



Arboricultural Assessment Precinct Structure Plan-42 North east Black Forest Road, Mambourin

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Contents.

Arboricultural Assessment	1
Precinct Structure Plan-42 North east	1
Black Forest Road, Mambourin	1
1 Executive summary	1
Client Brief	1
Key Objectives:	1
Summary of Opinion	2
2 Method:.....	3
3 Observations	4
4 Photographic catalogue:.....	6
5 Conclusion and Recommendations:.....	7
References:	8
Precedent disclaimer and copyright.....	8
Appendix 1: Tree and group details: Mambourin PSP 42 North east.....	9
Appendix 2: Tree and group numbers & locations: Mambourin PSP 42 North east.....	10
Appendix 3: Tree Descriptors.....	11
Appendix 4: Tree protection zones	15
Report assumptions	20

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1 Executive summary

Client Brief

The Growth Areas Authority (GAA) commissioned Tree Logic to undertake an arboricultural survey of tree features within the area defined as Precinct 42 North to inform the future precinct design process.

The tree study area, Precinct Structure Plan 43 (PSP43), comprised approximately 91 hectares and is defined to the south by Black Forest Road, Mambourin, to the east by the residential estate associated with Hanes Drive, to the north by Greens Road and nominated property boundaries to the west. The Refer to image below.



1a



1b

Figure 1a: Black Forest Road, Mambourin PSP 42 North Area and property boundaries (a)

and aerial image of tree study area (b).

The land is currently used for a variety of rural purposes and is zoned Urban Growth Zone with no other overlays parcels within the site. It is divided into 3 allotments of varying size from 28 to 70 hectares.

Key Objectives:

The arboricultural assessment was required to include:

- Identification of all trees considered to have High or Very High retention value by the consultant arborist. Trees that are considered to have less than High retention value are not required to be surveyed.
- Survey trees with High or Very High retention value that are over 150mm calliper measured at breast height (1.4m above surrounding ground level)
- Survey data collected was to include:
 - Tree number, Number of trees (if assessed as a group)
 - Location (XY co-ordinates)
 - Species (botanical and common name)
 - Tree origin (exotic, native, indigenous)
 - Dimensions (DBH, Height, Width)
 - Age class
 - Health rating
 - Structural rating
 - Useful life expectancy
 - Arboricultural retention value (High or Very High)
 - Tree Protection Zone
 - Any relevant comments
- Provide an arboricultural report which tables the collected data, illustrating the retention value of all surveyed trees on a plan of the PSP area, and includes discussion and clear recommendations regarding suitability for retention in an urban environment, required

protection zones (AS4970-2009) and strategies to maximise longer term viability, where relevant.

- Locate the trees in conjunction with cadastral layers provided by the GAA as site plans attached as Appendix 2.

Summary of Opinion

- 1.1 The tree population was sparse and confined only to the house lot at the western end of Black Forest Road.
- 1.2 Eight tree features were assessed within the study area including 4 individual specimens and 4 groups comprising approximately 267 trees. All trees were introduced planted specimens.
- 1.3 No tree features warranted an arboricultural rating of Very High or High.
- 1.4 The 4 individual trees were of Moderate arboricultural value and were suitable to be retained.
- 1.5 The groups of trees were in generally poor arboricultural condition and were attributed an arboricultural rating of None.
- 1.6 In general Moderate rated trees were of semi-mature age and size and could be readily replaced during development of the site. In certain landscape settings, smaller specimens in otherwise reasonable condition have the potential to offer an established tree resource, even if only as an interim measure.
- 1.7 Trees attributed an arboricultural value of None were not suitable to retain based on sound arboricultural principles, having significant health and / or structural defects.
- 1.8 Windrows with health and structural defects should generally be removed.

2 Method:

2.1. Site inspection methodology;

- 2.1.1 A site inspection was undertaken by Tree Logic staff during the week ending September 15, 2011. The trees were inspected from the ground and observations made of the growing environment and surrounding area. The trees were not climbed, no samples of the trees or site soil were taken and no investigation of the root plate below ground was undertaken.
- 2.1.2 Individually assessed trees and tree group features were attributed with unique identifying numbers. Trees numbers used in this report and appearing in column 1 of the tree assessment table in Appendix 1 correspond with unique identifying labels provided in the GIS data sets and plans compiled for the site.
- 2.1.3 Observations were made of the trees to determine age and condition, with measurements taken to establish tree height (measured with a height meter), crown width (paced) and trunk diameter (measured at 1.4m above grade unless otherwise stated). Definitions of arboricultural descriptors can be seen in Appendix 3.
- 2.1.4 Photographs of trees and site conditions were taken for further reference and inclusion in the report.
- 2.1.5 Spatial data relating to tree locations was recorded using a measuring tool equipped ruggedised tablet computers using a combination of GIS surveying software (ArcPad), orthorectified site aerial imagery and property boundary cadastre data supplied by the GAA.
- 2.1.6 Where sufficient identifying characteristics were present trees were identified to species level. Trees were assessed to determine their age class, structure and condition. Tree height was measured using a height meter. Where groups of close spaced trees were assessed, sample heights within the stand were taken and the height of remaining trees estimated against the sample heights. Crown spread was estimated by pacing the crown widths on the widest axis.
- 2.1.7 Trunk diameter was measured using a linear tape measure in 1cm increments. The default height for measurement was 1.4m above grade. Where short trunked trees forking at or below 1.4m above grade were assessed, trunk diameter was measured at the narrowest point of the single stem below the fork.

2.2. Field Survey Limitations

- 2.2.1. No assessment exclusion zones applied to the site.

2.3. Arboricultural assessment method;

- 2.3.1. The health and structural characteristics of each tree was assessed and each tree was attributed an 'Arboricultural Rating'. The arboricultural rating correlates the combination of tree condition factors (health, structure & form) with tree amenity value. Amenity relates to the trees biological, functional and aesthetic characteristics within a built environment. The arboricultural rating in combination with other factors can assist the project team and planners in nominating trees suitable for retention. The four arboricultural ratings used by Tree Logic include:

- **Very High:** Tree of very high quality in good condition. Generally a prominent arboricultural feature. Tree is capable of tolerating changes in its environment if managed appropriately.
- **High:** Tree of high quality with generally sound structural condition and good health. Generally is or has the potential to become a prominent landscape feature.

Trees that were considered to have less than High retention value were not required to be surveyed.

Trees that are generally desirable for retention typically display the following attributes:

- Are of a healthy condition that would allow it to tolerate development-associated modifications to its growing environment and,
- Have a structure that was not predisposed to potential failure that could cause damage or injury and,
- Are of an age and/ or size that provide an immediate and ongoing obvious contribution to the landscape.

Conversely trees in poor health, with suspect or deficient structure, or subject to pest or disease infestation that was having a discernable negative impact on tree condition are generally not considered suitable for retention in an urban environment. Trees recognised as environmental weeds and known to be potentially invasive in the locale of the subject site are generally not considered suitable for retention. Small specimens that provide negligible contribution to the landscape, irrespective of condition should not impede reasonable land use.

Full tree descriptors are attached as Appendix 3.

2.3 Establishing Tree Protection Zones (TPZ);

- 2.3.1 To successfully retain suitable trees within or around a development site, consideration must be given to protecting the trunk, crown and roots of each specimen. Tree protection zones (TPZ's) are used to provide adequate space for the preservation of sufficient roots to maintain tree health (particularly important for mature trees) whilst providing a buffer zone between construction activity and the tree trunk and crown.
- 2.3.2 The method for determining tree protection zones adopted in this report is the Australian Standard for protection of trees on development sites (AS4970-2009). It provides a method for establishing a TPZ area that is based on the trunk diameter measurement measured at 1.4m and multiplied by 12. The trunk of the tree is used as the centre point for the measurement.
- 2.3.3 TPZ measurements are included in the tree assessment data in Appendix 1.
- 2.3.4 The method employed in this document for assigning tree protection zones is a guide for planning purposes. Additional guidelines are outlined in Appendix 4 for establishment and maintenance of the tree protection

2.4 Documents reviewed include;

- Planning property reports and Wyndham City council planning overlays relevant to the sites including:
- Urban Growth Zone.
- Clause 52.17 applies to sites greater than 4,000 m² in area.
Under the clause it is a requirement to '*demonstrate the steps taken to*;
 - *Avoid the removal of vegetation native to Victoria.*
 - *Minimise the removal of native vegetation.*
 - *Appropriately offset the loss of native vegetation if required.*'

3 Observations

3.1 Site description.

The site is generally flat land on the volcanic plains west of Melbourne which is highly disturbed with a long history of previous land uses including farming for grazing and crop raising. Despite the ostensibly flat appearance there was a modest rise of approximately 6m extending up to the middle of the site before falling back to the northern boundary on Greens road. The gradient is less than 0.8%

A natural pooling of water or marshland existed at the western end of Black Forest Road which eventually drains to Lollipop Creek to the south east.

There was one house lot within the study area which had a weatherboard house and associated farm sheds, all in a relatively dilapidated condition.

Within the tree study area there was no remnant indigenous vegetation identified and there was no recruitment of naturally occurring indigenous species.

The existing tree cover was very sparse with the entire tree cover estimated to occupy less than 1% of the PSP area. All assessed trees were planted specimens, predominantly installed for functional purposes as screens, windrows and shelterbelts and occurring along internal and boundary fence lines. No trees occurred along natural contour lines. No trees were installed as ornamental specimens.

The tree stock predominantly comprised maturing to over-mature Sugar Gums (*Eucalyptus cladocalyx*) planted generally as groups along paddock boundaries, as close spaced woodlots or as individual specimens around the house lot.

Suffice to say the overall impression of the site was that vegetation comprised planted trees of introduced species for mostly agricultural purposes and were generally in a similarly dilapidated condition as the house. There were no trees that were of high arboricultural value or that were dominant landscape features.

The predominant tree feature recorded comprised a woodlot of 250 Sugar Gum trees that existed off site in the neighbouring property to the west. The trees had been previously coppiced at 1m and had been allowed to reshoot and were now ranging from 10 to 20m in height and included many dead and failed stems and spars.

3.2 Tree population.

Eight trees were observed across the site comprising approximately 271 individual trees of which 4 were attributed a Moderate arboricultural rating and the remainder were attributed an arboricultural rating of None.

All were planted introduced specimens.

3.3 Tree health:

The health rating was assessed based on foliage colour, size and density as well as shoot initiation and elongation or presence of crown dieback.

Only 2 trees displayed Fair health considered to be typical for the species growing in this environment under current conditions and at the end of more than a decade of drought.

Health deficiencies were typically associated with conditions including;

- Drought stress exhibited as crown dieback and desiccation of trees/branches.
- Age related decline.
- Overcrowding and suppressed conditions.

3.4 Tree structure:

The structure of the trees was assessed for structural defects and deficiencies, likelihood of failures and presence of targets.

Only 2 trees displayed Fair structural condition and 2 trees had Fair-poor structural condition with minor deficiencies that were considered to be within acceptable tolerances that could be retained. The remainder were of Poor to Very poor structural quality.

Defects and deficiencies were generally observed as trees that;

- Had been lopped or coppiced or were stump re-sprouts.
- Had been subject to major limb/stem failure.
- Had included bark forks and /or over-extended limbs.
- Had excessive dieback and deadwood.

3.5 Arboricultural rating.

Each of the assessed tree features was attributed an 'Arboricultural Rating'. Definitions of arboricultural ratings can be reviewed in Appendix 3. Given that there were so few trees within the study area and none were worthy of a High arboricultural rating the

3.5.1 Table 1 indicates the arboricultural ratings attributed to the trees inspected.

Table 1: Arboricultural rating	Total	Tree numbers
Moderate	4	1, 2, 3, 4
None	4	G1, G2, G3, G4
Total	8	

(Refer to Appendix 2 for tree location and numbering).

4 Photographic catalogue:



1



2

- 1 Shows the relative size, condition and location of Moderate rated Yellow Gum, Tree 1 and Sugar Gum, Tree 2 located in the house lot at the end of Black Forest Road. .
- 2 Shows the relative size, condition and location of Moderate rated Peppercorn Tree, Tree 3 located near the farm sheds at the end of Black Forest Road.



3



6

- 3 Shows the relative location, size and condition of the decay affected Sugar Gums adjacent to the house lot on Black Forest Road.
- 4 Shows the relative location, size and condition of the group of 250 Sugar Gum trees in the adjoining property to the west of the study area. Each tree had been coppiced at 1m above ground level and was decay affected and unsuitable to retain in conjunction with any urban development of the site.

5 Conclusion and Recommendations:

- 5.1 Tree Logic was commissioned by the Growth Areas Authority to survey and assess trees within the Wyndham Vale precinct identified as PSP40E. The survey was commissioned primarily for the purpose of providing information on the arboricultural merit of larger trees onsite to inform the design process.
- 5.2 The tree population was sparse and unremarkable across the site and no tree features attracted a High arboricultural rating.
Refer to Table 1, Arboricultural ratings on Page 6.
- 5.3 In the absence of site design plans, it is not appropriate to speculate on which trees are most appropriate for retention, beyond the general guide provided by the arboricultural ratings attributed to each feature. Retention suitability correlates with the future landscape setting around retained trees, which will vary given the scale of the intended development. Therefore, on the basis of tree quality and potential amenity, preference should be given to retaining trees of Very High or High arboricultural rating in built areas, or areas of increased target potential. Design modification should be altered where such trees have relatively long lifespan.
- 5.4 Conversely, areas of public open space are not only suited to the retention of quality stock, but may also provide opportunity to retain low quality trees either as interim canopy until such time as new landscapes establish or as longer term landscape elements in areas where risk associated with the retention of such trees is acceptable. Arboricultural ratings and useful life spans have been provided for all assessed trees/groups in the tree assessment table in Appendix 1 of this document.

I am available to answer any questions arising from this report.

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Appendix 1: Tree and group details: Mambourin PSP 42 North east

All trees and groups.

Refer to following page.

DBH = Diameter at Breast Height (measured in centimetres at 1.3m above ground unless otherwise stated).

H x W = Height x Width of crown (measured in metres).

TPZ = Tree Protection Zone (metre radius). Radius distances measured in metres from the centre of the trunk.

For tree location and numbering refer to plans at Appendix 2. See Appendix 3 for tree descriptors.

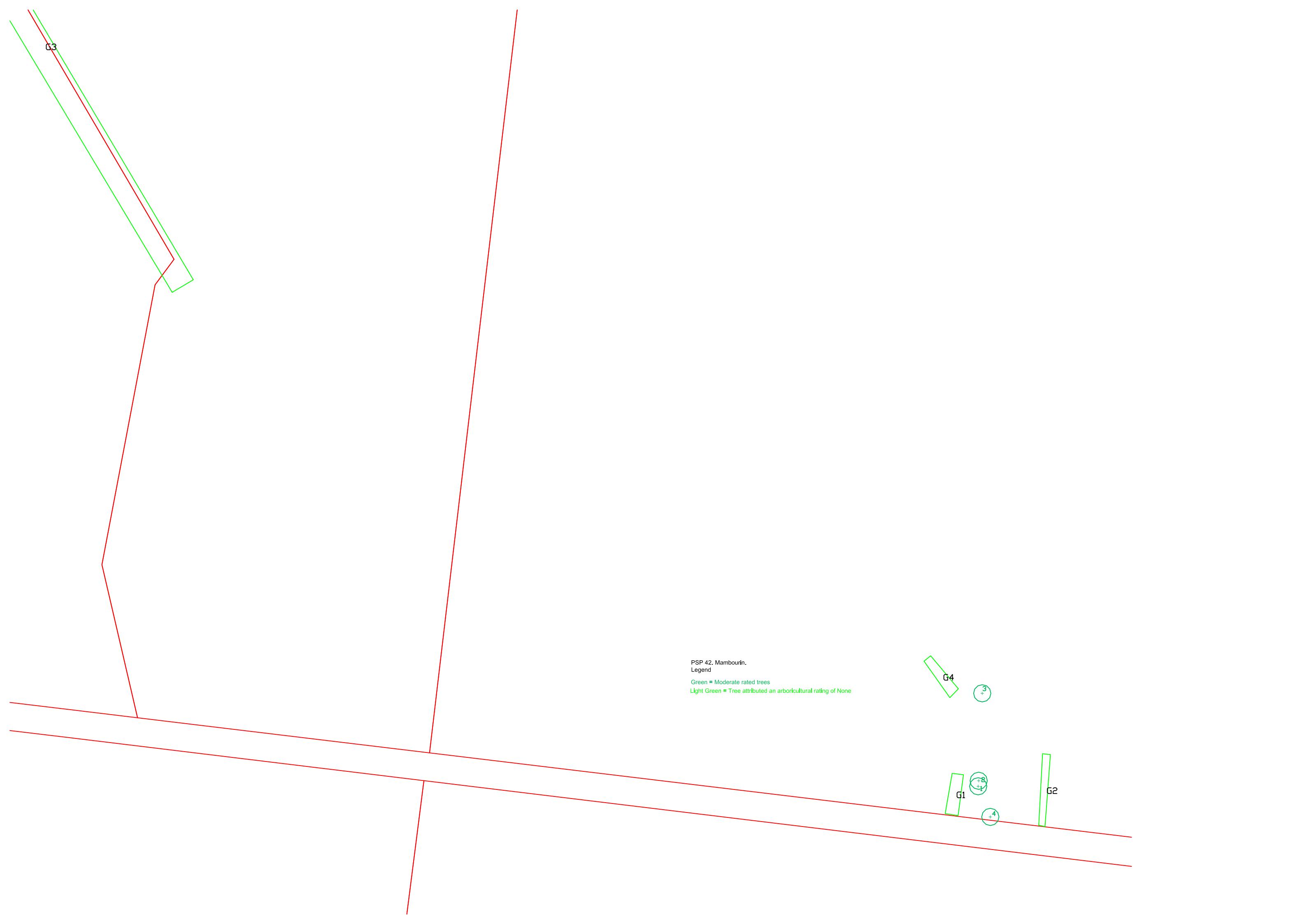
Feature No.	No of trees	Common Name (Botanic Name)	DBH (cm)	Height (m)	Width (m)	Health	Structure	Origin	Maturity	Arboricultural rating	Comments	TPZ (m radius)	ULE (years)	X	Y
1	1	Yellow Gum (Eucalyptus leucoxylon)	40	12	9	Fair to poor	Fair to poor	Victorian native	Semi-mature	Moderate	Reduced foliage density. Trunk wound.	4.8	15-25	288744.355180702	5802805.616789690
2	1	Sugar Gum (Eucalyptus cladocalyx)	35	12	12	Fair	Fair	Australian native	Semi-mature	Moderate		4.2	25-50	288744.701506163	5802809.446010260
3	1	Peppercorn Tree (Schinus areira)	50	8	10	Fair to poor	Fair	Exotic evergreen	Maturing	Moderate	Reduced foliage density	6	15-25	288747.175259451	5802870.233637120
4	1	Monnah (Melaleuca lanceolata)	34	6	10	Fair	Fair to poor	Victorian native	Maturing	Moderate	Multi-stemmed	4.1	5-15	288756.960000000	5802782.800000000
G1	6	Sugar Gum (Eucalyptus cladocalyx)	50	13	12	Fair to poor	Very poor	Australian native	Maturing	None	Previously lopped- Trunk decay	6	0-5	0.0000	0.0000
G2	8	Sugar Gum (Eucalyptus cladocalyx)	50	18	12	Poor	Poor	Australian native	Maturing	None	Crown Dieback, Borer damage. 1 Dead	6	0-5	0.0000	0.0000
G3	250	Sugar Gum (Eucalyptus cladocalyx)	40	16	9	Fair to poor	Very poor	Australian native	Maturing	None	Triple row wood lot. Multi-stemmed. Previously coppiced at 1m. Trunk	4.8	0-5	0.0000	0.0000
G4	3	Monterey Cypress (Cupressus macrocarpa)	50	11	13	Dead	Failed	Exotic conifer	Over-mature	None	In severe decline	6	0	0.0000	0.0000

Appendix 2: Tree and group numbers & locations: Mambourin PSP 42 North east

All trees and groups.

Refer to following page.





Appendix 3: Tree Descriptors, Version 3 (June 2006) Tree Logic Pty. Ltd.

Tree Condition: The assessment of tree condition evaluates factors of health, structure and form. The descriptors of health and structure attributed to a tree evaluate the individual specimen to what could be considered typical for that species growing in its location. For example, some species can display inherently poor branching architecture, such as multiple acute branch attachments with included bark. Whilst these structural defects may technically be considered arboriculturally poor, they are typical for the species and may not constitute an increased risk of failure. These trees may be assigned a structural rating of fair-poor (rather than poor) at the discretion of the author.

The normal distribution curve is a statistical model which shows that for a large number of observations of a particular population, the frequency of the observations creates a bell-shaped curve. This pattern is commonly found in the natural and behavioural sciences. Diagram 4, provides an indicative distribution curve for tree condition to illustrate that within a normal tree population the majority of specimens are centrally located within the condition range. Furthermore, that those individual trees with an assessed condition approaching the outer ends of the spectrum occur less often.

Tree name: Provides botanical name, (genus, species, variety and cultivar) according to accepted international code of taxonomic classification, and common name.

DBH: Indicates the trunk diameter (expressed in centimetres) of an individual tree measured at 1.3m above the existing ground level (Diagram 1) or where otherwise indicated (Diagram 2), multiple leaders are measured individually (Diagram 3). Plants with multiple leader habit, e.g. *Cotoneaster* sp., may be measured at the base. Measurements undertaken with foresters' tape or builders' tape.

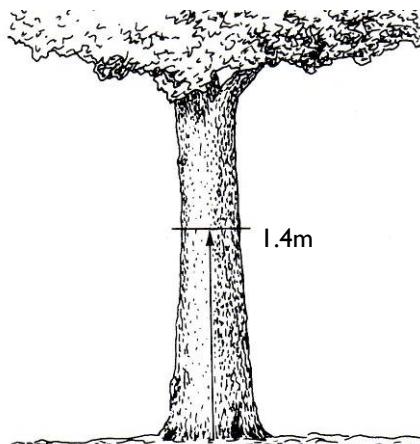


Diagram 1: Measurement of DBH on tree with single trunk

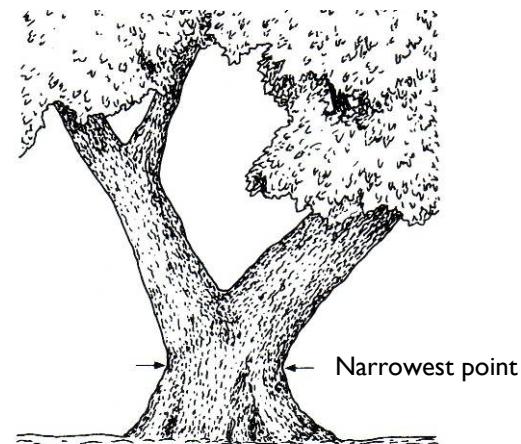


Diagram 2: Measurement of basal diameter at narrowest point above the basal flare

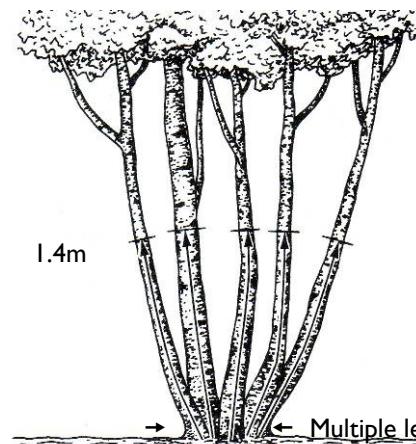


Diagram 3: Measurement of DBH on tree with multiple trunks, measured individually or at the base

Diagrams 1-3 adapted from Gooding et al. (2000)

H x W: Indicates height and width of the individual tree; dimensions are expressed in metres. Crown heights are measured with a clinometer where possible. Due to the topography of some sites and/or the density of vegetation it may not be possible to do this for every tree. Tree heights may be estimated in line with previous clinometer readings in conjunction with author's experience. Crown widths are generally paced (estimated) at the widest axis or can be measured on two axes and averaged.

Tree type: Describes the general geographic origin of the species and its type e.g. deciduous or evergreen.

Category	Description
<i>Indigenous</i>	Occurs naturally in the area or region of the subject site
<i>Victorian native</i>	Occurs naturally within some part of the State of Victoria (not exclusively) but is not indigenous
<i>Australian native</i>	Occurs naturally within Australia but is not a Victorian native or indigenous
<i>Exotic deciduous</i>	Occurs outside of Australia and typically sheds its leaves during winter
<i>Exotic evergreen</i>	Occurs outside of Australia and typically holds its leaves all year round
<i>Exotic conifer</i>	Occurs outside of Australia and is classified as a gymnosperm
<i>Native conifer</i>	Occurs naturally within Australia and is classified as a gymnosperm
<i>Palm</i>	Woody monocotyledon
<i>Other</i>	Other descriptions as indicated

Age: Relates to the physiological stage of the tree's life cycle.

Category	Description
<i>Young</i>	Sapling tree and/or recently planted
<i>Semi-mature</i>	Tree rapidly increasing in size and yet to achieve expected size in situation
<i>Maturing</i>	Specimen approaching expected size in situation, with reduced incremental growth
<i>Over-mature</i>	Tree is senescent and in decline

Form: Describes the general shape of the tree.

Category	Description
<i>Symmetric</i>	Generally evenly balanced and full crown
<i>Asymmetric</i>	Crown generally biased in one direction; can be minor or major
<i>Stump re-sprout</i>	Adventitious shoots originating from stump or trunk (after severe dieback or lopping)
<i>Suppressed</i>	Tree form inhibited
<i>Manipulated</i>	Hedge, pollard, topiary, windrow; managed for specific landscape use or aesthetic

Health: Assesses various attributes to describe the overall health and vigour of the tree.

Category	Vigour/Extension growth	Decline symptoms/Deadwood	Foliage density, colour, size, intactness	Pests and or disease
<i>Good</i>	Above typical	None or minimal	Better than typical	None or minimal
<i>Fair</i>	Typical	Typical or expected	Typical	Typical, within damage thresholds
<i>Fair to Poor</i>	Below typical	More than typical	Exhibiting deficiencies	Exceeds damage thresholds
<i>Poor</i>	Minimal	Excessive and large amount/size	Exhibiting severe deficiencies	Extreme and contributing to decline
<i>Dead</i>	N/A	N/A	N/A	N/A

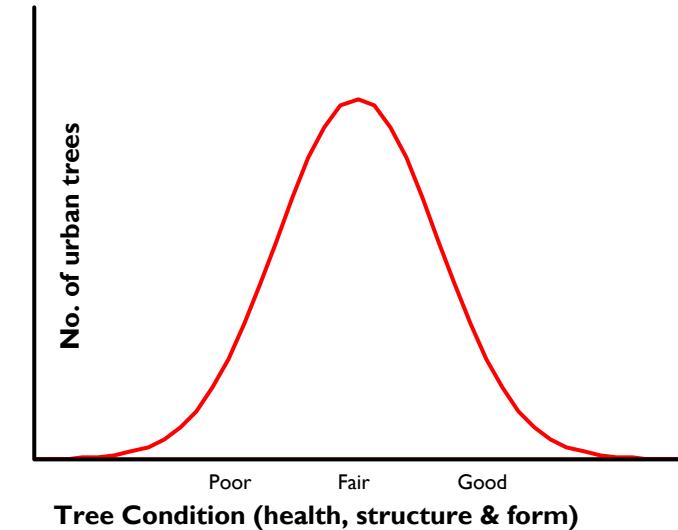


Diagram 4: Indicative normal distribution curve for tree condition

Structure: Assesses principal components of tree structure (Diagram 5).

Descriptor	Zone 1 Root plate & lower stem	Zone 2 Trunk	Zone 3 Primary branch support	Zone 4 Outer crown and roots	Lean from vertical	Risk potential if targets present
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	Low or none	Low or none
Fair	Minor damage or decay	Minor damage or decay	Typically formed, attached, spaced and tapered	Minor damage, disease or decay; minor branch end-weight or over-extension	Minor / natural	Minor
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	Moderate	Moderate
Poor	Major damage, disease or decay; fungal fruiting bodies present	Major damage, disease or decay; exceeds recognised thresholds; fungal fruiting bodies present	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	Acute	High
Very Poor	Excessive damage, disease or decay; unstable / loose in ground; failure probable	Excessive damage, disease or decay; cavities	Decayed, cavities or branch attachments with active split; failure imminent	Excessive damage, disease or decay; excessive branch end-weight or over-extension	Excessive – root plate failure or stem failure probable	Severe/imminent

The lowest or worst descriptor assigned to the tree in any column could generally be the overall rating assigned to the tree.

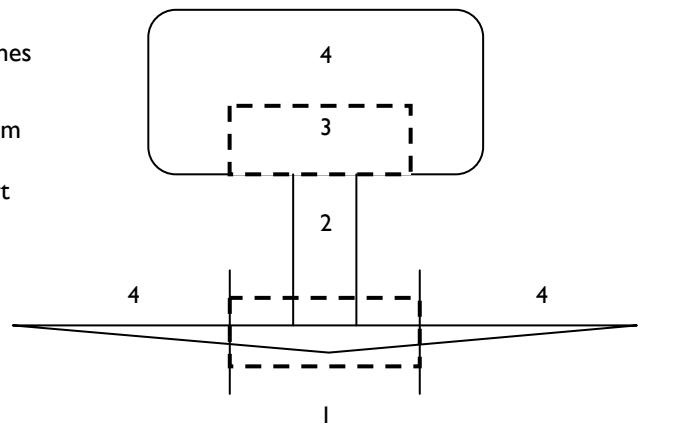
The assessment for structure is limited to observations of external and above ground tree parts. It does not include any exploratory assessment of underground or internal tree parts unless this is requested as part of the investigation.

Trees are assessed and given a rating for a point in time. Generally, trees with a poor or very poor structure are beyond the benefit of practical arboricultural treatments.

The management of trees in the urban environment requires appropriate arboricultural input and consideration of risk.

Diagram 5: Tree structure zones

1. Root plate & lower stem
2. Trunk
3. Primary branch support
4. Outer crown & roots



Arboricultural Rating: Relates to the combination of previous tree condition factors, including health, structure and form (arboricultural merit), and also conveys an amenity value. Amenity relates to the trees biological, functional and aesthetic characteristics (Hitchmough 1994) within an urban landscape context.

Category	Description
Very High	<p>Tree of very high quality in good condition. Generally a prominent arboricultural feature. Tree is capable of tolerating changes in its environment if managed appropriately.</p> <p>These trees have the potential to be a long-term component of the landscape if managed appropriately. Retention of these trees is highly desirable.</p>
High	<p>Tree of high quality with generally sound structural condition and good health. Generally is or has the potential to become a prominent landscape feature.</p> <p>Tree is capable of tolerating changes in its environment and has the potential to be a long-term component of the landscape if managed appropriately.</p>
Moderate	<p>Tree of moderate quality, in fair or better condition. Tree may have a condition, and or structural problem that will respond to arboricultural treatment. Tree is capable of tolerating changes in its environment if managed appropriately.</p> <p>These trees have the potential to be a medium- to long-term component of the landscape if managed appropriately. Retention of these trees is generally desirable.</p>
Low	<p>Tree of low quality and/or little amenity value. Tree in poor health and/or with poor structure. Tree unlikely to respond positively to changes in its environment and does not warrant design modification to preserve it.</p> <p>Tree is not significant for its size and/or young. These trees are easily replaceable.</p> <p>Tree (species) is functionally inappropriate to specific location and would be expected to be problematic if retained.</p> <p>Retention of such trees may be considered if not requiring a disproportionate expenditure of resources for a tree in its condition and location.</p>
None	<p>Tree has a severe structural defect and/or health problem that cannot be sustained with practical arboricultural techniques and the loss of tree would be expected in the short term.</p> <p>Tree whose retention would be unviable after the removal of adjacent trees (includes trees that have developed in close spaced groups and would not be expected to acclimatise to severe alterations to surrounding environment – removal of adjacent shelter trees)</p> <p>Tree has a detrimental effect on the environment, for example, the tree is a woody weed.</p> <p>These trees should be removed on the basis of sound arboricultural management.</p>

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Appendix 4: Tree protection zones. Tree logic Pty. Ltd. © 2009

1.0 Introduction

In order to sustain trees on a development site consideration must be given to the establishment of tree protection zones.

The physical dimensions of tree protection zones can sometimes be difficult to define. The projection of a tree's crown can provide a guide but is by no means the definitive measure. The unpredictable nature of roots and their growth, differences between species and their tolerances, and observable and hidden changes to the trees growing environment, as a result of development, are variables that must be considered.

Most vigorous, broad canopied trees survive well if the area within the drip-line of the canopy is protected. Fine root density is usually greater beneath the canopy than beyond (Gilman, 1997). If few to no roots over 3cm in diameter are encountered and severed during excavation the tree will probably tolerate the impact and root loss. A healthy tree can sustain a loss of between 30% and 50% of absorbing roots (Harris, Clark, Matheny, 1999), however encroachment into the structural root system of a tree may be problematic.

The structural root system of a tree is responsible for ensuring the stability of the entire tree structure in the ground. A tree could not sustain loss of structural root system and be expected to survive let alone stand up to average annual wind loads upon the crown.

2.0 Allocation of tree protection zone (TPZ)

The method of allocating a TPZ to a particular tree will be influenced by site factors, the tree species, its age and developed form.

Once it has been established, through an arboricultural assessment, which trees and tree groups are to be retained, the next step will require careful management through the development process to minimise any impacts on the designated trees. The successful retention of trees on any particular site will require the commitment and understanding of all parties involved in the development process. The most important activity, after determining the trees that will be retained is the implementation of a TPZ.

The intention of tree protection zones is to:

- mitigate tree hazards;
- provide adequate root space to sustain the health and aesthetics of the tree into the future;
- minimise changes to the trees growing environment, which is particularly important for mature specimens;
- minimise physical damage to the root system, canopy and trunk; and
- define the physical alignment of the tree protection fencing

Tree protection

The most important consideration for the successful retention of trees is to allow appropriate above and below ground space for the trees to continue to grow. This requires the allocation of tree protection zones for retained trees.

The Australian Standard AS 4970-2009 Protection of trees on development sites has been used as a guide in the allocation of TPZs for the assessed trees. The TPZ for individual trees is calculated based on trunk (stem) diameter (DBH), measured at 1.4 metres up from ground level. The radius of the TPZ is calculated by multiplying the trees DBH by 12. The method provides a TPZ that addresses both the stability and growing requirements of a tree. TPZ distances are measured as a radius from the centre of the trunk at (or near) ground level. The minimum TPZ should be no less than 2m and the maximum no more than 15m radius. The TPZ of palms should be not less than 1.0m outside the crown projection.

Encroachment into the TPZ is permissible under certain circumstances though is dependent on both site conditions and tree characteristics. Minor encroachment, up to 10% of the TPZ, is generally permissible provided encroachment is compensated for by recruitment of an equal area contiguous with the TPZ. Examples are provided in Diagram 1. Encroachment greater than 10% is considered major encroachment under AS4970-2009 and is only permissible if it can be demonstrated that after such encroachment the tree would remain viable.

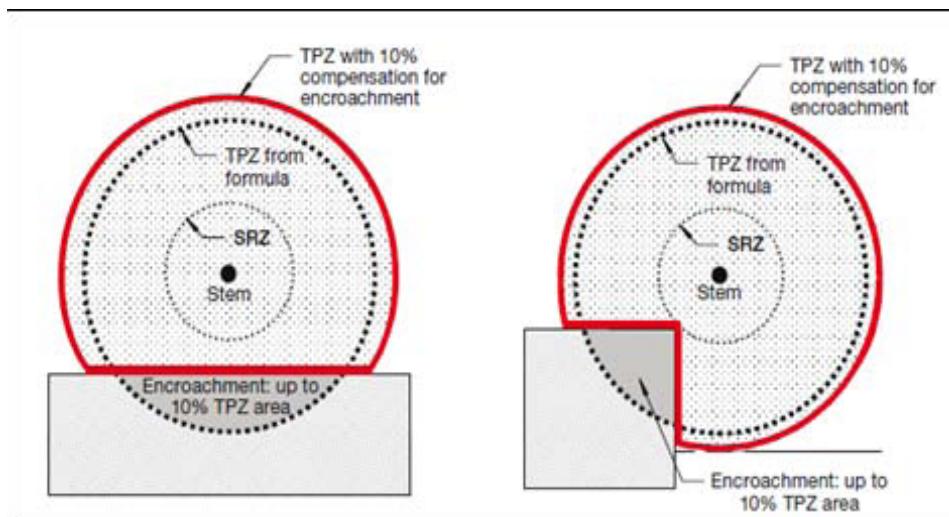


Diagram 1: Examples of minor encroachment into a TPZ. Extract from: AS4970-2009, Appendix D, p30 of 32

The 10% encroachment on one side equates to approximately $\frac{1}{3}$ radial distance. Tree root growth is opportunistic and occurs where the essentials to life (primarily air and water) are present. Heterogeneous soil conditions, existing barriers, hard surfaces and buildings may have inhibited the development of a symmetrically radiating root system.

Existing infrastructure around some trees may be within the TPZ or root plate radius. The roots of some trees may have grown in response to the site conditions and therefore if existing hard surfaces and building alignments are utilised in new designs the impacts on the trees should be minimal. The most reliable way to estimate root disturbance is to find out where the roots are in relation to the demolition, excavation or construction works that will take place (Matheny & Clark, 1998). Exploratory excavation prior to commencement of construction can help establish the extent of the root system and where it may be appropriate to excavate or build.

The TPZ should also give consideration to the canopy and overall form of the tree. If the canopy requires severe pruning in order to accommodate a building and in the process the form of the tree is diminished it may be worthwhile considering altering the design or removing the tree.

General tree protection guidelines

The most important factors are:

- Prior to construction works the trees nominated for tree works should be pruned to remove larger dead wood. Pruning works may also identify other tree hazards that require remedial works.
- Installation of tree protection fencing. Once the tree protection zones have been determined the next step is to mulch the zone with woodchip and erect tree protection fencing. This must be completed prior to any materials being brought on-site, erection of temporary site facilities or demolition/earth works. The protection fencing must be sturdy and withstand winds and construction impacts. The protection fence should only be moved with approval of the site supervisor. Other root zone protection methods can be incorporated if the TPZ area needs to be traversed.
- Appropriate signage is to be fixed to the fencing to alert people as to importance of the tree protection zone.
- The importance of tree preservation must be communicated to all relevant parties involved with the site.
- Inspection of trees during excavation works.

Exploratory excavation

The most reliable way to estimate root disturbance is to find out where the roots are in relation to the demolition, excavation or construction works that will take place (Matheny & Clark, 1998).

Exploratory excavation prior to commencement of construction can help establish the extent of the root system and where it may be appropriate to excavate or build. This also allows management decisions to be made and allows time for redesign works if required.

Any exploratory excavation within the allocated TPZ is to be undertaken with due care of the roots. Minor exploration is possible with hand tools. More extensive exploration may require the use of high pressure water or air excavation techniques. Either hydraulic or pneumatic excavation techniques will safely expose tree roots; both have specific benefits dependent on the situation and soil type. An arborist is to be consulted on which system is best suited for the site conditions.

Substantial roots are to be exposed and left intact.

Once roots are exposed decisions can be made regarding the management of the tree. Decisions will be dependent on the tree species, its condition, its age, its relative tolerance to root loss, and the amount of root system exposed and requiring pruning.

Other alternative measures to encroaching the TPZ may include boring or tunnelling.

How to determine the diameter of a substantial root

The size of a substantial root will vary according to the distance of the exposed root to the trunk of the tree. The further away from the trunk of a tree that a root is, the less significant the root is likely to be to the tree's health and stability.

The determination of what is a substantial root is often difficult because the form, depth and spread of roots will vary between species and sites. However, because smaller roots are connected to larger roots in a framework, there can be no doubt that if larger roots are severed, the smaller roots attached to them will die. Therefore, the larger the root, the more significant it may be.

Gilman (1997) suggests that trees may contain 4-11 major lateral roots and that the five largest lateral roots account (act as a conduit) for 75% of the total root system. These large lateral roots quickly taper within a distance to the tree, this distance could be referred to as the Root Plate Radius (Mattheck & Breloer, 1994). Within the Root Plate Radius (RPR) distance, all roots and the soil surrounding the roots are deemed significant.

No root or soil disturbance is permitted within the RPR. In the area outside the RPR, the tree may tolerate the loss of one or a number of roots. The table below indicates the size of tree roots, outside the RPR that would be deemed substantial for various tree heights. The assessment of combined root loss within the TPZ would need to be undertaken by an arborist on an individual basis because the location of the tree, its condition and environment would need to be assessed.

Table 1: Estimated significant root sizes outside RPR

Height of tree	Diameter of root
Less than 5m	≥ 30mm
Between 5m - 15m	≥ 50mm
More than 15m	≥ 70mm

Construction Guidelines

The following are guidelines that must be implemented to minimise the impact of the proposed construction works on the retained trees.

- The Tree Protection Zone (TPZ) is fenced and clearly marked at all times. The actual fence specifications should be a minimum of 1.2 - 1.5 metres of chain mesh or like fence with 1.8 meter posts (e.g. treated pine or star pickets) or like support every 3-4 metres and a top line of high visibility plastic hazard tape. The posts should be strong enough to sustain knocks from on site excavation equipment. This fence will deter the placement of building materials, entry of heavy equipment and vehicles and also the entry of workers and/or the public into the TPZ. Note: There are many different variations on the construction type and material used for TPZ fences, suffice to say that the fence should satisfy the responsible authority.
- Contractors and site workers should receive written and verbal instruction as to the importance of tree protection and preservation within the site. Successful tree preservation occurs when there is a commitment from all relevant parties involved in designing, constructing and managing a development project. Members of the project team need to interact with each other to minimise the impacts to the trees, either through design decisions or construction practices. The importance of tree preservation must be communicated to all relevant parties involved with the site.
- The consultant arborist is on-site to supervise excavation works around the existing trees where the TPZ will be encroached.
- A layer of organic mulch (woodchips) to a depth of no more than 100mm should be placed over the root systems within the TPZ of trees, which are to be retained so as to assist with moisture retention and to reduce the impact of compaction.
- No persons, vehicles or machinery to enter the TPZ without the consent of the consulting arborist or site manager.
- Where machinery is required to operate inside the TPZ it must be a small skid drive machine (i.e Dingo or similar) operating only forwards and backwards in a radial direction facing the tree trunk and not altering direction whilst inside the TPZ to avoid damaging, compacting or scuffing the roots.
- Any underground service installations within the allocated TPZ should be bored and utility authorities should common trench where possible.
- No fuel, oil dumps or chemicals shall be allowed in or stored on the TPZ and the servicing and re-fuelling of equipment and vehicles should be carried out away from the root zones.
- No storage of material, equipment or temporary building should take place over the root zone of any tree.
- Nothing whatsoever should be attached to any tree including temporary services wires, nails, screws or any other fixing device.
- Supplementary watering should be provided to all trees through any dry periods during and after the construction process. Proper watering is the most important maintenance task in terms of successfully retaining the designated trees. The areas under the canopy drip lines should be mulched with woodchip to a depth of no more than 100mm. The mulch will help maintain soil moisture levels. Testing with a soil probe in a number of locations around the tree will help ascertain soil moisture levels and requirements to irrigate. Water needs to be applied slowly to avoid runoff. A daily watering with 5 litres of water for every 30 mm of trunk calliper may provide the most even soil moisture level for roots (Watson & Himelick, 1997), however light frequent irrigations should be avoided. Irrigation should wet the entire root zone and be allowed to dry out prior to another application. Watering should continue from October until April.

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