

## **APPENDIX 6 – ARBORICULTURAL ASSESSMENT**

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# **Construction Impact Assessment**

for

## **Ecology and Heritage Partners**

Assessment of trees and vegetation patches at  
Delburn Wind farm

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## Executive Summary

21 trees and 68 vegetation patches were assessed at Delburn, Victoria in relation to road upgrade works required to facilitate the construction of a wind farm by OSMI.

Of the 21 trees assessed, all are expected to remain viable:

- **Eight trees (Asset IDs 1, 3, 4, 9-13) have a TPZ encroachment from proposed road upgrades.** Each of these trees are expected to remain viable under the proposed design due to the fact that the road upgrade works will occur at or above grade and within the existing road footprint.
- The remaining **13 Trees (Asset IDs 2, 5-8, and 14-21) have no TPZ encroachment** from the proposed works and are expected to remain viable with standard TPZ provisions and exclusions.

Of the 68 vegetation patches nominated for assessment:

- **7 patches (Asset ID 11, 19, 34, 64, 65, 66, and 67) are considered 'lost'** because of the impact of the proposed works or because they could not be located for assessment
- **10 patches (Asset IDs 1, 7, 10, 26-28, 40-42, and 45) are considered partially viable.**
  - In order to ensure ongoing viability of these vegetation patches a 7.5m clearance must be maintained from the centre of reticulation trenches. Parts of these vegetation patches are located within 7m or less of proposed reticulation and are considered 'lost'. The remainder of the vegetation patch outside this 7.5m buffer will remain viable. See Section 7.2 for more detail.
- **The remaining 51 vegetation patches are considered viable** as they are either;
  - only impacted by road upgrades occurring at or above grade, within the existing road footprint. Or
  - they are located at least 7.5m away from proposed reticulation trenching.

All retained trees and vegetation patches require protection to ensure they remain viable throughout the works. The following is recommended:

1. All road upgrade works must take place within the existing road footprint and at or above the existing soil grade.
2. All open trenching is to be conducted at least 7.5m from the closest vegetation patch. Any part of a vegetation patch located within 7.5m of the centre of a reticulation trench is considered 'lost'.
3. Establish a Tree Protection Zone for all trees to be retained. Where works are permitted within the TPZ, fencing is to be taken in to only the minimum amount necessary to allow the works to be completed.

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

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## 1. Introduction

Homewood Consulting Pty Ltd has been engaged to provide a construction impact assessment on 21 nominated trees and 68 groups of trees at Delburn, Victoria in relation to road upgrade works required to facilitate the construction of a wind farm by OSMI.

As set out in the Victorian Department of Environment, Land, Water and Planning's (DELWP) 'Assessor's Handbook for Applications to remove, destroy or lop native vegetation': *"Unless an arborist report indicates otherwise, a tree, or trees will be deemed lost if the encroachment (of compaction and excavation) into the TPZ is greater than 10 per cent, or is inside the SRZ."*

This report has been requested in order to assess the impact of the proposed development on nominated trees with the intention of identifying vegetation that can be successfully retained and protected throughout the proposed construction.

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 and structure and identifies the impact of the proposed development on the future longevity of the trees.

## 2. Method

On Thursday 25, Friday 26 and Tuesday 30 June 2020, John Brennan and Liam Ainsworth conducted site inspections.

21 individual trees were assessed and 68 groups of trees/vegetation patches were assessed.

### 2.1 Individual trees

Data collected for the 21 individually assessed trees includes:

- Photograph of the tree
- Botanical Name
- Canopy Dimensions
- Diameter at Breast Height (DBH)
- Diameter above basal root flare
- Health
- Structure
- Useful Life Expectancy (ULE)

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.

Tree location was recorded using differentially corrected GPS (generally +/- 1.0m accuracy). Location should be verified by a surveyor if decision making requires greater accuracy.

Table 2 shows the data collected for the trees (page 16). For definitions and descriptors of the data collected on site see Appendix 1.

### 2.2 Groups of Trees/Vegetation Patches

68 groups of trees or patches of vegetation were nominated for assessment. Two of these patches (Asset ID 11 and 19) could not be located for assessment. Within the remaining 66

patches, trees were not individually assessed and recorded, instead a general assessment of the whole patch was conducted in order to determine the impact of proposed construction on the patch. Consideration was given to general site conditions, the extent of canopy overhanging the area of proposed works, the type of proposed works and their proximity to the nominated vegetation patches.

Ecology and Heritage Partners provided GIS data for patches of vegetation throughout the assessment area; this data was used to locate the patches.

### 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; 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: <ul style="list-style-type: none"> <li>• Alternative construction methods are proposed which reduce the impact on the tree</li> <li>• Site conditions have limited root development within the proposed area of works</li> </ul>

Category	Description
	<ul style="list-style-type: none"> <li>The species is known to be particularly tolerant to root disturbance</li> <li>A non-destructive root exploration was undertaken and demonstrated that root distribution was limited in the proposed area of works.</li> </ul> <p>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.</p>
Impact - Minor	<p>The proposed design has a Tree Protection Zone area encroachment of less than 10%, and does not impact the structural root zone.</p> <p>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.</p>
No impact	<p>The proposed design does not enter the Tree Protection Zone.</p> <p>The tree is expected to remain a viable landscape component with the establishment of a Tree Protection Zone prior to the commencement of works.</p>

## 4. Design Proposal

### 4.1 Existing Conditions

The assessed area spans approximately 15km from north to south and is roughly located between Thorpdale and Hazelwood. Throughout the assessment area much of the land is occupied by forestry plantations intersected by numerous access tracks of varying types.



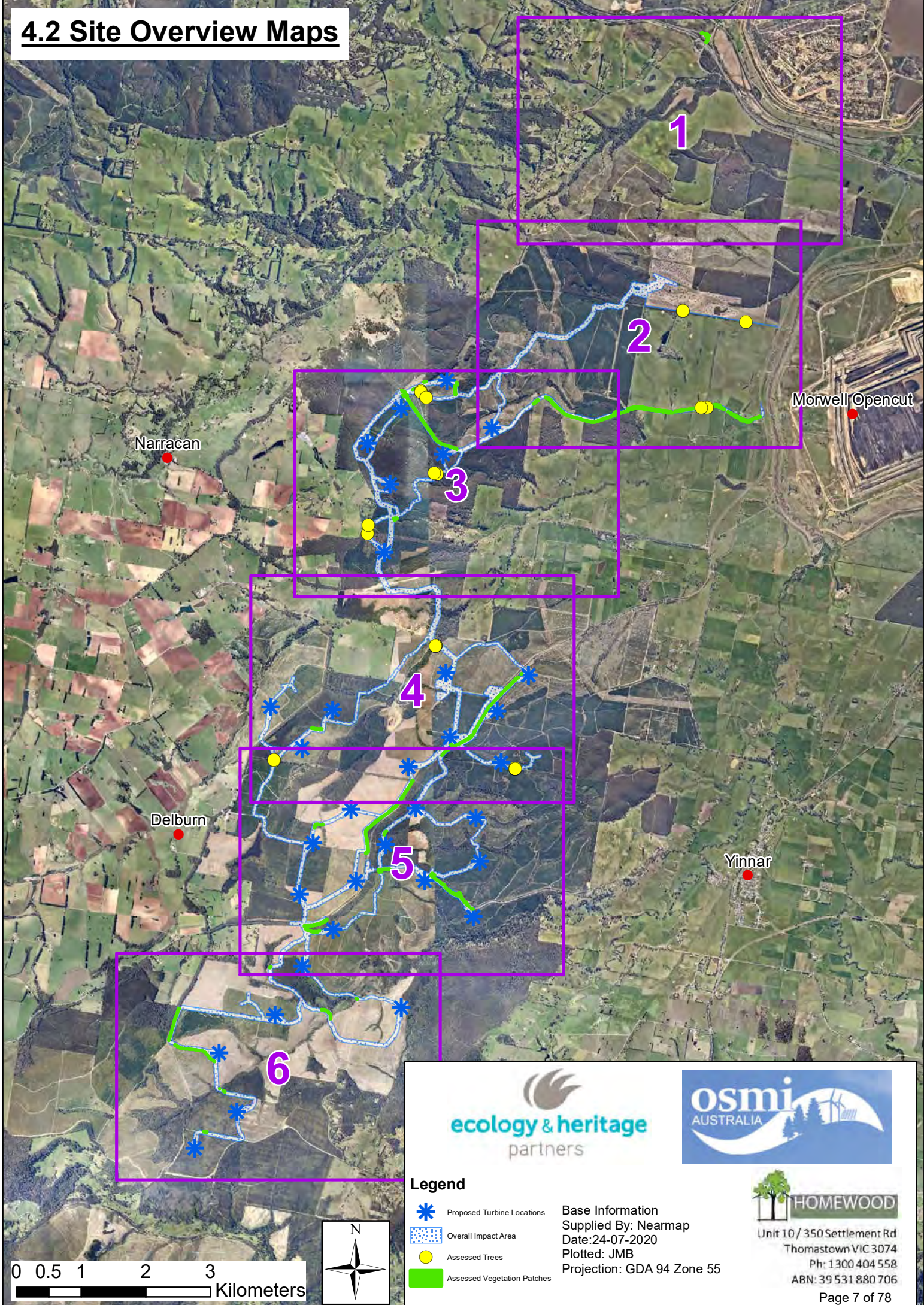
Figure 1: Deans Rd looking east with Tree 10 in the foreground. An example of an unsealed road within the assessment area.



Figure 2: An unsealed access track passing through a pine plantation north of Creamery Rd, with Vegetation Patch 52 on the right-hand side.



4.2 Site Overview Maps



Legend

- Proposed Turbine Locations
- Overall Impact Area
- Assessed Trees
- Assessed Vegetation Patches

Base Information  
Supplied By: Nearmap  
Date: 24-07-2020  
Plotted: JMB  
Projection: GDA 94 Zone 55



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## 4.2 Site Overview Map 1 of 6

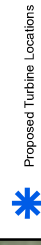
Patch66  
Patch67



0 0.25 0.5 1 1.5 2 Kilometers



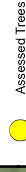
### Legend



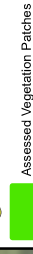
Proposed Turbine Locations



Overall Impact Area



Assessed Trees



Assessed Vegetation Patches

### Base Information

Supplied By: Nearmap

Date: 24-07-2020

Plotted: JMB

Projection: GDA 94 Zone 55



Unit 10 / 350 Settlement Rd

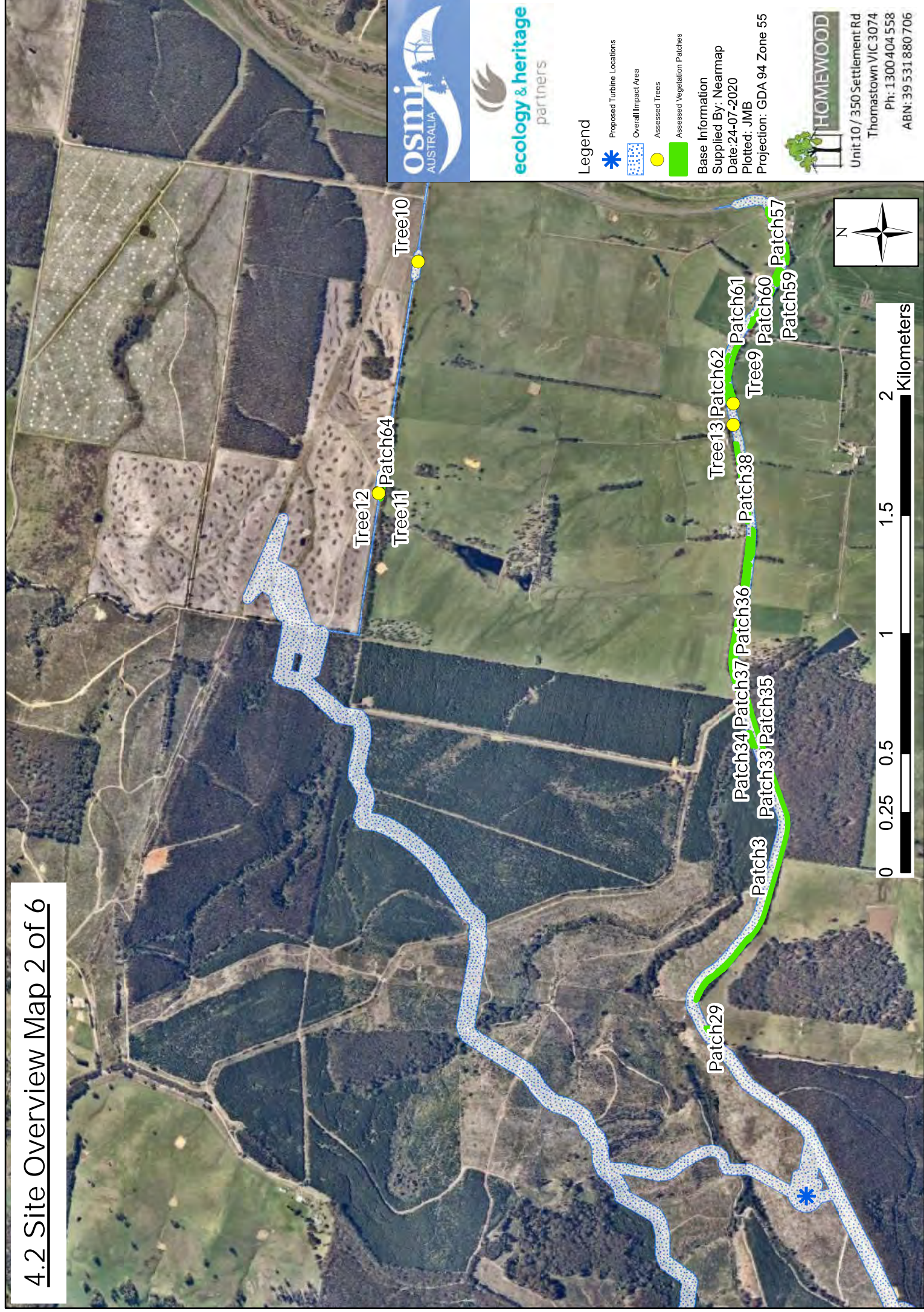
Thornastown VIC 3074

Ph: 1300 404 558

ABN: 39 531 880 705

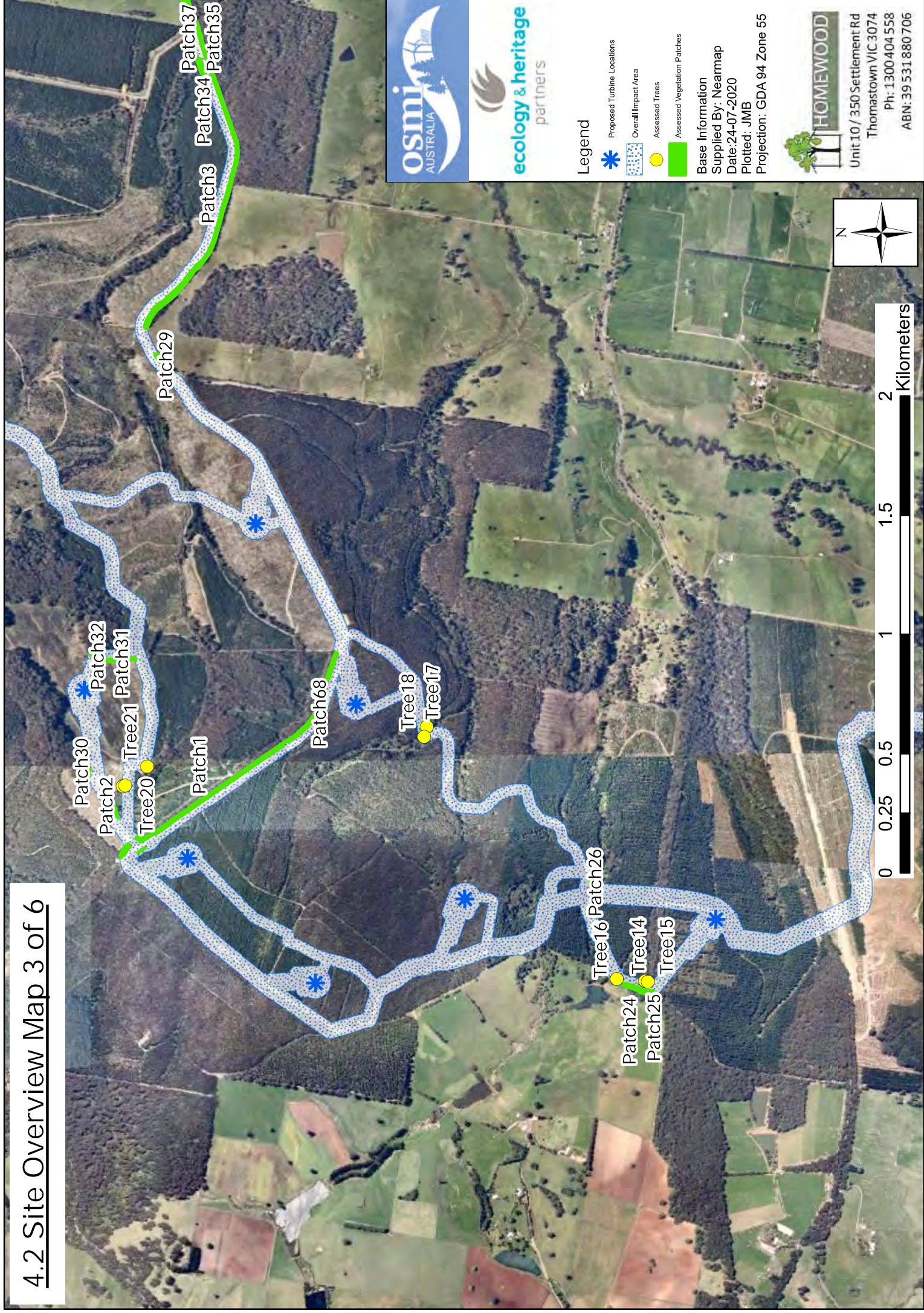


## 4.2 Site Overview Map 2 of 6



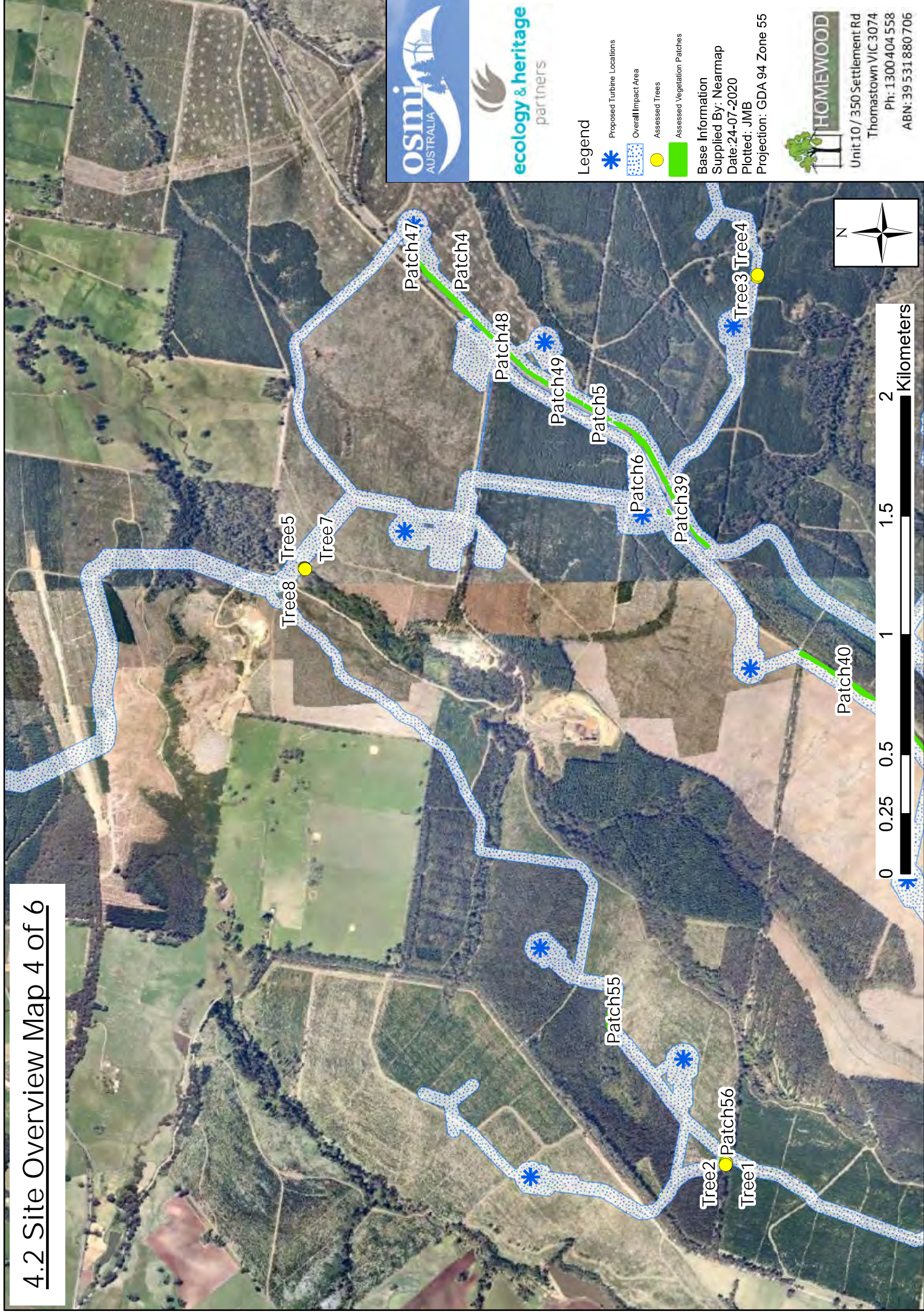


## 4.2 Site Overview Map 3 of 6



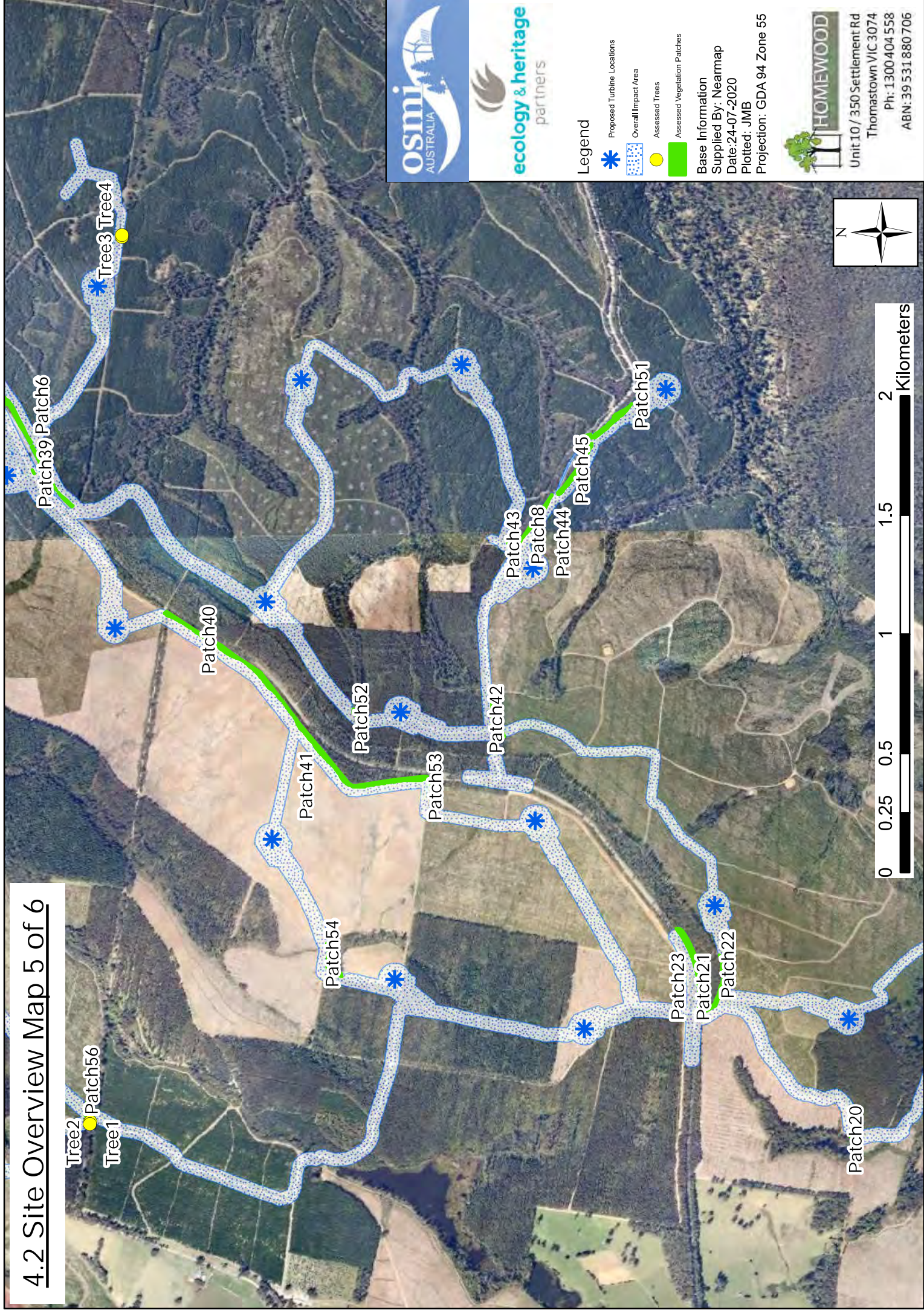


## 4.2 Site Overview Map 4 of 6



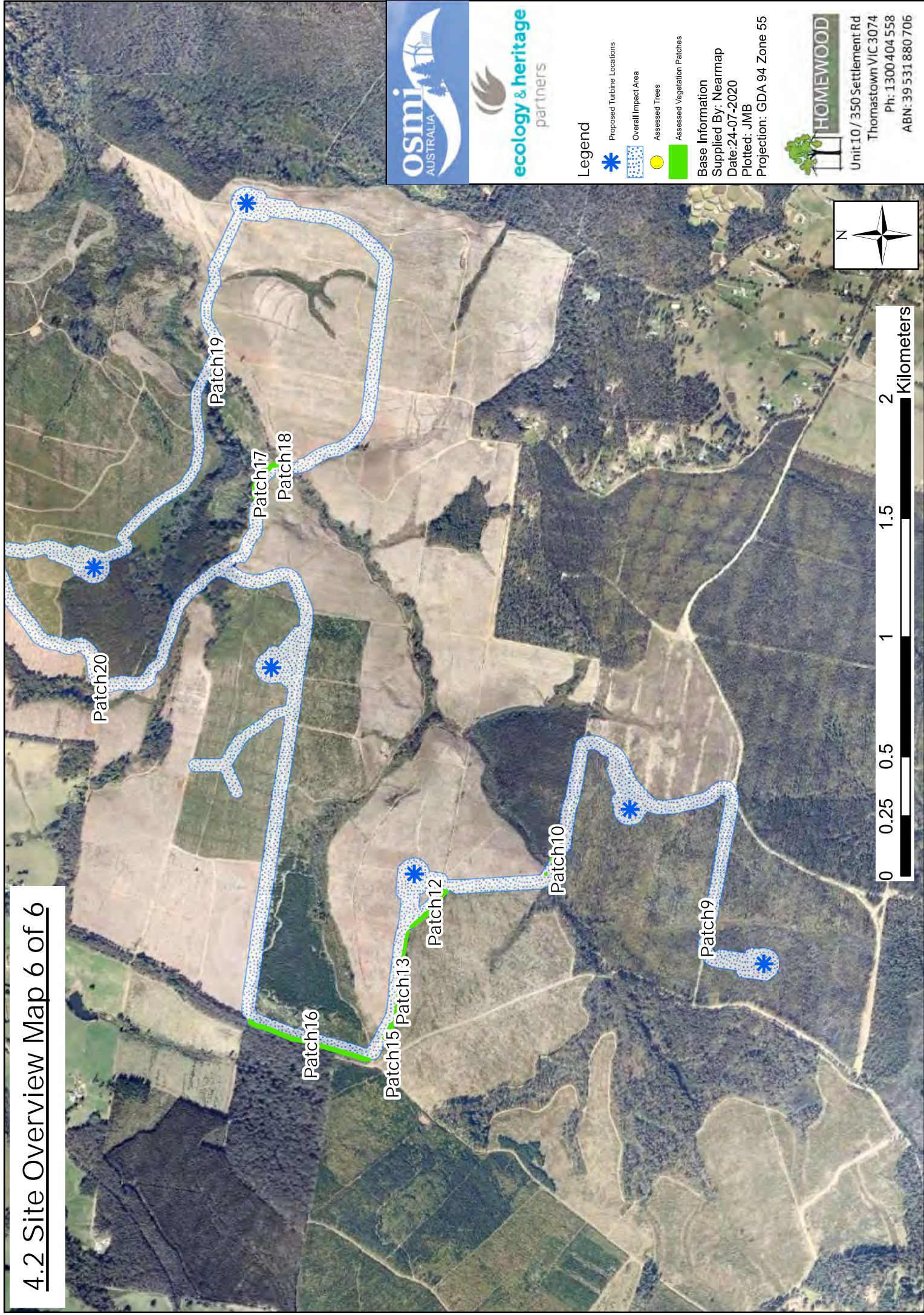


## 4.2 Site Overview Map 5 of 6





## 4.2 Site Overview Map 6 of 6





### 4.3 Proposed Works

Upgrades to existing roads throughout the assessment area have been proposed along with installation of underground services via open trenching. The proposed works have been detailed by OSMI in 3 different scenarios. These scenarios are represented in the following images (Figure 3 to Figure 5)

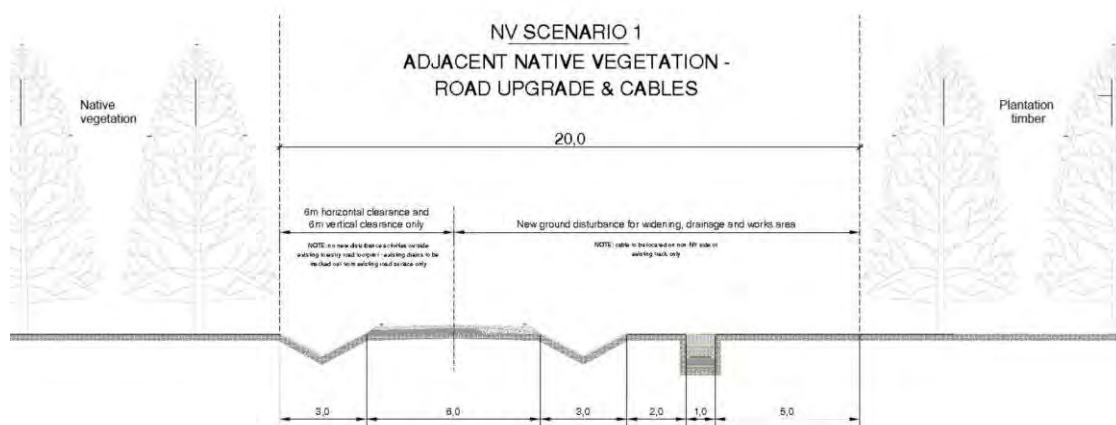


Figure 3: Scenario one

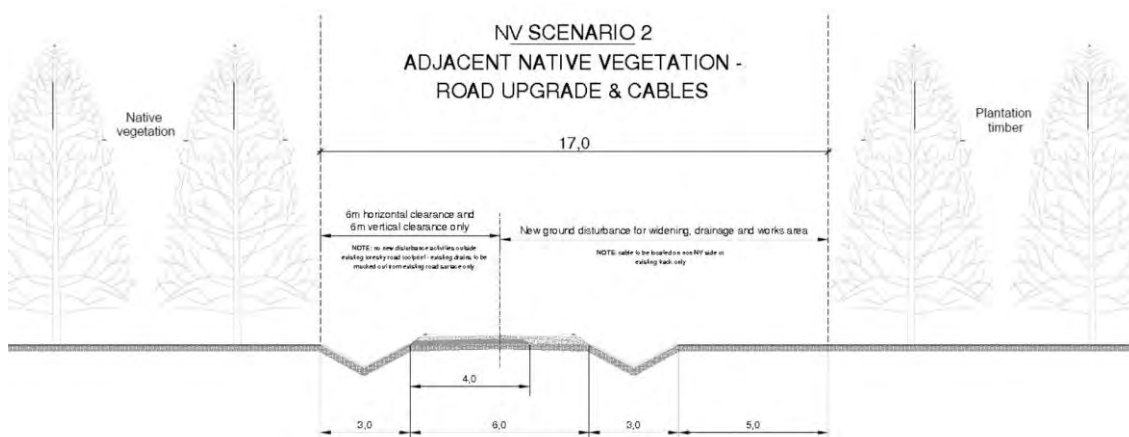


Figure 4: Scenario two

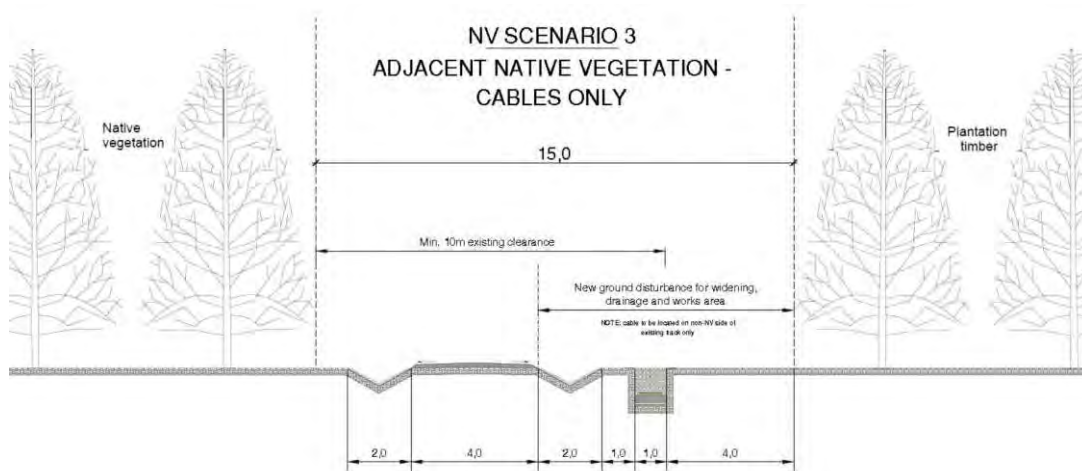


Figure 5: Scenario three

For the purposes of assessing the impact of the proposed works on adjacent trees these works have been classified as either;

- Reticulation (trenching) and Road Upgrade (Scenario 1),
- Road Upgrade only (Scenario 2), or
- Reticulation (trenching) only (Scenario 3)

Table 2 displays the assessment data for all individually recorded trees, as well as the dimensions of the TPZs, SRZs, the impact type and whether or not the proposed work encroaches the TPZ.

Table 3 displays the assessment data for all assessed vegetation patches.

## 5. Tree Assessments

Table 2: Summary of tree assessments and construction impact from the proposed design

ID	EHP ID	Botanical Name	Height & Width (m)	DBH (cm)	TPZ Radius (m)	SRZ Radius (m)	Tree Age	Health	Structure	ULE	COMMENTS	Impact within TPZ	Impact Type
1	537	<i>Eucalyptus cypellocarpa</i>	30 x 18	164	15.00	4.55	Mature	Fair	Fair	20 to 40 years	Viable	Yes	Road Upgrade
2	538	<i>Eucalyptus cypellocarpa</i>	28 x 16	99	11.88	3.63	Mature	Good	Fair	20 to 40 years	Viable	No	Road Upgrade
3	344	<i>Eucalyptus obliqua</i>	18 x 11	66	7.92	3.25	Mature	Good	Fair	20 to 40 years	Viable	Yes	Road Upgrade
4	343	<i>Eucalyptus obliqua</i>	17 x 10	75	9.00	3.43	Mature	Good	Fair	20 to 40 years	Viable	Yes	Road Upgrade
5	614	<i>Eucalyptus strzeleckii</i>	17 x 8	48	5.76	2.74	Mature	Fair	Fair	20 to 40 years	Viable	No	Reticulation
6	615	<i>Eucalyptus strzeleckii</i>	28 x 14	62	7.44	2.80	Mature	Fair	Fair	20 to 40 years	Viable	No	Reticulation
7	616	<i>Eucalyptus strzeleckii</i>	17 x 8	36	4.32	2.28	Mature	Poor	Fair	10 to 20 years	Viable	No	Reticulation
8	617	<i>Eucalyptus strzeleckii</i>	32 x 14	65	7.80	2.85	Mature	Good	Fair	40+ years	Viable	No	Reticulation
9	143	<i>Eucalyptus goniocalyx</i>	16 x 14	117	14.04	3.62	Mature	Good	Fair	40+ years	Viable	Yes	Road Upgrade
10	145	<i>Eucalyptus goniocalyx</i>	14 x 11	76	9.12	3.31	Mature	Good	Fair	40+ years	Viable	Yes	Road Upgrade
11	152	<i>Eucalyptus goniocalyx</i>	16 x 10	68	8.16	2.92	Mature	Fair	Fair	20 to 40	Viable	Yes	Road Upgrade



ID	EHP ID	Botanical Name	Height & Width (m)	DBH (cm)	TPZ Radius (m)	SRZ Radius (m)	Tree Age	Health	Structure	ULE	COMMENTS	Impact within TPZ	Impact Type
12	153	<i>Eucalyptus angophoroides</i>	16 x 10	76	9.12	2.90	Mature	Good	Fair	20 to 40 years	Viable	Yes	Road Upgrade
13	141	<i>Eucalyptus viminalis subsp. pryoriana</i>	13 x 9	97	11.64	3.82	Mature	Poor	Fair	5 to 10 years	Viable	Yes	Road Upgrade
14	606	<i>Eucalyptus cypellocarpa</i>	19 x 14	93	11.16	3.67	Mature	Good	Fair	40+ years	Viable	No	Road Upgrade
15	607	<i>Eucalyptus obliqua</i>	20 x 15	98	11.76	3.31	Mature	Good	Fair	40+ years	Viable	No	Road Upgrade
16	604	<i>Eucalyptus radiata</i>	9 x 8	57	6.84	2.78	Mature	Good	Fair	40+ years	Viable	No	Road Upgrade
17	634	<i>Eucalyptus cypellocarpa</i>	23 x 17	96	11.52	3.60	Mature	Good	Fair	40+ years	Viable	No	Reticulation
18	632	<i>Eucalyptus cypellocarpa</i>	23 x 12	64	7.68	2.85	Mature	Good	Fair	40+ years	Viable	No	Reticulation
19	652	<i>Eucalyptus obliqua</i>	9 x 8	51	6.12	2.39	Mature	Good	Fair	40+ years	Viable	No	Road Upgrade and Reticulation
20	651	<i>Eucalyptus obliqua</i>	10 x 8	44	5.28	2.47	Mature	Good	Fair	40+ years	Viable	No	Road Upgrade and Reticulation
21	647	<i>Eucalyptus strzeleckii</i>	8 x 6	34	4.08	2.30	Mature	Good	Fair	40+ years	Viable	No	Reticulation

Table 3: Summary of Vegetation Patch assessments and construction impact from the proposed design

Asset ID	Inspected	Impact Type	Recommendation	Canopy Overhang
1	YES	Road Upgrade and Reticulation	Partially viable -Allow for 7.5m clearance from centre of reticulation	Medium
2	YES	Road Upgrade and Reticulation	Viable	Medium
3	YES	Road Upgrade	Viable	Low
4	YES	Road Upgrade and Reticulation	Viable	Low
5	YES	Road Upgrade and Reticulation	Viable	High
6	YES	Road Upgrade and Reticulation	Viable	Medium
7	YES	Road Upgrade and Reticulation	Partially viable -Allow for 7.5m clearance from centre of reticulation	None
8	YES	Road Upgrade and Reticulation	Viable	None
9	YES	Road Upgrade and Reticulation	Viable	None
10	YES	Road Upgrade and Reticulation	Partially viable -Allow for 7.5m clearance from centre of reticulation	None
11	NO	Not assessed	Lost -unable to access	N/A
12	YES	Road Upgrade	Viable	Low
13	YES	Road Upgrade and Reticulation	Viable	Low
14	YES	Road Upgrade and Reticulation	Viable	None
15	YES	Road Upgrade and Reticulation	Viable	Low
16	YES	Road Upgrade and Reticulation	Viable	Low
17	YES	Road Upgrade	Viable	None
18	YES	Road Upgrade	Viable	None
19	NO	Not assessed	Lost -unable to access	N/A
20	YES	Road Upgrade and Reticulation	Viable	None
21	YES	Road Upgrade and Reticulation	Viable	None
22	YES	Road Upgrade	Viable	Low

Asset ID	Inspected	Impact Type	Recommendation	Canopy Overhang
23	YES	Road Upgrade	Viable	Low
24	YES	Road Upgrade	Viable	Low
25	YES	Road Upgrade	Viable	None
26	YES	Road Upgrade and Reticulation	Partially viable -Allow for 7.5m clearance from centre of reticulation	None
27	YES	Reticulation	Partially viable -Allow for 7.5m clearance from centre of reticulation	None
28	YES	Reticulation	Partially viable -Allow for 7.5m clearance from centre of reticulation	None
29	YES	Road Upgrade	Viable	Low
30	YES	Road Upgrade and Reticulation	Viable	Low
31	YES	Reticulation	Viable	None
32	YES	Reticulation	Viable	Low
33	YES	Road Upgrade	Viable	Low
34	YES	Road Upgrade	Lost	N/A
35	YES	Road Upgrade	Viable	Low
36	YES	Road Upgrade	Viable	Low
37	YES	Road Upgrade	Viable	Low
38	YES	Road Upgrade	Viable	None
39	YES	Road Upgrade	Viable	Medium
40	YES	Road Upgrade and Reticulation	Partially viable -Allow for 7.5m clearance from centre of reticulation	Low
41	YES	Road Upgrade and Reticulation	Partially viable -Allow for 7.5m clearance from centre of reticulation	None
42	YES	Road Upgrade and Reticulation	Partially viable -Allow for 7.5m clearance from centre of reticulation	Low
43	YES	Road Upgrade	Viable	Medium
44	YES	Road Upgrade and Reticulation	Viable	None
45	YES	Road Upgrade and Reticulation	Partially viable -Allow for 7.5m clearance from centre of reticulation	Low



Asset ID	Inspected	Impact Type		Recommendation	Canopy Overhang
46	YES	Road Upgrade		Viable	none
47	YES	Road Upgrade		Viable	Low
48	YES	Road Upgrade and Reticulation		Viable	Medium
49	YES	Road Upgrade and Reticulation		Viable	Low
50	YES	Road Upgrade and Reticulation		Viable	Low
51	YES	Road Upgrade and Reticulation		Viable	Medium
52	YES	Road Upgrade and Reticulation		Viable	Medium
53	YES	Road Upgrade and Reticulation		Viable	High
54	YES	Road Upgrade and Reticulation		Viable	High
55	YES	Road Upgrade and Reticulation		Viable	Low
56	YES	Road Upgrade		Viable	Low
57	YES	Road Upgrade		Viable	Medium
58	YES	Road Upgrade		Viable	Low
59	YES	Road Upgrade		Viable	High
60	YES	Road Upgrade		Viable	Medium
61	YES	Road Upgrade		Viable	High
62	YES	Road Upgrade		Viable	High
63	YES	Road Upgrade		Viable	Medium
64	YES	Road Upgrade		Lost	N/A
65	YES	Unknown		No trees present	N/A
66	YES	Unknown		Lost -impact unclear	N/A
67	YES	Unknown		Lost -impact unclear	N/A
68	YES	Road Upgrade		Viable	High

## 6. Construction Impact Assessment Summary

The following provides a summary of the impact of proposed works to both the 21 individually assessed trees and the 68 vegetation patches. Specific impacts are discussed in more detail in Section 7.

### 6.1 Impacts to Individually Assessed Trees

Of the 21 trees assessed, all are expected to remain viable:

- **Eight trees (Asset IDs 1, 3, 4, 9-13) have a TPZ encroachment from proposed road upgrades.** Each of these trees are expected to remain viable under the proposed design due to the fact that the road upgrade works will occur at or above grade and within the existing road footprint.
- The remaining **13 Trees (Asset IDs 2, 5-8, and 14-21) have no TPZ encroachment** from the proposed works and are expected to remain viable with standard TPZ provisions and exclusions.

### 6.2 Impacts to Vegetation Patches

Of the 68 vegetation patches nominated for assessment:

- **7 patches are considered lost.**
  - Two patches (Asset ID 11 and 19) could not be located and so were not assessed.
  - Three patches (Asset ID 65, 66, and 67) were located approximately 4km north of the study area adjacent to public roads and the proposed works were unclear. Additionally, there were no trees present within Patch 65.
  - Patch 34 is considered lost due to the close proximity of proposed works.
  - Patch 64 is considered lost. Proposed works adjacent to this patch involve widening the existing road for creation of a passing bay. Two large trees (Asset ID 11 and 12) are also located nearby and if these trees are retained the vegetation patch cannot be retained.
- **10 patches (Asset IDs 1, 7, 10, 26-28, 40-42, and 45 are considered partially viable.**
  - In order to ensure ongoing viability of vegetation patches a 7.5m clearance must be maintained from the centre of reticulation trenches. Parts of these vegetation patches are located within 7m or less of proposed reticulation and are considered lost. The remainder of the vegetation patch outside this 7.5m buffer will remain viable. See Section 7.2 for more detail.
- **The remaining 51 vegetation patches are considered viable** as they are either;
  - only impacted by road upgrades occurring at or above grade, within the existing road footprint. Or
  - they are located at least 7.5m away from proposed reticulation.

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

## 7. Impact Considerations

### 7.1 Road upgrade

OSMI have stated that all road upgrades will occur at or above grade and within the existing road footprint (P Marriott 2020, pers. comm., 25 June). The construction and usage of roads compacts the soil profile which can impede root growth and function (Figure 6).

To understand why compaction to the soil can be detrimental to tree health, a basic understanding of soil properties and tree root requirements is required. For simplicity it is best to understand that soil is composed of various sized particles that have variable sized spaces (pores) between them. These pores allow for water and gases to move through the soil profile, with faster movement occurring through larger sized pores. Compacting 'squashes' the pores in the soil thus inhibiting or completely preventing water infiltration and gas exchange through the soil profile.



Figure 6: Example of heavily compacted existing road surface on the right; creating unfavourable conditions for root growth. Contrasting with the uncompacted vegetation patch on the left.

If roads were to be created within the root zones of existing trees where soil had not previously been compacted then this would be likely to have a significant detrimental effect on the trees. Confining the road upgrades within the footprint of the existing roads will ensure that impacts are limited to those areas where the soil profile has already been compacted. Additionally, the lack of excavation means that roots will not be directly mechanically damaged.

Therefore, trees with TPZ encroachment from proposed road upgrades will remain viable as long as:

- Construction is kept within the existing road footprint,
- No excavation occurs, and
- Standard TPZ provisions and exclusions are adhered to.

## 7.2 Reticulation

The 21 individually assessed trees do not have any TPZ encroachment from the proposed installation of underground services (reticulation). However reticulation adjacent to vegetation patches needs to be considered.

Unlike the proposed road upgrades, the proposed reticulation will require excavation of an open trench. If tree roots are located in the areas to be trenched then they will be damaged. In order to ensure that trees remain viable a minimum distance of 7.5m must be maintained between trees and the centre of reticulation. If the reticulation is a 1m wide trench then this allows for a minimum 7m clearance between the edge of the trench and the closest edge of vegetation patches.

As individual trees were not assessed within vegetation patches, the clearance distance was calculated based on a hypothetical worst case scenario of a large tree located on the edge of the vegetation patch closest to the reticulation. If said tree had a TPZ radius of 15m (the largest possible TPZ under Australian Standard 4970-2009) then an open trench located 7m from the tree would constitute a TPZ encroachment of 21.4%. Given the surrounding undisturbed landscape, this loss would be compensated for elsewhere and contiguous with the TPZ as per the Australian Standard, and the tree should remain viable.

If the distance between trench and tree increases then the encroachment decreases and the tree still remains viable. If the distance between trench and tree decreases then the encroachment increases and the tree should be considered lost.

The proposed reticulation is already at least 7m clear of the majority of the assessed vegetation patches. Where portions of vegetation patches are located less than 7m from proposed reticulation, these portions within this 7m buffer should be considered lost (Figure 7).

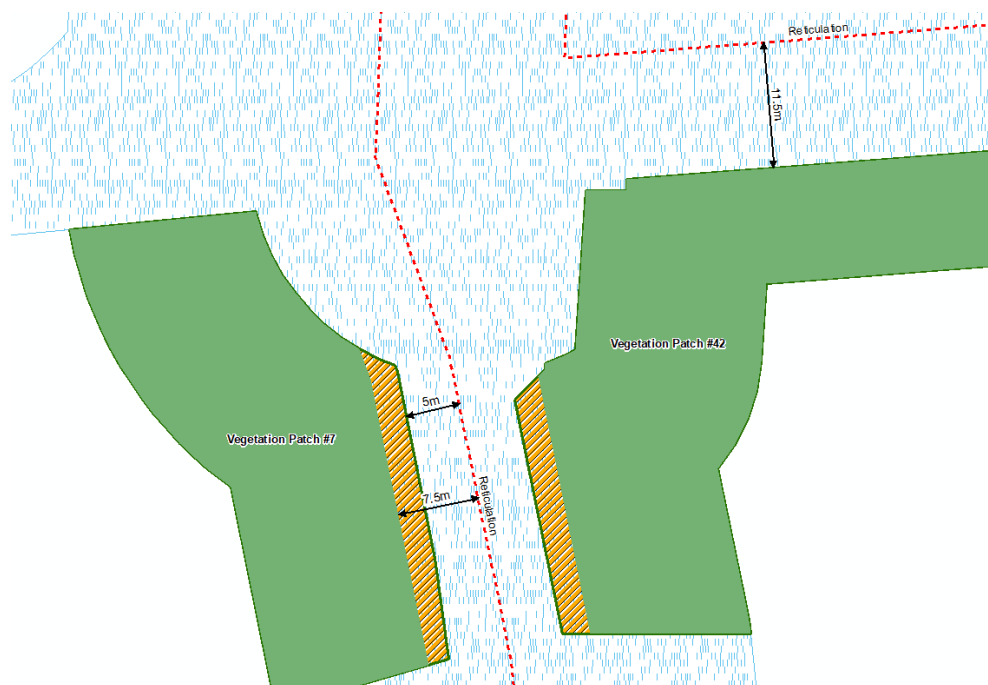


Figure 7: Orange hatched area representing lost portions of vegetation patches

This is a conservative approach but it still minimises vegetation loss while also accounting for the potential (but unlikely) presence of the largest plausible trees, combined with arguably the greatest tolerable impact.



## **7.3 Scattered tree loss within vegetation patches**

Vegetation patches considered to remain viable throughout the construction process may contain scattered individual trees that will not remain viable. The factors detailed below may impact on the viability of individual trees within vegetation patches. The number of potentially affected trees is expected to be small and the remainder of the vegetation patch would remain viable.

### **7.3.1 Canopy Overhang**

The extent to which tree canopy from vegetation patches overhangs the construction footprint of proposed works has been classified as either 'High', 'Medium', 'Low', or 'None' (see Figure 8, Figure 9, and Figure 10).

It should be noted that these classifications are only generalised observations intended as a guide to help identify vegetation patches that may require significant pruning depending on vertical clearance requirements. Additionally, the assessed vegetation patches are generally quite linear and the extent of canopy overhang is not always uniform across the full length of a vegetation patch boundary.



Figure 8: Vegetation patch 54 with canopy overhang classified as 'High'



Figure 9: Vegetation patch 57 with canopy overhang classified as 'Medium'

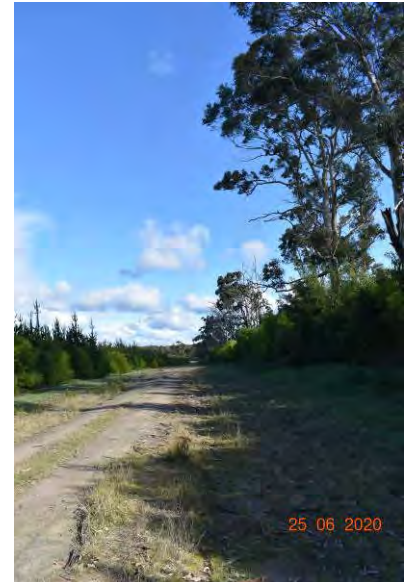


Figure 10: Vegetation patch 04 displaying 'Low' canopy overhang

Tree canopy overhang is an important consideration due to potential vertical clearance requirements throughout the construction process. Where tree canopies encroach on these vertical clearance requirements, pruning will be required. Vegetation patches with canopy overhang classified as 'High' are more likely to contain trees requiring pruning than vegetation patches with canopy overhang classified as 'Medium' or 'Low'.

Removing large amounts of photosynthetic material through heavy pruning reduces a tree's ability to produce energy and thus can put a tree under considerable stress. This increased stress in turn makes trees more susceptible to pests and diseases.

When pruning trees, consideration must be given to how much live foliage is to be removed, taking into account the fact that the tree should not be adversely affected by pruning (AS 4373 – 2007). As a general rule however, no more than 25% of live foliage should be removed from a tree at once (Harris, Clark & Matheny 1999).

Within a vegetation patch, scattered individual trees may not remain viable throughout the construction process if more than one third of their canopy requires removal in order to achieve necessary vertical clearances.

### **7.3.2 Trees within construction footprint**

Across the site some young trees were observed on the edge of vegetation patches, growing within drainage channels adjacent to existing roads (Figure 11). These trees will require removal in order to facilitate the proposed upgrade.



Figure 11: Juvenile tree growing within existing drainage outlined in yellow

## **8. Conclusions**

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

4. All road upgrade works must take place within the existing road footprint and at or above the existing soil grade.
5. All open trenching is to be conducted at least 7.5m from the closest vegetation patch. Any part of a vegetation patch located within 7.5m of the centre of a reticulation trench is considered lost.
6. Establish a Tree Protection Zone for all trees to be retained.
  - 6.1 Where works are permitted within the TPZ, fencing is to be taken in to only the minimum amount necessary to allow the works to be completed.
  - 6.2 Where machinery will be working adjacent to trees to be retained, protection for the trunk and branches will be required.

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

## **9. References**

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

AS 4373 - 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.

Harris, R.W., Clark, J.R. & Matheny, N.P., 1999, *Arboriculture; Integrated management of landscape trees, shrubs, and vines* (3<sup>rd</sup> ed.), Prentice Hall, Upper Saddle River, New Jersey.

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.

## 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 12). 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:

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

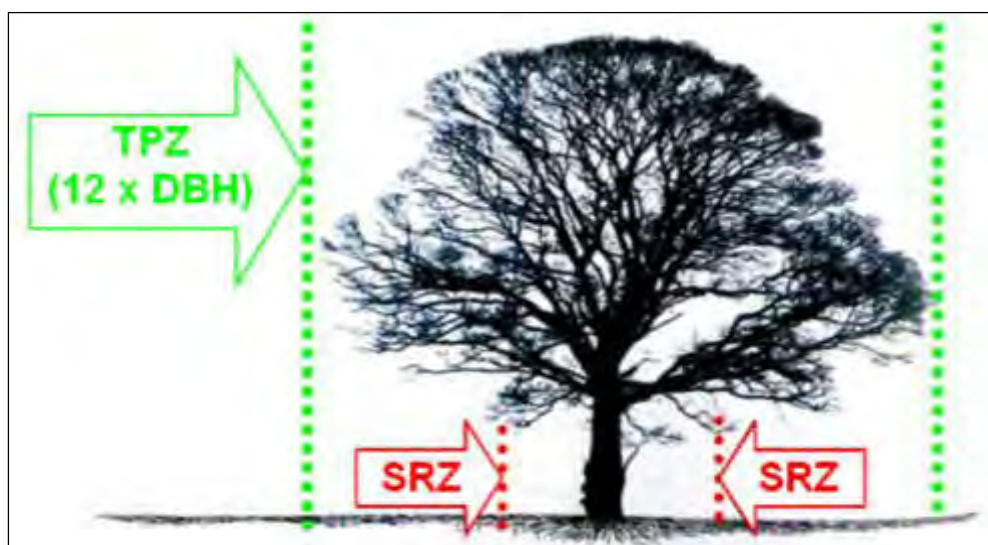


Figure 12: The SRZ = minimum volume of roots required for tree stability. Image from Biddle 1998.

### 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 4: 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 13). 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.

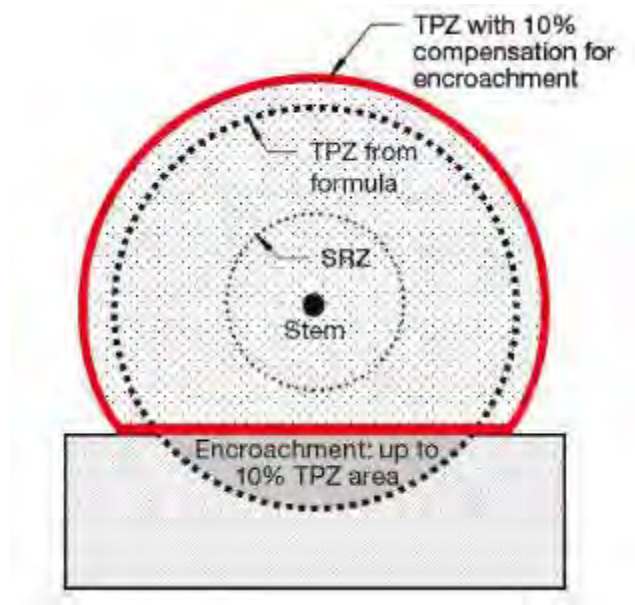


Figure 13: Example of minor TPZ encroachment and compensatory offset (image from AS 4970-2009).



## **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 14). 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 14: 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 15).



Figure 15: 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 16).

### 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 16). 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.

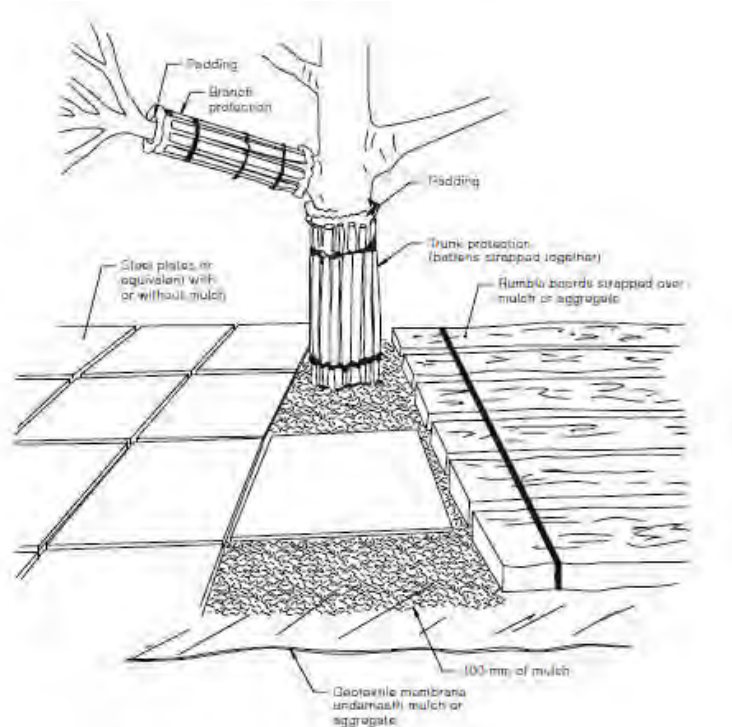


Figure 16: Example of trunk, branch and ground protection (Source: AS 4970-2009).

### 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.