognised Visual Tree Assessment (VTA) methodology (Dunster. 2019), the recognised Institute of Australian Consulting Arboriculturists (IACA) *Significance of a Tree Assessment Rating System (STARS)* and *AS4970-2009 Protection of trees on development sites*.

ii. Albeit whilst this arboricultural assessment is thorough it should be noted that trees are dynamic living organisms exposed to both unforeseeable biotic and abiotic variables which on occasion can be harsh and severe. Therefore, this arboricultural assessment will consider on the balance of probabilities the most likely outcome(s) as opposed to those which could, may or fancifully occur.

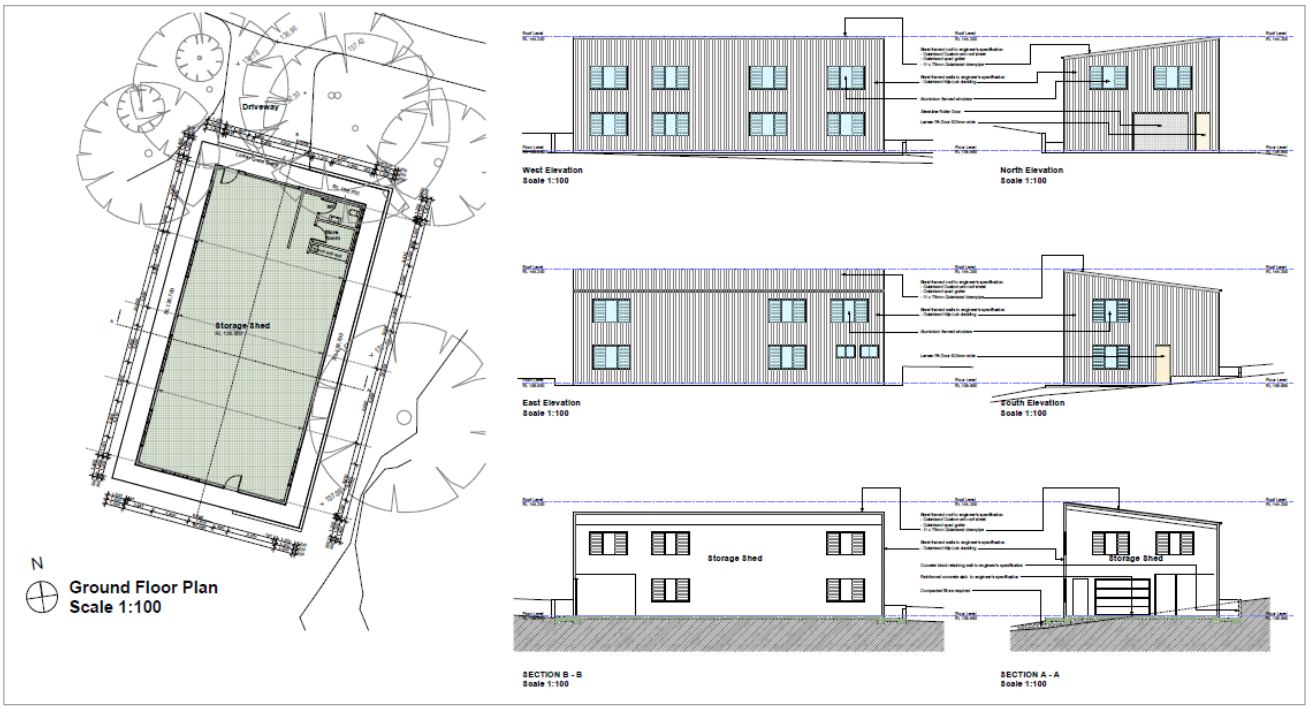
2.4 Arboricultural References

i. As a progressive arboricultural company AGS keeps abreast of research data relating to all aspects of arboriculture and urban forestry. Hence, the following arboricultural reasonings, conclusions and recommendations of this Report are founded on current research and industry standards.

ii. In addition, supplementary educational material has been appended to aid in furthering Arboricultural - Best Management Practice and contemporary Tree Sensitive Urban Design (TSUD).

2.5 Scope of Works

i. As per the below design provided by MPD Architects, a large storage shed is proposed to be built at 2 Bloodwood Road, Ingleside. Hence an AIA has been requested to assess the potential impact of the construction works on the adjacent trees. (A full set of design plans can be made available upon request).



Proposed Storage Shed Build (Design courtesy of MDP Architects)

3 Mapping

3.1 Indicative Tree Geo-location and Root Zones

i. Eleven (11) significant trees within close proximity of the provided build site were identified. These subject trees were subsequently visually assessed, and GPS located on the Esri Field Maps Application. In addition, all of the subject trees have been individually tree tagged at approximately 1.5m. On this tree tag is an engraved number that corresponds to the below satellite maps and Visual Tree Assessment Data table. Photo image hyper-links have also been provided in the VTA table to assist in tree identification.

ii. The below satellite map indicatively shows the location of the subject trees, and both their calculated Structural Root Zones (SRZ) and Tree Protection Zones (TPZ). This to aid in the visualisation of where tree sensitive methodology needs to be utilised, tree protection is to be installed, and where NDRE may need to be initiated per the site-specific TPMP.

ACTIVE GREEN SERVICES

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Scale :
1:400

Spatial Reference :
GDA2020 MGA Zone 56

Legend

Tree Impact Level
- Major
- Minor
- Tree Protection Zone (TPZ)
- Structural Root Zone (SRZ)
- Proposed Building Footprint
- NDRE

Project :
STORAGE SHED
2 Bloodwood Rd, Ingleside NSW 2101

Map :
Tree Impact Level Map

4 Tree Assessment Methodology

4.1 Visual Tree Assessment Methodology

i. Visual Tree Assessments (VTA) consistent with modern arboricultural practices and the International Society of Arboriculture standards were conducted by a suitably qualified and experienced arborist on the subject tree population. These assessments were conducted at ground level and therefore classified as *Level 2: Basic Assessment* (Dunster et al. 2019).

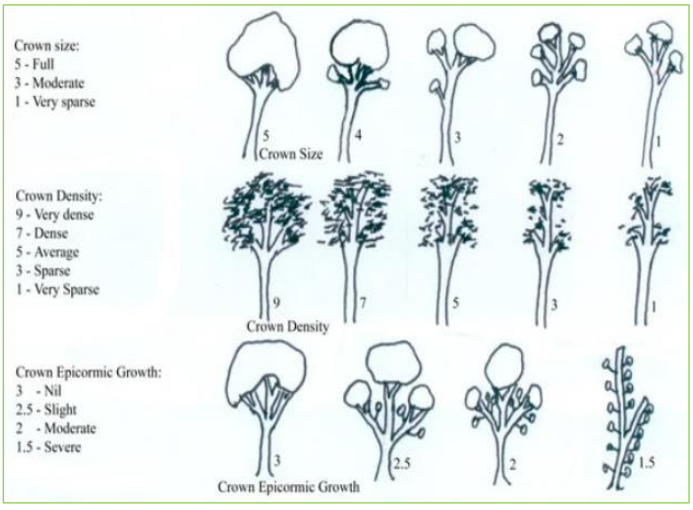
ii. The tools used onsite to gather the necessary VTA data were a nylon percussion hammer, mobile phone, and an iPad. Tree height and canopy spread were recorded using a digital laser range finder (Nikon Forestry Pro). The trunk diameter and DBH height measurements were made by using a forestry DBH measuring tape. No dendrological diagnostics, soil analysis, tissue sampling and/or geological investigations were conducted at that time. For ease of identification the subject trees have been GPS located and photographed.

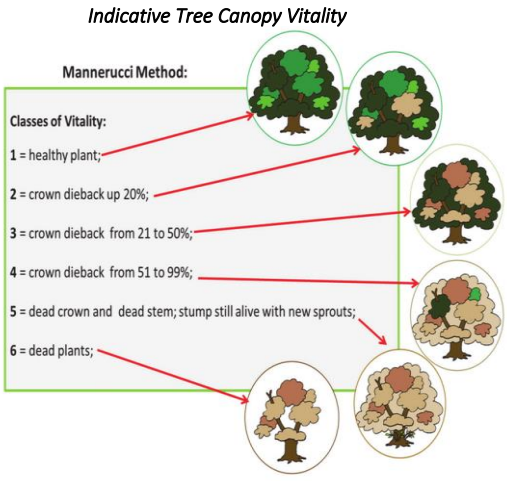
4.2 Visual Tree Assessment attributes

i. The following descriptors are used to visually assess a tree. These parameters relate to the tabled Visual Tree Assessment data below.

Tree Vitality: is categorised through a visual determination using:

- leaf, twig or needle size, shape, and colour
- seasonal growth rates
- reaction and adaptive wood development
- foliage density & foliage coverage throughout the crown
- branch architecture & ecophysiology
- species specific traits & biomechanics
- branch-tip dieback & branch senescence
- relevant biotic and abiotic signs, symptoms and indicators.





Visual vitality index for mature trees (Callow,2018)

Pedology: a visual assessment of the general health and condition of the soil within the trees root zone. For example, such considerations such as soil porosity, compaction level, topography, hydrology, soil profile and root zone growth frustrations both infrastructural and/or otherwise.

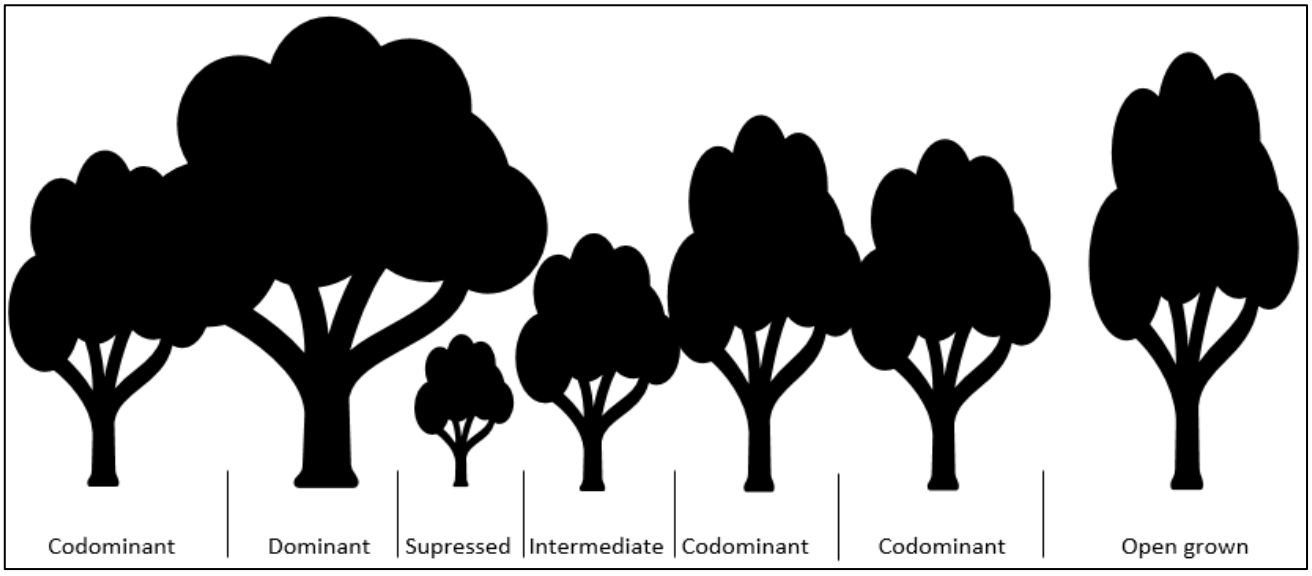
Structure & Biomechanics: a general evaluation of a tree's branch union formation, growth formation and architecture (this may affect branch weight and/or mass damping). This assessment is species-specific as it is derived from the typical structure and branch formation of the subject species.

Form: *'Trunk Form'* is an assessment of the trees basal flare, taper, decay, cavities, formation of multi-stems that develop near and/or at ground level, girdling roots and growing angles. Whilst general *'Tree Form'* is an indication of crown shape. Crown shapes are influenced by their surroundings, light availability and branch loss, which can have varying impacts on their symmetry. A tree is assessed on its individual crown shape. However, as the tree may be growing within a group environment, this could lead to the individual shape being assessed further down the scale. Although a poor rating may be attributed to the tree, the tree's contribution to the setting may be high through association within the group canopy. This can be generally recognised through the Crown Class rating.

Function: this assesses the site-specific usefulness of the tree *in situ*. Examples include soil retention, stormwater attenuation and mitigation of the Urban Heat Island. This is weighed up against any negative issues the tree(s) may be causing regarding persons, utilities and/or infrastructure.

Impediments: (rootzone & canopy) are structures that impede or supress normal tree development and/or function. This can include hard impervious surfaces within the rootzone or powerlines and other structures within or adjacent to the canopy.

Crown Class: this rating provides an indication on the tree's relationship with other trees in the subject environment. The categories used include Dominant, Codominant, Intermediate, Suppressed and Open grown, as shown in the below diagram.



Indicative Crown Class (adapted from the International Society of Arboriculture)

Useful Life Expectancy: A Useful Life Expectancy (ULE) rating is determined by using the adapted Safe Useful Life Expectancy (SULE) and TreeAZ methodologies (Barrell. 1996, 2000). The aim of these two systems is to convert what amounts to a complex arboricultural assessment into a few broad categories that are more logically understood. A ULE rating provides an estimate of a tree's expected remaining lifespan after considering the current condition, vigour, and vitality of the subject tree(s) *in situ*. The main aim is the establishment of a tree Retention Value. The objective of a calculated ULE assessment is to contribute to the relative value of individual trees for the purpose of informing future management options and residual risk. This calculated ULE rating will be inserted into the above-mentioned STARS Matrix (please refer to the Appendix section for further information).

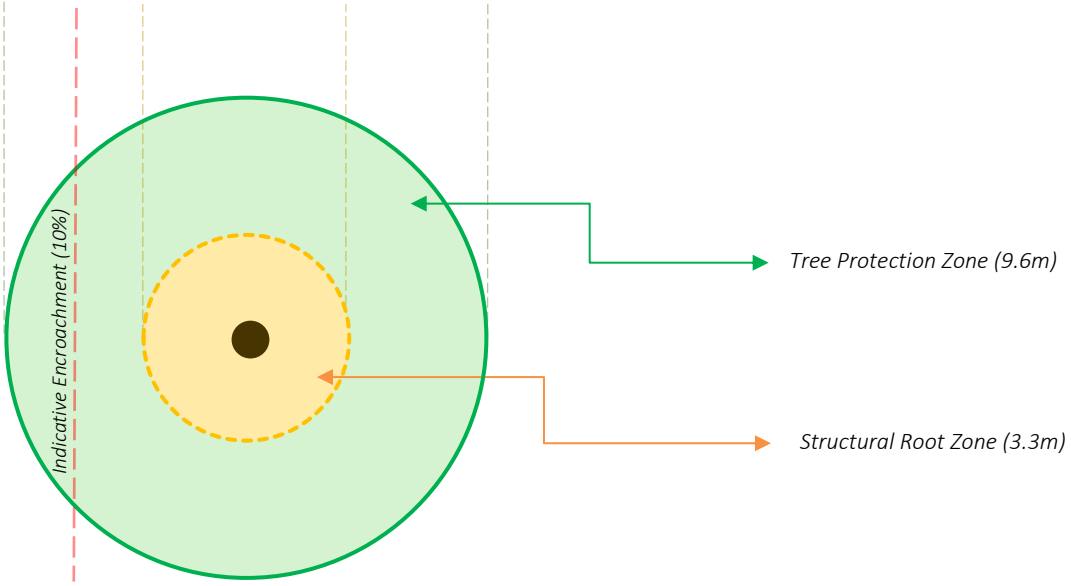
Retention Value: The *Significance of a Tree, Assessment Rating System (STARS)* provides the Retention Value of a tree and/or group of trees by balancing a combination of environmental, cultural, physical, amenity and social values. The Landscape Significance of a tree is an essential criterion to establish the importance that a particular tree may have on a site. However, rating the significance of a tree becomes subjective and difficult to ascertain in a consistent and repetitive fashion due to assessor bias. It is therefore necessary to have a rating system utilising structured qualitative criteria to assist in determining the Retention Value for a tree. Therefore, a tree retention assessment is undertaken in accordance with the *Institute of Australian Consulting Aboriculturalists (IACA) Significance of a Tree, Assessment Rating System (STARS)*. The system uses a scale of *High, Medium,* and *Low* significance in the landscape. Once the landscape significance of a tree has been defined, the Retention Value can be determined congruent with the trees' abovementioned Useful Life Expectancy (ULE).

4.3 Root Zone Encroachment

i. Root depth and extension can be severely limited and highly irregular in urban settings. When root restrictions are minimal, root spread shows a strong relationship with trunk diameter, which is a more reliable predictor than canopy diameter ('drip-line') or tree height (Day et al. 2010). Therefore, all arboricultural recommendations and conclusions contained in this AIA with regards to tree root protection/retention were based upon and determined in accordance with *AS4970-2009 Protection of Trees on Development Sites.*

ii. An infographic indicative of a calculated Tree Protection Zone (TPZ), a Structural Root Zone (SRZ) and Encroachment is included below to aid in the visualisation of the 'No-Dig' zones; and where initial Non-Destructive Root Exploration (NDRE) must be carried out under the direct supervision of the Project Arborist if the tree is to be retained. This diagram can be used to indicatively portray a SRZ and TPZ of any tree within close proximity to works.

(Tree 3) *Eucalyptus microcorys*



- Whilst working within the Tree Protection Zone (TPZ) of any retained tree it is recommended that initial Non-Destructive Root Exploration (NDRE) is utilised under the guidance of an appointed Project Arborist; and
- Any retained tree within 5m of development works requires tree protection. The tree protection is to be installed per the calculated TPZ and the site-specific Tree Protection Plan prior to the

Root Zone Calculations

- *AS4970-2009 Protection of trees on development sites s3:* The radius of the TPZ is calculated for each tree by multiplying its Diameter @ Breast Height measured @ 1.4m from ground level (DBH × 12 = TPZ). (DBH = Trunk Girth @ 1.4m ÷ π).
- To calculate the SRZ: Radius SRZ = **D**iameter above **R**oot **C**rown (**DRC** x 50) ^ 0.42 x 0.64. If the DRC is less than 0.15m the SRZ will be 1.5m. (Please note that the SRZ should be no less than 1.5m; and a TPZ should not be less than 2m)

5 Visual Tree Assessment Data

Visual Tree Assessment Data: December 2024 (all measurements are shown in metres)

Tree Tag	*Botanical Name* Common Name	Age Class	Height	Canopy Spread	DBH DRC	SRZ TPZ	Form	Structure	Vitality	ULE	Retention Value	Encrh	Photo Link
1	*Eucalyptus robusta* Swamp Mahogany	Mature	14	EW:13 NS:12	0.51 0.75	2.9 6.1	Fair	Fair	Poor	Medium	Medium	*Minor*	Photo
2	*Melaleuca quinquenervia* Broad-leaved Paperbark	Semi Mature	9	EW:2 NS:2	0.25 0.30	2.0 3.0	Poor	Poor	Poor	Short	Low	*Minor*	Photo
3	*Eucalyptus microcorys* Tallowwood	Mature	18	EW:11 NS:12	0.80 1.00	3.3 9.6	Fair	Fair	Fair	Medium	High	*Major*	Photo
4	*Eucalyptus haemastoma* Scribbly Gum	Semi Mature	9	EW:5 NS:6	0.30 0.40	2.3 3.6	Poor	Poor	Poor	Short	Low	*Minor*	Photo
5	*Eucalyptus haemastoma* Scribbly Gum	Mature	17	EW:12 NS:13	0.40 0.55	2.6 4.8	Poor	Poor	Poor	Dead	Remove	*Minor*	Photo
6	*Eucalyptus haemastoma* Scribbly Gum	Semi Mature	10	EW:5 NS:8	0.35 0.45	2.4 4.2	Poor	Poor	Fair	Short	Low	*Minor*	Photo
7	*Corymbia gummifera* Red Bloodwood	Semi Mature	16	EW:3 NS:3	0.30 0.35	2.1 3.6	Poor	Poor	Fair	Medium	Low	*Minor*	Photo
8	*Acacia decurrens* Black Wattle	Mature	19	EW:9 NS:8	0.45 0.60	2.7 5.4	Fair	Fair	Fair	Medium	Medium	*Minor*	Photo
9	*Corymbia gummifera* Red Bloodwood	Mature	14	EW:10 NS:9	0.50 0.60	2.7 6.0	Poor	Poor	Dead	Dead	Remove	*Minor*	Photo
10	*Eucalyptus propinqua* Grey Gum	Semi Mature	9	EW:3 NS:3	0.20 0.30	2.0 2.4	Poor	Fair	Fair	Medium	Medium	*Minor*	Photo
11	*Eucalyptus haemastoma* Scribbly Gum	Mature	9	EW:7 NS:9	0.65 0.75	2.9 7.8	Poor	Poor	Poor	Short	Low	*Minor*	Photo

Key

- **Age Class, Form, Structure & Vitality:** per the International Society of Arboriculture descriptors.
- **Canopy Spread**: estimation of canopy spread to the four (4) cardinal points in metres. (North-South) & (East-West)
- **Diameter at Breast Height (DBH) & Diameter at Root Collar (DRC):** per *AS4970-2009 Protection of trees on development sites*.
- **Structural Root Zone (SRZ) & Tree Protection Zone (TPZ):** per *AS4970-2009 Protection of trees on development sites* & calculated per the QAA & ProofSafe Calculators.
- **Useful Life Expectancy (ULE):** adapted per (Barrell, 1996) & (Barrell, 2000).
- **Landscape Significance & Retention Value:** *Significance of a Tree Assessment Rating System (STARS), Institute of Australian Consulting Arboriculturists (2010).*
- **Encroachment (Encrh):** per *AS4970-2009 Protection of trees on development sites* & calculated per the ProofSafe Calculator.

6 Summary

6.1 Key Points

i. In total eleven (11) significant trees were identified within close proximity of the proposed build site. These subject trees were subsequently visually assessed, photographed, tree-tagged and satellite mapped. Under the currently proposed design works footprint and per *AS4970-2009 Protection of trees on development sites* it was calculated that:

- Tree 3 (*Eucalyptus microcorys*) has a TPZ encroachment that is *'Major' (>10%).* However, the encroachment does not extend into the trees Structural Root Zone (SRZ). Therefore, with a pre-adopted tree sensitive ideology it is foreseeable that this tree will remain biologically viable and can be retained. This confirmed by the post-construction NDRE findings, whereby no significant roots were visibly present in the proposed construction footprint. (Albeit to err on the side of caution, whilst the earthworks for the construction are being carried out a Consulting Arborist will be onsite to oversee the works).
- The remaining ten (10) identifed trees will foreseeably have minimal TPZ encroachment – *'Minor' (<10%).* Therefore, these trees are to be retained and afforded protection per the site-specific TPMP.

  Please note: Trees 5 and 9 are dead and have limited habitat value. Therefore, it is recommneded that these trees are proactively removed and Compensatory Replanting adopted to offset tree canopy coverage loss.

ii. Initial Non Destructive Root Exploration (NDRE) is to be utilised whilst working within the calculated TPZ of any retained tree; and prior to tree removal if tree viability post-development is arguable. NDRE can also be utilised to map root zones so 'tree sensitive' design alternatives and installations can be candidly considered (*Refer s12.4 & s12.5 for further information*).

iii. In summary it is concluded that with all due care shown and the implementation of a pre-determined tree sensitive design ideology the project scope can be achieved with all the identified trees retained. The caveat being that the project works are carried out with strict adherence to the site-specific Tree Protection Management Plan that follows.

7 Tree Protection Management Plan

7.1 Disclaimer

i. The following site-specific Tree Protection Management Plan (TPMP) is to be used throughout the duration of the abovementioned Project. Although the framework includes monitoring controls operated by the appointed Project Arborist, compliance to the TPMP is the responsibility of the 'Client,' and as such AGS cannot accept liability for any adverse effects arising from 'non-compliance' to documented controls and/or any subsequent changes to the scope or methods documented in the TPMP provided to the 'Client.'

7.2 Overview

i. Trees are dynamic living organisms and therefore are susceptible to development impact either direct and/or indirect, biotic and/or abiotic. Arboricultural impact due to development encroachment, especially within the calculated Tree Protection Zone (TPZ), causes 'dendrological stress' in varying degrees. This stress has the potential to heavily impact upon tree vitality and thus tree longevity (Boddy. 1983). Therefore, the Australian Standard *AS4970-2009 Protection of trees on development sites* must always be adhered to. The objective of this Standard is to provide guidance through the use of a science-based methodology to arborists and others concerned with the care and protection of trees; and all others interested in the integration between trees and construction. Hence safeguarding community tree assets.

ii. This Tree Protection Management Plan (TPMP) includes both activity specific controls as well as a range of generic tree protection controls. The control framework pre-dominantly focuses on identifying and mitigating aspects of the design and construction process that can adversely affect tree vitality, stability and/or useful life expectancy. In addition, it includes preventative controls (designed to prevent adverse outcomes), directive controls (designed to promote desired outcomes) and detective controls (designed to monitor compliance with any statutory requirements and the agreed control framework). The engagement of a Project Arborist is a key element of the control framework and is a multi-faceted control, in terms of preventing damage, providing direction, and detecting areas of non-compliance/improvement.

7.3 Project Arborist Site Inspection Schedule

i. In accordance with the Australian Standard *AS4970-2009 Protection of Trees on Development Sites,* inspections must be conducted by the appointed Project Arborist at the following key project stages:

- Prior to any work commencing on-site (including demolition, earthworks, or site clearing) and following the installation of tree protection.
- During any excavations, building works, and any other activities carried out within the Tree Protection Zone (TPZ) of any tree to be retained and protected.

- A minimum of once per month during the construction phase.
- After all major construction has ceased, following the removal of tree protection. It shall be the responsibility of the project manager to notify the project arborist prior to any works within the TPZ of any protected tree at a minimum of forty-eight (48) hours' notice. To ensure the tree protection plan is implemented, hold points have been specified in the following table.

Development Stage	Hold Point	Description
Pre-Construction	1	• Appoint a Project Arborist (minimum AQF Level 5) • Prior to any development works, any tree for removal is to be marked clearly (tape, paint, tag etc.) by the Project Arborist
	2	• Scheduled *'Pre-Start'* meeting. • Tree Protection for any retained tree(s) will be installed prior to demolition and/or site establishment. The appointed arborist will inspect and certify the tree protection per the Tree Protection Management Plan. A Tree Protection Compliance Memorandum issued.
During Construction	3	• Monthly scheduled site inspections of the retained tree population will be conducted (if works are outside the TPZ) and memorandum provided.
	4	• The appointed Project Arborist will oversee, and document all works carried out within the TPZ of any retained tree. A weekly Works Memorandum to be provided.
	5	• Visual tree inspection by the appointed arborist of the retained tree population once the major works have been completed and the tree protection has been removed.
Post Construction	6	• Final Visual Tree Inspection of the retained tree population and a Completion of Arboricultural Works Memorandum provided. • Ongoing Monthly Inspections & Memorandums issued at the discretion of the Project Arborist.
Plant Health Care (PHC) *(Recommended s.9)*	7	• Top dressing of Organic Mulch – where applicable. • Liquid solution of Organic nutrients (Botanicals). • PHC Memorandum provided.

7.4 Summary

i. A Pre-commencement of Work ('Pre-Start') onsite meeting must be held with the appointed Project Arborist and all other parties deemed to have *locus standii.*

ii. Proactive canopy modifications (pruning) options with regards to the facilitation of machinery and/or pedestrian access should be considered, discussed and if deemed necessary scheduled prior to the commencement of the main development works.

iii. Tree Protection Fencing is to be erected around any tree within five (5) metres of the development works; and temporary hard surfaces are to be made readily available and on site whilst working within close proximity of any trees calculated Tree Protection Zone (i.e., rumble boards & track-mats).

iv. The appointed onsite Project Arborist is to guide/supervise any works within close proximity of the tree(s) Tree Protection Zone. Whilst working within the Tree Protection Zone (TPZ) of any tree, the excavations must be undertaken by initial Non-Destructive Root Exploration through the use of Hand-digging, Air - Spade, Air- Vac or a combination thereof under the direct supervision/guidance of the appointed onsite Project Arborist.

v. The Project Arborist is to author and issue a Completion of Arboricultural Works Memorandum at the end of the works/project.

vi. A Plant Health Care regimen is to be undertaken post-development and a memorandum issued.

vii. The caveat for the abovementioned project proceeding and its continuance is that the site-specific Tree Protection Management Plan provided must be strictly adhered to at all times.

7.5 General Comments

i. All construction work within the TPZ of any retained tree must be authorised & supervised by the appointed Project Arborist and/or the Tree Manager/Owner.

ii. The use of 'strip-style' excavation adjacent to and/or within the TPZ of any retained tree is strictly prohibited.

iii. When removing an existing surface (concrete or similar hardscape), excavation must occur from above the existing surface; the removal work is to be carried out with a straight batter bucket; a 'lifting motion' is to be adopted; and the machinery is to move in a backward direction toward the extremity of the trees TPZ. In addition, all due care must be taken to ensure that the TPZ of any adjacent tree(s) are isolated and protected from vehicular entry (both above and below ground); and soil compaction is minimised within the TPZ by utilising ground protection as outlined in the Tree Protection Installation protocols.

iv. On completion of the hardscape removal, the onsite Project Arborist is to document any significant root observations; and where applicable carry out NDRE (root mapping) with regards to future construction, arboricultural impact. TSUD options and alternatives are also to be provided where applicable.

v. With regards to the reinstatement of ground, the addition and application of any new soil (or replanting mediums) must be carried out with all due care (e.g., root collar, topography and hydrology considerations), and with prior express consent from the Project Arborist. All new mediums are to comply with *AS4454-2003 Composts, soil conditioners and mulches*.

vi. Where fencing is to be replaced, it is preferable to use existing post holes when they located within TPZs. New pier holes are to be hand dug or by air-vac excavation under the supervision/guidance of the Project Arborist.

vii. It is imperative that TPZ fencing, or main stem, branch and ground protection measures are installed for the protection of all retained trees prior to the commencement of the future Construction Phase, and that it remains *in situ* for the duration and until completion of proposed construction works.

viii. TPZ fencing and other measures must be fixed so that they cannot be moved either by accidental physical impact or other inadvertent means. There shall be no entry within any TPZ by any construction crew or other persons during the construction phase without authorisation and/or attendance of the Project Arborist. That includes, no storage of builders' materials, machinery, pedestrian traffic, disposal of waste paints, fuels etc as listed below.

7.6 Restricted activities within the Tree Protection Zone

i. As per *AS4970-2009 Protection of trees on development sites* - Activities generally excluded from the TPZ include but are not limited to are as follows:

a) Machine excavation including trenching.
b) Cultivation.
c) Storage.
d) Preparation of chemicals, including preparation of cement products.
e) Parking of vehicles and plant.
f) Refuelling.
g) Dumping of waste.
h) Wash down and cleaning of equipment.
i) Placement of fill.
j) Soil level changes.
k) Temporary or permanent installation of utilities and signs, and
l) Physical damage to the tree.

8 Tree Protection Control Framework

8.1 Compliance and Reporting

i. The generic tree protection controls in this section are designed to be used in conjunction with the recommendations of this site-specific Arboricultural Report.

ii. All relevant standards, specifications, policies, and resource conditions of consent are incorporated into the TPMP.

iii. The Project Arborist will undertake scheduled and unscheduled site visits to monitor compliance with all aspects of the TPMP.

iv. Any deviations from the TPMP must be approved by the Council Arborist. Non-compliance issues must be reported to the Project Management immediately.

v. An Arboricultural Completion Memorandum must be prepared by the Project Arborist including but not limited to comments and observations about any root pruning/root retention and compliance to the TPMP.

vi. The TPMP must always be available on site and be included in site inductions and 'toolbox' sessions.

vii. Any damage to tree protection fencing or trees must be reported to the Project Arborist immediately (including damage not caused by activities associated with the project).

viii. Non-compliance issues must be documented and addressed at daily pre-start meetings/toolbox sessions.

8.2 Root Collar Management

i. The Root Collar[5] of a tree requires the movement of oxygen and carbon dioxide (in and out of the phloem) to survive. Planting too deep or adding excess material (i.e., soil, mulch, grass-clippings) to an extent that the root collar is buried inhibits this gaseous exchange and subsequently kills the phloem cells which in turn interferes with the downward movement of food (photosynthate) to the roots. This results in root dieback and a reduced uptake of water and micro-nutrients, which stresses tree and can ultimately result in premature tree mortality. Other concerns associated with Root collar burial are Root-girdling[6], Collar-rot and nutrient and moisture deficiency's due to the 'sealing-off'[7] of the root-ball. In addition, secondary biotic infectors such as insect borers and pathogenic fungi (*Phytophthora spp* and *Armillaria spp*), which can stress and cause premature mortality. Therefore, it is critical to both the functionality and longevity of a tree that when tree planted the root collar is at the correct height (at ground level), stays at the correct level and remains relatively unfettered (Smiley. 2012).

ii. With regards to best managing a tree's root zone and root collar post-development, any excess soil or other medium should be removed from around the root collar carefully (i.e., Non-Destructive Root Exploration). Once the excess debris is removed the roots can be inspected and proactive recommendations made by a Consulting Arborist per Arboricultural Best Management Practice.

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[5] *Root collar (or root crown, root flare, trunk flare) - is the flared area at the tree trunk base where the roots and trunk come together. This area is typified by a flare leading to the major buttress roots" (Draper.2009).*

[6] *Root Girdling - When the root crown is buried, roots grow upwards into this new layer of media haphazardly. Commonly, those new roots at the base of the stem benefit from extra water due to stem flow and grow vigorously around the base of the stem. This can result in 'girdled' roots at the base of the trunk. As the roots and trunk expand, the result can be fatal (Clark. 2015).*

[7] *Sealing off - The texture of the site soils is almost invariably finer than that of the potting mix in the root ball. This means capillary tension will be greater in the site soils than in the root ball. If trees are planted too deeply, the finer site soils on top of the root ball hold water 'perched' above the root ball, with any excess moisture draining away to the sides. Similarly, even a very thin cap of site soil washed across the root ball can seal the top causing water to run off without penetrating. The root balls can then dry out, resulting in stressed, dying, or dead trees (Clark. 2015).*

8.3 Root Protection

i. Root pruning should be kept to the absolute minimum and should only be completed by the Project Arborist. All root pruning assessments should be made initially by the Project Arborist, and the Council Arborist contacted where approval is required. All roots larger than 25mm in diameter are to be retained in an undamaged state and protected, unless the Council Arborist gives permission for them to be pruned. Irrespective of size, any roots which have a significant effect on the health and stability of a tree shall not be removed without the prior approval of the Council's Arborist, and this may include tree roots that are less than 25mm in diameter.

ii. Roots must be severed using a sharp pruning saw/tool to create a clean cut that is flush with the face of the completed excavations.

iii. Retained roots and cut surfaces should be protected from desiccation and physical/frost damage. The method will depend on the seasonal weather conditions and length of time expected between completing the excavations and reinstatement works and should be determined by the Project Arborist. Typically, retained roots must be wrapped in a suitable wool much or hessian product that is secured in place using bio-degradable string and kept moist, however supplementary watering may be required depending on the weather conditions based on the Project Arborist's discretion.

8.4 Soil Protection

i. All machines shall only operate from either formed surfaces, surfaces that will be excavated or from an appropriate load bearing protective matting. The area covered by the protective matting shall be sufficient to allow ground protection for all vehicle movements, including the turning of any vehicles. (Please refer to Branch, Trunk & Ground Protection in the Appendix).

ii. No chemicals, re-fueling operations, spoil, fill, soil, materials of any kind, or equipment will be stored, emptied, disposed of, or temporarily placed in areas that the tree's root system could be utilizing unless approved by the Project Arborist and this is on an existing hard impermeable surface.

iii. Water used for washing down machinery must not be allowed to runoff and contaminate soil volumes/water sources that are either currently or are likely to be utilised by the tree.

iv. The risk of soil borne infections being introduced to the site from equipment, tools and footwear must be assessed by the Project Arborist and mitigated as necessary (mitigation will typically involve cleaning the equipment before it is used on the site with a sterilizing agent, such as Trigene or Sterigene).

8.5 Canopy Modifications

i. Trees are complex living organisms and the intervention in the natural growth of a tree should only occur where the biology and the physiology of the organism are understood to such a level that intervention will have clear and predictably beneficial outcomes.

ii. However, pruning may be required to accommodate construction, plant & equipment and/or vehicles.

Thus, any pruning assessments pertaining to the development must be visually made by an AQF Level 5 arborist; and if pruning is deemed necessary a Pruning Specifications Report is to be authored *per AS4373-2007 Pruning of amenity trees* by an AQF Level 5 arborist and provided to the relevant Tree Manager/Owner and Council representative.

iii. Once the Pruning Specifications Report is formerly approved by the appropriate authority the requested the pruning can be carried out by a minimum AQF Level 3 arborist pursuant to *AS4373-2007 Pruning of amenity trees.*

iv. In addition, the risk of damaging agents being introduced from pruning saws/tools must be assessed by the Project Arborist and mitigated as necessary (mitigation will typically involve cleaning the equipment before it is used on the site with a sterilizing agent, such as Trigene or Sterigene). It may be necessary to clean pruning tools during work on the site if there is the potential of transmitting a damaging biotic agent between trees on the same site.

8.6 Tree Protection Zones

i. Tree Protection Zones are also Exclusion Zones and must be created using tree protection fencing that is consistent with the requirements of *AS4970-2009 Protection of trees on development sites.* The position of the fencing will be determined by the Project Arborist and once positioned shall not be altered without the prior consent from the Project Arborist.

ii. If it is not pragmatic to use the abovementioned tree protection fencing then individual trunk, branch and ground protection must be installed to any retained tree located within five (5) metres of any proposed work zone. (Please refer to the diagram in the appendix).

iii. Tree protection zones must be clearly labelled displaying the words ‘Tree Protection Zone’. Signs will be placed on fencing of individual trees or every 10 linear metres on groups of trees.

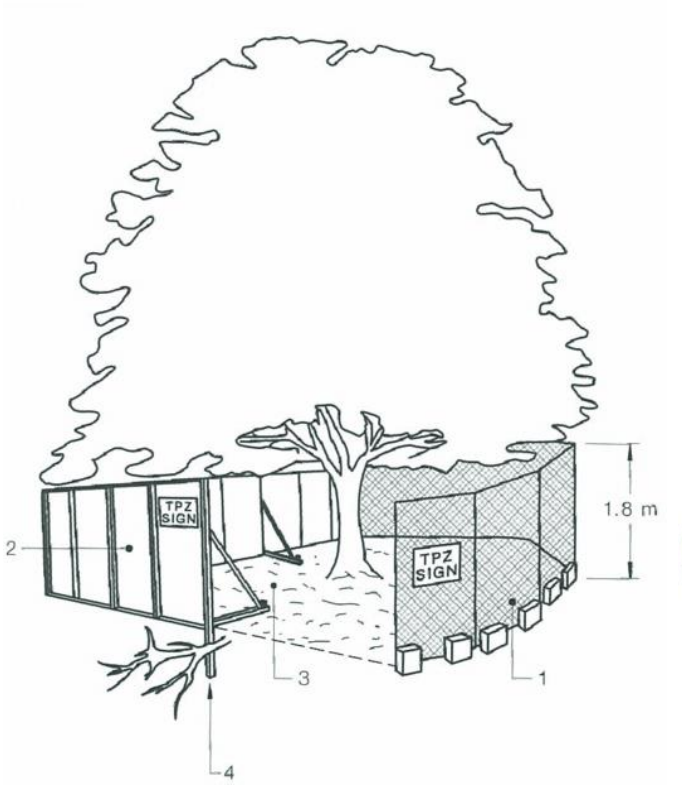
iv. Where the work site is only on one side of the tree, the barrier may be erected along the face of the tree adjacent to the work site.

v. Tree Protection Barriers must be erected before any site works commence and shall not be removed or moved closer to the trunk of the tree, until after site works are complete. No person, vehicle or machinery may enter the Tree Protection Zone unless otherwise authorised to do so by the Project Arborist.

vi. Operating plant must be positioned to avoid the expellant of exhaust fumes and radiant operating heat damaging the physiological functions of the tree.

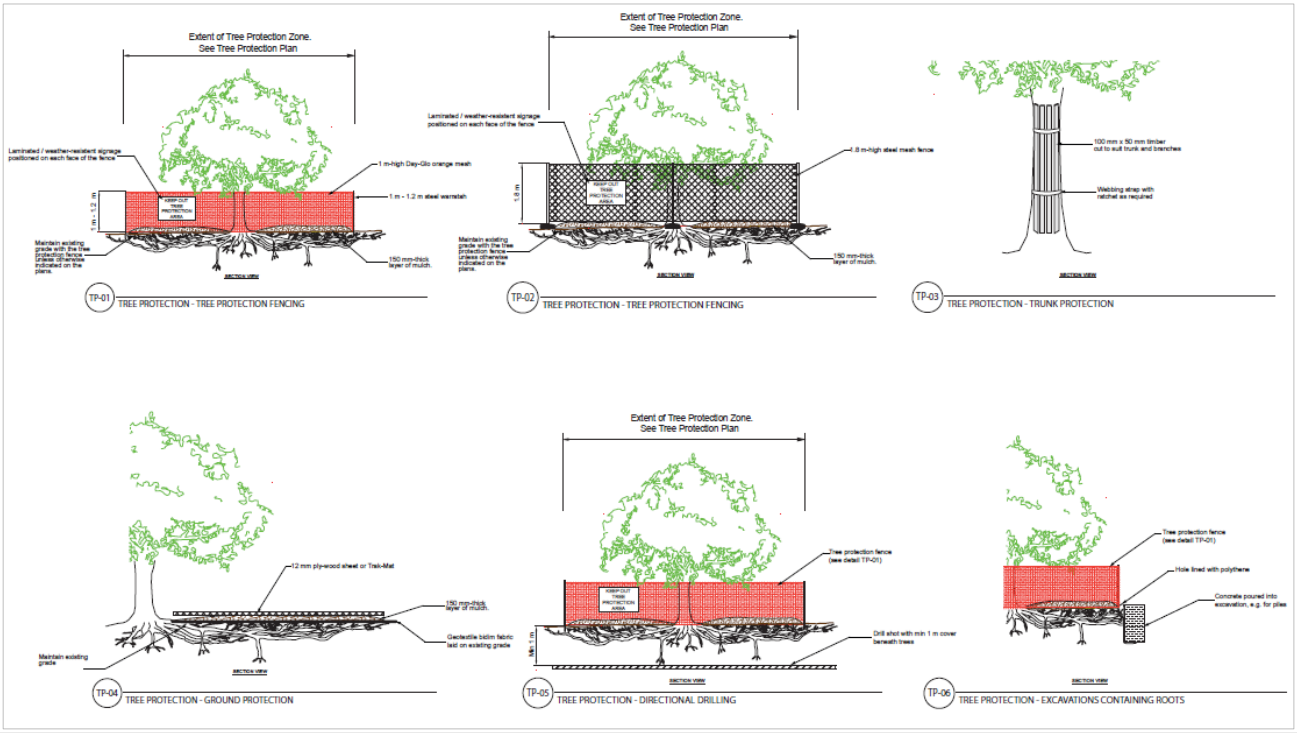
8.7 Tree Protection Installations

i. Tree Protection is to be erected around any tree within five (5) metres of development per *AS4970-2009 Protection of trees on development sites.*



LEGEND:

1 Chain wire mesh panels with shade cloth (if required) attached, held in place with concrete feet.
2 Alternative plywood or wooden paling fence panels. This fencing material also prevents building materials or soil entering the TPZ.
3 Mulch installation across surface of TPZ (at the discretion of the project arborist). No excavation, construction activity, grade changes, surface treatment or storage of materials of any kind is permitted within the TPZ.
4 Bracing is permissible within the TPZ. Installation of supports should avoid damaging roots.

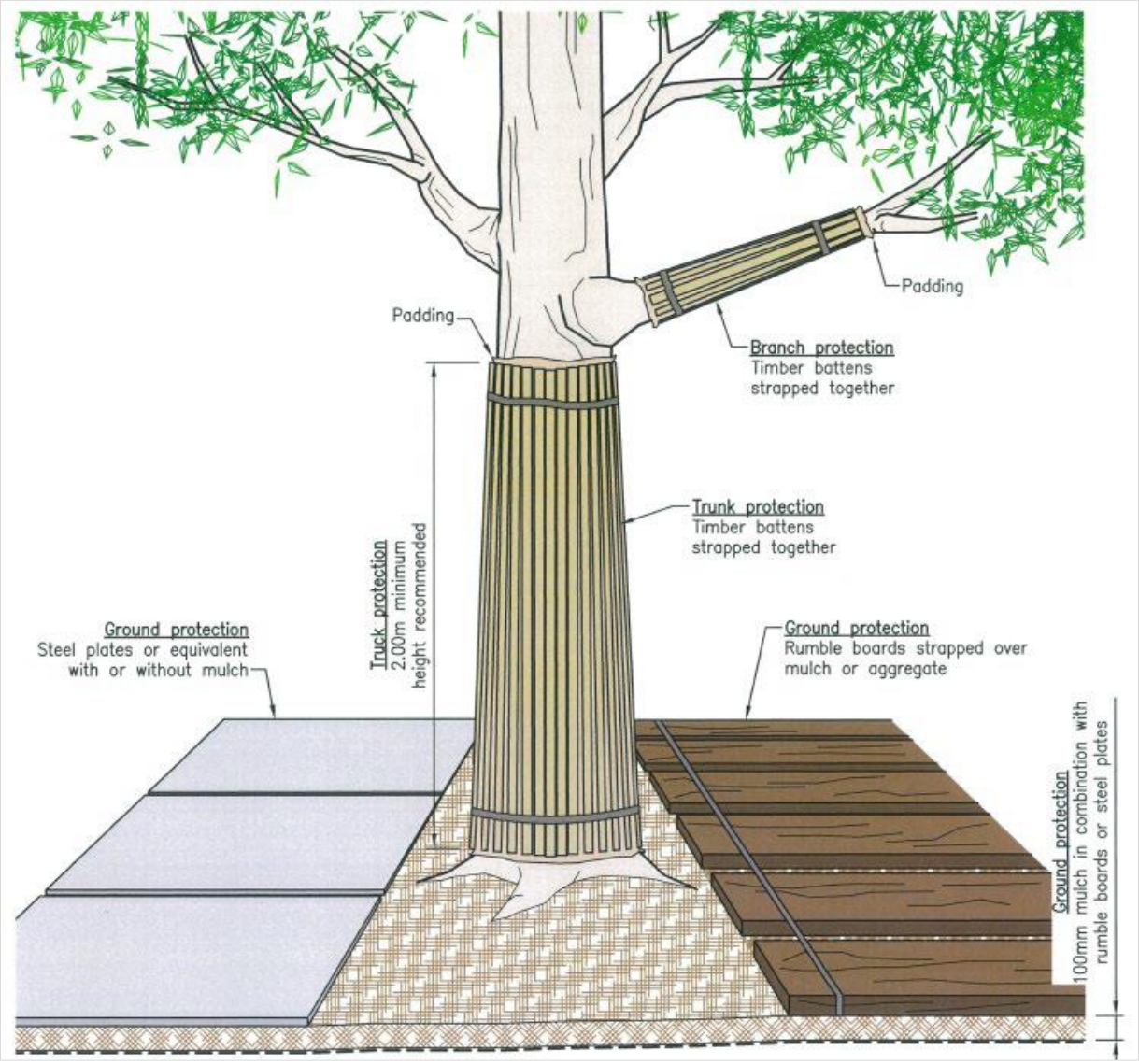


Alternative Trunk, Branch & Ground Protection

i. When tree protection fencing cannot be installed or requires temporary removal, other tree protection measures should be used. Where necessary, install protection to the trunk and branches of trees as pictured below.

ii. The materials and positioning of protection are to be specified by the Project Arborist and are to include:

- For the trunk and branch protection use boards and padding that will prevent damage to the bark. For the trunk boards a minimum height of two (2) metres is recommended. Boards are to be strapped to trees, not nailed or screwed. Do not attach temporary powerlines, stays or guys to the tree.
- If temporary access for machinery is required within the Tree Protection Zone (TPZ) such as site access, ground protection measures will be required. The purpose of ground protection is to prevent root damage and soil compaction within the TPZ. Measures may include a permeable membrane such as geotextile fabric beneath a layer of mulch or crushed rock below rumble boards. (These measures may be applied to root zones beyond the TPZ).
- Rumble boards should be of a suitable thickness to prevent soil compaction and root damage and a top dressing of Organic Mulch (60mm-70mm deep) is to be applied where pragmatically possible.



9 Plant Health Care

9.1 Overview

i. It is well documented that even minor encroachments due to urban development and construction pressures can 'stress' a tree, which in turn can result in a reduced useful life expectancy (Watson, 2014). Therefore, it is strongly recommended that a proactive species-specific Plant Health Care Plan is formulated and implemented with regards to any development and tree vitality. Plant Health Care (PHC) is a holistic approach to best management practice with regards to urban tree care and the understanding of the various interactions within the environment in which they grow. The core objectives being the management and enhancement of the tree(s) biological, physiological, and aesthetic traits whilst maintaining and/or improving the surrounding landscape's appearance. As PHC is science-based it involves routine arboricultural monitoring, proactive soil, and plant treatments, along with the identification and mitigation of foreseeable arboricultural risks to person, property and/or the environment.

9.2 Post Development Plant Health Care Recommendations

i. With an educated understanding of the functions of tree roots and the potentially negative effects of development impact it is strongly recommended that a post-development Plant Health Care regimen is formulated by the Project Arborist and enacted. This should include:

- *An application of Organic Botanicals:* Organic materials are essential components which stimulate vitality leading to root development and thus development of new tissue. This whilst enacting a tree's defence system improving resistance to disease and increasing defence responses and capabilities.
- *Top-dressing of Organic Mulch:* It is strongly recommended that a top-dressing of organic composted mulch or woodchips is applied to the TPZ of all retained trees post-development. This layer should be added to a depth of 60-70mm (Urban. 2010). A composted mulch application will:
  - Prevent soil compaction and minimise future root damage.
  - Amend soil structure to improve the water-holding capacity and fertility by affecting both texture, porosity and structure.
  - Reduces soil moisture loss through lower temperatures & supress undesirable plant species.
  - Promote root generation & increase soil organic matter and avail nutrients to the tree.
  - Stimulate soil microflora and micro fauna activity and assist in the survival of affected tree(s) maintaining and ensuring optimum vitality and structural stability so as to maximize its ability to resist pest and diseases (Chalker-Scott. 2007) (Watson et. al. 2014).

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11 Glossary

The following definitions are stated in the Glossary of Arboricultural Terms, International Society of Arboriculture 2011, unless otherwise stated.

Abiotic: plant ailment caused by non-living, environmental, or man-made agents

Adaptive Growth: or Response Growth is new wood produced in response to damage or loads, which compensates for higher strain (deformation) in marginal fibres; it includes reaction wood (compression & tension) and wound wood.

Barrier Zone: chemically defended tissue formed by the still living cambium, after a tree is wounded or invaded by pathogens to inhibit the spread of decay into new annual growth rings. Wall 4 in CODIT model. Contrast with reaction zone

Bifurcation: Natural division of a branch or stem into two or more stems or parts

Biotic: pertaining to non-human living organism/ biotic agent: a living organism capable of causing disease/ biotic disorder: disorder caused by a living organism.

Bracket: British English term for fruiting body of a decay fungus. See *Conk*.

Codominant Structure: Stems or trunks of about the same size originating from the same position from the main stem52. When the stem bark ridge turns upward the union is strong; when the ridge turns inward the union is weak, a likely point of failure in storm or windy weather conditions or where increasing weight causes undue stress on the defective union.

CODIT: acronym for Compartmentalisation of Decay/Disease In Trees (refer Compartmentalisation).

Compartmentalisation: Dynamic tree defence process involving protection features that resist the spread of pathogens and decay causing organisms. Natural defence process in trees by which chemical and physical boundaries are created that act to limit the spread of disease and decay organisms.

Compaction: Results from loads or stress forces applied to the soil as well as shear forces. Both foot traffic and vehicle traffic exert both forces on soils. Vehicle traffic may cause significant compaction at depths of 150–200 mm (the area in which most absorbing roots are located). The degree of compaction will depend on weight of vehicles, number of movements, soil moisture levels and clay content. Soil handling, stockpiling, and transporting also tend to lead to the breakdown of soil structure and thus to compaction. Vibration as a result of frequent traffic or adjacent construction activities will also compact soils.

Compression wood: (1) in mechanics, the action of forces to squeeze, crush or push together any material (s) or substance(s): contrast with tension. (2) the ability of an internal combustion engine to contain or pressurized a combustible fuel - air mixture.

Conk: Fruiting body or non-fruiting body (sterile conk) of a fungus. Often associated with decay.

Crown/Canopy: The main foliage bearing section of the tree, these terms are interchangeable.

Crown damage: The canopy of trees can be directly or indirectly damaged. Incorrect techniques of pruning such as lopping or flush cutting may produce wounds that are susceptible to infection by wood decay organisms. Similarly, mechanical damage to branches by machinery, etc. will also create wounds. Trees automatically respond to wounding and in doing so use stored sugars. Any wound places an additional load on trees that will inevitably be stressed during construction.

Damping: Damping occurs where energy is dissipated. In trees, damping occurs naturally in three main ways with aerodynamic damping of the leaves, internal damping in the wood and root zones, and with mass damping of the branches.

Deadwood: Dead branches within the canopy of tree. Deadwood is a naturally occurring feature of most tree species and comprises dead or decaying branches within the canopy of a tree. Deadwood may have habitat value and require removal only according to the considered risk of its location, i.e. high use pedestrian area or damage to adjacent infrastructure.

Removal of deadwood is generally recommended only where it represents an unacceptable level of hazard. Consideration of the need for deadwood removal should take into account the occupancy of the target zone, i.e. high use pedestrian area or presence of infrastructure, possible damage to the tree during its removal as well as its conservation for habitat value. In some instances, retention of a reduced tree structure for habitat purposes maybe considered appropriate, especially when hollows are present.

Further reference: *Principles of Tree Hazard Assessment. Lonsdale, David. TSO, (2009).*

Dead wooding: **(Crown cleaning)**: The removal of dead branches60. Recommendation to remove deadwood is for removal of all dead branches within tree canopy > 30mm diameter in trees which overhang pedestrian or vehicular areas and removal of all dead branches within tree canopy > 50mm diameter if trees are located in a Parkland or similar area.

Decay: The process of degradation of woody tissues by micro-organisms.

Desiccation: Severe drying out. Dehydration.

Drip Line: Is the imaginary perimeter line at soil surface level which is directly below the outermost edge of the tree's foliage or canopy.

Estimated Life Expectancy (ELE): Assessed on trees of particular species in the urban environment, including health and structural conditions which may exist.

Epicormic bud: Latent or adventitious bud located at the cambium and concealed by the bark.

Epicormic shoots: Shoots produced from epicormic buds at the cambium of trunks or branches.

Field Capacity: Maximum soil moisture content following the drainage of water due to the force of gravity.

Hollow: is a semi-enclosed cavity which has naturally formed in the trunk or branch of a tree.

Included bark: Inwardly formed bark within the junction of branches or codominant stems.

Kino: Dark red to brown resin-like substance produced by trees in the genera Eucalyptus, Pterocarpus and Butea and related genera. Kino forms in the barrier zones. Large kino veins form in some tree in response to injury and infection.

Leaves: The main function of leaves is photosynthesis, that is, the production of sugars and oxygen. The sugars produced by the leaves (and any other green tissue) are the source of chemical energy for all living cells in the entire plant and as such are essential for the normal functioning and survival of the tree. Anything that directly or indirectly damages the leaves will interfere with photosynthesis.

Non-Destructive Root Exploration (NDRE): is the most reliable way to conscientiously locate tree roots pre-development; and thus, assist in TSUD options and the subsequent determination of tree viability. Therefore, all excavations that are calculated as a *'Major'* Encroachment must be initiated by non-destructive means (Hand-digging, Air Vac and/or Air -Spade) under the guidance of the Project Arborist. Machine excavations will only be permitted within the TPZ if and when the Project Arborist is satisfied that the excavation envelope is free of any significant root biomass.

Non-woody part of tree: 'organs that increase the surface area of vascular plants, thereby capturing more solar energy for photosynthesis'. … maybe classified as microphylls (usually spine-shaped leaves with a single vein) or megaphylls (leaves with a highly branched vascular system). Needles and leaves are major energy trapping organs of a tree. Flowers are modified leaves …. as they fit the definition of an organ (*Shigo.2003).*

Macropore: Relatively larger space between soil particles that is usually air-filled and allows for water movement and root penetration. Contrast with micropore.

Minor encroachment (<10%): If the proposed encroachment is less than 10% (total area) of the TPZ, and outside of the SRZ, detailed root investigations should not be required. The area lost to this encroachment should be compensated for elsewhere and be contiguous with the TPZ.

Major encroachment (>10%): If the proposed encroachment is greater than 10% (total area) of the TPZ, the project arborist must demonstrate that the tree(s) remain viable. The area lost to this encroachment should be compensated for elsewhere and be contiguous with the TPZ. Tree sensitive construction techniques may be used for minor works within this area providing no structural roots are likely to be impacted, and the project arborist can demonstrate that the tree(s) remain viable. Root investigation by non-destructive methods may be required for proposed works within this area. All work within the TPZ must be carried out under the supervision of the project arborist.

Micropore: Space between soil particles that is relatively small and likely to be water filled.

Mortality Spiral: Sequence of stressful events or conditions causing the decline and eventual death of a tree. Once in a mortality spiral trees are more likely to succumb to any further or additional stress factors such as drought, pest infestation or disease. (See definition Stress)

Necrosis: Localised death of tissue in a living organism.

Occlusion (See wound): Shut in or out. Occlusion is the process of trees forming callus and clear wood over wounds.

Pathogen: A disease-causing organism.

Phototropism: Influence of light on the direction of plant growth. Tendency of plants to grow towards light.

Phloem: Plant vascular tissue that transports photosynthates and growth regulators. Situated on the inside of the bark, just outside the cambium. Is bidirectional (transports up and down). Contrast with xylem.

Photosynthesis: Process in green plants (and in algae and some bacteria) by which light energy is used to form glucose (chemical energy) from water and carbon dioxide.

Reaction wood: Wood forming in leaning or crooked stems or on lower or upper sides of branches as a means of counteracting the effects of gravity. See compression wood and tension wood.

Shrub: A woody plant similar to a tree except it is usually several-stemmed and smaller than a tree.

Significance: The quality of being worthy of attention; importance.

Stem / Trunk: Organ which supports branches, leaves, flowers and fruit; may also be referred to as 'the trunk'.

Stress: In Plant Health Care, (1) a factor that negatively affects the health of a plant; a factor that stimulates a response. (2) mechanics, a force per unit area.

Stress – acute: Disorder or disease that occurs suddenly and over a short period of time.

Stress – chronic: Disorder or disease occurring over a longer time.

Structural Root Zone (SRZ): The SRZ is the area of the root system (as defined by AS 4970-2009) used for stability, mechanical support, and anchorage of the tree. Severance of structural roots (>50 mm in diameter) within the SRZ is not recommended as it may lead to the destabilisation and/or serious decline of the tree.

Tree: Long lived woody perennial plant greater than (or usually greater than) 3 m in height with one or relatively few main stems or trunks. A tree has 3 major organs – roots, stem and leaves.

Tree Protection Zone (TPZ): *AS4970-2009 Protection of trees on development sites s1.4.7,* Tree Protection Zone (TPZ): A specified area above and below ground and at a given distance from the trunk set aside for the protection of a tree's roots and crown to provide for the viability and stability of a tree to be retained where it is potentially subject to damage by development.

Vigour: Ability of a tree to sustain its life processes. The term 'vigour' in this document is synonymous with commonly used terms such as 'health' and 'vitality'. Inherent genetic capacity of a plant to deal with stress. Physical strength and health. A tree with good vigour has the ability to sustain life processes and synonymous with good health.

Visual Tree Inspection (VTA): Is a detailed visual inspection of a tree and surrounding site.

Vitality: Ability of plant to deal effectively with stress.

Watersprouts/ Epicormic growth (Usually multiple shoots): Shoots produced from epicormic buds at the cambium of trunks or branches. Grows 'from the stub ends and only grows from the outermost living tissue layer of that year's growth. They are weakly attached and prone to falling out or being blown off with the risk increasing markedly as they increase in size. When epicormic shoots arise from stub ends that are decaying, the chances of them falling out are significantly greater'.

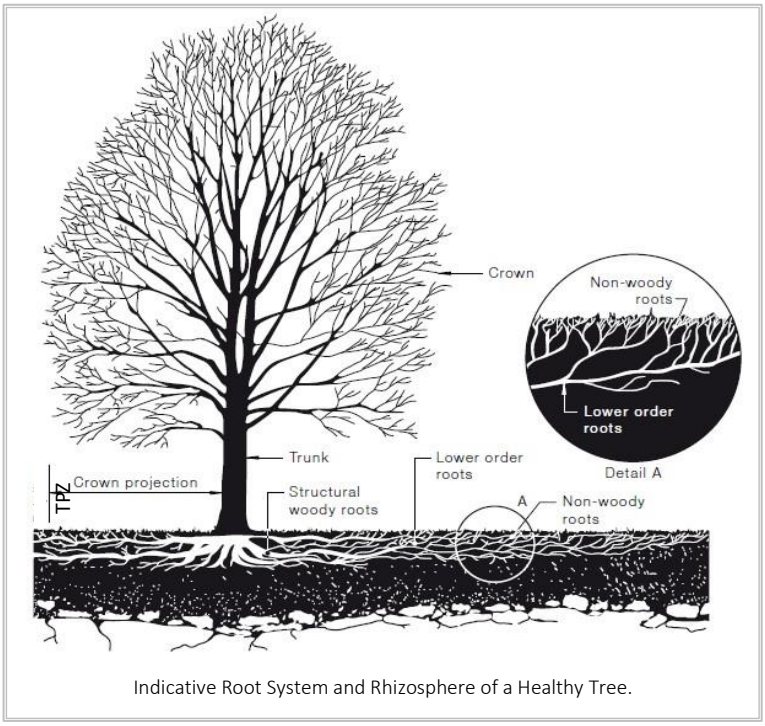
Wound: An opening that is created when the bark is cut, removed, or injured.

Xylem: Main water and mineral-conducting (unidirectional, up only) tissue in trees and other plants. Provides structural support. Arises (inward) from the cambium and becomes wood after lignifying. Contrasted with phloem.

Zone of *Rapid Taper*: The area within 1–2m of the trunk on larger trees is frequently referred to as the *'Zone of Rapid Taper'* because structural roots found there often exhibit considerable secondary thickening- not present on roots farther from the trunk (*Wilson 1964*). *Wilson (1964)* additionally reviews the development of this zone and its relation to mechanical stability.

12 Appendix

12.1 Root Morphology Considerations



Indicative Root System and Rhizosphere of a Healthy Tree.

Image credit: AS4970-2009 Protection of trees on developmnet sites

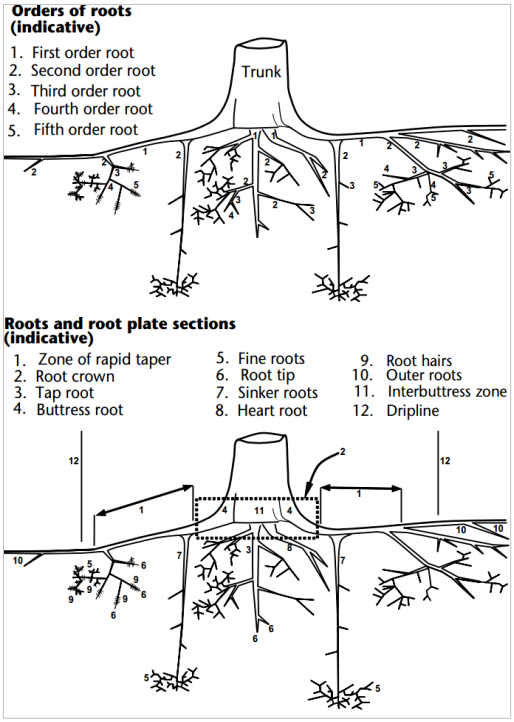


Image credit: Perry. 1992

i. The main functions of roots include the uptake of water and nutrients, anchorage, storage of sugar reserves and the production of some plant hormones required by the shoots. For roots to function, they must be supplied with oxygen from the soil. The root system of trees consists of several 'types' of roots found in different parts of the soil and is generally much more extensive than commonly thought. The importance of roots is easily overlooked because they are not visible, that is 'out of sight, out of mind'. Damage to the root system is a common cause of tree decline and death and is the most common form of damage associated with development sites (Matheny et. al, 1998).

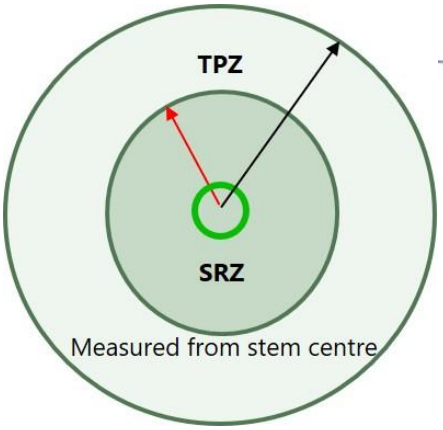
ii. Root systems consist of three main parts: (Sutton and Tinus, 1983).

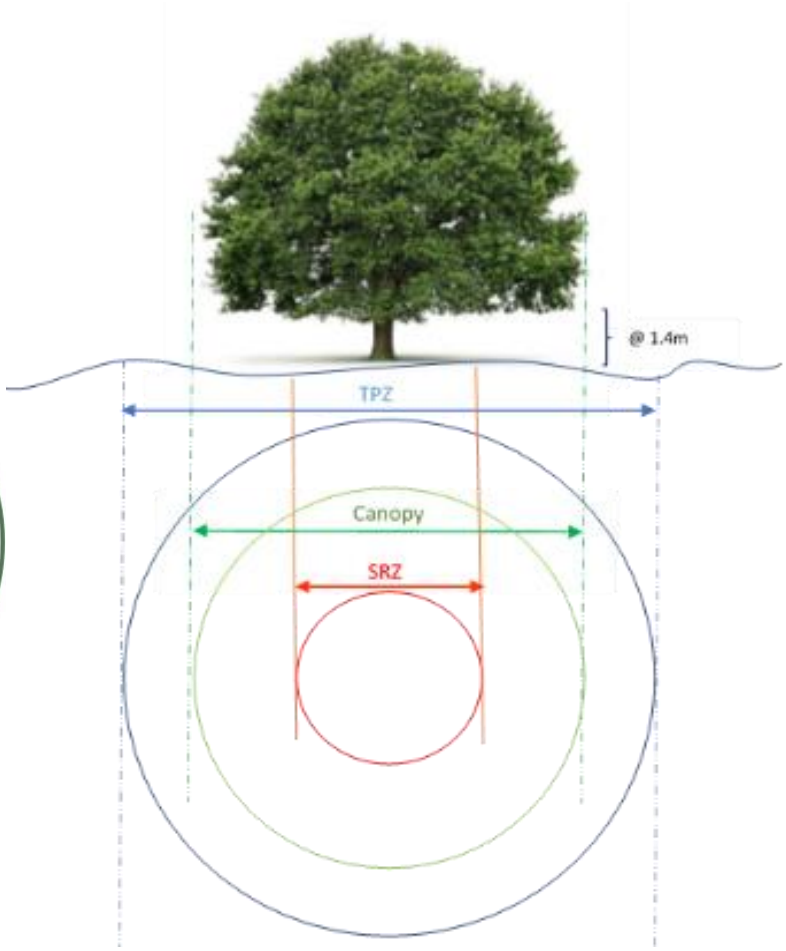
- The structural woody roots (anchorage, storage and transport);
- Lower order roots (anchorage, storage and transport); and
- Non-woody roots (absorption of water and nutrients, extension, synthesis of amino acids and growth regulators) (please refer to Drawing above).

iii. In addition to lateral root spread being underestimated, root depth in trees has also been grossly exaggerated. Deep root systems or taproots are the exception rather than the rule. Most roots of most trees are found in the very top of the soil. The vast majority of these roots are small non-woody absorbing roots which grow upward into the very surface layers of the soil and leaf litter. This delicate, non-woody system, because of its proximity to the surface, is very vulnerable to injury (Watson et. al, 2014).

12.2 Tree Protection Zone (TPZ) & Structural Root Zone (SRZ).

i. The Australian Standard *AS4970-2009 - Protection of trees on development sites* is used for the allocation of tree protection zones. This method provides a TPZ that addresses both tree stability and growth requirements. TPZ distances are measured as a radius from the centre of the trunk at ground level.





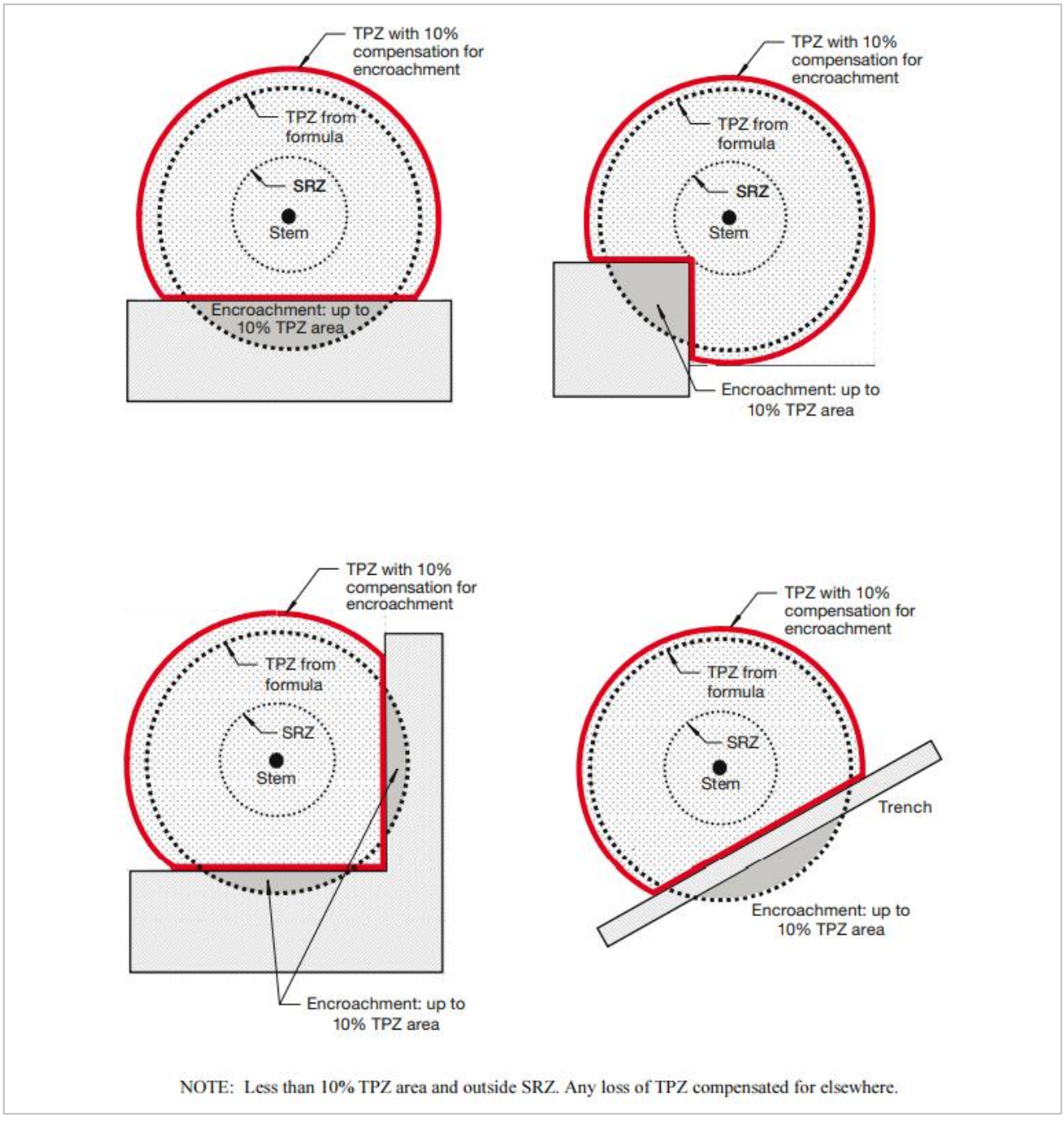
ii. As per *AS4970-2009 Protection of trees on development sites* the following calculations are to be used:

- *s3: The radius of the TPZ is calculated for each tree by multiplying its Diameter @ Breast Height measured @ 1.4m from ground level (DBH × 12 = TPZ). (DBH = Trunk Girth @ 1.4m ÷ π).*
- *To calculate the SRZ: Radius SRZ = **D**iameter above **R**oot **C**rown (**DRC** x 50) ^ 0.42 x 0.64. If the DRC is less than 0.15m the SRZ will be 1.5m.*
- *Note: A TPZ should not be less than 2m or more than 15m from the tree stem.*

You do not need to calculate the TPZ of palms, cycads and tree ferns. For these plants, the TPZ should not be less than 1m outside the crown.

12.3 Compensation for Tree Protection Zone Encroachment

i. Encroachment into the Tree Protection Zone (TPZ) is sometimes unavoidable. The images above are analogous to the abovementioned works scenario and indicate how encroachment within the tree protection zone can be compensated for elsewhere per *AS4970-2009 Protection of Trees on Development Sites*.



NOTE: Less than 10% TPZ area and outside SRZ. Any loss of TPZ compensated for elsewhere.

12.4 Non-Destructive Root Exploration & Root Mapping

i. Non-Destructive Root Exploration (NDRE) or Root Mapping is the most reliable way to locate tree roots pre-development and therefore should always be implemented when a tree is to be retained and impending earthworks are to be undertaken within the TPZ. This NDRE should consist of Hand-digging and/or AirSpade under the guidance of the Project Arborist (Watson et. al. 2014).

ii. NDRE will often be initiated with the excavation of a 'Slot-Trench' on the edge of the TPZ and/or the required excavation footprint. This will assist in determining the extent of the tree root architecture and provide accurate root location(s) along with additional morphological data. This objective root mapping data can then be utilised to explore and/or implement pragmatic tree sensitive design modifications regarding site-specific tree protection, tree retention and Plant Health Care regimens post development.

iii. Please note that the Root Mapping findings will ultimately determine foreseeable tree viability and whether tree sensitive design modifications and/or tree removal will need to be undertaken on this Project. (All of the findings from the NDRE should be paroled by the appointed Project Arborist and made available to all parties with *locus standii* upon request. This in the form of a Root Mapping Report).

12.5 Tree Sensitive Urban Design (TSUD)

i. A commonsensical approach with regards to tree retention and development should always be adopted. I.e., any excavations within the calculated TPZ of a retained tree should be initiated with NDRE; and where practicable should be limited in depth so as to not impact tree roots. However, if during the NDRE a 'significant root' (>30mm in diameter) is encountered candid tree sensitive design modifications will need to be discussed and/or incorporated into the project where reasonably practicable.

ii. Tree Sensitive Urban Design (TSUD) for both new and existing trees simply aims to provide adequate space for desirable root growth, whilst safeguarding against infrastructure and root damage from potential conflict alike. Some of these proactive solutions include:

- Sensitive Construction: Directional-drilling, Screw-Piling, Cantilevers, 'Build-outs' and 'Build-overs'.
- Irrigation, Tree Root Trenches & Paths, Root Barrier, Root Deflectors and Root Directors and De-Compaction/Compaction to direct root growth.
- Porous Permeable Pavers, Asphalt, Concrete and Resin Bound Aggregates.
- Structural Confinement System installations with structural soil: Some of these include Natural Cell, Silva Cell, Strata Vault, Strata Pit, Geo Cell, and Terra Vault. In summary these cells can be installed in an urban scape to provide space for root growth limit soil and root compaction, whilst facilitating necessary infrastructure installations.

iii. Please note that tree roots travel the 'path of least resistance' and like most living organisms require oxygen and water (an aerobic soil with good moisture levels). Therefore, one of the easiest techniques to keep tree roots from growing in unwanted areas is to remove these two essential elements by heavily compacting the soil. Alternatively, by providing ideal levels of these essential resources (water, friable aerobic soil, and organic nutrients), tree roots can be encouraged to grow in that direction.

12.6 Visual Tree Assessment Descriptors

(Age Class relates to the ecophysiological stage of the trees life cycle – *UK Veteran Trees & Forestry Commission*)

TREE AGE CLASS

Life Cycle Stage	Category & Descriptor
Formative Stage	**Young or Juvenile:** Recently planted or approximately 1-7 years.
Maturing or Mature Stage	**Semi-mature:** Tree actively growing in size and yet to achieve the expected size *in situ.* **Mature:** Tree is approaching the expected size or has reached the expected size *in situ*
Senescent Stage	**Over Mature:** Tree is full-size and has started to decline (possible crown retrenchment)

TREE VITALITY

Good	Foliage of the tree is entire, with good colour, very little sign of pathogens and of good density. Growth indicators are good i.e., Extension growth of twigs and wound wood development. Minimal or no canopy dieback (deadwood).
Fair	Tree is showing one or more of the following symptoms: <25% dead wood, minor canopy dieback, foliage generally with good colour though some imperfections may be present. Minor pathogen damage present, with growth indicators such as leaf size, canopy density and twig extension growth typical for the species in this location.
Poor	Tree is showing one or more of the following symptoms of decline; >25% deadwood, canopy dieback is observable, discoloured or distorted leaves. Pathogens present, stress symptoms are observable as reduced leaf size, extension growth and canopy density.
Very Poor	The tree appears to be in a state of decline. The tree is not growing to its full capacity. The canopy may be very thin and sparse. A significant volume of deadwood may be present in the canopy and/or pest and disease problems may be causing a severe decline in tree vitality.
Serious Decline or Dead	Tree is in severe decline; >55% deadwood, very little foliage, possibly Epicormic shoots and minimal extension growth or the tree is completely dead and exhibits no new growth or live tissue.

***Please note that tree vitality cannot be measured directly, hence growth and physiological parameters that indicate tree vitality are used. Health or Vitality of a tree is evidenced by the general appearance of crown density, leaf colour, presence of epicormic shoots, ability to withstand disease invasion including pathogens and presence of dieback in crown at the time of inspection. Vigour may vary according to seasonal weather patterns and rainfall received (Dobbertin, 2005).*

***Tree Condition: The assessment of a tree(s) condition evaluates factors of tree vitality, form and structure. These descriptors of vitality, form and structure attributed to a tree evaluate the individual specimen to what could be reasonably considered by the arborist as typical for that species growing in situ. It is well documented that specific tree species can display inherently poor biomechanics, such as acute branch attachments with included bark, co-dominant leaders and other poor branch and root architecture. Whilst these 'structural defects' may be deemed arboriculturally flawed, they are typical for the species and my not constitute a foreseeable increased risk. These trees may be assigned a 'structural rating' of 'fair-poor' (as opposed to poor) at the arborist's discretion*

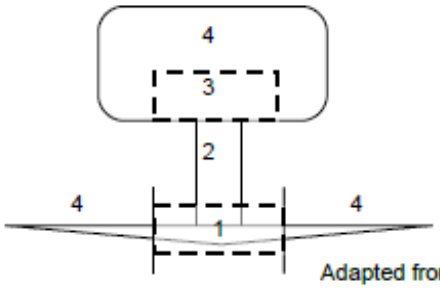
TREE STRUCTURE

Good: Trunk and scaffold branches show good taper and attachment with minor or no structural defects. Tree is a good example of species with well-developed form showing no obvious root problems or pests and diseases.
Fair/Fair-Poor: Tree shows minor structural defects or minor damage to trunk e.g., bark missing, there could be cavities present. Minimal damage to structural roots. Tree could be seen as typical for this species.
Poor/Very Poor: There are major structural defects, damage to trunk or bark missing. Co-dominant stems could be present with likely points of failure. Girdling or damaged roots obvious. Tree is structurally problematic.
Hazardous: Tree is immediate hazard with potential to fail, this should be rectified as soon as possible.

Tree Structure Matrix

Descriptor	Zone 1 - Root plate & lower stem	Zone 2 - Trunk	Zone 3 - Primary branch support	Zone 4 - Outer crown and roots
Good	No damage, disease or decay; obvious basal flare / stable in ground	No damage, disease or decay; well tapered	Well formed, attached, spaced and tapered	No damage, disease, decay or structural defect
Fair	Minor damage or decay. Basal flare present.	Minor damage or decay	Typically formed, attached, spaced and tapered	Minor damage, disease or decay; minor branch end-weight or over-extension
Fair to Poor	Moderate damage or decay; minimal basal flare	Moderate damage or decay; approaching recognised thresholds	Weak, decayed or with acute branch attachments; previous branch failure evidence	Moderate damage, disease or decay; moderate branch end-weight or over-extension
Poor	Major damage, disease or decay; fungal fruiting bodies present. Excessive lean placing pressure on root plate	Major damage, disease or decay; exceeds recognised thresholds; fungal fruiting bodies present. Acute lean. Stump resprout	Decayed, cavities or has acute branch attachments with included bark; excessive compression flaring; failure likely	Major damage, disease or decay; fungal fruiting bodies present; major branch end-weight or over-extension
Very Poor	Excessive damage, disease or decay; unstable / loose in ground; altered exposure; failure probable	Excessive damage, disease or decay; cavities. Excessive lean. Stump resprout	Decayed, cavities or branch attachments with active split; failure imminent	Excessive damage, disease or decay; excessive branch end-weight or over-extension

Diagram 2: Tree structure zones
1. Root plate & lower stem
2. Trunk
3. Primary branch support
4. Outer crown & roots



Adapted from Coder (1996)

Structure ratings will also take into account general tree architecture which considers aspects of stem taper, live crown ratio, branch distribution or crown bias and position such as a tree being suppressed amongst more dominant trees.

Useful Life Expectancy (ULE)

The ULE is adapted from (*Barrell, 2001)*. The objective of a ULE assessment is to determine the relative value of individual trees for the purpose of informing future management options.

Useful Life Expectancy – Assessment Criteria			
Dead / Serious Decline	**Short**	**Medium**	**Long**
Trees with a high level of risk that would need removing within the next 5 years. Dead trees. Trees that should be removed within the next 5 years. Dying or suppressed or declining trees through disease or inhospitable conditions. Dangerous trees through instability or recent loss of adjacent trees. Dangerous trees through structural defects including cavities, decay, included bark, wounds or poor form. Damaged trees that considered unsafe to retain. Trees that could live for more than 5 years but may be removed to prevent interference with more suitable individuals or to provide space for new planting. Trees that will become dangerous after removal of other trees for the reasons.	Trees that appear to be retainable with an acceptable level of risk for 5-15 years. Trees that may only live between 5 and 15 more years. Trees that may live for more than 15 years but would be removed to allow the safe development of more suitable individuals. Trees that may live for more than 15 years but would be removed during the course of normal management for safety or nuisance reasons. Storm damaged or defective trees that require substantial remedial work to make safe and are only suitable for retention in the short term.	Trees that appear to be retainable with an acceptable level of risk for 15-40 years. Trees that may only live between 15 and 40 more years. Trees that may live for more than 40 years but would be removed to allow the safe development of more suitable individuals. Trees that may live for more than 40 years but would be removed during the course of normal management for safety or nuisance reasons. Storm damaged or defective trees that require substantial remedial work to make safe and are only suitable for retention in the short term.	Trees that appear to be retainable with an acceptable level of risk for more than 40 years. Structurally sound trees located in positions that can accommodate future growth. Storm damaged or defective trees that could be made suitable for retention in the long term by remedial tree surgery. Trees of special significance for historical, commemorative or rarity reasons that would warrant extraordinary efforts to secure their long-term retention

IACA Significance of Tree, Assessment Rating System (STARS)

Institute of Australian Consulting Arboriculturists: Significance of a Tree Assessment Rating System (STARS) *The tree is to have a minimum of three (3) criteria in a category to be classified in that group*		
Low	**Medium**	**High**
The tree is in fair-poor condition and good or low vigour. The tree has form atypical of the species. The tree is not visible or is partly visible from the surrounding properties or obstructed by other vegetation or buildings. The tree provides a minor contribution or has a negative impact on the visual character and amenity of the local area. The tree is a young specimen which may or may not have reached dimensions to be protected by local Tree Preservation Orders or similar protection mechanisms and can easily be replaced with a suitable specimen. The tree's growth is severely restricted by above or below ground influences, unlikely to reach dimensions typical for the taxa in situ – tree is inappropriate to the site conditions. The tree is listed as exempt under the provisions of the local Council Tree Preservation Order or similar protection mechanisms. The tree has a wound or defect that has the potential to become structurally unsound.	The tree is in fair to good condition. The tree has form typical or atypical of the species. The tree is a planted locally indigenous or a common species with its taxa commonly planted in the local area. The tree is visible from surrounding properties, although not visually prominent as partially obstructed by other vegetation or buildings when viewed from the street. The tree provides a fair contribution to the visual character and amenity of the local area. The tree's growth is Mediumly restricted by above or below ground influences, reducing its ability to reach dimensions typical for the taxa in situ.	The tree is in good condition and good vigour. The tree has a form typical for the species. The tree is a remnant or is a planted locally indigenous specimen and/or is rare or uncommon in the local area or of botanical interest or of substantial age. The tree is listed as a heritage item, threatened species or part of an endangered ecological community or listed on councils' significant/notable tree register. The tree is visually prominent and visible from a considerable distance when viewed from most directions within the landscape due to its size and scale and makes a positive contribution to the local amenity. The tree supports social and cultural sentiments or spiritual associations, reflected by the broader population or community group or has commemorative values. The tree's growth is unrestricted by above and below ground influences, supporting its ability to reach dimensions typical for the taxa in situ – tree is appropriate to the site conditions.
Remove ***ENVIRONMENTAL PEST/NOXIOUS WEED*** The tree is a listed environmental weed species. This due to invasiveness or its poisonous/allergenic properties/ declared noxious weed. **HAZRADOUS / IRREVERSIBLE DECLINE** The tree is structurally unsound unstable and considered potentially dangerous. The tree is dead or in irreversible decline with the potential to fail/collapse.		

(STARS) Tree Retention Value - Priority Matrix

Significance of a Tree, Assessment Rating System (STARS), Institute of Australian Consulting Arboriculturists, Australia 2010.

		Landscape Significance				
		1.High	2.Medium	3.Low		
		Significance in Landscape	Significance in Landscape	Significance in Landscape	Environmental Pest/Noxious Weed Species	Hazardous / Irreversible Decline
Useful Life Expectancy	1.Long **>40 Years**					
	2.Medium **15-40 Years**					
	3.Short **<1-15 Years**					
	Dead					

	Priority for Retention (High) - These trees are considered important for retention and should be retained and protected. Design modification or re-location of building/s should be considered to accommodate the setbacks as prescribed by the Australian Standard *AS4970 Protection of trees on development sites.* Tree sensitive construction measures must be implemented (pier and beam cantilever, Structural Confinement Cells etc if works are to proceed within the TPZ).
	Consider for Retention (Medium) - These trees may be retained and protected. These are considered less critical; however, their retention should remain priority with removal considered only if adversely affecting the proposed building/works and all other alternatives have been considered and exhausted.
	Consider for Removal (Low) - These trees are not considered important for retention, nor require special works or design modification to be implemented for their retention.
	Priority for Removal - These trees are considered hazardous, or in irreversible decline, or weeds and should be removed irrespective of development.

12.7 AGS Quality Control

Document control

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Communication register

Date	Type	From	To	Description
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Review register

Date	File reference	Reviewer	Qualification	Company
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