



Construction Impact Report

for



Assessment of trees adjacent to 257 Crawford Street,
Queanbeyan

Prepared by

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Executive Summary

Four trees were assessed adjacent to 257 Crawford Street, Queanbeyan in relation to construction of the Queanbeyan-Palerang Regional Council (QPRC) Head Office and Smart Hub (HOSH). The table below summarises the impact of the proposed works on the assessed trees.

Construction Impact	Tree Retention Value				Total No. of Trees
	High	Medium	Low	Third Party	
Impact Removal	0	0	0	0	0
Impact Major - not viable	1	0	0	0	1
Impact Major - viable	0	0	0	0	0
Impact Minor	0	1	0	0	1
No Impact	0	2	0	0	2
Remove (tree condition)	0	0	0	0	0

- One tree (Tree 4) **has a major TPZ encroachment** under the proposed design and is not expected to tolerate this impact.
 - Works are proposed across almost the entirety of the TPZ. Of most concern is the impact of the proposed brick retaining wall/seating which is likely to require excavation for footings within the SRZ.
 - The tree has a 'High' retention value and all efforts should be made to retain and protect it throughout the construction process. Recommendations are provided below to enable retention of the tree.
 - Council has advised that the tree has been subject to some root damage during the demolition process. Based on the information provided this is not expected to adversely affect the tree, however root zone mulching has been recommended as a proactive impact mitigation measure.
- **Tree 1 has a minor TPZ encroachment** (less than 10% TPZ area and no SRZ incursion) from the proposed design.
 - This tree is expected to remain viable with standard TPZ provisions and exclusions and with compensation for the area lost to encroachment.
 - In addition, to ensure the tree remains viable post-construction, it is recommended that the proposed crossover/kerb replacement works are undertaken under direct arborist supervision.
- **Trees 2 & 3 have no TPZ encroachment** from the proposed works and are expected to remain viable with standard TPZ provisions and exclusions.

The following is recommended (see Section 8 for more detail):

1. The existing area of mulch around Tree 4 is expanded as soon as practicable to cover the entirety of the TPZ not currently covered by paving.
2. Tree Protecting Fencing as indicated in Section 9 is erected prior to commencement of construction.
3. All underground services are located outside of TPZs of retained trees or bored to a depth of 600mm (top of bore).
4. The design for the proposed brick retaining wall/seating adjacent to Tree 4 is modified to a lighter construction type, void of a concrete strip foundation and subsequent excavation (e.g. stump foundations). These foundations should be installed in a tree sensitive manner.
5. The proposed garden bed at the base of Tree 4 is a mulched bed at grade, with no soil profile changes or deposition of fill.
6. Existing paving within the TPZ of Tree 4 is left *in situ* so as to protect the tree from root zone soil disturbance. This paving should only be removed immediately prior to installation of proposed paving.
7. The proposed paving within the TPZ of Tree 4 should be porous e.g. Eco-Trihex and laid at or above grade.
 - 7.1 In general, level changes associated with paving should be minimised. If fill is required, it should be limited to 100mm above existing grade and used in conjunction with geocells.
8. Where within the TPZ of Tree 1, the proposed crossover/kerb replacement works are undertaken under direct arborist supervision with all major roots (over 40mm dia.) cleanly pruned.
9. Canopy pruning is undertaken on Trees 1 & 4 prior to the commencement of works to limit the potential for mechanical damage to branches during the construction process.

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1. Introduction

Homewood Consulting Pty Ltd has been engaged to provide a construction impact assessment on trees adjacent to 257 Crawford Street, Queanbeyan in relation to the proposed construction of the Queanbeyan-Palerang Regional Council (QPRC) Head Office and Smart Hub (HOSH).

This report has been prepared in accordance with Australian Standard 4970-2009 *Protection of Trees on Development Sites*. It provides an assessment of the trees with regard to their health, structure and retention value in the landscape and identifies the impact of the proposed development on the future longevity of the trees.

The report recommends design and construction methods to minimise impacts on retained trees where there is encroachment into the Tree Protection Zone.

A Tree Protection Plan has been prepared which depicts Tree Protection Zones for trees to be retained and specifies the measures necessary to protect the trees throughout all stages of the proposed works.

2. Method

On Monday, 9 September 2019 Jason Clifford conducted a site inspection.

Data collected for the trees includes:

- Botanical Name
- Canopy Dimensions
- Diameter at Breast Height (DBH)
- Diameter above basal root flare
- Health and Structure
- Useful Life Expectancy (ULE)
- Landscape Contribution
- Retention Value.

A 'Visual Tree Assessment' (VTA) was conducted for each tree. A VTA consists of a detailed visual inspection of a tree and its surrounding site, including a complete walk around the tree, looking at the buttress roots, trunk, branches and leaves. The tree is observed from a distance and close up to consider crown shape, landscape context and surroundings.

The assessment was conducted from ground level with no instruments used other than a diameter tape to measure trunk diameter. Any assessments of decay are qualitative only.

A Preliminary Sketch Plan Report (28/05/2019) has been provided by Cox Architecture. Site Plans located therein (Section 5 of report) have been used to locate Trees 1, 2 & 4 on site. Tree 3 was not plotted on these plans and tree location has been recorded using differentially corrected GPS (generally +/- 1.0m accuracy). Location should be verified by a surveyor if decision making requires greater accuracy.

Section 5 shows the data collected for the trees. For definitions and descriptors of the data collected on site see Appendix 1.

3. Protection of Trees on Development Sites

The Tree Protection Zone (TPZ) is the principal means of protecting trees on development sites. It is a combination of the root area and crown area which is isolated from construction disturbance, so that the tree remains viable. The TPZ incorporates the Structural Root Zone (SRZ), the area around the base of a tree required for the tree's stability in the ground; with the woody root growth and soil cohesion in this area necessary to hold the tree upright. Further description of the TPZ and SRZ, and methods used for their calculation can be seen in Appendix 2.

3.1 Construction impact

The construction impact of a proposed design is determined based on the level of encroachment into the TPZ of a tree as specified in Australian Standard AS4970-2009. The broad types of impact are described below:

Table 1: Construction Impact categories and descriptors

Category	Description
Impact - Removal	The tree is within the footprint of the proposed design and will require removal to facilitate the design. In order to successfully retain the tree, a design modification would be required.
Impact - Major, not viable	The proposed design has a Tree Protection Zone area encroachment greater than 10%, or it impacts the Structural Root Zone. While the tree does not require outright removal under the design, the proposed works are expected to have a significant impact on the tree such that it is expected to die or fail in the future as a result of the works. In order to successfully retain the tree, a design modification would be required which reduces the impact to an acceptable level, unless a non-destructive root exploration has demonstrated that root distribution is limited in the proposed area of works.
Impact - Major, viable	The proposed design has a Tree Protection Zone area encroachment greater than 10%, or impacts the Structural Root Zone. The tree is expected to remain viable because of one, or a combination of the following: - Alternative construction methods are proposed which reduce the impact on the tree - Site conditions have limited root development within the proposed area of works - The species is known to be particularly tolerant to root disturbance - A non-destructive root exploration was undertaken and demonstrated that root distribution was limited in the proposed area of works. The tree will require the establishment of a Tree Protection Zone prior to the commencement of works, which may require compensation for the area lost to encroachment.
Impact - Minor	The proposed design has a Tree Protection Zone area encroachment of less than 10%, and does not impact the structural root zone. The tree is expected to remain a viable landscape component with the establishment of a Tree Protection Zone prior to the commencement of works, which may require compensation for the area lost to encroachment.
No impact	The proposed design does not enter the Tree Protection Zone. The tree is expected to remain a viable landscape component with the establishment of a Tree Protection Zone prior to the commencement of works.
Remove tree (condition)	The tree is in such poor condition that it is recommended for removal, regardless of the proposed design. The tree does not warrant retention and protection throughout the proposed works.

4. Design Proposal

4.1 Existing Conditions

The subject site is located within the CBD of Queanbeyan and is directly adjacent to high-use public spaces such as the Queanbeyan Bicentennial Hall and Queanbeyan Performing Arts Centre, and within proximity to the local library and Council Chambers (Figure 1).

The site was previously occupied by the Queanbeyan Local Library which was demolished between late 2018 and mid-2019. The property is currently vacant; a layer of top soil was spread evenly across the site post-demolition. Council has reported that some root damage occurred to Tree 4 during this process, however based on the information provided this is not expected to adversely affect the tree (root zone mulching has been recommended to mitigate any potential adverse impact of these works).

Three of the assessed trees are located within planting pits between parking bays and are part of a consistent avenue along Crawford Street. The pits are quite large (roughly the size of one parking bay) and are topped with compacted granitic sand.

The remaining tree is located on the adjacent parcel (253 Crawford St- Queanbeyan Bicentennial Hall), but is very near (~2.5m) to the shared property boundary with the subject site and the former library. The majority of the tree's root zone is covered by brick paving which forms a pedestrian thoroughfare between Crawford Street and the Queanbeyan Performing Arts Centre/Public Parking to the rear of the site.



Figure 1: Subject site and existing trees

4.2 Proposed Works

The QPRC HOSH project has involved demolition of the existing building on site and construction of a new Council office and customer service building (Figure 2). The proposed building will include basement carparking, a rear civic square and entry forecourt.

Paving, landscaping and minor roadworks associated with the entry forecourt area are the major design features within the vicinity of the trees.



Figure 2: The proposed QPRC HOSH and subject trees (foreground)

Site Plans showing the location of existing trees and the proposed works have been prepared by Cox Architecture (Section 9 of Preliminary Sketch Plan Report, 28/05/2019). These plans have been used to determine the impact of proposed works on the assessed trees.

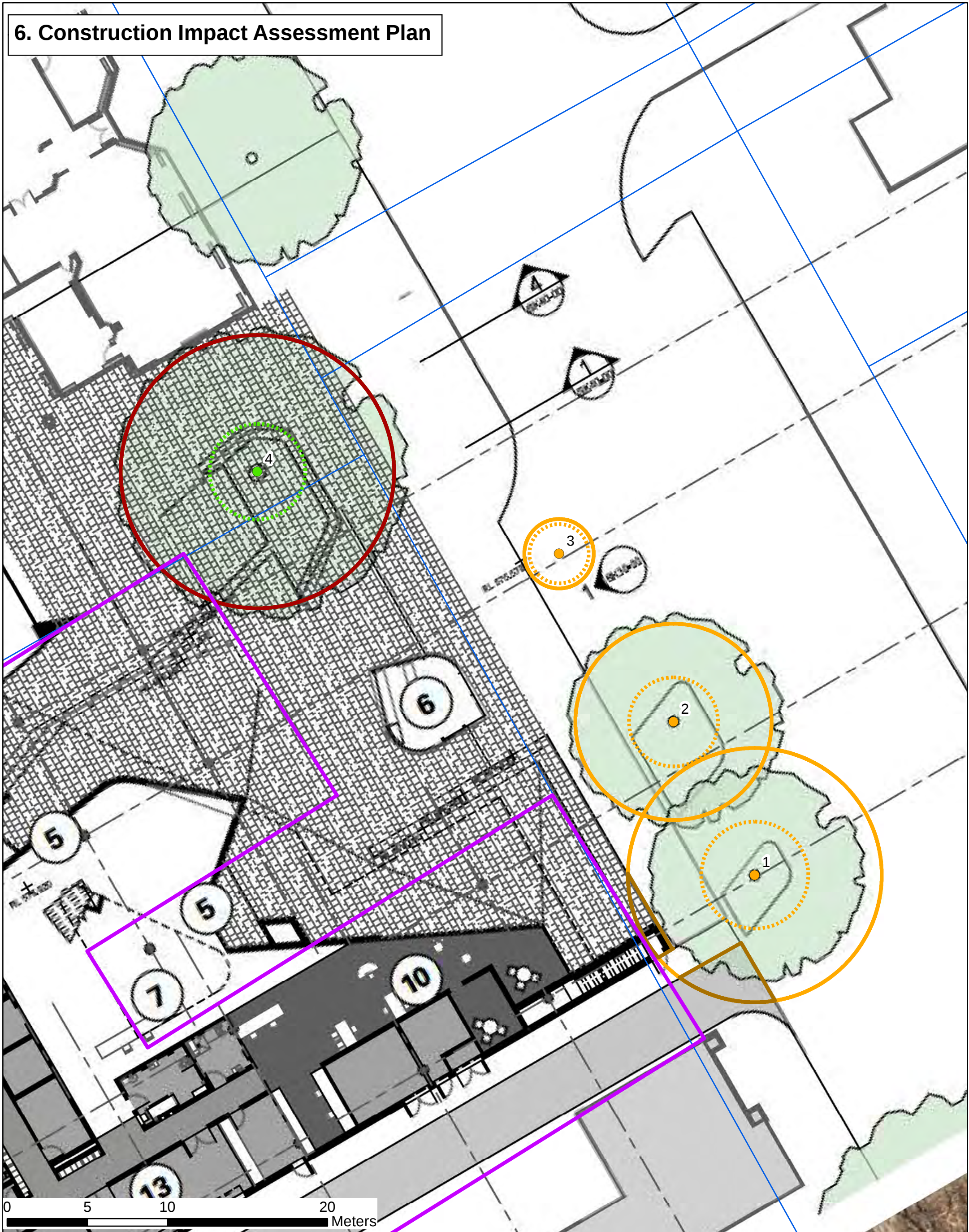
Section 5 displays the assessment data for all trees, as well as the dimensions of the TPZs, SRZs and the construction impact from the proposed design.

Section 6 shows the Construction Impact Assessment Plan. TPZs and SRZs for the assessed trees are depicted to scale and the construction footprint of the proposed works is indicated.

5. Tree Assessments

ID	Botanical Name	Origin	Height & Width (m)	DBH (cm)	Age Class	Health	Structure	ULE (years)	Retention Value	Comments	TPZ Radius (m)	SRZ Radius (m)	TPZ Encroachment (%)	TPZ Impact
1	<i>Quercus palustris</i>	Exotic	9 x 10	66	Mature	Fair	Poor	10 - 20	Medium	Hanging branches	7.92	3.34	8	Impact Minor
2	<i>Quercus palustris</i>	Exotic	9 x 9	51	Mature	Fair	Poor	10 - 20	Medium	Hanging branches	6.12	2.78	0	No impact
3	<i>Quercus palustris</i>	Exotic	7 x 4	18	Semi mature	Good	Fair	20 - 40	Medium		2.16	1.85	0	No impact
4	<i>Platanus x acerifolia</i>	Exotic	14 x 14	71	Mature	Good	Fair	20 - 40	High	SRZ mulched, Shallow fill over much of TPZ, Pruned from removed building	8.52	2.98	100	Impact Major - not viable

6. Construction Impact Assessment Plan



Assessment of TPZ encroachment adjacent to 257 Crawford Street, Queanbeyan

Legend

Trees/TPZs/SRZs by Retention value

● High ● Medium Levels 1-5

TPZ Encroachment

Major
Minor

Base information supplied by: Cox Architecture
Plan: Ground Level
Plotted: JSC
Coordinate System:
GDA 1994 MGA Zone 55
Date: 13/09/2019



7. Construction Impact Assessment Summary

Table 2: Summary of construction impact from the proposed design

Construction Impact	Tree Retention Value				Total No. of Trees
	High	Medium	Low	Third Party	
Impact Removal	0	0	0	0	0
Impact Major - not viable	1	0	0	0	1
Impact Major - viable	0	0	0	0	0
Impact Minor	0	1	0	0	1
No Impact	0	2	0	0	2
Remove (tree condition)	0	0	0	0	0

Of the four trees assessed:

- One tree (Tree 4) **has a major TPZ encroachment** under the proposed design and the tree is not expected to tolerate this impact.
 - Works are proposed across almost the entirety of the TPZ. Of most concern is the impact of the proposed brick retaining wall/seating which is likely to require excavation for footings within the SRZ.
 - The tree has a 'High' retention value and all efforts should be made to retain and protect it throughout the construction process. Recommendations to minimise impact to this tree are provided in Section 8.
- **Tree 1 has a minor TPZ encroachment** (less than 10% TPZ area and no SRZ incursion) from the proposed design.
 - This tree is expected to remain viable with standard TPZ provisions and exclusions and with compensation for the area lost to encroachment.
 - In addition, to ensure the tree remains viable post-construction, it is recommended that the proposed crossover/kerb replacement works are undertaken under direct arborist supervision.
- **Trees 2 & 3 have no TPZ encroachment** from the proposed works and are expected to remain viable with standard TPZ provisions and exclusions.

All retained trees require protection to ensure they remain viable throughout demolition and construction.

8. Recommended Tree Protection Measures

In order to protect retained trees and ensure they remain viable, the following is recommended:

1. The existing area of mulch around Tree 4 is expanded as soon as practicable to cover the entirety of the TPZ not currently covered by paving.
2. Tree Protecting Fencing as indicated in Section 9 is erected prior to commencement of construction. Where works will require access to the TPZ, fencing is to be adjusted with approval of the project arborist, following completion of works fencing should be reinstated to its previous location.
3. All underground services are located outside of TPZs of retained trees or bored to a depth of 600mm (top of bore).
4. The design for the proposed brick retaining wall/seating adjacent to Tree 4 is modified to a lighter construction type void of a concrete strip foundation and subsequent excavation (e.g. stump foundations). These foundations should be installed in a tree sensitive manner:
 - 4.1 Stump holes to be manually excavated under direct arborist supervision.
 - 4.2 Where roots >40mm in diameter are encountered, stumps should be relocated.
5. The proposed garden bed at the base of Tree 4 is a mulched bed at grade, with no soil profile changes or deposition of fill.
 - 5.1 Any planting within the garden bed is done sensitively with holes manually excavated to avoid damage to roots.
6. Existing paving within the TPZ of Tree 4 is left *in situ* so as to protect the tree from root zone soil disturbance. This paving should only be removed immediately prior to installation of proposed paving.
7. The proposed paving within the TPZ of Tree 4 should be porous e.g. Eco-Trihex and be laid at or above grade.
 - 7.1 In general, level changes associated with paving should be minimised. If fill is required, it should be limited to 100mm above existing grade and used in conjunction with geocells.
8. Where within the TPZ of Tree 1, the proposed crossover/kerb replacement works are undertaken under direct arborist supervision with all major roots (over 40mm dia.) cleanly pruned.
9. Canopy pruning is undertaken on Trees 1 & 4 to limit the potential for mechanical damage to branches during the construction process.
 - 9.1 Both trees will require pruning of branches to the south-east of the trunk that are abutting the proposed building footprint. Clearance of 2m from the proposed works footprint is recommended.
 - 9.2 In addition, Tree 1 has a number of low branches (3-4m above ground level) that may require vertical clearance pruning if machinery are accessing the site within the vicinity of the tree. Clearances of 5m above ground level is recommended to provide adequate clearance for machinery.
 - 9.3 In general, clearance pruning should be limited to the minimum amount necessary to obtain required clearances.
 - 9.4 All pruning should be undertaken by a qualified arborist in accordance with AS4373-2007 *Pruning of Amenity Trees*

Further description of the tree protection measures listed can be seen in Appendix 3.

9.Tree Protection Plan

+ Tree Protecting Fencing as indicated to be erected prior to commencement of construction.
- Where works will require access to the TPZ, fencing is to be adjusted with approval of the project arborist, following completion of works fencing should be reinstated to its previous location.
+ All underground services to be located outside of TPZs of retained trees or bored to a depth of 600mm (top of bore).

+ Seating/retaining wall design to be amended to a lightweight construction type e.g. stump foundations.
- Stumps to be manually excavated under direct arborist supervision.
- Where major roots (>40mm) are encountered stumps should be relocated.

+ Existing paving to be left in situ and only removed immediately prior to installation of proposed paving.
+ Proposed paving to be porous and laid at or above grade.
+ If fill is required, it should be limited to 100mm above existing grade and used in conjunction with geocells.

+ Proposed garden bed to be a mulched bed at grade.
- Any planting holes to be manually excavated.

+ Existing area of mulch around Tree 1 is expanded as soon as practicable to cover the entirety of the TPZ not currently covered by paving.

+ Trees 1 & 4 are subject to clearance pruning from the proposed building footprint.
+ Tree 4 may also required vertical clearance pruning of northern branches for machinery access.

+ Proposed crossover/kerb replacement works to be undertaken under direct arborist supervision with all major roots (>40 mm) cleanly pruned.



Tree protection measures for proposed works at 257 Crawford Street, Queanbeyan

Legend

Trees- Retain
Trees- Retain
with design change



TPZ
SRZ



TPZ Fencing
Levels 1-5



Base information supplied by: Cox Architecture
Plan: Ground Level
Plotted: JSC
Coordinate System:
GDA 1994 MGA Zone 55
Date: 13/09/2019



10. References

AS 4970 - 2009, *Australian Standard, Protection of Trees on Development Sites*, Standards Australia.

AS 4374 - 2007, *Australian Standard, Pruning of Amenity Trees*, Standards Australia.

Biddle, P.G., 1998, *Tree root damage to buildings, Causes, Diagnosis and Remedy*, Willowmead Publishing Ltd., Wantage, UK.

Mattheck, C. and Breloer, H. 1994, *The body language of trees: a handbook for failure analysis*, London: HMSO.

Appendix 1. Data Collection Definitions & Descriptors

Tree assessments are based on the assessor's experience and opinion of the tree.

1.1 Botanical name

The scientific name identifying the genus and species of the tree. Each species has only one scientific name.

1.2 Common Name

The colloquial name for a tree species, usually in plain English. Common names for a species are often local or regional and each species can have multiple common names.

1.3 Tree dimensions

Tree height and canopy width in metres (estimated unless stated otherwise).

1.4 DBH

Diameter of the trunk at breast height (1.4m above ground level) measured using a diameter tape. Used to calculate the Tree Protection Zone radius.

1.5 Basal diameter

Diameter of the trunk above the root buttress, measured using a diameter tape. Used to calculate the Structural Root Zone radius.

1.6 Health

Category	Description
Very Good	The tree is demonstrating excellent or exceptional growth. The tree exhibits a full canopy of foliage and is free of pest and disease problems.
Good	The tree is demonstrating good or exceptional growth. The tree exhibits a full canopy of foliage, and has only minor pest or diseases problems.
Fair	The tree is in reasonable condition and growing well. The tree exhibits an adequate canopy of foliage. There may be some deadwood present in the crown. Some grazing by insects or possums may be evident.
Poor	The tree is not growing to its full capacity; extension growth of the laterals is minimal. The canopy may be thinning or sparse. Large amounts of deadwood may be evident throughout the crown. Significant pest and disease problems may be evident or there may be symptoms of stress indicating tree decline.
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 or pest and disease problems may be causing a severe decline in tree health.
Dead	The tree is dead.

1.7 Structure

Category	Description
Good	The tree has a well-defined and balanced crown. Branch unions appear to be sound, with no significant defects evident in the trunk or the branches. Major limbs are well defined. The tree is considered a good example of the species.
Fair	The tree has some minor problems in the structure of the crown. The crown may be slightly out of balance, and some branch unions may be exhibiting minor structural faults. If the tree has a single trunk, it may be on a slight lean or exhibiting minor defects.
Poor	The tree may have a poorly structured crown. The crown may be unbalanced or exhibit large gaps. Major limbs may not be well defined. Branches may be rubbing or crossing over. Branch unions may be poor or faulty at the point of attachment. The tree may have suffered root damage.
Very Poor	The tree has a poorly structured crown. The crown is unbalanced or exhibits large gaps with possibly large sections of deadwood. Major limbs may not be well defined. Branches may be rubbing or crossing over. Branch unions may be poor or faulty at the point of attachment. Branches may exhibit large cracks that are likely to fail in the future. The tree may have suffered major root damage.
Has Failed	A section of the tree has failed or is in imminent danger of failure and the tree is no longer a viable specimen.

1.8 Age Class

Category	Description
Mature	Tree has reached the expected size for the species at the site.
Semi-mature	Established tree that has not yet reach the expected size for the species at the site.
Young	Recently planted tree or juvenile self-sown tree (generally less than 5 years old).

1.9 Useful Life Expectancy (ULE)

Category	Description
40+ years	The tree is in excellent condition and under normal conditions and with appropriate management is expected to continue as a viable landscape component in excess of 40 years.
20 - 40 years	The tree is in good condition and under normal conditions and with appropriate management is expected to continue as a viable landscape component for 20-40 years.
10 - 20 years	The tree is in fair condition and under normal conditions and with appropriate management is expected to continue as a viable landscape component for 10-20 years.
5 - 10 years	The tree is in fair to poor condition or it is not a long lived species. Removal and replacement may be required within the next 10 years.
1 - 5 years	The tree is in poor condition due to advanced decline or structural defect. Removal and replacement may be required within the next 5 years.
0 years	The tree is dead, or is considered hazardous in the location. Removal may be required.

1.10 Tree Origin

Category	Description
Exotic	The species originates in a country other than Australia.
Australian Native	The species originates within Australia.
Indigenous	The species originates within the local environs.

1.11 Contribution to the Landscape

Category	Description
High	Generally a large tree which is a significant component of the local landscape and provides canopy cover to the site. May offer shade and other amenities such as screening. The tree may assist with erosion control, offer a windbreak or perform a vital function in the location (e.g.: Habitat, shade, flowers or fruit).
Medium	Generally a medium sized tree or group of small-medium trees which provide a moderate contribution to the local landscape and canopy cover. The tree may offer screening in the landscape or serve a particular function in the location.
Low	The tree offers little in the way of screening, amenity or canopy cover.
Negligible	The tree offers extremely little to nothing in the way of screening, amenity or canopy cover.

1.12 Tree Retention Value

Term	Description
Very High	Tree of exceptional quality in good condition. A prominent landscape feature and/or of historic, cultural, ecological or other significance. Has the potential to be a medium to long-term landscape component where managed appropriately. All efforts should be made to retain the tree and protect from construction impact.
High	Tree of high quality in good to fair condition. Generally a prominent landscape feature. Has the potential to be a medium to long-term landscape component where managed appropriately. All efforts should be made to retain the tree and protect from construction impact.
Medium	Tree of moderate quality in fair condition. Generally a modest landscape feature. May have a health or structural issue that can be resolved with arboricultural input, or may refer to a medium to small tree in good condition. Has the potential to be a medium to long-term landscape component where managed appropriately. Where practical, design modifications should be considered in order to retain and protect from construction impact.
Low	Either: Tree of low quality in poor condition. Generally provides little amenity value. Unlikely to be a long or medium term landscape component. The tree may be considered a weed species, structurally unsound, dead/dying/diseased, nearing the end of its ULE or may not be suitable for the site. Or: small tree of good or fair condition which is easily replaced in the landscape through planting of advanced stock.
Third party ownership	The tree is located outside of the subject site and is owned by a third party. It may be owned by a private entity (residential) or public body (council). Third party owned trees must be retained and protected from construction impact, unless a mutually acceptable outcome is negotiated with the tree owner and relevant authorities.

Appendix 2. Tree Protection Zones & Structural Root Zones

All parts of the tree may be damaged by development and damage to any one part of the tree will affect its functioning as a whole.

Root damage is the most common cause of damage to trees on development sites. Roots may be removed, wounded, crushed or torn during grading, excavation or trenching. Soil compaction from foot traffic and vehicle traffic results in loss of pore space within the soil which is essential for the exchange of gases between the soil and atmosphere and soil drainage.

Trunks of trees may be wounded mechanically during demolition and construction work. This not only predisposes a tree to potential decay but it also interferes with the transport of water, nutrients and sugars throughout the tree. Serious impacts may structurally weaken the tree.

The canopy of trees can be damaged through incorrect pruning techniques or mechanical injury by trucks, cranes, excavators etc. The removal of leaves reduces the level of photosynthesis and reduces the tree's capacity to function normally and to withstand stresses. Incorrect pruning and mechanical damage can produce wounds that are susceptible to infection by wood decay organisms.

For trees to be retained and their requirements met, procedures have to be in place to protect trees at every stage of the development process. This needs to be taken into account at the earliest planning stage of any outdoor event or design of a development project where trees are involved.

2.1 Tree Protection Zones

The most common method of protecting trees during construction is by setting up a Tree Protection Zone (TPZ). The TPZ is an area isolated from construction disturbance area, so that the tree remains viable. The TPZ has been calculated according to the Australian Standard (AS 4970-2009) for the subject trees. This method calculates the TPZ as 12 times the trunk diameter at 1.4m above ground level (DBH).

A TPZ should not be less than 2m nor greater than 15m, except where additional crown protection is required. The TPZ of palms, other monocots, cycads and tree ferns should not be less than 1m outside of the crown projection.

2.2 Structural Root Zones

The Structural Root Zone (SRZ) is the minimum volume of roots required by the tree to remain stable in the ground. If the SRZ is breached the chances of windthrow are significantly increased. Windthrow is an event where the entire tree fails/falls over.

It is important to note that the SRZ is not related to tree health. It refers to the physical volume of roots required for the tree to remain stable in the ground (Figure 3). It is in no way related to the physiological requirements of the tree, but is the minimum volume of roots required for the tree to remain standing (Mattheck and Breloer 1994).

According to AS4970-2009 the SRZ of the trees has been calculated using the equation:

$$R_{srz} = (D \times 50)^{0.42} \times 0.64$$

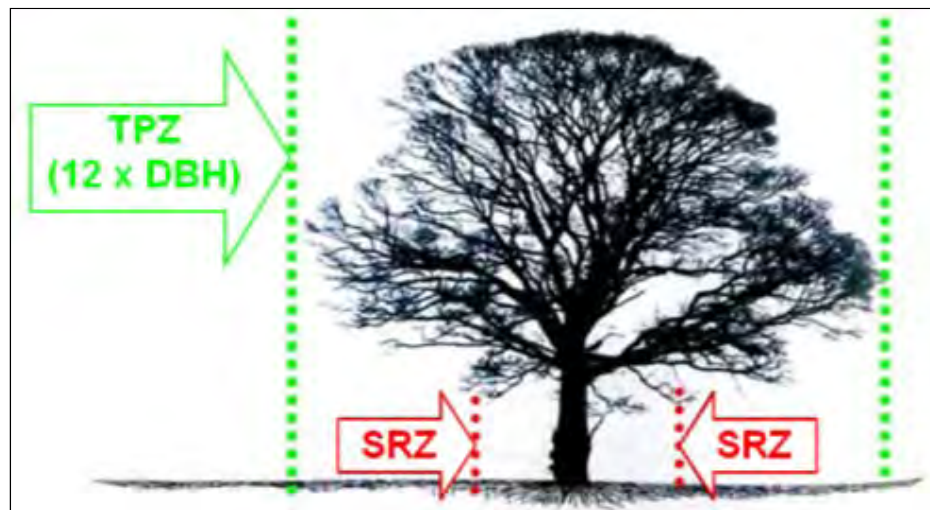


Figure 3: The SRZ = minimum volume of roots required for tree stability. Image from Biddle 1998.

2.3 TPZ and SRZ encroachment

It may be possible to encroach into or make variations to the standard TPZ. Encroachment includes (but is not limited to) excavation, compacted fill and machine trenching.

Table 3: Levels of TPZ encroachment as defined by AS4970-2009

Level of Encroachment	Description / Definition	Requirements
Minor	Encroachment of less than 10% of the TPZ and outside the SRZ is deemed to be minor encroachment.	Detailed root investigations should not be required but the encroachment must be compensated with an extension to the TPZ elsewhere (Figure 4). Variations must be made by the project arborist considering other relevant factors including tree health, vigour, stability, species sensitivity and soil characteristics.
Major	Encroachment of more than 10% of the TPZ or into the Structural Root Zone (SRZ) is deemed to be major encroachment.	The project arborist must demonstrate that the trees would remain viable. This may require root investigation by non-destructive methods and consideration of relevant factors of tree health, vigour, stability, species sensitivity and soil characteristics. The area lost to this encroachment should be compensated for elsewhere and contiguous with the TPZ.

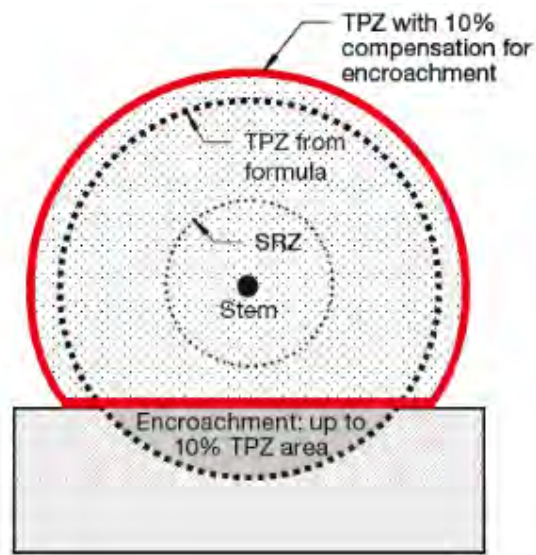


Figure 4: Example of minor TPZ encroachment and compensatory offset (image from AS 4970-2009).

Appendix 3. Tree Protection Measures

3.1 Tree Protection Fencing

The TPZ acts as a physical barrier of protective fencing that is a minimum of 1.8m high. It is installed around retained trees prior to site establishment and retained intact until completion of the works (Figure 5). Once erected, protective fencing must not be removed or altered without approval by the project arborist. The TPZ fence should be secured to restrict access.

Where TPZ fencing is impractical - e.g. if site access is required through the TPZ, other tree protection measures should be used, including ground protection and/or trunk and branch protection.



Figure 5: TPZ fencing is erected around retained trees prior to site works.

3.2 Signs

Signs identifying the TPZ should be placed around the edge of the TPZ and be visible from within the development site (Figure 6).



Figure 6: Example of a TPZ warning sign clearly displayed on TPZ fencing.

3.3 Ground Protection

If temporary access for machinery is required within the TPZ 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 (Figure 7).

3.4 Trunk and Branch Protection

Where trees cannot be isolated from vehicles or machinery by TPZ fencing, trunk and branch protection may be required to prevent mechanical damage. Protection may consist of padding surrounding the trunk or branch, held in place with batons strapped together, or similar (Figure 7). Boards are to be strapped to trees, not nailed or screwed.

Crown protection may also include pruning, tying-back of branches or other measures. If pruning is required, it must be undertaken as per the specifications of AS 4373-2007 *Pruning of Amenity Trees* and should be undertaken before the establishment of the TPZ.

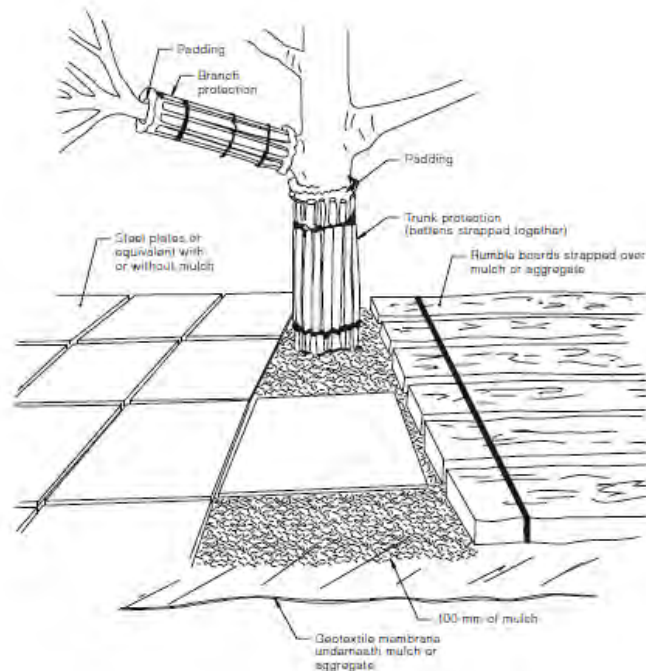


Figure 7: Example of trunk, branch and ground protection (Source: AS 4970-2009).

3.5 TPZ Maintenance

The area within the TPZ should be mulched. The mulch must be maintained to a depth of 50-100 mm. Where the existing landscape within the TPZ is to remain unaltered (e.g. garden beds or turf) mulch may not be required.

Soil moisture levels should be regularly monitored by the project arborist. Temporary irrigation or watering may be required within the TPZ. An above-ground irrigation system should be installed and maintained by a competent individual.

All weeds should be removed by hand without soil disturbance or should be controlled with appropriate use of herbicide.

3.6 Activities restricted within the TPZ

Activities restricted within the TPZ are included but are not limited to:

- machine excavation including trenching
- excavation for silt fencing
- cultivation
- storage
- preparation of chemicals, including preparation of cement products
- parking of vehicles and plant
- refuelling
- dumping of waste
- wash down and cleaning of equipment
- placement of fill
- lighting of fires
- soil level changes
- temporary or permanent installation of utilities and signs
- physical damage to the tree.

3.7 Working within the TPZ

Some works and activities within the TPZ may be authorized by the determining authority. These must be supervised by the project arborist. Any additional encroachment that becomes necessary as the site works progress must be reviewed by the project arborist and be acceptable to the determining authority before being carried out.

3.8 Landscaping

Soft and hard landscaping within Tree Protection Zones should be assessed by the project arborist at the design stage, and prior to the commencement of works. In general:

- There should be no grade changes within the TPZ of trees to be retained. If a level surface is required, no more than 100mm of fill (e.g. topsoil or crushed rock) should be used.
- There should be no soil preparation for landscaping (cultivation, replacement of existing substrate or compaction) within the TPZ of trees to be retained.
- Excavation for planting holes, fence posts, garden edging, etc. should be undertaken manually within the TPZ of trees to be retained. If large roots are encountered these are to be retained unscathed and the location of the landscape component shifted. Any small roots are to be CLEANLY pruned by the project arborist, at right angles, using sharp, clean tools. Paths should be constructed from a permeable or porous material within the TPZ of trees to be retained. Paths must be constructed at or above grade with minimal compaction of the material. There should be no compaction of the subgrade.

3.9 Underground Services

Underground services within Tree Protection Zones should be assessed by the project arborist at the design stage, and prior to the commencement of works.

- All underground services (including water, electricity, gas and telephone) should be located outside of the TPZ of trees to be retained.
- If underground services are to be routed within an established TPZ, they should be installed by directional boring with the top of the bore to be a minimum depth of 600mm below the existing grade.
- Bore pits should be located outside of the TPZ or manually excavated under the direct supervision of the Project Arborist

3.10 Scaffolding

Where scaffolding is required it should be erected outside the TPZ. Where it is essential for scaffolding to be erected within the TPZ, branch removal should be minimised. Ground below the scaffolding should be protected by boarding (e.g. scaffold board or plywood sheeting). Where access is required, a board walk or other surface material should be installed to minimize soil compaction. Boarding should be placed over a layer of mulch and impervious sheeting to prevent soil contamination. The boarding should be left in place until the scaffolding is removed

3.11 Geocells

Porous paving can be used in conjunction with a product such as Geoweb® Cellular Confinement System, which is manufactured in Australia by Geofabrics Australasia Pty Ltd. The system is an expandable, flexible, polymeric, 3-dimensional cellular structure into which infill material is placed (Figure 8). This free draining system (or similar) allows relatively unrestricted movement of air and water into soil. It stabilises soils against erosion and also provides a load support system that minimises long term soil compaction, therefore reducing damage to roots.



Figure 8: Geoweb® Cellular Confinement System

Asset ID:	1		
Botanical Name:	<i>Quercus palustris</i>		
Common Name:	Pin Oak		
Origin:	Exotic		
Height & Width (m):	9 x 10	DBH (cm):	66
Maturity:	Mature	Health:	Fair
ULE:	10 to 20 years	Structure:	Poor
Comments: Hanging branches			

Encroachment Percentage:	8%	TPZ radius (m):	7.92
TPZ Impact (AS 4970):	Minor	SRZ radius (m):	3.34
Retention Value:	Medium		



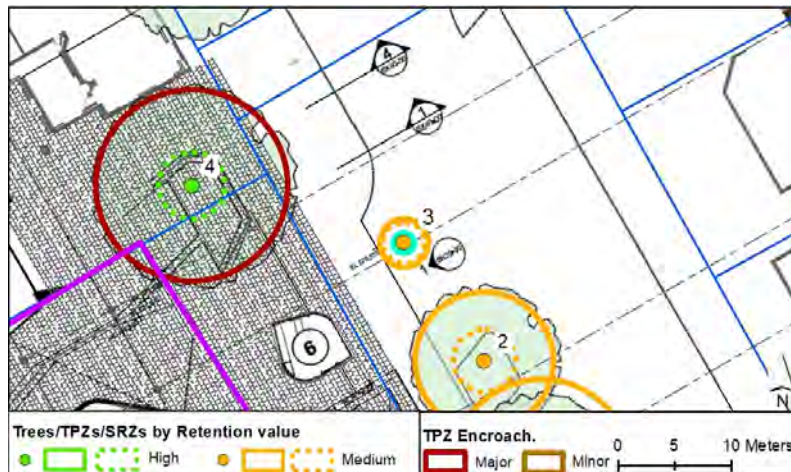
Asset ID:	2		
Botanical Name:	<i>Quercus palustris</i>		
Common Name:	Pin Oak		
Origin:	Exotic		
Height & Width (m):	9 x 9	DBH (cm):	51
Maturity:	Mature	Health:	Fair
ULE:	10 to 20 years	Structure:	Poor
Comments: Hanging branches			

Encroachment Percentage:	0%	TPZ radius (m):	6.12
TPZ Impact (AS 4970):	No impact	SRZ radius (m):	2.78
Retention Value:	Medium		



Asset ID:	3		
Botanical Name:	<i>Quercus palustris</i>		
Common Name:	Pin Oak		
Origin:	Exotic		
Height & Width (m):	7 x 4	DBH (cm):	18
Maturity:	Semi mature	Health:	Good
ULE:	20 to 40 years	Structure:	Fair
Comments:			

Encroachment Percentage:	0%	TPZ radius (m):	2.16
TPZ Impact (AS 4970):	No impact	SRZ radius (m):	1.85
Retention Value:	Medium		



Asset ID:	4		
Botanical Name:	<i>Platanus Xacerifolia</i>		
Common Name:	London Plane		
Origin:	Exotic		
Height & Width (m):	14 x 14	DBH (cm):	71
Maturity:	Mature	Health:	Good
ULE:	20 to 40 years	Structure:	Fair
Comments: SRZ mulched, Shallow fill over much of TPZ, Pruned from removed building			

Encroachment Percentage:	100%	TPZ radius (m):	8.52
TPZ Impact (AS 4970):	Major	SRZ radius (m):	2.98
Retention Value:	High		

