Tree Assessment & Management Report for selected trees at Parks Victoria Werribee Park Mansion

24 January 2022

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green change solutions

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Version 1	Simon Branson	24.01.22
Version 2	Simon Branson	22.01.24

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1. Title Page

Report prepared by:

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Relevant skills and experience:

I have over 30 years' experience as a consulting Arborist as well as delivery of practical services in tree care and tree root management.

The report author has experience and knowledge in: -

- Tree assessments for planning and construction of residential and commercial developments.
- Expertise in tree preservation, and determination of the acceptable tolerances for root loss for existing trees on and in close proximity to the development site.
- Knowledge of root physiology, tree root patterns of growth and construction methods sympathetic to the retention of worthwhile trees, utilizing horticultural and engineering solutions.
- Knowledge of environmental factors determining the behaviour of roots and their impact on hard assets and building footing performance.

Site Address:

Main Drive
Werribee South Vic 3030

2. Executive Summary

Green Change Solutions was engaged by Parks Victoria to undertake an arboricultural assessment of selected trees within the gardens of Werribee Park mansion. The inspection and investigation assessed the potential impact resulting from proposed fire services upgrade works.

Of the sixty-two (62) trees assessed for this report, thirty-one trees (50%) can be classified as mature (or veteran). Although not listed on the significant trees register, they each contribute significantly to the historic nature of the landscape and the overall aesthetics.

The proposed fire services upgrade works will encroach into the TPZs of many trees. It was also determined the proposed alignment of the water supply would encroach into the SRZs of some trees.

Each service will require a trench measuring approximately 500mm wide and 600mm deep. Where there are multiple underground systems required, these will be laid parallel to each other. Any penetration into the soil profile has potential and likely impact on a tree's root system and in turn, potential and likely impact on tree health. Excavation methods such as trenching have the potential to result in severance of the primary woody root system of the trees and significant deleterious impact.

In December 2021, an initial (draft) fire services upgrade layout was provided by the fire services engineer, Omni, for review and comment by Green Change Solutions. The TPZs and SRZs of the proposed layout were overlaid to determine potential impacts to trees. The proposed layout ran through the SRZs of a number of major trees. Discussions with the fire services engineer has resulted in the preparation of a revised layout (January 2022), which significantly reduced potential impact to many of the trees. This revised layout still requires incursion into the TPZs of many trees. Section 5.4.1 of this report proposes excavation alternatives to reduce the potential impact to many of these trees.

In May 2023, a further revision was made to the location of the water storage tanks and the associated pumping equipment. As a result of the revised storage tanks location, two trees (#59 & #60) require removal to facilitate the installation and location of these storage tanks.

To minimise the potential impact and reduce severance of any primary woody roots of trees to be retained, the proposed methodology should be followed:

1. Initial Exploration

The use of an airspade or similar technology that blasts a stream of pressurised air can be used to remove soil in a non-destructive manner with only minimal damage to tree roots. This technique should be used as an 'exploratory' dig to where significant incursion (>10%) into a tree's TPZ is likely to occur.

2. Trenching Technique

The excavation technique proposed for the majority of the underground services is trenching. This technique Involves digging a trench along the length of the proposed pipeline, placing the pipe in the trench on suitable bedding materials and then backfilling. Trenching for underground services, especially if carried out close to the trunk can cause major damage to root systems.

3. Trenchless Technology

Where significant incursion (>10%) is likely to occur, the implementation of trenchless technology or underground boring is advised. The technique minimises disturbance to the tree's root system. Underground boring does require the creation of access pits.

3. Introduction

This report provides:

- an objective assessment of the trees in their current state;
- determines tree protection zones (TPZ) and structural root zones (SRZ) of the subject trees; and
- tree and site management options to ensure the subject trees are expected to remain viable resulting from the proposed fire service upgrade works.

3.1 Survey Purpose

Green Change Solutions was engaged to undertake an arboricultural assessment of specimen trees located within the parkland, to assess the potential impact to their health resulting from proposed fire service upgrade works.

The purpose of the survey is to determine the type and condition of the identified trees within the proposed construction zone and to provide appropriate tree protection measures.

3.2 Management Plan Purpose

This tree management plan is to inform the fire services engineers and contractors of tree-related constraints in relation to the proposed fire service upgrade works. The report provides information on sixty-two (62) specimen trees within the proposed construction zone.

The tree management plan (TMP) proposes:

1. all impacted trees should be represented on future designs and feature surveys as well as respective Tree Protection Zone and Structural Root Zone dimensions applied to scale allowing the tree to be considered and incorporated into the proposal;
2. the fire services engineer and contractors maintain contact with the Project Arborist to minimise potential impact to assessed trees; and
3. details on how impacted trees and their root systems should be managed and protected during excavation works.

Refer to the Attachment A for details on:

- tree location plan;
- TPZ dimensions and encroachment details; and
- proposed tree protection measures.

4. Site Survey

4.1 Site Description

Werribee Park Mansion and its surrounding gardens are included on the Victorian Heritage Register and are of architectural, historic, horticultural, archaeological, and aesthetic significance.

The property is located at the eastern side of the Werribee Plains, approximately 33km south-west of the Melbourne GPO. The establishment of the English-style park setting in the nineteenth century has created a microclimate, assisting in the development of an important stand of mature and significant trees.

The arboricultural specimens within the parkland are an important asset and have been managed well under Parks Victoria's custodianship.

A site inspection was carried out on Monday, November 15, 2021, to assess the identified trees for likely impact resulting from the proposed construction works.

Figure 1 – Aerial view of the Property

4.2 Heritage Victoria Requirements

The entire Werribee Park landscape is classified under the Victoria Heritage Register as a site of "cultural heritage significance". The classification applies to the both the built environment and the scientific (horticultural) environment.

Consequently, Section 36 of the Heritage Act 1995 places a number of obligations on owners of a registered place or object to ensure the protection of the place or object until Heritage Victoria has made its determination. These include the owner being required to advise Heritage Victoria within 10 days if:

- any works are carried out in relation to the place or object; or
- any other activities are being carried out or are proposed to be carried out in relation to the place or object

Parks Victoria is required to comply with the Permit Policy detailed in the Werribee Park Heritage Register H16 that sets out these requirements.

Against the requirements of the Permit Policy, there are a number of exceptions that could apply to the management of the veteran trees covered in these guidelines. Specifically, exceptions to the Permit Policy apply if:

- the removal of dead or dangerous trees and emergency tree works is required to maintain public safety and protect significant buildings, structures and the landscape.

If a tree is removed under this policy exception, a tree removal report must be submitted to Heritage Victoria within 21 days of the removal.

- Trees are managed in accordance with AS4373-1996 Pruning of Amenity Trees
- Trees are managed in accordance with As4790-2009 Protection of Trees on Development Sites

4.3 Arboricultural Assessment Data

The following table presents the collected data on all sixty-two (62) assessed trees covered in this report. The data collected is:

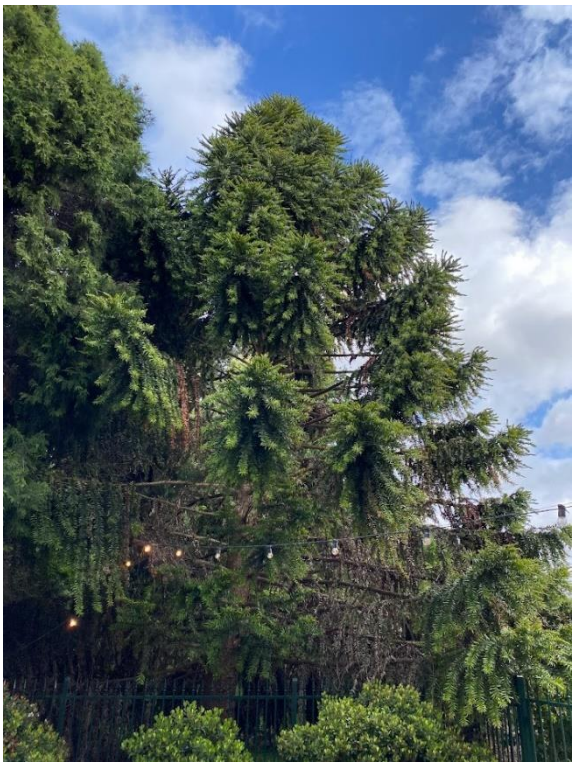
- Tree number
- Genus
- Species
- Quantity
- Origin
- Age
- Height
- Canopy width
- Trunk diameter at breast height (DBH)
- Trunk diameter at ground level
- Structure
- Health
- Useful life expectancy (ULE)
- Tree protection zone (TPZ) (m^2)
- Structural root zone (SRZ) (m^2)
- TPZ area (m^2)
- Incursion area (m^2)
- TPZ encroachment (%)
- Notes / Comments

Tree No.	Genus	Species	Qty	Origin	Age	Height(m)	Width(m)	DBH (m)	D (m)	Structure	Health	ULE (years)	TPZ (m)	SRZ (m)	TPZ Area m^2	Incursion Area m^2	TPZ encroachment %	Notes / Comments
1	Chamaecyparis	lawsoniana	1	Exotic	Semi-mature	12	6	0.8	1.0	Good	Fair to good	30 +	9	3.3	254.5	8.8	3.46%	
2	Araucaria	bidwillii	1	Native	Semi-mature	15	12	0.45	0.6	Good	Good	50+	5.4	2.7	91.6	0.0	0.00%	
3	Cupressus	torulosa	1	Exotic	Mature	15	12	1.76	2.0	Good	Good	50+	21.1	4.4	1401.3	21.0	1.50%	Significant tree register
4	Araucaria	heterophylla	1	Native	Mature	20	15	1.2	1.5	Good	Good	50+	14.4	3.9	651.4	0.0	0.00%	
5	Liquidambar	styraciflua	1	Exotic	Mature	10	8	0.6	0.8	Fair	Good	30+	7.2	3.0	162.9	21.2	13.01%	
6	Quercus	robur	1	Exotic	Mature	12	20	1.7	2.0	Good	Good	50+	20.4	4.4	1307.4	28.1	2.15%	
7	Laguinaria	patersonia	1	Exotic	Semi-mature	6	4	0.4	0.6	Good	Good	30+	4.8	2.7	72.4	0.0	0.00%	
8	Ulmus	procera	1	Exotic	Mature	5	5	0.6	0.75	Good	Good	30+	7.2	2.9	162.9	15.4	9.46%	
9	Arbutus	unedo	1	Exotic	Semi-mature	5	5	0.76	0.9	Good	Good	30+	9.12	3.2	261.3	2.0	0.76%	
10	Pittosporum	undulatum	2	Native	Semi-mature	5	4	0.4	0.6	Good	Good	30+	4.8	2.7	72.4	14.2	19.59%	Weed species
11	Pinus	canariensis	1	Exotic	Mature	18	10	0.65	0.75	Good	Good	30+	7.8	2.9	191.1	35.3	18.47%	Underground boring within TPZ recommended
12	Eucalyptus	globulus	1	Native	Mature	25	12	1.5	1.9	Fair to good	Good	50+	18	4.3	1017.9	230.9	22.68%	Underground boring within TPZ recommended
13	Eucalyptus	leucoxylon	1	Native	Mature	15	8	0.7	0.95	Good	Good	50+	8.4	3.2	221.7	72.6	32.75%	Underground boring within TPZ recommended
14	Fraxinus	angustifolia	1	Exotic	Mature	8	6	0.7	1.0	Good	Good	30+	8.4	3.3	221.7	44.4	20.03%	Underground boring within TPZ recommended
15	Fraxinus	angustifolia	1	Exotic	Semi-mature	8	4	0.33	0.5	Good	Good	30+	3.96	2.5	49.3	0.0	0.00%	
16	Fraxinus	angustifolia	1	Exotic	Semi-mature	8	4	0.7	0.85	Good	Good	30+	8.4	3.1	221.7	7.2	3.25%	
17	Fraxinus	angustifolia	1	Exotic	Semi-mature	8	6	0.5	0.65	Good	Good	30+	6	2.8	113.1	10.7	9.45%	
18	Fraxinus	angustifolia	1	Exotic	Semi-mature	8	3	0.36	0.5	Good	Good	30+	4.3	2.5	58.6	0.0	0.00%	
19	Fraxinus	angustifolia	1	Exotic	Semi-mature	8	3	0.5	0.65	Good	Good	30+	6	2.8	113.1	9.7	8.55%	
20	Fraxinus	angustifolia	1	Exotic	Semi-mature	8	4	0.3	0.5	Good	Good	30+	3.6	2.5	40.7	0.0	0.00%	
21	Fraxinus	angustifolia	1	Exotic	Semi-mature	8	5	0.42	0.55	Good	Good	30+	5.0	2.6	79.8	2.4	2.96%	
22	Fraxinus	angustifolia	1	Exotic	Semi-mature	8	5	0.55	0.65	Fair	Good	30+	6.6	2.8	136.8	15.7	11.47%	
23	Fraxinus	angustifolia	1	Exotic	Mature	8	6	0.42	0.65	Fair	Good	30+	5.0	2.8	79.8	15.5	19.45%	
24	Fraxinus	angustifolia	1	Exotic	Semi-mature	8	6	0.55	0.65	Fair	Good	30+	6.6	2.8	136.8	0.0	0.00%	
25	Fraxinus	angustifolia	1	Exotic	Semi-mature	8	4	0.45	0.6	Fair	Good	30+	5.4	2.7	91.6	0.0	0.00%	
26	Fraxinus	angustifolia	1	Exotic	Semi-mature	8	4	0.48	0.6	Good	Good	30+	5.8	2.7	104.2	0.0	0.00%	
27	Fraxinus	angustifolia	1	Exotic	Semi-mature	8	4	0.3	0.45	Fair	Good	30+	3.6	2.4	40.7	0.0	0.00%	
28	Fraxinus	angustifolia	1	Exotic	Semi-mature	8	6	0.35	0.5	Good	Good	30+	4.2	2.5	55.4	0.0	0.00%	
29	Fraxinus	angustifolia	1	Exotic	Semi-mature	8	6	0.5	0.65	Good	Good	30+	6	2.8	113.1	21.5	18.99%	
30	Cupressus	macrocarpa	1	Exotic	Mature	25	10	2	2.7	Fair	Fair	30+	24	5.0	1809.6	322.5	17.82%	Underground boring within TPZ recommended
31	Pittosporum	undulatum	16	Native	Semi-mature	10	5	0.35	0.55	Fair	Fair	20+	4.2	2.6	55.4	0.0	0.00%	Weed species

Tree No.	Genus	Species	Qty	Origin	Age	Height(m)	Width(m)	DBH (m)	D (m)	Structure	Health	ULE (years)	TPZ (m)	SRZ (m)	TPZ Area m^2	Incursion Area m^2	TPZ encroachment %	Notes / Comments
32	Eucalyptus	maculata	1	Native	Mature	15	5	0.6	0.8	Good	Good	50+	7.2	3.0	162.9	14.2	8.72%	
33	Eucalyptus	maculata	1	Native	Mature	15	5	0.5	0.75	Good	Good	50+	6	2.9	113.1	11.2	9.90%	
34	Eucalyptus	maculata	1	Native	Mature	15	5	0.55	0.8	Good	Good	50+	6.6	3.0	136.8	0.0	0.00%	
35	Eucalyptus	maculata	1	Native	Mature	15	5	0.45	0.55	Good	Good	50+	5.4	2.6	91.6	0.0	0.00%	
36	Araucaria	cunninghamii	1	Native	Mature	25	10	1.5	1.8	Fair to good	Good	50+	18	4.2	1017.9	317.5	31.19%	Underground boring within TPZ recommended
37	Araucaria	cunninghamii	1	Native	Mature	25	10	1.5	1.8	Fair to good	Good	50+	18	4.2	1017.9	185.3	18.20%	Underground boring within TPZ recommended
38	Cupressus	cashmeriana	1	Exotic	Mature	10	8	0.35	0.55	Good	Good	50+	4.2	2.6	55.4	0.0	0.00%	
39	Pinus	halepensis	1	Exotic	Mature	15	15	0.92	1.3	Fair	Fair	30+	11.0	3.7	382.9	25.5	6.66%	
40	Araucaria	cunninghamii	1	Native	Mature	20	10	0.7	1.0	Fair to good	Good	50+	8.4	3.3	221.7	57.5	25.94%	Underground boring within TPZ recommended
41	Grevillea	robusta	1	Native	Semi-mature	8	5	0.35	0.45	Fair	Fair	50+	4.2	2.4	55.4	5.5	9.92%	
42	Schinus	molle	1	Exotic	Mature	15	15	1	2	Fair	Fair to good	50+	12	4.4	452.4	41.7	9.22%	
43	Araucaria	cunninghamii	1	Native	Mature	20	10	0.8	1.2	Fair	Fair to good	50+	9.6	3.6	289.5	0.0	0.00%	
44	Pinus	halepensis	1	Exotic	Mature	12	10	1.3	1.9	Fair to good	Good	50+	15.6	4.3	764.5	94.5	12.36%	Underground boring within TPZ recommended
45	Pittosporum	undulatum	1	Native	Semi-mature	5	3	0.3	0.45	Fair to good	Good	30+	3.6	2.4	40.7	2.0	4.86%	Weed species
46	Agonis	flexuosa	1	Native	Semi-mature	5	3	0.25	0.35	Fair to good	Good	30+	3	2.1	28.3	0.0	0.00%	
47	Araucaria	cunninghamii	1	Native	Mature	20	10	0.8	1.2	Fair to good	Good	50+	9.6	3.6	289.5	24.7	8.53%	Underground boring within TPZ recommended
48	Cupressus	macrocarpa 'Pendula'	1	Exotic	Semi-mature	12	5	0.6	0.7	Fair to good	Good	50+	7.2	2.8	162.9		0.00%	Underground boring within TPZ recommended
49	Araucaria	cunninghamii	1	Exotic	Mature	18	6	0.6	0.85	Fair to good	Good	50+	7.2	3.1	162.9	13.6	8.35%	
50	Pinus	halepensis	1	Exotic	Mature	15	15	1.5	1	Fair	Fair to good	50+	18	3.3	1017.9	99.8	9.80%	Underground boring within TPZ recommended
51	Cupressus	macrocarpa	1	Exotic	Mature	20	8	0.7	0.85	Fair to good	Good	50+	8.4	3.1	221.7	42.3	19.08%	Underground boring within TPZ recommended
52	Araucaria	cunninghamii	1	Native	Mature	20	10	1	1.4	Fair to good	Good	50+	12	3.8	452.4	58.9	13.02%	Underground boring within TPZ recommended
53	Olea	europaea	1	Exotic	Semi-mature	4	3	0.15	0.3	Fair to good	Good	50+	1.8	2.0	10.2	0.0	0.00%	
54	Araucaria	cunninghamii	1	Exotic	Mature	20	10	0.8	1	Good	Good	50+	9.6	3.3	289.5	26.6	9.19%	Underground boring within TPZ recommended
55	Araucaria	cunninghamii	1	Native	Mature	18	8	1.1	1.6	Fair to good	Good	50+	13.2	4.0	547.4	30.5	5.57%	
56	Olea	europaea	1	Exotic	Semi-mature	4	4	0.12	0.3	Fair to good	Good	50+	1.4	2.0	6.5	0.0	0.00%	
57	Olea	europaea	1	Exotic	Semi-mature	4	4	0.15	0.35	Fair to good	Good	50+	1.8	2.1	10.2	0.0	0.00%	
58	Olea	europaea	1	Exotic	Semi-mature	4	4	0.29	0.7	Fair to good	Good	50+	3.5	2.8	38.0	7.8	20.50%	
59	Olea	europaea	1	Exotic	Semi-mature	4	4	0.36	0.7	Fair to good	Good	50+	4.3	2.8	58.6	0.0	0.00%	Removal required
60	Schinus	molle	1	Exotic	Semi-mature	3	5	0.49	1.1	Fair to good	Good	50+	5.9	3.4	108.6	0.0	0.00%	Removal required
61	Olea	europaea	1	Exotic	Semi-mature	3	4	0.23	0.6	Fair to good	Good	50+	2.8	2.7	23.9	0.0	0.00%	
62	Ficus	macrophylla	1	Native	Mature	16	20	1.1	1.9	Good	Good	50+	13.2	4.3	547.4	34.7	6.34%	

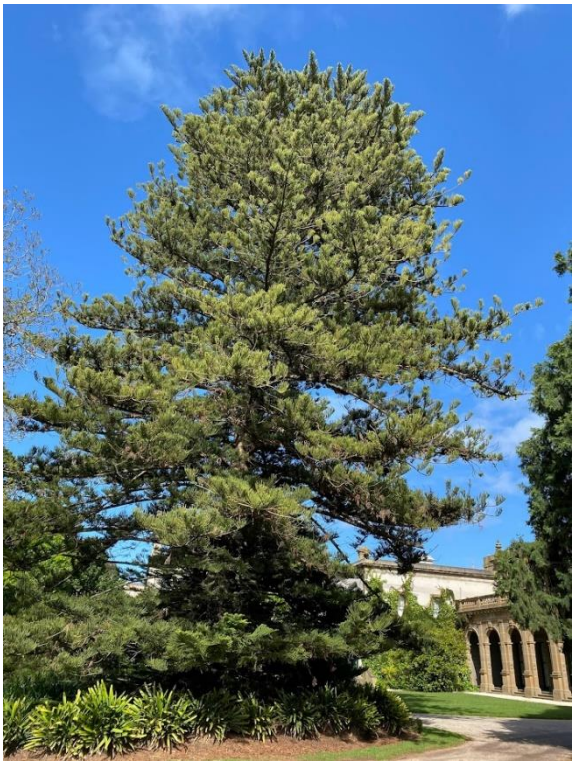
4.4 Arboricultural Assessment Images

Tree #1



Tree #2

Tree #3



Tree #4

Tree #5

Tree #6

Tree #7

Tree #8

Tree #9

Tree #10

Tree #11

Tree #12

Tree #13

Tree #14

Tree #15

Tree #16

Tree #17

Tree #18

Tree #19

Tree #20

Tree #21

Tree #22

Tree #23

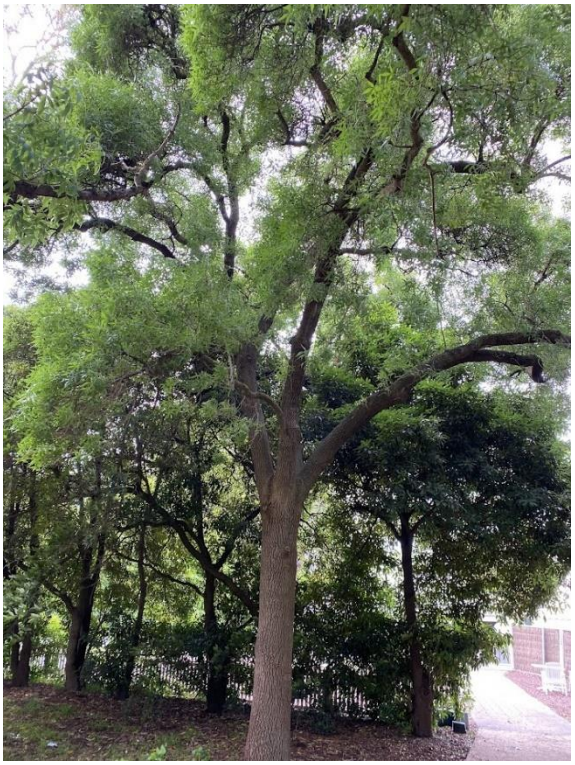
Tree #24

Tree #25

Tree #26

Tree #27

Tree #28



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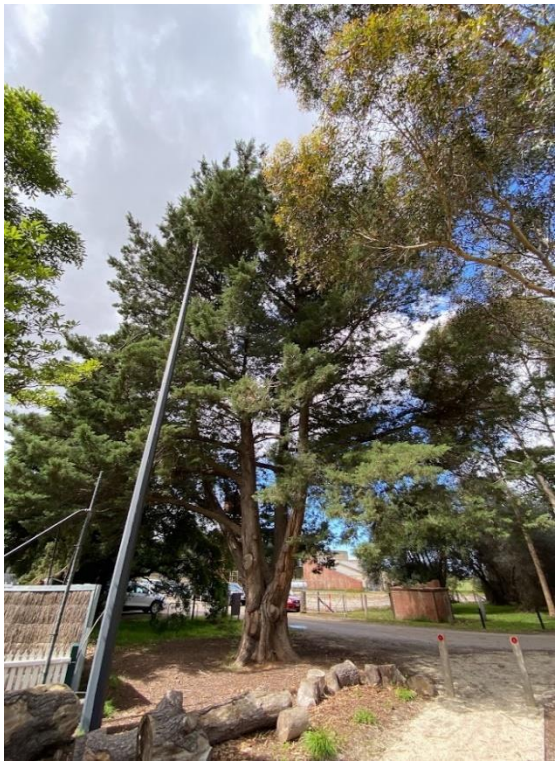


Tree #30

Tree #31

Tree #32

Tree #33

Tree #34

Tree #35

Tree #36

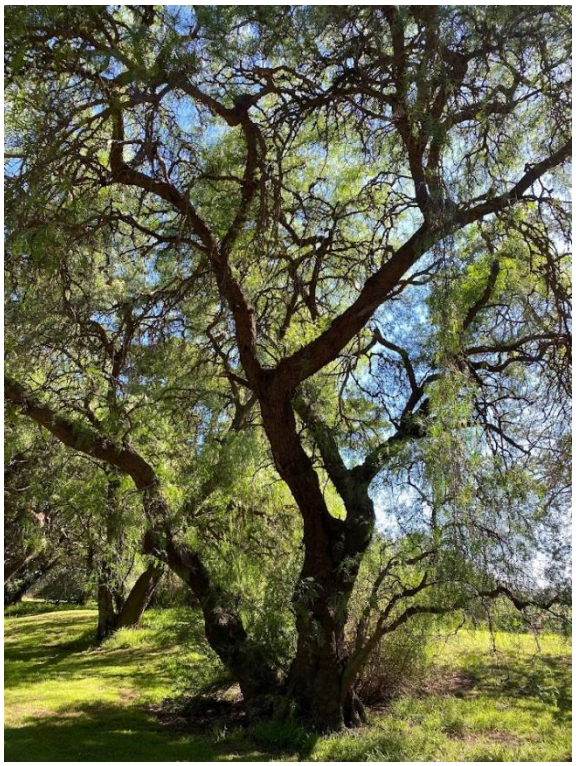
Tree #37

Tree #38

Tree #39

Tree #40

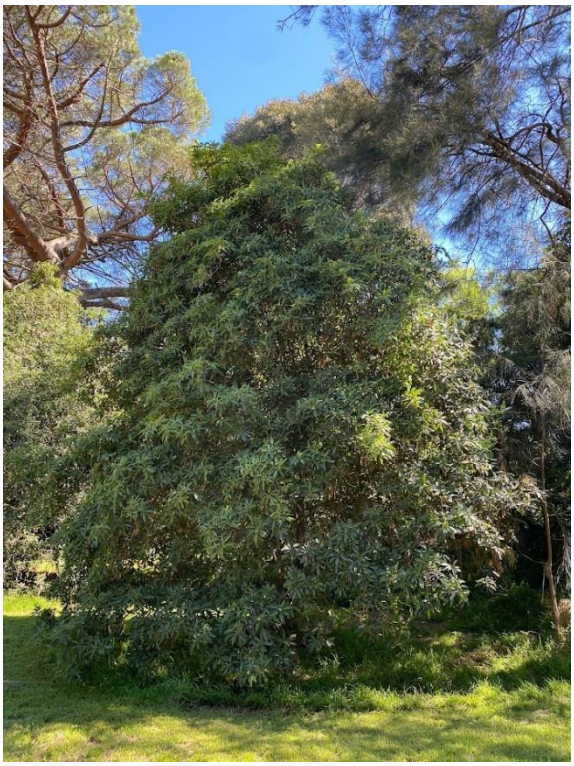
Tree #41



Tree #42

Tree #43

Tree #44



Tree #45

Tree #46

Tree #47

Tree #48

Tree #49

Tree #50

Tree #51

Tree #52

Tree #53

Tree #54

Tree #55

Tree #56

Tree #57

Tree #58

Tree #59

Tree #60

Tree #61

Tree #62

4.5 Observations

The grounds of the Werribee Park Mansion contain a large number of mature, significant and veteran trees. A veteran tree can be defined as: 'a tree that is of interest biologically, culturally or aesthetically because of its age, size or condition'. Some trees are instantly recognisable as veterans, but many are less obvious. Within the landscape there are seventeen (17) trees on the National Trust of Victoria's significant tree register.

Of the sixty-two (62) trees assessed for this tree management plan, only one tree, tree number **three** (*Cupressus torulosa*) is on the significant tree register. The description of this tree on the Trust Trees' website (https://trusttrees.org.au/tree/VIC/Werribee/Werribee_Park_Mansion_320_K_Road_3) cites multiple areas of significance for this tree:

- Outstanding size (Scientific)
- Outstanding species (Scientific)
- Location/Context (Social)
- Landscape (Social)

Of the sixty-two trees assessed for this report, thirty-one trees (50%) can be classified as mature (or veteran). Although not listed on the significant trees register, they each contribute significantly to the historic nature of the landscape and the overall aesthetics, in addition to making positive environmental contributions.

The health, condition and structure of these trees varies greatly. Some trees are in a good state of health and present a sound structure, whilst others have only fair health and present a fair structure – refer to 4.3 Arboricultural Assessment Data for individual tree details.

There is a tendency to view old and mature trees as immutable and immortal. They have demonstrated resilience to past threats but some of the potential threats today don't have precedents or are taking place at a rate that may outstrip the ability of the trees to adapt. Vigilance is required to identify future risks and threats.

As to be expected with trees of the size and age assessed, their root systems will be extensive. Root systems consist of three main parts - the primary woody root system (anchorage, storage and transport), secondary woody roots (anchorage, exploration, storage and transport) and non-woody roots (absorption of water and nutrients, storage, synthesis of amino acids and growth regulators). Hand digging a number of test trenches is the only way to confirm the location of major woody roots, thereby reducing potential negative impact on the trees.

The closer the invasive activity is to the trunk, the greater the potential for root damage resulting in an increased risk of future tree failure. Consequently, it will be critical for the contractors to ensure TPZ distances are 'religiously' applied during construction / excavation activities. Trees generally have stored energy in their branches and trunks to allow them to survive after the roots are damaged. It may take 2 or 3 years for a tree to begin to look like it is declining. It may take up to 5 years for root damage to result in tree death.

An initial (draft) fire services upgrade layout was provided by the fire services engineer, Omni, for review and comment by Green Change Solutions. The TPZs and SRZs of the proposed layout were overlaid to determine potential impacts to trees. The proposed layout ran through the SRZs of a number of major trees. Discussions with the fire services engineer has resulted in the preparation of a revised layout, which will significantly reduce potential impact on many of

trees. This revised layout will still require incursion into the TPZs of many trees. Section 5.2.1 of this report details the impacted trees and the % incursion into their TPZs. Section 5.4.1 of this report proposes excavation alternatives to reduce the potential impact to many of these trees.

It must be noted, trees are living organisms; the responses can be predicted but not definitively asserted. Nevertheless, the implementation of recommendations in this report will reduce potential negative impacts to assist with the long-term survival of these trees.

4.6 Tree Root Growth: An Overview

Tree roots are composed of woody lateral roots radiating from the trunk. These provide a supporting framework for the tree anchoring it to the ground. The size of these decreasing with increasing distance from the trunk. These larger roots located in what is termed the SRZ Structural root zone provide a supporting framework for the finer 'feeder' roots both woody and non woody roots, (many which are not visible to the human eye) absorb nutrients and water and are in symbiotic mutually beneficial relationships with soil biota such as fungi. In most soils upward of 90 % of tree roots can be found in the upper 600 mm of the soil profile, where there is available moisture and oxygen to sustain root growth.

The SRZ Structural root zone, is that radial area as measured from the trunk centre in which there must not be any disturbance or root pruning.

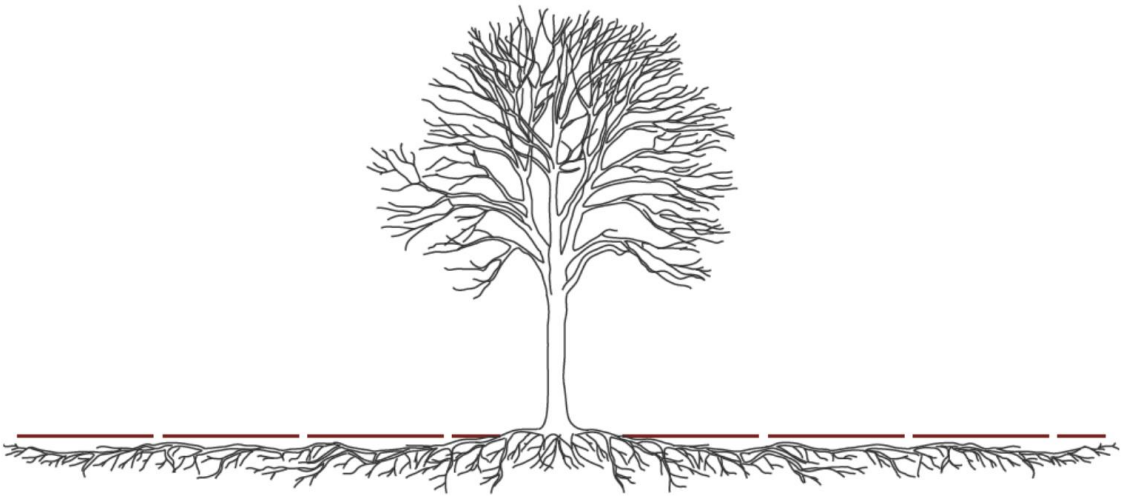


Figure 2 (Watson & Neely 1994)

5. Arboricultural Impact Assessment

The intention of this assessment is to determine the incursion to the root zones by the proposed excavation works and evaluate the likely impact of the proposed works on the assessed trees. Details shown on the following plans were used in this assessment:

Table 2

Title	Author	Dwg No.	Date
Upgrade Works Site Plan / Survey	Omni	F-SP-00 (T2) & F-SP-01 (T2)	Jan 2023
Site Plan TPZ Encroachment	Green Change Solutions	N/A	05.06.23

The following criteria have been examined as part of this assessment:

- Tree Protection Zone (TPZ);
- Structural Root Zone (SRZ);
- Footprint and envelope of the proposed excavation works and new structures;
- Incursions to the TPZ & SRZ, including estimated excavation areas; and
- Assessment of the likely impact of the works on existing trees.

The proposed excavation works will encroach into the majority of the assessed trees. The extent of this encroachment ranges from less than 1% up to over 32% during construction. The extent to which the excavation works will impact negatively on the health of the tree will be influenced by the proposed excavation methods.

5.1 Impact Assessment

There are two types of zones (as defined by AS 4970-2009) that need to be considered when undertaking an arboricultural impact assessment:

- **Tree protection zone (TPZ)**: The TPZ is the optimal combination of crown and root area (as defined by AS 4970-2009) that requires protection during the construction process so that the tree can remain viable. The TPZ is calculated by measuring the diameter at breast height (DBH) and multiplying it by twelve (12). The resulting value is applied as a radial measurement from the centre of the trunk to delineate the TPZ.
- **Structural root zone (SRZ):** The SRZ is the area of the root system used for stability, mechanical support, and anchorage of the tree.
  The SRZ is the absolute minimum that should be considered for protection. Any violation of this zone creates a high probability of tree failure. The impact of violating the SRZ is greatly compounded if damage occurs on multiple sides. The loss of multiple flare roots sets the stage for catastrophic tree failure.

Encroachment within the TPZ is acceptable, providing that the arborist can demonstrate that the tree will remain viable. There are three (3) levels of encroachment (as defined by AS 4970-2009):

- No encroachment (0%): No encroachment within the TPZ.
- Minor encroachment (<10%): The encroachment is less than 10% of the TPZ.
- Major encroachment (>10%): The encroachment is greater than 10% of the TPZ.

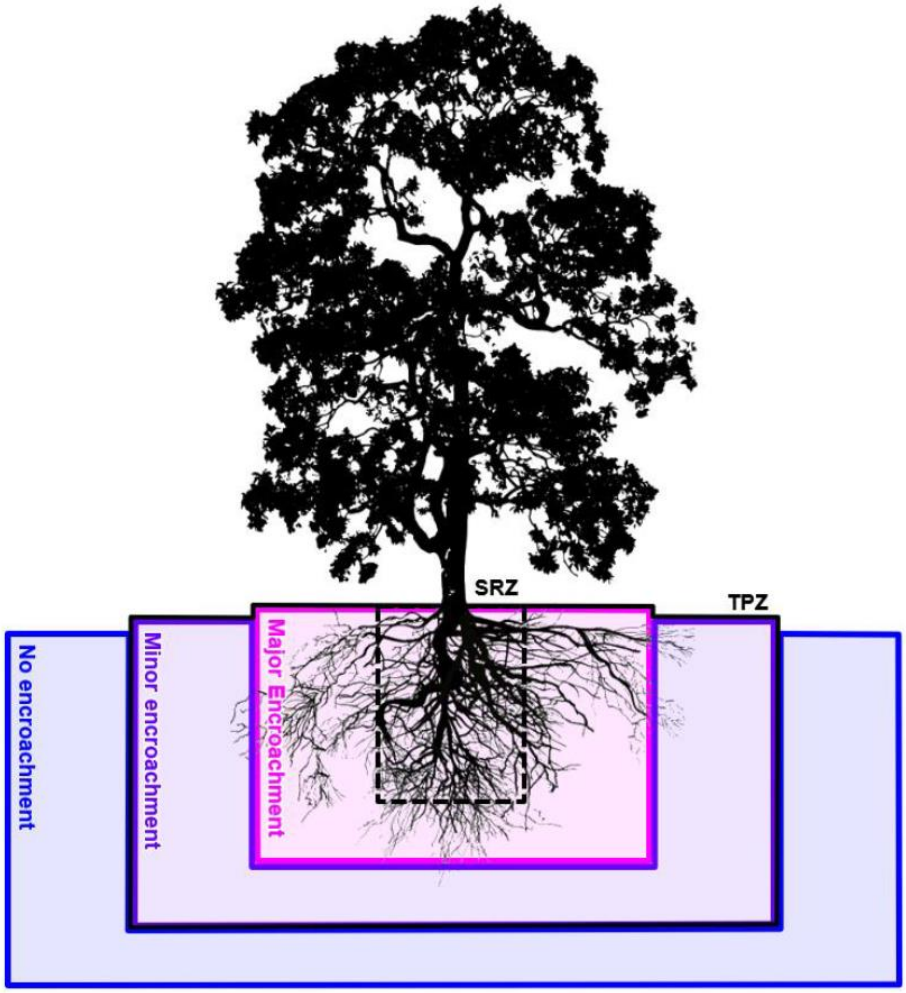


Figure 3: Three (3) Levels of Encroachment

5.1.1 Minor encroachment AS 4970-2009

Encroachment of less than 10% of the TPZ and outside the SRZ is deemed to be minor encroachment according to AS 4970-2009. Detailed root investigations should not be required but must be compensated with an extension to the TPZ elsewhere (refer Figure 8). Variations must be made by the Project Arborist considering other relevant factors including tree health, vigour, stability, species sensitivity and soil characteristics.

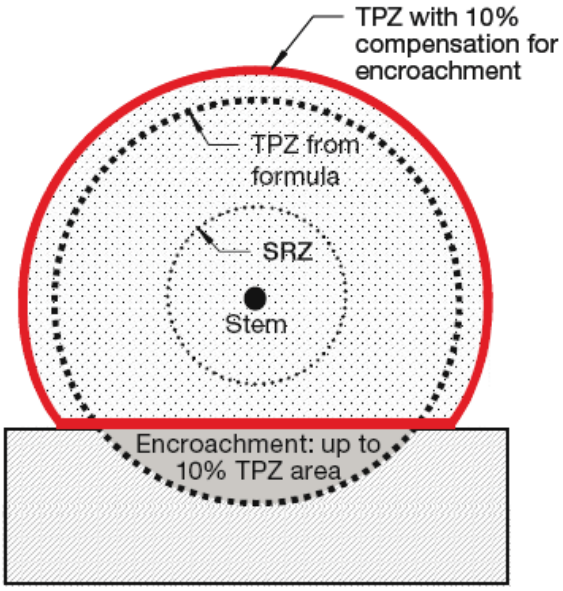


Figure 4: Example of TPZ encroachment and compensatory offset (image from AS 4970-2009)

5.1.2 Major encroachment AS 4970-2009

Encroachment of more than 10% of the TPZ or into the SRZ is deemed to be major encroachment according to AS 4970-2009. The Project Arborist must demonstrate 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 tree health, vigour, stability, species sensitivity and soil characteristics.

5.2 Summary of Encroachment

The following table presents the percentage encroachment of the proposed excavation works into TPZ for all assessed trees.

5.2.1 TPZ Dimension Summary

The following table provides a summary of the TPZ dimensions, incursion areas and % TPZ encroachment for all trees.

Table 3

Tree No.	Genus	Species	TPZ (m)	TPZ Area m^2	Incursion Area m^2	TPZ encroachment %
1	Chamaecyparis	lawsoniana	9	254.5	8.8	3.46%
2	Araucaria	bidwillii	5.4	91.6	0.0	0.00%
3	Cupressus	torulosa	21.1	1401.3	21.0	1.50%

Tree No.	Genus	Species	TPZ (m)	TPZ Area m²	Incursion Area m²	TPZ encroachment %
4	Araucaria	heterophylla	14.4	651.4	0.0	0.00%
5	Liquidambar	styraciflua	7.2	162.9	21.2	13.01%
6	Quercus	robur	20.4	1307.4	28.1	2.15%
7	Laguinaria	patersonia	4.8	72.4	0.0	0.00%
8	Ulmus	procera	7.2	162.9	15.4	9.46%
9	Arbutus	unedo	9.12	261.3	2.0	0.76%
10	Pittosporum	undulatum	4.8	72.4	14.2	19.59%
11	Pinus	canariensis	7.8	191.1	35.3	18.47%
12	Eucalyptus	globulus	18	1017.9	230.9	22.68%
13	Eucalyptus	leucoxylon	8.4	221.7	72.6	32.75%
14	Fraxinus	angustifolia	8.4	221.7	44.4	20.03%
15	Fraxinus	angustifolia	3.96	49.3	0.0	0.00%
16	Fraxinus	angustifolia	8.4	221.7	7.2	3.25%
17	Fraxinus	angustifolia	6	113.1	10.7	9.45%
18	Fraxinus	angustifolia	4.3	58.6	0.0	0.00%
19	Fraxinus	angustifolia	6	113.1	9.7	8.55%
20	Fraxinus	angustifolia	3.6	40.7	0.0	0.00%
21	Fraxinus	angustifolia	5.0	79.8	2.4	2.96%
22	Fraxinus	angustifolia	6.6	136.8	15.7	11.47%
23	Fraxinus	angustifolia	5.0	79.8	15.5	19.45%
24	Fraxinus	angustifolia	6.6	136.8	0.0	0.00%
25	Fraxinus	angustifolia	5.4	91.6	0.0	0.00%
26	Fraxinus	angustifolia	5.8	104.2	0.0	0.00%
27	Fraxinus	angustifolia	3.6	40.7	0.0	0.00%
28	Fraxinus	angustifolia	4.2	55.4	0.0	0.00%

Tree No.	Genus	Species	TPZ (m)	TPZ Area m²	Incursion Area m²	TPZ encroachment %
29	Fraxinus	angustifolia	6	113.1	21.5	18.99%
30	Cupressus	macrocarpa	24	1809.6	322.5	17.82%
31	Pittosporum	undulatum	4.2	55.4	0.0	0.00%
32	Eucalyptus	maculata	7.2	162.9	14.2	8.72%
33	Eucalyptus	maculata	6	113.1	11.2	9.90%
34	Eucalyptus	maculata	6.6	136.8	0.0	0.00%
35	Eucalyptus	maculata	5.4	91.6	0.0	0.00%
36	Araucaria	cunninghamii	18	1017.9	317.5	31.19%
37	Araucaria	cunninghamii	18	1017.9	185.3	18.20%
38	Cupressus	cashmeriana	4.2	55.4	0.0	0.00%
39	Pinus	halepensis	11.0	382.9	25.5	6.66%
40	Araucaria	cunninghamii	8.4	221.7	57.5	25.94%
41	Grevillea	robusta	4.2	55.4	5.5	9.92%
42	Schinus	molle	12	452.4	41.7	9.22%
43	Araucaria	cunninghamii	9.6	289.5	0.0	0.00%
44	Pinus	halepensis	15.6	764.5	94.5	12.36%
45	Pittosporum	undulatum	3.6	40.7	2.0	4.86%
46	Agonis	flexuosa	3	28.3	0.0	0.00%
47	Araucaria	cunninghamii	9.6	289.5	24.7	8.53%
48	Cupressus	macrocarpa 'Pendula'	7.2	162.9		0.00%
35	Araucaria	cunninghamii	7.2	162.9	13.6	8.35%
36	Pinus	halepensis	18	1017.9	99.8	9.80%
37	Cupressus	macrocarpa	8.4	221.7	42.3	19.08%
38	Araucaria	cunninghamii	12	452.4	58.9	13.02%
39	Olea	europaea	1.8	10.2	0.0	0.00%

Tree No.	Genus	Species	TPZ (m)	TPZ Area m²	Incursion Area m²	TPZ encroachment %
40	Araucaria	cunninghamii	9.6	289.5	26.6	9.19%
41	Araucaria	cunninghamii	13.2	547.4	30.5	5.57%
42	Olea	europaea	1.4	6.5	0.0	0.00%
43	Olea	europaea	1.8	10.2	0.0	0.00%
44	Olea	europaea	3.5	38.0	7.8	20.50%
45	Olea	europaea	4.3	58.6	0.0	0.00%
46	Schinus	molle	5.9	108.6	0.0	0.00%
47	Olea	europaea	2.8	23.9	0.0	0.00%
48	Ficus	macrophylla	13.2	547.4	34.7	6.34%

5.2.2 Structural Root Zones

The structural root zone (SRZ) is an area considered essential for tree stability. Loss of roots in this area is likely to cause the tree to become unstable in the ground. The dimensions of the SRZ are determined from the diameter of the tree taken above the root flare.

Based on the proposed layout provided by Omni (FS-SP-00 & FS-SP-01) there will not be any incursion into the SRZs of any of the trees – nor should there be.

5.3 Corrective Works

The following table summarises the recommend and proposed corrective works required for the assessed trees.

Table 4

Tree No.	Genus & species	Works Required
1	Chamaecyparis lawsoniana	Minimise disturbance within TPZ
2	Araucaria bidwillii	Minimise disturbance within TPZ
3	Cupressus torulosa	Significant tree register - minimise disturbance within TPZ
4	Araucaria heterophylla	Minimise disturbance within TPZ
5	Liquidambar styraciflua	Minimise disturbance within TPZ
6	Quercus robur	Minimise disturbance within TPZ
7	Laguinaria patersonia	Minimise disturbance within TPZ
8	Ulmus procera	Minimise disturbance within TPZ
9	Arbutus unedo	Minimise disturbance within TPZ
10	Pittosporum undulatum	Weed species
11	Pinus canariensis	Underground boring within TPZ recommended

Tree No.	Genus & species	Works Required
12	Eucalyptus globulus	Underground boring within TPZ recommended
13	Eucalyptus leucoxylon	Underground boring within TPZ recommended
14	Fraxinus angustifolia	Underground boring within TPZ recommended
15	Fraxinus angustifolia	Minimise disturbance within TPZ
16	Fraxinus angustifolia	Minimise disturbance within TPZ
17	Fraxinus angustifolia	Minimise disturbance within TPZ
18	Fraxinus angustifolia	Minimise disturbance within TPZ
19	Fraxinus angustifolia	Minimise disturbance within TPZ
20	Fraxinus angustifolia	Minimise disturbance within TPZ
21	Fraxinus angustifolia	Minimise disturbance within TPZ
22	Fraxinus angustifolia	Minimise disturbance within TPZ
23	Fraxinus angustifolia	Minimise disturbance within TPZ
24	Fraxinus angustifolia	Minimise disturbance within TPZ
25	Fraxinus angustifolia	Minimise disturbance within TPZ
26	Fraxinus angustifolia	Minimise disturbance within TPZ
27	Fraxinus angustifolia	Minimise disturbance within TPZ
28	Fraxinus angustifolia	Minimise disturbance within TPZ
29	Fraxinus angustifolia	Minimise disturbance within TPZ
30	Cupressus macrocarpa	Underground boring within TPZ recommended
31	Pittosporum undulatum	Weed species
32	Eucalyptus maculata	Minimise disturbance within TPZ
33	Eucalyptus maculata	Minimise disturbance within TPZ
34	Eucalyptus maculata	Minimise disturbance within TPZ
35	Eucalyptus maculata	Minimise disturbance within TPZ
36	Araucaria cunninghamii	Underground boring within TPZ recommended
37	Araucaria cunninghamii	Underground boring within TPZ recommended
38	Cupressus cashmeriana	Minimise disturbance within TPZ
39	Pinus halepensis	Minimise disturbance within TPZ
40	Araucaria cunninghamii	Underground boring within TPZ recommended
41	Grevillea robusta	Minimise disturbance within TPZ
42	Schinus molle	Minimise disturbance within TPZ
43	Araucaria cunninghamii	Minimise disturbance within TPZ
44	Pinus halepensis	Underground boring within TPZ recommended
45	Pittosporum undulatum	Weed species
46	Agonis flexuosa	Minimise disturbance within TPZ
47	Araucaria cunninghamii	Underground boring within TPZ recommended
48	Cupressus macrocarpa 'Pendula'	Underground boring within TPZ recommended
49	Araucaria cunninghamii	Minimise disturbance within TPZ
50	Pinus halepensis	Underground boring within TPZ recommended

Tree No.	Genus & species	Works Required
51	Cupressus macrocarpa	Underground boring within TPZ recommended
52	Araucaria cunninghamii	Underground boring within TPZ recommended
53	Olea europaea	Minimise disturbance within TPZ
54	Araucaria cunninghamii	Underground boring within TPZ recommended
55	Araucaria cunninghamii	Minimise disturbance within TPZ
56	Olea europaea	Minimise disturbance within TPZ
57	Olea europaea	Minimise disturbance within TPZ
58	Olea europaea	Minimise disturbance within TPZ
59	Olea europaea	Removal required
60	Schinus molle	Removal required
61	Olea europaea	Minimise disturbance within TPZ
62	Ficus macrophylla	Minimise disturbance within TPZ

5.4 Mitigating the Impacts

Encroachment within the TPZ should be compensated with a range of mitigation measures to ensure impacts to the subject tree are reduced or restricted wherever possible. Mitigation should be increased relative to the level of encroachment within the TPZ to ensure the subject tree(s) remain viable. The table below outlines requirements under AS 4970-2009, and mitigation measures required within each category of encroachment.

Table 5

Encroachment	Mitigation Measures
No encroachment (0%)	• N/A
Minor encroachment (<10%)	• The area lost to this encroachment should be compensated for elsewhere, contiguous to the TPZ • Detailed root investigations should not be required • Tree protection must be installed
Major encroachment (>10%)	• The project arborist must demonstrate the tree(s) would remain viable • Root investigation by non-destructive methods may be required for any trees proposed for retention • Consideration of relevant factors, including root location and distribution, tree species, condition, site constraints and design factors • The area lost to this encroachment should be compensated for elsewhere, contiguous with the TPZ • The project arborist will be required to supervise any works within the TPZ • Tree protection must be installed

5.4.1 Excavation Methodologies & Considerations

The fire hydrant supply line services, like a lot of utility service are located underground. The proposed fire service upgrade will necessitate the excavation of trenches to accommodate three underground services:

1. Fire systems main;
2. Fire hydrant system main; and
3. Dry fire conduit.

Each service will require a trench measuring approximately 500mm wide and 600mm deep. Where there are multiple underground systems required, these will be laid parallel to each other. Any penetration into the soil profile has potential and likely impact on a tree's root system and in turn, potential and likely impact on tree health. Excavation methods such as trenching have the potential to result in severance of the primary woody root system of the trees and significant deleterious impact.

i. Initial Exploration

The most reliable way to estimate root disturbance is to find out where the roots are in relation to the proposed activity such as excavation works. Exploratory excavation prior to commencement of an activity can help establish the extent of the root system and where it may be appropriate to excavate or use alternative methodology such as boring.

The use of an airspade or similar technology that blasts a stream of pressurised air can be used to remove soil in a non-destructive manner with only minimal damage to tree roots. This technique should be used as an 'exploratory' dig to where significant incursion (>10%) into a tree's TPZ is likely to occur.

ii. Trenching Technique

The excavation technique proposed for the majority of the underground services is trenching. This technique Involves digging a trench along the length of the proposed pipeline, placing the pipe in the trench on suitable bedding materials and then backfilling. Trenching for underground services, especially if carried out close to the trunk can cause major damage to root systems.

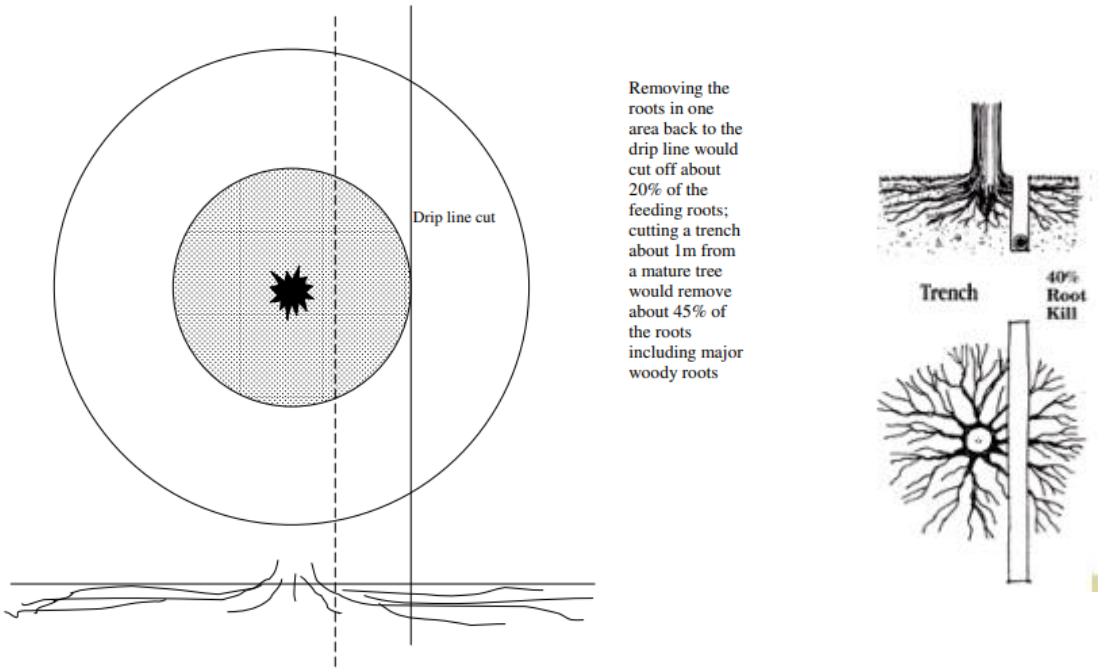


Figure 5: Root damage from trenching excavation

(image from Harris 1999)

Note the relative types of roots and the percentage of the root system damaged when trenches are located at varying distances from the trunk. This assumes the tree is growing in an originally unrestricted area. The percentage of roots damaged would increase if pavements or other infrastructure already constricts the root system.

iii. Trenchless Technology

Where significant incursion (>10%) is likely to occur, the implementation of trenchless technology or underground boring is advised. The technique minimises disturbance to the tree's root system. Underground boring does require the creation of access pits.

Entry and exit pits must be positioned outside the designated TPZ of each tree. This requirement should apply unless root mapping exploratory investigations have been undertaken and it has been determined that access within the TPZ will not significantly affect the tree.

The extent or length of boring in the vicinity of trees will be determined by the TPZ. The depth of the boring will depend on the size of the tree. Table 5 indicates the recommended boring depths for trees based on their trunk diameter. Where boring is unavailable, excavation should be by hand or non-destructive digging.

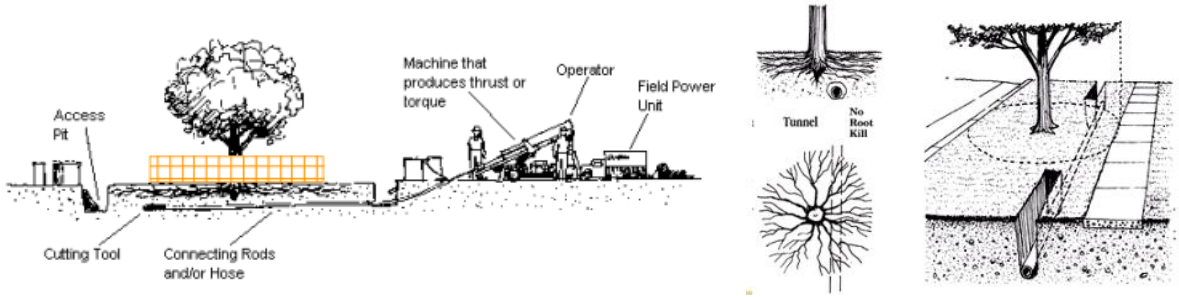


Figure 6: Underground Boring Techniques
(image from Davey Tree Expert Company website 2022)

Table 6 – Depth of Boring

Trunk Diameter	Minimum Depth to TOP
<100cm	800mm
100 – 150cm	950mm
>150cm	1100mm

6. Tree Protection Guidelines

6.1 Tree Protection Zone Specifications

Damage to trees during development can be direct and indirect. Direct damage can include mechanical injury to the trunk, the severing of roots, or alterations to the soil environment in the immediate vicinity of tree roots (ie. compaction or loss of organic matter).

Indirect effects of site development are usually related to soil hydrology. This includes alterations to soil moisture content, changes in the level of the water table and drainage patterns (Coder 1995).

The most common method of protecting trees during construction is establishing a Tree Protection Zone (TPZ). TPZs have been calculated according to Protection of Trees on Development Sites (AS 4970-2009) for all trees to be retained calculating the TPZ as 12 times the trunk diameter at 1.4m above ground level (DBH).

The TPZ fence is designed to act as a physical barrier of protective fencing that is a minimum of 1.8m high. It is erected around retained specimens (at the edge of the TPZ) before site works commence. See Figure 7.

Figure 7: TPZ fencing is erected around retained trees prior to site works.

6.2 Tree Protection Zone Guidelines

Careful adherence to the following exclusions and inclusions will maintain the health and longevity of retained tree specimens.

Exclude the following from taking place within any TPZ (adapted from AS 4970-2009):

- built structures or hard landscape features (i.e. paving, retaining walls);
- materials storage (ie. equipment, fuel, building waste or rubble);
- soil disturbance (ie. stripping or grade changes);
- excavation works including soil cultivation (specifically surface-dug trenches for underground utilities);
- placement of fill;
- lighting of fires;
- preparation of chemicals, including preparation of cement products; and
- pedestrian or vehicular access (ie. pathways).

Include the following procedures in setting up and maintaining any TPZ (adapted from AS 4970-2009):

- erect warning signs at regular intervals along the entire length of any protective TPZ fencing (Figure 8);
- construct TPZ fencing to prevent pedestrian access into the protected area;
- mulch the TPZ area to a depth of 100mm with woodchips (if available, use woodchips generated from on-site tree clearing); and
- irrigate TPZs periodically, as determined by the Project Arborist.

TPZ guidelines need to adhere to all stages of the design and construction process and are relevant to all on-site utilities.

Figure 8: Example of a TPZ warning sign clearly displayed on TPZ fencing

6.3 Tree Pruning and Removal

Pruning should be carried out or be directly supervised by qualified arborists. At least one fully qualified arborist must be present on-site at all times during pruning operations. The minimum qualification should be:

- An Advanced Certificate of Arboriculture.
- A National Certificate in Horticulture (Arboriculture) AQF Level 4.

Any pruning undertaken must conform to the Australian Standard Pruning of Amenity Trees (AS-4373 2007).

The replacement of removed trees will need to be addressed by Parks Victoria in future tree planting planning and planting projects.

7. Tree Protection Measures

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.

If all the trees are to be successfully managed to ensure survival during and post construction works, the following guidelines and requirements must be followed.

7.1. Design Considerations

As stated in section 4.5, a review of an initial (draft) fire services upgrade layout was provided by the fire services engineer, Omni was conducted. The review indicated significant incursion into the TPZs of many trees and the SRZs of some trees. Feedback provided to the fire services engineer has resulted in the preparation of a revised layout, which will significantly reduce potential impact on many of trees.

7.2. Pre-Demolition & Construction Protection

Contractors and site workers should receive written and verbal instruction as to the importance of the tree protection and preservation on the site. Successful tree preservation occurs when there is a commitment from all parties involved in the designing, constructing and managing a construction project. Members of the project team need to interact with each other to minimise the impacts to trees, either through design decisions or construction practices. The importance of tree preservation must be communicated to all parties working on the site.

7.2.1 Tree Protection Fencing

The TPZ fence is to be established before demolition, excavation or construction work commences. These fences must remain intact without any fill or rubbish entering them for the duration of the project.

If it must be removed or shifted within the project timeline, the period during which this occurs must be minimised. There must not be any excavation or soil compaction more than 10% of the TPZ area, unless this is shown on the site plan to occur or deemed by the Project Arborist as not being prejudicial to the safe useful life expectancy (SULE) during that time.

7.2.2 Trunk Protection

Where the provision of tree protection fencing is impractical or must be temporarily removed, trunk protection shall be installed to avoid accidental mechanical damage.

Specifications for trunk protection are as follows:

- A thick layer of carpet underfelt, geotextile fabric, or similar wrapped around the trunk to a minimum height of 2m.
- 1.8m lengths of softwood timbers aligned vertically and spaced evenly around the trunk (with a small gap of approximately 50mm between the timbers).
- The timbers must be secured using galvanised hoop strap (aluminium strapping).

The timbers shall be wrapped around the trunk but not fixed to the tree, as this will cause injury/damage to the tree.

7.2.3 Pruning Works

Any pruning necessary for work clearances or hazard reduction must be undertaken according to the Australian Standard AS4373 -2007 Pruning of amenity trees. Only the minimum amount necessary should be removed.

7.2.4 Ground Protection

If temporary access for plant or machinery is required within the TPZ, ground protection must be installed. The purpose of ground protection is to prevent root damage and soil compaction within the TPZ.

Specifications for light traffic access (<3.5 tonne) are as follows:

- Permeable membrane such as geotextile fabric.
- A layer of mulch or crushed rock (at a minimum depth of 100mm)

Specifications for heavy traffic access (>3.5 tonne) are as follows:

- Permeable membrane such as geotextile fabric.
- A layer of lightly compacted road base (at a minimum depth of 200mm)
- Geotextile fabric shall extend a minimum of 300mm beyond the edge of the road base.

Pedestrian, vehicular, and machinery access within the TPZ shall be restricted solely to areas where ground protection has been installed.

Existing soil grades should remain unaltered within the TPZ.

7.2.5 Mulch

The area within the TPZ should be mulched with good quality composted wood chip/leaf mulch that complies with Australian Standards, AS 4454-2012, Composts, soil conditioners, and mulches, and should be maintained at a depth of 150mm-200mm. Mulching around the base of the tree will provide nutrients and organic matter to the soil as it breaks down, improving and maintaining the overall health of the trees.

This to be retained during the project life to assist with moisture retention and to reduce the impact of compaction.

7.2.6 Irrigation

Temporary irrigation should be set up in the TPZ of trees and should distribute water evenly throughout the area of the TPZ. The irrigation should be used for at minimum 30 minutes daily during spring and summer throughout all stages of the excavation works.

The Project Arborist should advise of additional water requirements during periods of low rainfall throughout all stages of the project.

7.3. During Construction Protection

Maintain as per section 7.2.

There must not be any trenching, excavation, addition of fill or level reductions for any purpose, or significant soil compaction within more than 10% of the TPZ area of the retained tree, unless deemed by the Project Arborist as not being prejudicial to the safe useful life expectancy (SULE) during that time.

Avoid, if possible, placing drains and services within more than 10% of the TPZ area or 2/3 of the listed TPZ if encroaching from one side only. Drains or services, if they must go within the TPZ, must only be inserted by non-root destructive means such as horizontal boring at a depth greater than 800mm by pneumatic, hydraulic or hand digging means under Project Arborist supervision. This is conditional on the Project Arborist deeming the proposed works as not being prejudicial to the safe useful life expectancy (SULE) during that time.

The tree protection fences and signs must be maintained in good order for the life of the project. They can only be moved with the permission of the Project Arborist.

A suitably qualified arborist must be on site to oversee any works within the Tree Protection Zone of any tree affected by the development.

7.4. Irrigation / Watering

Any trees near the construction works must be irrigated. Proper watering is the most important maintenance task in terms of successfully retaining the designated trees.

The method of watering can include a drip system, hand held hose or water truck. The amount of irrigation will vary depending on seasons and weather conditions and observations from the Project Arborist. They must receive periodic irrigation over the summer and autumn periods of construction. A daily watering of 5 litres per 30mm of trunk calliper may provide the most even soil moisture level for roots (Watson & Himelick, 1997), Light frequent irrigations should be avoided. The irrigation event should wet the entire root zone and be allowed to dry out prior to another application. Watering should continue from October to April.

7.5. Monitoring Excavations & Notification

It is recommended the project arborist is on site on a daily basis or less frequently but regularly during excavation works. The project arborist should be readily contactable in respect to issues associated with particular trees or if there is a tree-related problem. A schedule of trees should be produced and records of inspection kept for each tree on each visit. Systematically record any damage or necessary treatments and attach relevant photographs.

The project arborist should be on site during critical phases such as any excavation, trenching or boring works carried out near or within protection zones.

After trenching or boring, install the services as soon as possible and backfill the hole. Replace the excavated material in its original order, that is, subsoil first and then topsoil. Take care not to mix soil horizons. It is acceptable to mix 50mm of organic matter such as cow manure into the top 100mm of backfill.

Place no organic matter below this level. Treat the severed roots with a liquid rooting hormone at the manufacturer's recommended rate.

The project arborist should notify the project manager or site supervisor should there be a breach of the tree protection conditions. Should damage occur, impose the pre-determined fine on the responsible contractor.

The Project Arborist should supervise and certify all excavations and root pruning are in accordance with AS4373-2007 and AS4970-2009. All excavations (including root investigations) within the TPZ must be carried out using tree sensitive methods under the supervision of the Project Arborist. These methods may include:

- Manual excavation (hand tools).
- Air spade.
- Hydro-vacuum excavations (sucker-truck).

7.6 Post Construction & Landscaping Protection

Do not trench, compact or excavate within the TPZs unless under arboricultural supervision and in a manner that does not inflict any root loss of significance.

If levels have to be raised by up to 200mm within the TPZs, then use of a friable organic rich top soil for this purpose is acceptable.

If the levels within the TPZs are to be raised more than 200mm, then a structural soil should be used with a 150mm layer of topsoil above. Structural soil maintains adequate aeration. It consists of a mixture of approximately 80% (by volume) of 100mm stone such as railway ballast and 20% topsoil. Ensure any applied soils are not heaped against tree trunks.

7.7 Site Inspections

In accordance with the Australian Standard, AS 4970-2009, Protection of Trees on Development Sites, inspections must be conducted by the 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 TPZ of any tree to be retained & 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 48 hours' notice. To ensure the tree protection plan is implemented, hold points have been specified in the schedule of work (Table 7).

Table 7

Construction Stage	Hold Point	Description
Pre-construction	1	Prior to excavation and/or site establishment, indicated clearly on ground the TPZs of all assessed trees.
	2	Tree protection (where required) to be installed prior to site establishment. This may include the mulching of areas within TPZs. The project arborist shall inspect and certify tree protection.
During construction	3	Scheduled inspections of tree by the project arborist should be undertaken regularly during the construction / excavation period.
	4	Project arborist to supervise and document all works carried out within the TPZ of assessed trees.
	5	Inspection of assessed trees by the project arborist after all major excavation works have ceased, following the removal of tree protection measures.
Post construction	6	Final inspection of all assessed trees by project arborist.

Attachment A – Site Survey & Tree Protection Plan

Refer to separate PDF document, titled, 'PV WP TPP v1'.

8. Guide to Terminology

Item	Description
Genus	Method of identification as determined by the International Code of Botanical Nomenclature (ICBN) to establish similarities, differences and likely relationships
Species	Applied by the ICBN to a particular plant type whose populations continue interbreeding from generation to generation, maintaining within limits a recognisable set of characteristics.
DBH	Diameter of trunk over bark at breast height, generally measured at 1.4m above ground level. Where the tree has multiple trunks the diameter is measured below the fork and an estimate is made for the single trunk equivalent at breast height.
Health	Objective assessment of the physical appearance of the specimen based on obvious condition, vigour and presence of pest and diseases on specimen.
Safe useful life expectancy (SULE)	Objective determination on the basis of expected resource input to maintain continued health vigour and aesthetic appearance without imposing an onerous financial burden to maintain relative safety and avoid excessive nuisance.
Works Required	Identification of any works required to improve health, vigour and/or prolong SULE.
Tree Protection Zone (TPZ)	Tree protection zone according to the Australian Standard 'AS4970-2009 – Protection of Trees on Building Sites'. The TPZ is the principal means of protecting trees on development sites. It is a combination of the root area and crown area requiring protection. It is an area isolated from construction disturbance, so that the tree remains viable.' The radius of the TPZ is calculated by multiplying the DBH by 12. The radius is measured from the centre of the stem at ground level. An area of 10% of the TPZ is deemed acceptable to violate if 10% of the area of the TPZ is made up in other directions. *Thus if encroachment is from one side only, encroachment to as close as approximately 8 times the DBH (2/3 the listed TPZ radius) is permissible according to the Standard.* Where the tree has more than one trunk, the TPZ is deduced by taking the square root of the sum of the squares of each of the DBHs, and multiplying this figure by 12 The AS 4970-2009 should be construed as a rough guide. It is only used in this statement because various local authorities now demand it in their assessments of development applications. Many factors such as the type of encroachment on the TPZ, species tolerance, age, tree height, presence of spiral grain, soil type, soil depth, tree lean, the existence of onsite structures or root directional impediments, level of wind exposure, irrigation and ongoing tree care and maintenance are each highly influential on the size and success of the TPZ estimation, therefore the figures derived from the Standard and provided in this report must be treated as rough guides only.
Structural Root Zone	According to AS 4970:2009, this is the area of the root plate required for a tree`s stability. In order to calculate the radius of such a zone from the trunk centre, according to AS 4970:2009, one uses the following formula: SRZ radius is $(D \times 50)^{0.42} \times 0.64$, where:

	• D is the trunk diameter in metres taken from just above the root buttress. According to AS 4970:2009, the minimum SRZ radius is 1.5m for any tree, irrespective of its size. AS 4970:2009 does not mention where this formula is taken. The figures derived for it are far greater than results from studies of upturned root plates of windblown and winched over trees (see Mattheck, & Breloer (1994) Typically, the radii calculated are much larger than necessary, except in cases such as where the soils are very shallow or where the structural root development is unidirectional or highly asymmetric for some reason, and the excavation is to be within the zone of the roots. The structural stability generally depends far more on what proportion of the circumference of the tree is to be excavated than the actual distance of excavation from a tree.

9. References

AS 2870 – 2011, *Australian Standard, Residential Slabs and Footings*, Standards Australia

AS 4373 – 2007, *Australian Standard Pruning of Amenity Trees*, Standards Australia.

AS 4454 – 2012 *Australian Standard Composts, Soil Conditioners and Mulch*, Standards Australia

AS 4687 – 2007 *Australian Standard Temporary Fencing and Hoardings*, Standards Australia

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

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Matheny, N and Clarke, J. 1998. Trees and Development – A Technical Guide to Preservation of Trees During Land Development. International Society of Arboriculture. Champaign, USA. 183pp.

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