CAPITAL METRO – TREE SELECTION MEMORANDUM

This memorandum outlines the process undertaken by the Advisory Team for selecting the replacement tree for the *Eucalyptus elata* (River Peppermint) trees in the Northbourne Avenue median, and how the Advisory Team arrived at the initial selection of the *Eucalyptus rossii* tree species.

Background

The selection of a suitable replacement for the *Eucalyptus elata* (River Peppermint) trees in the Northbourne Avenue median is significant. It represents the fourth major tree planting within the median of Northbourne Avenue since c1913. The previous tree plantings failed due to a number of factors including pest infestation, and in the case of the *Eucalyptus elata* trees it was the poor establishment and over dependency on irrigation.

Process for tree selection

The selection of the replacement tree was a rigorous process that included the review of the previous tree plantings within the median, including the current trees, to understand the local conditions and environmental requirements. This was combined with consideration of the specific constraints for trees in close proximity to light rail infrastructure.

The process was undertaken within the following steps, which are outlined below:

1. Assess existing trees, physical condition and life expectancy.
2. Assess site conditions and identification of specific requirements.
3. Establish key design requirements and performance criteria for the appropriate tree.
4. Review suitable tree species based on local research, specialist advice and site investigations.
5. Develop short list of suitable trees and select preferred species.
6. Finalise tree selection following site specific soil structure and chemical analysis and final arboriculture advice.

1. Assess existing trees, physical condition and life expectancy

The failure of the existing planting of *Eucalyptus elata* trees, as well as the combined effects of the construction impacts of the light rail corridor was investigated in the Scoping Design stage. The findings of this investigation were documented in the memo *Capital Metro – Preliminary assessment of tree impacts and opportunities* (14th May 2014) refer attachment 1.

2. Assess site conditions and identification of specific requirements

The existing site conditions of the Northbourne Avenue median was reviewed, through advice received from and meetings held with representatives of dsb Landscape Architects and TAMS. This advice identified that the existing conditions of the Northbourne Avenue median was of a very shallow top soil layer of approx. 300mm, with an underlying clay layer. This was documented in the memo *Capital Metro – Preliminary assessment of tree impacts and opportunities* (14th May 2014), refer Section 2.3 Local soil and environmental condition, attachment 1 below.

3. Establish key design requirements and performance criteria for the appropriate tree.

An important consideration in the tree selection was the overall form and scale of the tree, so that it represented a tree that is commensurate to the grand boulevard character of Northbourne Avenue, as the primary approach corridor in to the city. A primary consideration (National Capital Authority) is that the replacement trees are to be Eucalypts.

Another critical factor in the tree selection was the local Canberra climatic conditions. This in effect ruled out a number of the well-known tall and stately Eucalyptus trees which are commonly used in the warmer and wetter climates, such as the *Corymbia citriodora* (Lemon Scented Gum), which forms the well-known grand avenue planting in Kings Park, Perth.

In response to this, a set of general design and performance criteria was established to provide a benchmark to the selection of the appropriate Eucalypt tree. The criteria included the following:

> **Form and scale**: *tall stately form with aesthetic quality that is commensurate to the significant boulevard character of Northbourne Avenue.*
>
> **Native and characteristic of place**: *indigenous to the Canberra region.*
>
> **Height**: *mature height of 15m or greater, with a high canopy 10m or more to the general underside of canopy.*
>
> **Trunk**: *single trunked with a clean bark of a light colour, preferably smooth barked.*
>
> **High drought and frost tolerant**: *no requirement for irrigation beyond establishment.*
>
> **Proven suitability**: *have a proven record of successful growth in the urban areas of Canberra e.g. streets and parklands.*
>
> **Pest resistance**: *not highly susceptible to disease or pest infestation.*
>
> **Low maintenance and light rail suitability**: *not susceptible to excessive limb drop, wind throw, or large seed droppings.*

4. *Review suitable tree species based on local research, specialist advice and site investigations.*

Research into the suitable tree species was then undertaken, this included researching reference texts and documents about the trees and landscapes of Canberra; talking to specialist advisors with arboriculture and landscape design knowledge, especially those with experience with the local Canberra environment; and on-site investigations to see with our own eyes the trees that are performing and established around the Canberra area. This included reviewing established locations of the *Eucalyptus rossii* tree, which were provided by TAMS. Advice regarding potential suitable trees was received from specialist advisors/authorities, who are listed below:

- Territory and Municipal Services (TAMS) - Urban Treescapes Section
- dsb Landscape Architects and Arborist
- Norcue P/L, Arborist
- Environment and Planning Directorate (EPD), Planning and Heritage Branch
- Provincial Plants and Landscapes Nursery
- Australian National Botanic Gardens
- National Capital Authority

During the Definition Design Stage a long list of species was established and was incorporated into a Multi Criteria Analysis matrix, which considered design, environmental, and functional factors. This was documented in the attached *Tree Strategy – Multi Criteria Analysis*, refer attachment 2. Note this analysis was revised based on the recent feedback received from Norcue P/L regarding the characteristics of the *Eucalyptus mannifera* and *Eucalyptus rossii* tree species, refer attachments 7 and 8.

5. *Develop short list of suitable trees and select preferred species*

A short list of suitable trees was then established from the *Tree Strategy – Multi Criteria Analysis*, as well as advice received from Norcue P/L and TAMS. This list included, *Eucalyptus rossii, Eucalyptus mannifera, Eucalyptus meliodora* and *Eucalyptus maidenii.* From this list, and after further on-site investigations into established examples of these tree species around Canberra, it was determined at the time that the *Eucalyptus rossii* was the most appropriate species.

These parties were supportive of the selection of the *Eucalyptus rossii* species, and we note TAMS recommended that species specifically as the preferred succession to the *Eucalyptus elata* trees.
The TAMS technical note *Design Standards for Urban Infrastructure - Eucalyptus rossii* was also used as a key reference for the tree selection, refer attachment 5.

The selection of the *Eucalyptus rossii* species was affirmed in the report *Review of Planting Species Canberra Light Rail* (25th November 2014) refer attachment 3, and subsequent report *Norcue P/L memo for Eucalyptus rossii*, refer attachment 7.

This was documented in the attached *Northbourne median tree selection process*, refer attachment 4.

The characteristics of *Eucalyptus rossii* are detailed in *TAMS Design Standards for Urban Infrastructure – Eucalyptus rossii,* refer attachment 5.

Specialist soil advice and planted conditions

As part of the design verification process into the tree selection of the *Eucalyptus rossii* for the Northbourne Avenue median, Norcue P/L recommended that the Advisory Team engage a soils specialist to conduct a more detailed review of the existing soils within the Northbourne Avenue median, so that it may be checked against any specific soil requirements of the *Eucalyptus rossii* tree.

SESL Australia - Environment & Soil Sciences, who have an office in Canberra, were engaged to provide this advice. Their investigations looked into the existing soils in the Northbourne Avenue median, by undertaking lab testing of the existing soils in the Northbourne Avenue median (in 22 borehole locations), and Mount Ainslie (one of the natural communities of *Eucalyptus rossii*); to determine the chemical composition of the Northbourne Avenue soils and the Mount Ainslie soils. These chemical components were then reviewed by SESL against the specific requirements for the *Eucalyptus rossii* to determine if there are any issues of compatibility, and what modifications to the existing soils would be required to provide the optimal growing conditions for the trees.

In summary, the findings by SESL dated 9th April 2015, (which are confined to an analysis of one local community only of *Eucalyptus rossii*) have identified that there are high levels of manganese and phosphorus, and a low calcium to manganese ratio in the existing Northbourne Avenue soils; which are different to the soils in the natural growing conditions of the *Eucalyptus rossii* in Mount Ainslie. SESL has advised that these differences in soil chemistry presents a risk of potential issues with the successful growth of the *Eucalyptus rossii.* As a result, for the installation of the *Eucalyptus rossii*, SESL have recommended that the existing soils be modified with the application of dolomite, iron sulphate and quartz sand. The application of quartz sand being specific to the *Eucalyptus rossii.* This is further outlined in the SESL report dated 9th April 2015, an extract of which is included in attachment 9.

6. Finalise tree selection with soils analysis results and final arboriculture advice

Following the receipt of advice from SESL and based on the shared vision that the selection of the replacement trees for Northbourne Avenue is critical, and is ultimately a legacy for the success of the avenue, the Advisory Team has completed its design verification and reconsidered the recommendation for the proposed tree for the Northbourne Avenue median, because of the risk identified from the results of the soils analysis.

Based on this verification, and following further consultation with Norcue P/L, SESL, and TAMS it is recommended that *Eucalyptus mannifera* be the proposed replacement tree for Northbourne Avenue. The *Eucalyptus rossii* was previously selected over the *Eucalyptus mannifera* as it was deemed (marginally) a more beautiful tree, however these two tree species are very similar in appearance, indeed it is unlikely that the general public would be able to discern the difference between the trees without professional assistance.

The *Eucalyptus mannifera*, also known as Red Spotted or Manna Gum and Brittle Gum ('brittle' refers to strength of the timber not living branches), satisfies the design criteria established by the Advisory Team, and has been endorsed by our specialist consulting soil scientists (SESL Australia), consulting arborist / horticulturist (Norcue P/L), and TAMS as an appropriate tree for the existing soil, climatic and ornamental qualities in Northbourne Avenue (refer attachments 8 and 10). We note the advice from Norcue P/L that *Eucalyptus mannifera* may be subject to branch drop in mature specimens but that this factor is no worse than any other locally grown Eucalyptus species. Norcue P/L stresses the importance of proper arboriculture practices to ensure the optimum tree establishment and which will help reduce long term maintenance issues, refer attachment 8.

The *Eucalyptus mannifera* is one of the best performing Eucalyptus species in Canberra, based on the recent TAMS audit of trees in Canberra (>80,000 trees recorded). The *Eucalyptus mannifera* is also currently found along the Northbourne Avenue verges as a mature successful street tree albeit growing in constricted verge footpath spaces; it is also found in many parks and streetscapes / avenues across Canberra, notably Captain Cook Crescent in Griffith.

The characteristics of *Eucalyptus mannifera* are detailed in *TAMS Design Standards for Urban Infrastructure – Eucalyptus mannifera* (refer attachment 6), and *Memo – Norcue P/L memo for Eucalyptus mannifera* (refer attachment 8).

Tree procurement / planting

Regarding the potential early tree procurement for the Northbourne Avenue planting, the below information has been investigated to provide clarification on the most appropriate procurement method for approximately 800x Eucalypt trees within the Northbourne median.
One of the most important factors to the success of the tree planting is how they are propagated and grown in the nursery, and how they are planted. This includes the continued arborist and soils scientist advice and ongoing monitoring and maintenance throughout the nursery growing, planting, and operational periods. Modern standards in this respect have been established in the Barangaroo project in Sydney, where Nurcue P/L and SESL Australia were engaged for the procurement and installation of the trees and planting of this project. It is recommended that a qualified arborist and soil scientist be engaged in a similar fashion for the Capital Metro project for any tree and plant procurement.

The general horticultural rule of thumb for the optimal planted container size (for tree establishment) is between 25L and 100L – as establishment will generally be faster and better at this size. But for the case of Northbourne Avenue where the visual impact / size of tree when planted is an important factor, we recommend that the optimal planting size is a 200L tree. This will provide a tree that is approx. 3m tall when planted, as opposed to an approx. size of 1.5 – 2.0m for a 100L tree, or less for a 75L tree, and won't result in any foreseeable issues with establishment. *Note - we do not recommend planting larger than 200L as it may result in potential inherent root problems.*

Attachment 1

Capital Metro – Preliminary assessment of tree impacts and opportunities (14th May 2014).

CAPITAL METRO – DESIGN REPORT

Option ID:	CLR-RAL-OPR-00006
Issue for Decision:	Preliminary assessment of tree impacts and opportunities
Decision Level:	
Decision Maker:	
Recommendation:	

1 Introduction

The advisory team have prepared this design report to outline the impacts on the existing trees associated with the proposed light rail alignment. This assessment is based on the current centre running alignment at Feasibility Stage, extending from Alinga Street at Civic to Gungahlin Place at Gungahlin. It excludes the areas associated with the project stabling facilities, and any construction or temporary compounds (which are undefined at this stage).

The first part of this report reviews the impacts on trees within Northbourne Avenue, with a detailed assessment of the impacts associated with the construction of the light rail within the centre of the median. The assessment references the Northbourne Avenue and Federal Highway Tree Audit undertaken in 2010 by ACT Urban Treescapes, and the updated audit undertaken in 2014 by dsb Landscape Architects (included as an appendix to this report). A preliminary tree impact assessment has been undertaken, which is based on the following key criteria:

- Tree health and condition;
- Tree species growth habitat;
- Local soil and environmental conditions;
- Statutory regulations regarding to tree protection;
- Construction methodology and impacts;
- Root investigation methods;
- Overhead wires and impacts;
- Sight lines and tree proximity to light rail; and
- Further degradation and potential risks

The second part describes the path going forward for the advisory team, the process for reviewing the suitability of the existing tree plantings, the methodology for tree selection, and factors for locating new tree plantings as part of the project.

2 Tree impact assessment – Northbourne Avenue

2.1 Tree health and condition

An arborist assessment of the existing trees on Northbourne Avenue and Federal Highway was undertaken in 2010 by ACT Urban Treescapes, and an additional assessment conducted in association with the Capital Metro project was undertaken in 2014 by dsb Landscape Architects. This recent assessment included an update of the 2010 Treescapes Audit, and an assessment of the existing trees along Flemington Road to Hibberson Street in Gungahlin. These arborist assessments have provided the Advisory Team with the critical information required to review the tree impacts associated with the Capital Metro project within the areas currently defined.

A summary of the findings from the 2010, and 2014 tree audits are illustrated below (Figure 1). Overall, a high percentage of trees in the median are classified as being fair and poor health. In 2010 - 26% was fair health, and 10% poor health; and in 2014 – 39% was fair health, and 2% poor health. As can be seen in the illustration below, many trees were removed in the period between 2010 and 2014, which were trees that had already died, or that presented structural / health issues. It should also be noted that many of the trees that were classified as good health in 2010 were reduced in classification down to poor/fair-poor health in 2014, indicating a general decline in the health of the *E. elata* trees (refer tree audit in the appendix of this report).

The tree health scoring is explained below:

- Good: Above average vigour; no decline; 0% dieback; better than average foliage density; better than average leaf health; no pest / diseases. An Exceptional specimen.
- Fair: Average vigour; average decline; <10% dieback; >90% foliage density; >90% leaf health; pests / diseases within thresholds. The typical condition of the species.
- Fair-Poor: Below average vigour; more than average decline; 10-20% dieback; foliage deficiencies; 70-90% foliage density; 70-90% leaf health; pests / disease at thresholds.
- Poor: Minimal vigour; substantial decline; 20-30% dieback; considerable foliage deficiencies; 50-70% foliage density; 50-70% leaf health; pest / diseases exceed thresholds.
- Very Poor: Irreversible decline; 30-50% dieback; severe foliage deficiencies; 30-50% foliage density; 30-50% leaf health; severe pests / diseases.

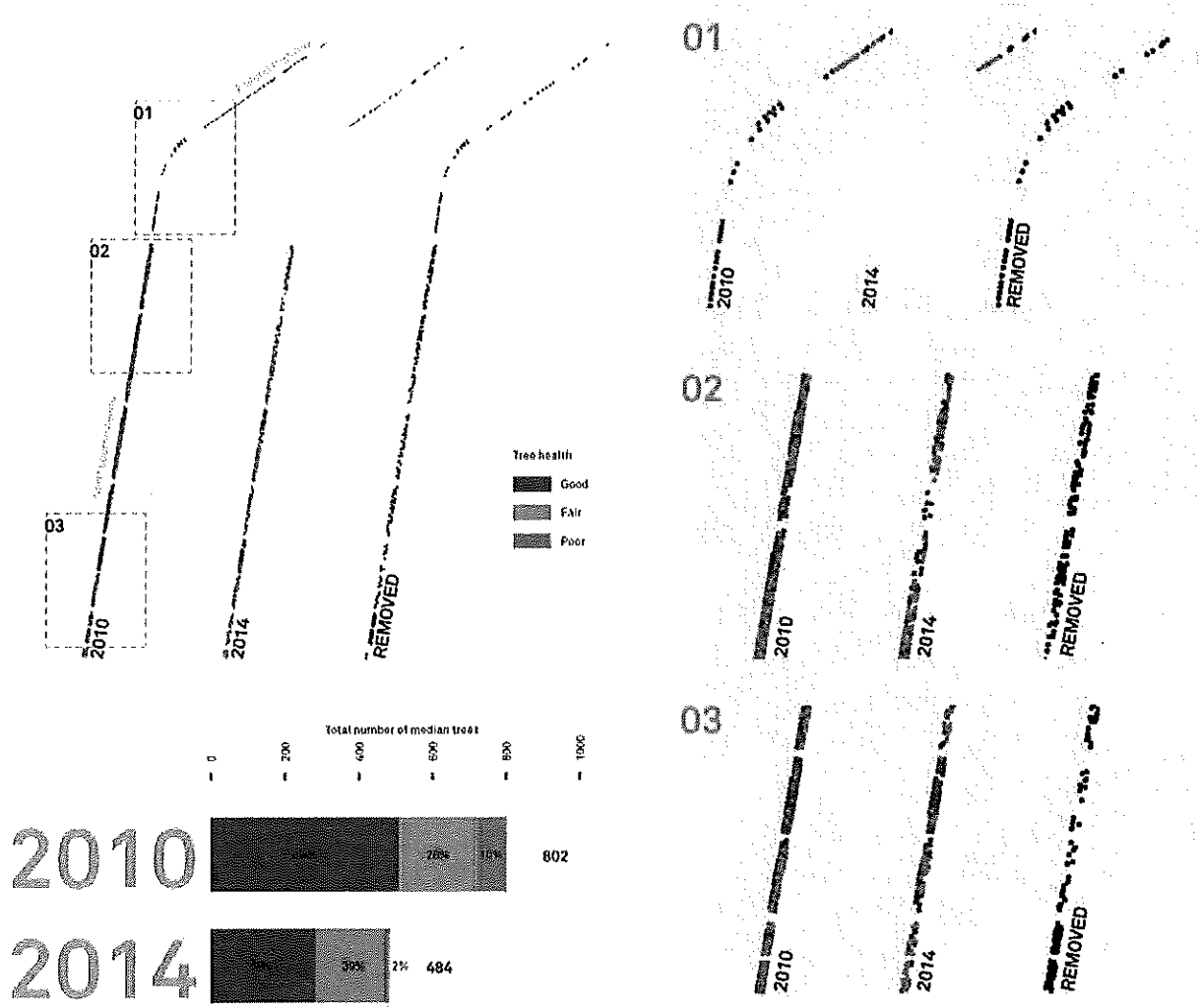


Figure 1: Summary of the findings from the 2010 and 2014 tree audits

2.2 Native growth habitat – *Eucalyptus elata*

The predominant tree species within the median of Northbourne Avenue is *Eucalyptus elata.* This tree is native to the south eastern regions of NSW and is found on the escarpment forests above Moruya, and grows naturally in the 'cloud forests' of that region. The cloud forests with high rainfall and humidity present the perfect growing conditions for the *E. elata* trees. The fact that the *E. elata* trees are surviving in the median of Northbourne Avenue is largely due to the irrigation that is currently provided to these trees, which is sustaining their growth. The plentiful supply of water means that the tree roots of the *E. elata* trees will generally have a shallower root system than most dry land Eucalyptus species; which also presents risks for wind throw are explained further in section 2.10 below.

2.3 Local soil and environmental condition

The *E. elata* trees within Northbourne Avenue were planted between 1983-87, and were installed in less than ideal conditions. They are planted in small tree pits with very shallow top soil (approx 300mm deep) over a clay sub base, and are supported with irrigation. It was noted that the trees responded badly when the irrigation was turned off during the latest ACT drought. It is likely that they will have the same response if irrigation turned off again in the future.

Due to these conditions it is likely that the trees will have developed shallow and fibrous root systems that are concentrated within the surface top soil layer. Evidence of this is supported by previous *E. elata* trees that have fallen in high winds, which have exposed their small root planes (see Figure 2 below). It has also been revealed that many of the trees have developed root rot, which over time causes critical structural failure of the roots, causing the trees to fall down unexpectedly. All of these factors have meant that wind throw and branch drop has been an ongoing characteristic of these trees in the median, and the extent of the tree loss is evidenced by the 'gaps' in the planting pattern within the median.

Another factor affecting the growth of the *E. elata* trees in the median is a result of the prevailing winds in Canberra coming from the northwest. The tree root systems generally have a bias towards northwest, so there is likely a greater proportion of their root system on the north western side. This means that disturbance to trees along the eastern side of the median may have a greater effect than it would to trees on the western side, as it may be compromising the tree roots that provide structural support which extend towards the construction zone.

Figure 2: Showing an *E. elata* tree with critical root failure thrown by wind on Northbourne Avenue

2.4 Statutory regulations regarding tree protection

The primary statutory regulation used in this assessment is the 'ACT Tree Protection Act 2005'. Also referenced is the Australian Standard 4970-2009 'Protection of trees on development sites', in which Section 2 Planning and the Tree Management Process Cl. 2.3.2 relates to tree protection guidelines.

The ACT Tree Protection Act includes the following key criteria:

- That any earthworks within 4m of trunk is prohibited, and if earthworks are required within this area, then each tree is to be assessed by an arborist to determine the effects or whether removal will be required.
- That up to 10% of ground disturbance within the Tree Protection Zone (TPZ) is 'tolerable', and this is used as a threshold and administrative guideline for tree impact assessment. Tolerable indicates that the tree is likely to survive without major adverse effect.
- Above 10% to 20% is 'negotiable' with alternate construction methods put in place to minimise ground (and TPZ) disturbance such as piers and floating slabs.
- The TPZ is classified as being: (a) the area under the canopy of the tree; and (b) the 2m wide area surrounding the vertical projection of the canopy; and (c) the 4m wide area surrounding the trunk as measured at 1m above natural ground level.

2.5 Construction methodology and impacts

For the purposes of determining the tree impacts on Northbourne Avenue, a typical light rail track construction methodology has been assumed as a means to estimate the extent of the zone of influence for the construction of the proposed track slab.

The anticipated construction methodology includes an excavation located within the proposed track zone in the centre of the median. The excavation will require the removal of top soil and any sub grade material from a minimum depth of 550mm, to an approximate maximum depth of 1.3m. The excavation and/or ground disturbance required to the areas immediately adjacent to the tracks will likely extend to approximately 2.5m from the edge of the trackform slab, resulting in an approximate total zone of disturbance of 11.8m (refer Figure 4 below).

The trees on Northbourne Avenue are aligned approximately into two rows on either side of the median - an inner row and an outer row. The anticipated construction zone will result in anticipated certain loss of the inner rows of trees, with a likely direct impact upon the root zones of the outer row. The extent of impact will vary from tree to tree, depending on the proximity of the roots to the required ground works. To determine the location of the tree roots some invasive root investigations will be required. This is explained further below in Section 2.7.

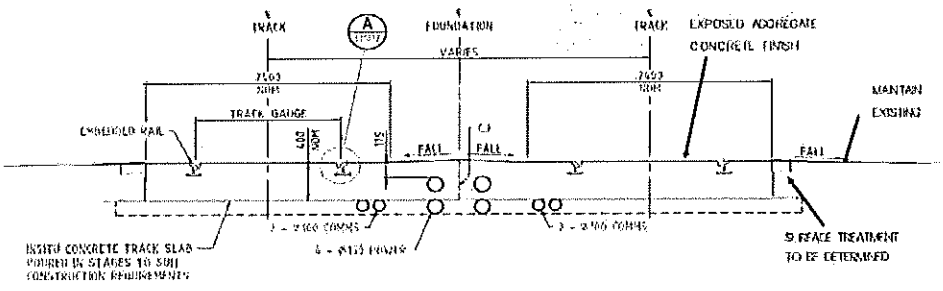


Figure 3: Showing a typical detail trackform cross section on Northbourne Avenue

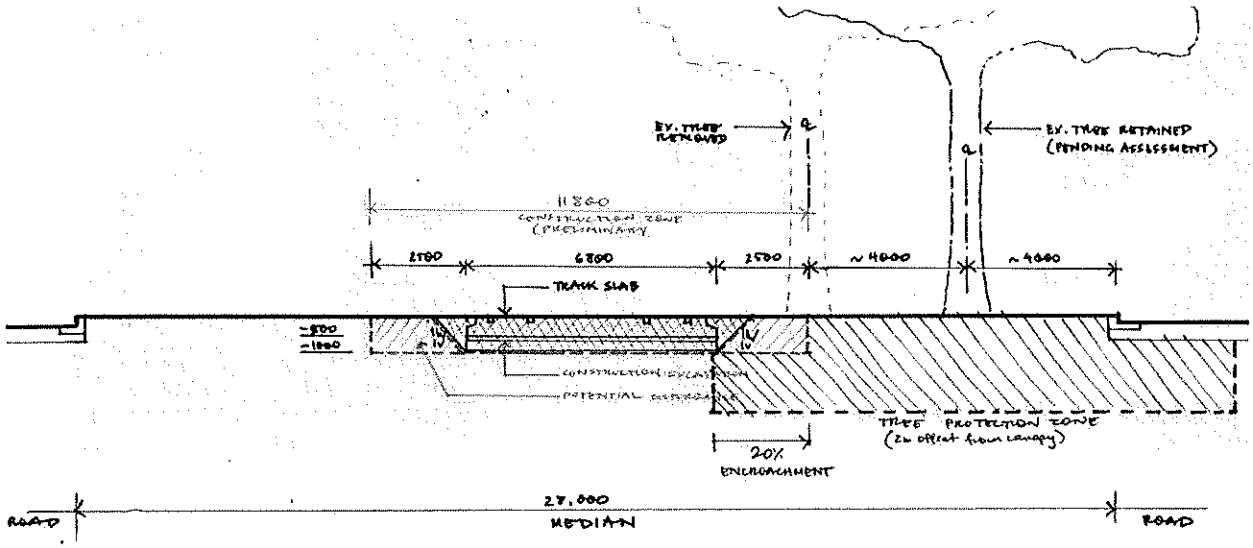


Figure 4: Typical cross section through Northbourne Avenue showing trackform, TPZ & construction zone

Figure 5: Showing tracks (grey), construction zone offset (orange line) and TPZs (blue circles)

2.6 Preliminary tree impact assessment methodology

The advisory team have undertaken a preliminary tree impact assessment of the trees within the median of Northbourne Avenue, based on the guidelines outlined in the ACT Tree Protection Act (2005). The assessment was based upon the following methodology, which identifies the probability for retention of existing trees based on the proximity to the proposed construction zone outlined above:

1. Firstly, encroachment of the proposed construction zone within the tree protection zone (TPZ) is determined, if no encroachment then the tree is identified as a **HIGH** probability of retention and no further arborist review would be required;

2. Secondly, if there is encroachment of the proposed construction zone into the TPZ then the tree will be identified as a **MEDIUM** probability for retention, which requires further arborist review to determine the retention or removal of the tree;

3. Thirdly, if there is greater than 20% encroachment of the proposed construction zone into the TPZ then the tree will be identified as a **LOW** probability for retention, which requires further arborist review to determine the retention or removal of the tree.

It should be noted that this preliminary assessment into the longevity of the trees and the durability of the trees on Northbourne Avenue is limited and based on predicted impacts. The determination of the precise impacts to the trees will require invasive examination of the tree roots to determine where they are located. The methodology for this is explained below.

2.7 Root investigation methods

A number of root investigation methods may be used to determine the location of the tree roots, these are:

- Method 1 – Potholing: least invasive, but least conclusive.
- Method 2 – Trenching with mini-excavator and backhoe.
- Method 3 – Water blasting (preferred): most invasive but most definitive method. This includes a full cross section of the median and the trees, which will provide definitive evidence of trees and extent of root systems.

Furthermore, to fully understand the extent of 'root rot' that has been identified on a number of existing *E. elata* trees within Northbourne Avenue, it may be required that a sonic wave analysis device be used to determine the extent of this. This device uses sound waves to measure the density of the root systems beneath the surface.

Figure 6: Example of root exploratory trenching

2.8 Overhead wires and impacts

There will also be an impact to existing and new trees that is associated with the installation and operation of the overhead traction power wires. In a typical wired light rail system overhead wires are located over the centre line of each track, at a height of 5.5m above the track surface level, and run continuously along the track. Typically in Australia, operators have adopted a control measure that maintains tree branches away from the wires at a certain radius around each overhead wire, called a 'vegetation exclusion zone' (refer Figure 7 below). It is understood that it is a 2.5m radius is used for the Sydney Light Rail network, and 1m + 3years growth is used in Melbourne. The impact will include pruning of branches so they are maintained outside of the exclusion zone. This may have an impact upon the overall health and longevity of the tree, with the extent to which trees can be pruned and still remain viable to be assessed individually, and additional pruning may be required to ensure that the tree is balanced.

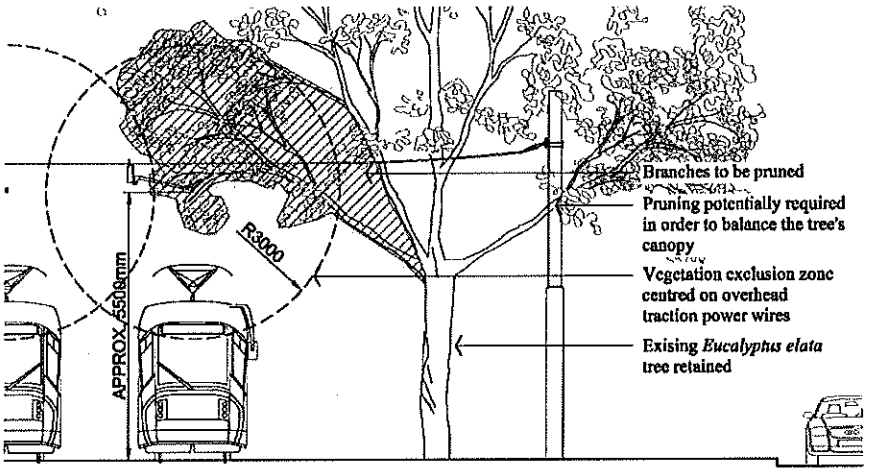


Figure 7: Typical cross section showing vegetation exclusion zone and potential tree impacts

2.9 Sight lines and tree proximity to light rail

The placement of new trees and the ongoing maintenance of existing trees will need to take into consideration the required provision for safety sight lines and view angles for the drivers of the LRVs and also for pedestrians / vehicle drivers. This will likely require the tree canopies to be maintained at a certain height above eye level for the LRV drivers, and also for the trees to be setback from the main intersections on Northbourne Avenue. This will be further developed in the Definition Design Stage with operational advice.

2.10 Further degradation and potential risks

The construction of the Capital Metro project into the existing mature landscape of the Northbourne median involves a certain level of risk. The risk is associated with the retention of existing mature trees, many of which are already of fair-poor/poor health. There is likely further reduction to the health of the retained trees with the associated earthworks in close proximity to or within the existing tree root zones. The further degradation of any retained trees would present risk of damage to the future light rail infrastructure and operations and the adjacent roadway of Northbourne Avenue. This would also be to the detriment of this prominent and spatially important feature within Canberra's city landscape.

Furthermore, the design of the *E. elata* median planting was undertaken at a time when water was considered an unlimited resource and the installation of an irrigated landscape was feasible. These design conditions have now changed and the suitability of *E. elata* trees under these changed circumstances is questionable.

3 Looking ahead – the opportunities

The Capital Metro project presents the opportunity to review the overall suitability of the existing *E. elata* trees, and the viability for their retention. Now is the time to review the potential benefits for a refreshed planting of trees, with the selection of a suitable species that will thrive within the unique and constrained local conditions of Northbourne Avenue. The opportunity is to put in place an urban, transport and landscape design construct that will last for the next hundred years.

Looking beyond Northbourne Avenue, the opportunity also exists to further improve the landscape of Flemington Road, which is largely a bare tree-less landscape within the median. With the introduction of light rail, there is the potential to plant trees on both sides of the light rail tracks within the median (reducing to a single side in narrow sections), to create a tree-lined boulevard, which represents the characteristics of the many other grand avenues across the city of Canberra.

3.1 Potential early works and community engagement

There may be some benefits in considering the staging of the Capital Metro project and the time between when existing trees are removed and new trees are planted. Some positive community benefits may result by early planting, prior to the substantial removal of trees along the median for the main works construction. Some potential methods could include:

- Verge planting, by 'filling in the gaps' along both verges of Northbourne Avenue through the planting of E. mannifera (Brittle Gum) and Crataegus tree (Hawthorn) in accordance with the original planting pattern.

- Removal and planting along one side of the median, potentially the outer edge of the median. This may assist in engendering a 'gesture of goodwill' toward the community, so that there may be visible replanting occurring prior to any major construction works of the light rail.

3.2 Alternative tree species selection process

As part of the Scoping Design Stage the advisory team will be developing a recommended list of suitable tree species as alternatives to the *E. elata* trees. To provide a comprehensive and reputable proposal, the advisory team have gained advice from a number of leading arboriculture professionals based in Canberra, who each have in-depth knowledge of the local conditions and tree species in the ACT. These professionals associated with the project are: Paul Scholtens and Michael Reeves (dsb Landscape Architects), and representative of Urban Treescapes at City Services, TAMS, ACT Govt, and Urban Development Advisor EDD. Independent advice has been provided by the National Botanical Gardens, and further advice will be sought in the next stage from Environment and Planning Directorate.
Based on the advice received from these professionals the advisory team will present a multi-criteria analysis (MCA) of proposed alternative tree species. This MCA will provide a ranking of the trees against critical environmental and urban design factors that will assist the advisory team in proposing suitable tree species.

3.3 Whole of corridor approach

In considering the opportunities of selecting a new species for Northbourne Avenue, the whole corridor of Northbourne Avenue must be considered. New trees along the median cannot be considered in isolation and the entire cross section of Northbourne Avenue, from building frontage to building frontage, must be considered as an integral whole.

Furthermore, Northbourne Avenue must be reviewed in context of the City, and how it relates to the number of other tree lined boulevards across Canberra and the variety of species (both native and exotic) which are present along them.

Attachment 2

Tree Strategy – Multi Criteria Analysis (revised 22nd April 2015).

Tree Strategy –
Multi criteria analysis

'-criteria analysis for tree selection

_ advisory team has developed a recommended list of suitable tree species as alternatives to the E. elata trees using the 'Design Standards for Urban Infrastructure: 23 Plant Species for Urban Landscape Projects, Urban Services'. Based on the advice received from these professionals the advisory team has developed a multi-criteria analysis (MCA) of the proposed alternative tree species. This MCA has provided a ranking of the trees against critical environmental and urban design factors that will assist the advisory team in proposing suitable tree species.

The MCA was carried out by scoring each species across 27 criteria, according to its proposed position within the corridor landscape and under the following themes;

- _proven performance specifically in Canberra's urban environment;
- _compatibility with light rail;
- _size and scale;
- _provenance (locally indigenous/Australian native/ exotic)
- _compatibility with Canberra's unique landscape character;
- _suitability to represent the National Capital; and
- _design factors including aesthetic value, shade provision and solar access in winter.

Tree species were initially selected for their proposed locations within the corridor based on existing examples of trees that are thriving under local conditions and on recommendations by TAMS and professional advice provided by individual local experts. The selection criteria were established with reference to those applied in other Australian centres and TAMS' Plant Species for Urban Landscape Projects in Canberra database.

Under each criterion each species was given a score between 0 and 1, with 0 being the least desirable _e and 1 being the most desirable. Depending on _criterion scoring was either on a six point scale _0.2/0.4/0.6/0.8/1) or binary (0/1).

Each criterion was then weighted by being multiplied by between 1 and 5, depending on its perceived importance to the overall success of the tree. The sum of the resulting scores was then divided by the total possible score, giving a rating percentage.

Note: this analysis was revised based on the recent feedback received from Norcue P/L regarding the characteristics of the Eucalyptus mannifera and Eucalyptus rossii tree species.

Multi criteria analysis

		DESIGN							ENVIRONMENTAL			
Botanical name	Common name	Height rating	Canopy spread rating	Structural form	Aesthetic value	Contribution to landscape character	Shade provision	Solar access	Locally indigenous / native / exotic	Climate suitability	Soils / geology suitability	Native wildlife habitat
Criteria scoring		0 to 1 (6 pt)	0 to 1 (6 pt)	0 to 1 (6 pt)	0 to 1 (6 pt)	0 to 1 (6 pt)	0 to 1 (6 pt)	0 to 1 (6 pt)	0/0.5/1	0 to 1 (6 pt)	0 to 1 (6 pt)	0 to 1 (6 pt)
Based on		Suitability	Suitability	Rating	Rating	Rating	Rating	Suitability	Rating	Rating	Rating	Rating
Weighting multiplier		2	1	5	2	5	1	1	2	3	2	1
HIBBERSON STREET												
PEDESTRIAN MALL/VERGE												
Fraxinus ornus	Manna Ash	0.6	0.6	0.6	0.6	0.2	0.6	1	0	0.6	0.6	0
Fraxinus pennsylvanica 'Cimmzam'	Cimmaron Green Ash	0.6	0.6	0.6	0.6	0.2	0.6	1	0	0.6	0.6	0
Fraxinus velutina	Arizona Ash	0.6	0.6	0.6	0.6	0.2	0.6	1	0	1	0.6	0
Gleditsia triacanthos	Honey Locust	0.6	0.6	0.6	0.6	0.2	0.6	1	0	0.6	1	0
Pistachia chinensis	Chinese Pistache	0.6	0.6	0.6	0.6	0.2	0.6	1	0	1	1	0
Pyrus calleryana	Ornamental Pear	1	0.4	0.6	0.6	0.2	0.4	1	0	1	0.6	0
Zelkova serrata 'Green Vase'	Japanese Zelkova	0.6	0.6	0.6	0.6	0.2	0.6	1	0	1	0.6	0
FLEMINGTON ROAD												
MEDIAN												
Eucalyptus rossii	Scribbly Gum	0.6	0.6	0.6	0.6	1	0.6	0.6	1	1	0.6	1
Eucalyptus maidenii	Maiden's Gum	0.6	1	0.6	0.6	0.6	0.6	0.6	1	1	0.6	1
Quercus palustris	Pin Oak	1	0.6	1	0.6	0.6	0.6	0	0	1	1	0
VERGE												
Eucalyptus mannifera	Brittle Gum	0.6	0.6	0.6	0.6	1	0.6	0.6	1	1	0.6	1
Eucalyptus macrorhyncha	Red Stringy Bark	0.6	0.6	0.6	0.6	0.6	0.6	0.6	1	1	0.6	1
Eucalyptus bicostata	Blue Gum	0.6	1	0.4	0.6	1	0.6	0.4	1	1	0.6	0.6
Quercus phellos	Willow Oak	1	0.6	1	0.6	0.4	1	1	0	0.6	1	0
FEDERAL HIGHWAY												
MEDIAN												
Eucalyptus mannifera	Brittle Gum	0.6	0.6	0.6	0.6	0.6	0.6	0.6	1	1	0.6	1
Eucalyptus rossii	Scribbly Gum	0.6	0.6	0.6	0.6	1	0.6	0.6	1	1	0.6	1
VERGE												
Eucalyptus macrorhyncha	Red Stringy Bark	0.6	0.6	0.6	0.6	0.6	0.6	0.6	1	1	0.6	1
Fraxinus angustifolia	Desert Ash	0.6	0.6	1	0.6	0.6	0.6	1	0	1	1	0
Fraxinus raywood	Claret Ash	0.6	0.6	1	0.6	0.6	0.6	1	0	1	1	0
Populus alba	Silver Poplar	0.6	0.6	1	0.6	0.6	0	1	0	1	1	0
NORTHBOURNE AVENUE												
MEDIAN												
Casuarina glauca	Swamp Oak	0.6	0.6	0.4	0.2	0.4	0.6	0.2	0.5	0.2	0.4	0.6
Eucalyptus bicostata	Blue Gum	0.6	1	0.4	0.6	1	0.6	0.4	1	1	0.6	0.6
Eucalyptus blakelyi	Blakelys Red Gum	0.6	0.6	0.6	0.6	1	0.6	0.6	1	1	0.6	1
Eucalyptus maidenii	Maiden's Gum	0.6	1	0.6	0.6	0.6	0.6	0.6	1	1	0.6	1
Eucalyptus mannifera	Brittle Gum	0.6	0.6	0.6	0.6	1	0.6	0.6	1	1	0.6	1
Eucalyptus rossii	Scribbly Gum	0.6	0.6	0.6	0.6	1	0.6	0.6	1	1	0.6	1
Quercus palustris	Pin Oak	1	0.6	1	0.6	0.6	0.6	0	0	1	1	0
VERGE												
Crataegus 'smithiana' (local clone)	Red Mexican Hawthorne	0.4	0.6	0	0.4	0.4	0.4	1	0	1	0.6	0.6
Eucalyptus mannifera	Brittle Gum	0.6	0.6	0.6	0.6	0.6	0.6	0.6	1	1	0.6	1
Fraxinus ornus	Manna Ash	0.6	0.6	0.6	0.6	0.2	0.6	1	0	0.6	0.6	0
Fraxinus pennsylvanica 'Cimmzam'	Cimmaron Green Ash	0.6	0.6	0.6	0.6	0.2	0.6	1	0	0.6	0.6	0
Fraxinus velutina	Arizona Ash	0.6	0.6	0.6	0.6	0.2	0.6	1	0	1	0.6	0
Gleditsia triacanthos	Honey Locust	0.6	0.6	0.6	0.6	0.2	0.6	1	0	0.6	1	0
Pistachia chinensis	Chinese Pistache	0.6	0.6	0.6	0.6	0.2	0.6	1	0	1	1	0
Pyrus calleryana	Ornamental Pear	1	0.4	0.6	0.6	0.2	0.4	1	0	1	0.6	0
Zelkova serrata 'Green Vase'	Japanese Zelkova	0.6	0.6	0.6	0.6	0.2	0.6	1	0	1	0.6	0

	FUNCTIONAL																
Invasive-ness	Suitability to urban conditions	Proven performance locally	Longevity	Growth rate	Availability	Toxicity / allergens	Limb drop	Litter drop	Flammability	Disease / pest resistance	Toleration of pruning	Drought tolerance	Frost tolerance	Irrigation requirement	Root Invasive-ness	Comments	Rating percentage
0/1	0 to 1 (6 pt)	0/1	0 to 1 (6 pt)	0 to 1 (6 pt)	0/1	0/1	0/1	0 to 1 (6 pt)	0/1	0 to 1 (6 pt)	0/1	0 to 1 (6 pt)	0 to 1 (6 pt)	0/1	0/1		
+/-	Rating	+/-	Rating	Rating	+/-	+/-	+/-	Rating (inverse)	+/-	Rating	+/-	Rating	Rating	+/-	+/-		
1	2	5	2	1	1	1	3	2	1	1	1	2	2	3	1		
1	1	1	1	0.2	1	1	1	0.2	1	1	1	0.6	0.8	1	1		71%
1	1	1	0.6	0.6	1	1	1	0.2	1	1	1	0.6	0.8	1	1		73%
1	1	1	0.6	0.6	1	1	1	0.2	1	1	1	0.8	0.6	1	0		72%
0	1	1	0.6	0.8	1	1	1	0.2	1	1	1	0.8	0.6	1	0		71%
0	1	1	0.6	0.4	1	1	1	0.2	1	1	1	1	1	1	1		74%
1	1	1	0.6	0.6	1	1	1	0.2	1	1	1	1	1	1	1		76%
1	1	0	0.6	0.8	1	1	1	0.2	1	1	1	1	1	1	1		67%
1	0.8	1	0.8	0.6	1	1	0.2	0.4	1	1	1	1	1	1	1		83%
0.6	0.8	0.8	0.8	0.8	1	1	0.8	0.2	0	1	1	1	1	1	1		80%
1	0.8	1	1	0.2	1	1	0	0.6	1	1	1	1	1	1	1		77%
1	0.8	1	0.8	0.8	1	1	0	0.4	0	0.4	1	1	1	1	1		78%
1	0.8	1	0.8	0.4	1	1	1	0.4	0	0	1	1	1	1	1		81%
0	0	0.2	0.8	0.6	1	1	0.2	0.4	0.2	1	0.6	1	1	1	0		65%
1	0.8	0	1	1	1	1	1	0.4	1	1	1	0.6	0.8	1	1		72%
1	0.8	1	0.8	0.8	1	1	0	0.4	0	0.4	1	1	1	1	1		77%
1	0.8	1	0.8	0.6	1	1	0	0.4	1	1	1	1	1	1	1		81%
1	0.8	1	0.8	0.4	1	1	1	0.4	0	0	1	1	1	1	1		81%
0	1	1	0.8	0.6	1	1	1	0.4	1	1	1	1	0.8	1	0		80%
0	1	1	0.8	0.6	1	1	1	0.4	1	1	1	1	0.8	1	0		80%
0	1	1	0.8	0.8	1	1	1	0.8	1	1	1	1	1	1	0		83%
0	0.6	0	0.8	1	1	1	1	0.2	1	1	1	0	0	1	0	Propensity to	48%
1	0	0.2	0.8	0.6	1	1	0.2	0.4	0.2	1	0.6	1	1	1	0		67%
1	0.8	1	0.8	0.8	1	1	0	0.4	0.4	0.4	1	1	1	1	0.6		81%
0.6	0.8	0.6	0.8	0.8	1	1	0.8	0.2	0	1	1	1	1	1	1		77%
1	1	1	0.8	0.8	1	1	0.8	0.4	0	0.4	1	1	1	1	1		84%
1	0.8	0.6	0.8	0.6	1	1	0.8	0.4	1	1	1	1	1	1	1		81%
1	0.8	1	1	0.2	1	1	0	0.6	1	1	1	1	1	1	1		77%
1	1	1	0.8	0.6	0	1	1	0.6	1	0.6	1	1	1	1	1		68%
1	0.8	1	0.8	0.8	1	1	0	0.4	0	0.4	1	1	1	1	1		76%
1	1	1	1	0.2	1	1	1	0.2	1	1	1	0.6	0.8	1	1		71%
1	1	1	0.6	0.6	1	1	1	0.2	1	1	1	0.6	0.8	1	1		73%
1	1	1	0.6	0.6	1	1	1	0.2	1	1	1	0.8	0.6	1	0		72%
0	1	1	0.6	0.6	1	1	1	0.2	1	1	1	0.8	0.6	1	0		71%
0	1	1	0.6	0.4	1	1	1	0.2	1	1	1	1	1	1	1		74%
1	1	1	0.6	0.6	1	1	1	0.2	1	1	1	1	1	1	1		76%
1	1	0	0.6	0.8	1	1	1	0.2	1	1	1	1	1	1	1		67%

Attachment 3

Review of Planting Species Canberra Light Rail (25th November 2014).

Note: This document makes reference to the *Arup HASSELL Tree Master Plan*, which is the document *Tree Strategy – Multi Criteria Analysis (21st July 2014)* as included in Attachment 2.

Review of Planting Species

Capital Metro-
Canberra's Light Rail
Corridor Planting Strategy

Prepared by:

[redacted]

Registered Landscape Architect
Horticulturist/Consultant Arborist
November 2014

Introduction

This review of the plantings species nominated for the Capital Metro-Canberra's Light Rail was prepared at the request of Hassell Landscape Architects.

The report addresses the planting species nominated throughout the various precincts of the **ARUP HASSELL** Tree Master Plan starting at Precinct 1 Gungahlin through to Precinct 6 Civic ACT.

Text and reference material cited in the preparation of this report include:

- A key to the Eucalyptus - *W.F. Blakely 3rd. edition 1965*
- Plants Local to the Canberra Region -*Yarralumla Nursery*
- Garden & Landscape Trees in Australia Harry Oakman - *former Chief Landscape Architect for the NCDC Canberra and*
- Ornamental Flowering Trees in Australia - *Raymond J. Rowell*

Precinct 1
Urban town Centre - Gungahlin Terminus - Hibberson Road

Deciduous trees.
The nominated deciduous street tree species are supported except for Malus floribunda *Crab apple* as the crown spread at maturity may be too low and too broad. Mature fruit dropping on the adjacent pavements may also create a hazardous situation during the trees fruiting season.

Grasses and Accents
The nominated species are supported except for Agapanthus orientalis which may suffer during the severe winter frosts

Precinct 2
Lowland Woodland with Boulevard Median - Flemington Road North

Native trees indigenous to the locality include the following. Tree marked with *** are considered the preferred species for planting within and adjacent to the light rail corridor.

Botanical name	Common name	Mature height	Comments
Eucalyptus amplifolia	Cabbage gum	8-12m	Medium- sized to large tree, smooth bark, found growing on shallow alluvial flats, with a heavy clayey subsoil.
Eucalyptus blakelyi ***	Blakely's Red gum	9-30m.	Bark smooth, mottled. Prefers damp alluvial soil ,an excellent tree for planting in the locality.
Eucalyptus maculosa ***	Red spotted gum	6-20m	Useful for ornamental purpose, mainly on acid sandstone

			and on granite formations.
Eucalyptus mannifera	Brittle Gum	10 20 m	Smooth white bark. As the common name implies the wood is very brittle, often shedding limbs. Should not be planted near building & structures.
Eucalyptus ovata	Swamp gum	8-20m	Bark rough at butt, smooth and ribbons on trunk. Occurs mainly on sandy flats with a clay subsoil.
Eucalyptus camphora	Broad-leaved sally	9-20m	Bark black, broad ribbons, thrives in damp cold situations.
Eucalyptus bridgesiana	But But or Apple	8-20m	Large often scrambling tree, box like persistent bark. Likes alluvial flats, a very fine tree for shade and shelter, parklands and pleasure grounds.
Eucalyptus rubida ***	Candle-bark gum	9-30m	Bark smooth, flakes or rolled ribbons..Trunk white eventually changes to a pale salmon pink colour..Suitable for quartz, and granite soils or alluvial flats. Suitable for parklands and pleasure grounds.
Eucalyptus dalrympleana	Broad-leaved Kindlingbark	20-30m	Smooth whit bark, changing with age to a pale salmon pink. Suited to granite and basaltic soils.
Eucalyptus glaucescens ***	Tingiringi gum	3-12m	Mallee, bark smooth, white decorting to reddish-brown flakes. Good small ornamental tree with silvery foliage.
Eucalyptus pauciflora ***	Cabbage gum	4-15m	Bark smooth ,white or mottled throughout. Stands severe cold, wind and snow. Flowers profusely.
Eucalyptus stellulata ***	Black sally	6-15m	Tall spreading habit, butt has rough bark, trunk and branches smooth white bark changing to olive green as it ages. Prefers light granite and light basaltic moist soils. An ideal shade tree with excellent flowers. Withstands severe winds and frost.
Eucalyptus dives ***	Broad-leaved peppermint	8-20m	Medium-sized spreading tree, with a squat bole. Rough bark to trunk and branches Good tree for poor ridges, excellent flowers, good shade tree.
Eucalyptus rossii ***	White gum	6-12m	Small to medium tree, bark smooth. Good ornament tree for parks and the like.
Eucalyptus cinerea ***	Argyle apple	7-15m	Small to medium tree, attractive glaucous foliage, rugged bark. Ideal park tree
Eucalyptus melliodora ***	Yellow box	12-30m	Medium to tall tree, graceful tree with pendulous branches and narrow

			Sub-glaucous leaves. Fine shade tree suited to granite soils and alluvial flats. A good all round ornamental tree adaptable to most soils.
Eucalyptus nortonii	Long-leaved box	6-12m	Tall tree, rough bark. Good ornamental tree
Eucalyptus polyanthemos ***	Red box	10-20m	Medium size low branching tree with short trunk. Scaley bark on trunk, smooth on branches. Grows well on poor slatey and shaley ridges in moist or dry areas. Good shape and form, not too large.

Deciduous trees.
The nominated deciduous street tree species are supported except for Malus floribunda *Crab apple* as the crown spread at maturity may be too low and too broad. Mature fruit dropping on the adjacent pavements may also create a hazardous situation during the trees fruiting season.

Alternative species suitable to the site and environmental conditions and of a similar scale would be Lagerstroemia indica *Crepe myrtle* or Pistacia chinensis a tough hardy tree , grows to approximately 8m tall x 6 m spread - brilliant Autumn foliage.

Precinct 3
Lowland Woodland - Flemington Road

Native Trees
Native trees indigenous to the locality- Refer to the previous recommendations noted under Precinct 2 with an emphasis on the Eucalyptus species with shorter trunks and wide spreading crowns ie. Euc .blakeiyi, Euc, bridgesiana and Euc. melliodora.
The Silver Wattle *Acacia dealbata* also grows in association with the above listed Eucalyptus spp. A tall shrub or medium-sized tree to about 30 metres high. The tree displays fern-like, bipinnate foliage.

Deciduous Trees
Same comment and recommendations as noted for Precinct 2

Natural temperate grassland species.
As nominated in the Master Plan.

Precinct 4
Exotic Gateway - Federal Highway

Deciduous Trees
All deciduous trees nominated in the Master Plan supported except for Malus floribunda.

Alternative species suitable to the site and environmental conditions and of a similar scale would be Lagerstroemia indica *Crepe myrtle* or Pistacia chinensis a tough hardy tree, grows to approximately 8m tall x 6 m spread - fast growing ,brilliant Autumn foliage.

Ornamental Verge Plantings

The use of Agapanthus orientalis, Trachelospermum jasminoides, Philodendron ' Xanadu', and Aspidistra elatior are all questionable species that will tolerate serve winter climatic conditions.

Canna x generalis is the preferred species for cold climates.

Precinct 5
Native Boulevard - Northbourne Avenue

Native Trees
Native trees indigenous to the locality- Refer to the previous recommendations noted under Precinct 2 with an emphasis on the taller stately Eucalyptus species with clean trunks and species that lend themselves to tight copse plantings ie Eucapyptus rossii - *White gum*

Deciduous Trees
All deciduous trees nominated in the Master Plan supported

Wild Flowers of Canberra
All species as nominated in the Master Plan supported

Riparian Corridors
Removal of Dietes spp. recommended . Add Casuarina cunninghamiana *River She oak* as a suitable canopy trees.

Precinct 6 - Urban City Centre
Civic Terminus

Native Trees
Native trees indigenous to the locality- Refer to the previous recommendations noted under Precinct 2 with an emphasis on the taller stately Eucalyptus species with clean trunks and species that lend themselves to tight copse plantings ie Eucalyptus rossii - *White gum*

Deciduous Trees
All deciduous trees nominated in the Master Plan supported

Ornamental Plantings Trachelospermum spp questionable during severe frosts.

Summary and Recommendations

- It should be noted that Eucalyptus mannifera *Brittle Gum* as the common name implies often shed limbs during severe weather events or following periods strong winds.
  It is therefore recommended to plant this species be planted clear of buildings and structures to avoid injury and damage to property.

- The species Eucalyptus bicostata *Southern Blue Gum* is not native to the locality. The tree produces a large warty seed capsule that can be hazardous for pedestrians when the hardened capsules are shed on adjacent pavements.

- Recommendation is made to use the services of Soil Scientist / Consultant to advise on site soil deficiencies and to provide input into nursery stock production.

[redacted]

Registered Landscape Architect
Registered Horticulturist / Consultant Arborist

Attachment 4

Northbourne median tree selection process (revised 13th April 2015).

Northbourne median tree selection process

...pose of the process

The following tree selection for a suitable replacement species for the median of Northbourne Avenue was necessitated by the failure of the current planting of *Eucalyptus elata* (River Peppermint), as well as the combined effect of the light rail construction.

Key design criteria - finding a suitable replacement tree
The selection of a suitable and successful tree to replace the Eucalyptus elata trees is significant. It represents the fourth tree planting within the median of Northbourne Avenue since c1913. The three previous tree plantings failed due to pest infestation and, in the case of the *E.elata*, the non-suitability to the local conditions. This selection will be a success.

The selection of the replacement tree was a rigorous process that included the review of the previous plantings withing the median, including the current trees, to understand the local conditions and environmental requirements. This was combined with consideration of the specific requirement for trees in close proximity to light rail infrastructure and the specific requirements that are associated with this.

An important factor in the tree selection was the form and scale of the tree, commensurate to the grand boulevard character, and the climatic suitability to the region of Canberra. This criterion resulted in many of the well known stately Eucalyptus trees, such as the *Corymbia citriodora* (Lemon Scented Gum) (Kings Park, Perth), being deemed unsuitable.

The process was undertaken with the following stages:

1. *Assess existing trees, physical condition and life expectancy.*
2. *Assess site conditions and identification of specific requirements.*
3. *Establish key design requirements and performance criteria for the appropriate tree.*
4. *Review suitable tree species based on local research, specialist advisors, and site investigations.*
5. *Develop short list of suitable trees, and select preferred species.*
6. *Finalise tree selection with soils analysis and final arboriculture advice.*

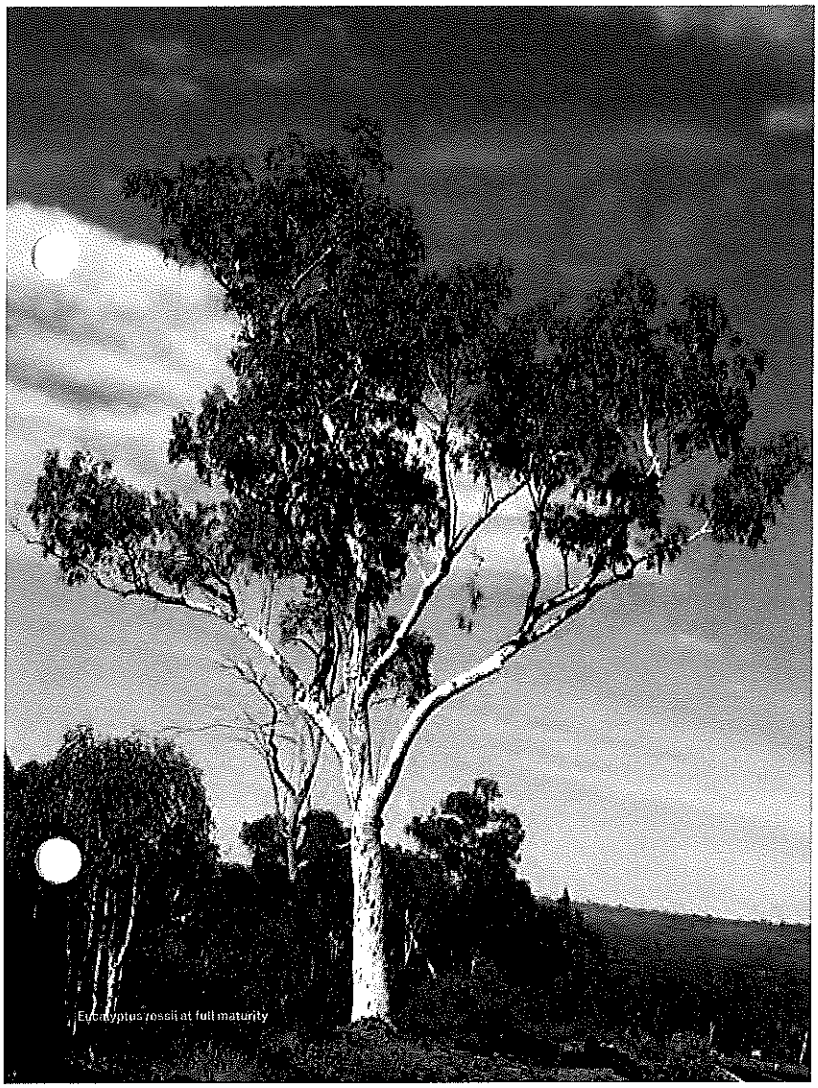
Further review by specialist advisors regarding the selection of suitable tree species was sought from the following parks managers, nurseries, arborists, landscape architects and professionals, each of whom have knowledge of the local conditions and tree species:
- Territory and Municipal Services (TAMS)
- ...dah Landscape Architects
- Stuart Pittendrigh Arborist (Norcue P/L)
- Environmental and Planning Directorate (EPD), Planning and Heritage Branch
- ...rovincial Nursery, ACT
- ...tralian National Botanic Gardens
- ...ional Capital Authority

Based on this advice, a multi-criteria analysis matrix (MCA) of the potential tree species was developed. This MCA provided a ranking across critical environmental and urban design factors. A representation of this matrix, showing the short list of trees, is outlined opposite.

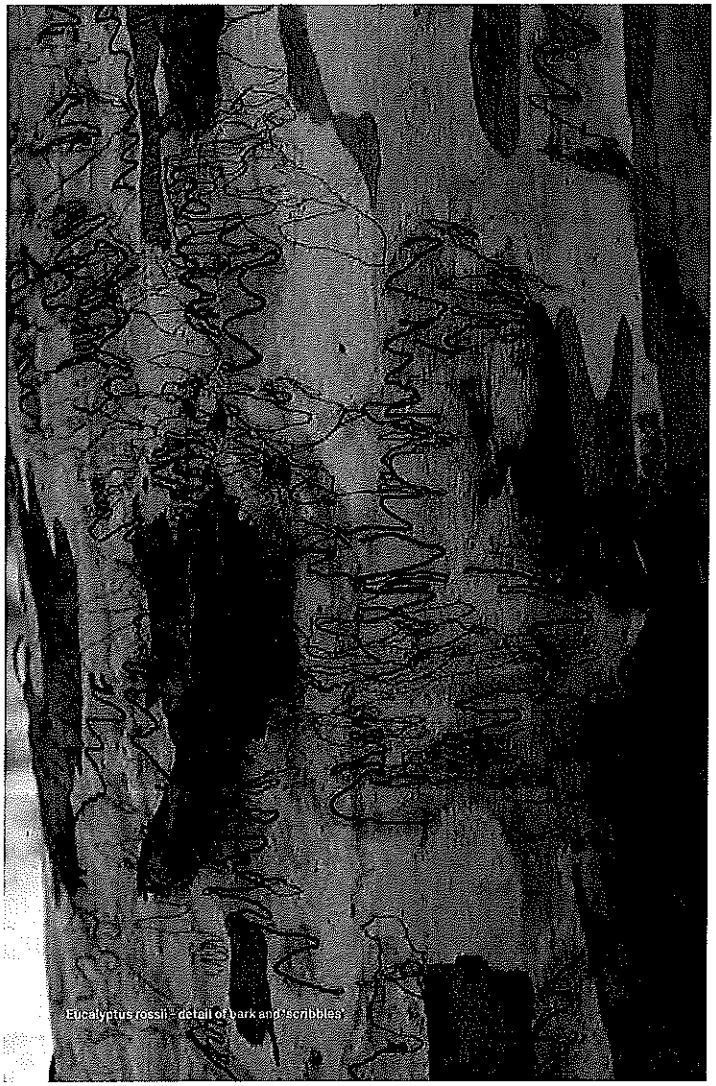
Note: This MCA has been revised following advice received from Norcue P/L (consulting arborist) on the 13th April 2015. This advice included specific and revised advice on the characteristics of the *Eucalyptus mannifera* tree species, which resulted in this species being considered suitable for the Northbourne Avenue median planting.

Revised 13th April 2015

KEY PERFORMANCE CRITERIA	Eucalyptus rossii (Scribbly Gum)	Eucalyptus mannifera (Brittle Gum)	Eucalyptus melliodora (Yellow Box)	Eucalyptus maidenii (Maiden's Gum)
Form and scale: tall stately form with aesthetic quality that is commensurate to the significant boulevard character of Northbourne Avenue.	✓	✓	✗	✗
***Native and characteristic of place:** indigenous to the Canberra region.*	✓	✓	✓	✗
***Height:** mature height of 15m or greater, with a high canopy 10m or more to the general underside of canopy.*	✓	✓	✓	✓
***Trunk:** single trunked with a clean bark of a light colour, preferably smooth barked.*	✓	✓	✗	✗
***High drought and frost tolerant:** no requirement for irrigation beyond establishment.*	✓	✓	✓	✗
***Proven suitability:** have a proven record of successful growth in the urban areas of Canberra eg. streets and parklands.*	✓	✓	✓	✗
***Pest resistance:** not highly susceptible to disease or pest infestation.*	✓	✓	✓	✗
***Low maintenance and light rail suitability:** not susceptible to limb drop or wind throw, or large seed droppings.*	✓	✓	✓	✗
	SELECTED	*SUITABLE*	*NOT SUITABLE*	*NOT SUITABLE*



Eucalyptus rossii at full maturity



Eucalyptus rossii - detail of bark and 'scribbles'

Attachment 5

TAMS Design Standards for Urban Infrastructure – *Eucalyptus rossii*

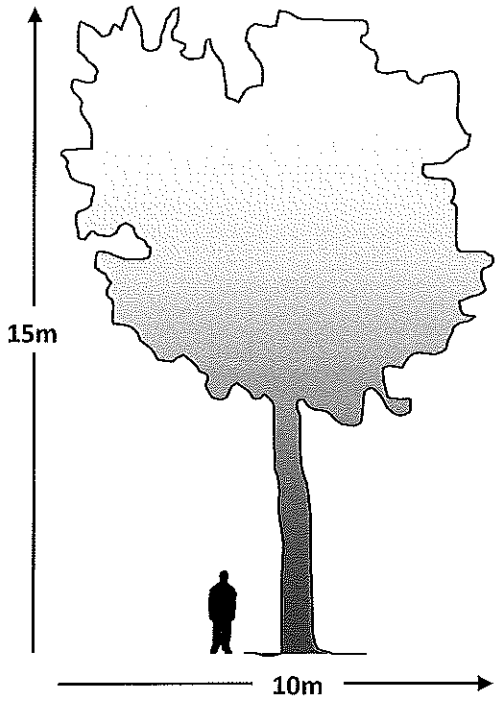
Design Standards for Urban Infrastructure

Plant Species for Urban Landscape Projects in Canberra

Botanical Name: *Eucalyptus rossii* (Ero)
Common Name: Scribbly Gum

Species description

- Evergreen
- Usually a single trunked tree with an open canopy
- Smooth white to blotchy grey bark with distinctive scribbles
- Grey green lanceolate leaves
- White flowers in December-February
- Small hemispherical woody fruit



Height and width

15 metres tall by 10 metres wide

Species origin

Occurs naturally in dry sclerophyll forests on tablelands and slopes in New South Wales and Victoria

Landscape use

- Can be used as a street tree and in parks
- Suitable for use in wildlife corridors, and for restoring or recreating dry forest landscapes
- Best used in conjunction with other dry forest species in low use or aesthetic landscapes
- Requires a minimum clearance of 6 metres from buildings

Use considerations

- Performs fairly well in the Canberra climate
- High frost tolerance and very high drought tolerance
- Grows on poor quality skeletal soils, particularly those of sedimentary origin
- Does not tolerate water logging or compaction
- Medium to long lived
- Can have slow and unpredictable growth rates
- Low flammability, being smooth barked
- Does not tolerate shade
- Mature trees often shed limbs
- Provides significant wildlife habitat through hollows in old trees

Examples in Canberra

Australian National Botanic Gardens and Black Mountain

Availability

Specialist nurseries

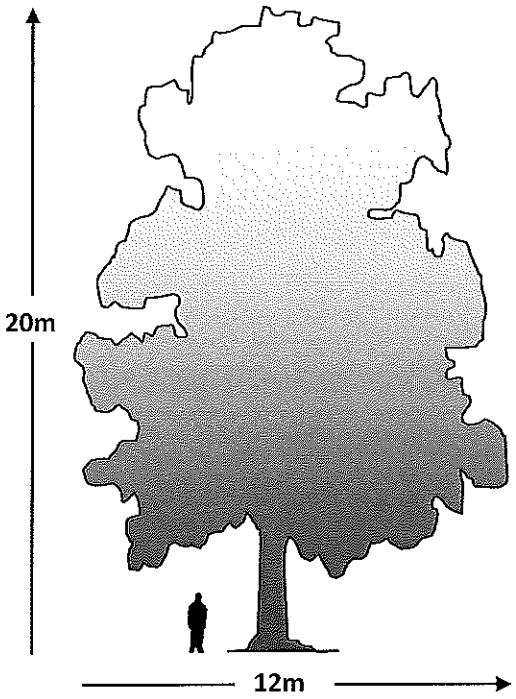
Attachment 6

TAMS Design Standards for Urban Infrastructure – *Eucalyptus mannifera*

Design Standards for Urban Infrastructure

Plant Species for Urban Landscape Projects in Canberra

Botanical Name: *Eucalyptus mannifera* (Emf)
Common Name: Brittle Gum, Red-spotted Gum



Species description

- Evergreen
- Single trunked tree with a rounded crown
- Attractive smooth white bark turning red to pink in summer
- Bluish green lanceolate leaves
- Flowers in spring to autumn
- Small rounded woody fruit

Height and width

20 metres tall by 15 metres wide

Species origin

Indigenous to the ACT (subspecies *maculosa*), central and southern tablelands of New South Wales and adjacent areas of Victoria; a common species in dry sclerophyll forests and on dry mountain slopes

Landscape use

- Useful as both a street and park tree, and is suitable for wide verges
- Suitable for use in revegetation areas and could be used in larger open spaces or wildlife corridors to assist wildlife migration
- Requires a minimum clearance of 9 metres from buildings

Use considerations

- Suited and adaptable to a wide range of sites in Canberra, and has performed very well in Canberra
- High frost and drought tolerance
- Grows naturally on poorer clayey soils to rocky shallow soils
- Medium to long lived
- Fast to moderate growth rate
- A flammable tree, but usually less problematic than other eucalypts, and could be used in the inner asset protection zone
- Subject to usual eucalypt pests and disease
- Responds well to formative pruning and may require periodic dead wooding
- Can be subject to large branch drop
- Bird damaged specimens are a potential hazard in high traffic areas

Examples in Canberra

Mugga Way, Red Hill and Black Mountain Nature Reserve

Availability

Commercially available

Attachment 7

Memo – Norcue P/L memo for *Eucalyptus rossii* (31st March 2015)

NORCUE Pty. Ltd.
ABN 24 090 141 085

[redacted]
Registered Landscape Architect
Registered Consultant Arborist-Horticulturist
3B Mason Ave., Cheltenham NSW 2119
Te[redacted] Fax[redacted]

Hassell Landscape Architecture
PO Box 5487
Sydney NSW 2000

Dear Sir,

Re: Capital Metro- Canberra ACT

Further to your recent inquiry please find attached details with regard to the species Eucalyptus rossii recommended as a street tree for Northbourne Avenue - Capital Metro project.

Eucalyptus rossii –*White Gum*
A small to medium sized broad domed solitary trunked evergreen tree to about 8 - 15m. The trees bark is smooth, pale blotchy grey to salmon and pink. The leaves are narrow oblong to lanceolate slightly glucose in colour displaying dappled foliage at maturity in full sun. The bark is shed annually to expose attractive insect scribbles along the trunk hence its common name Inland Scribbly Gum.

The species is naturally distributed throughout the southern, western and north-western interior of NSW. Findings are naturally found in Mt Ainslie, Canberra Queanbeyan and Bungendore.

Eucalyptus rossii natural soil habitat is low-nutrient, dry, rocky, skeletal soils on a variety of substrates including sandstone, granite and mudstones. The tree is known to occasionally grow on flats and valley bottoms. The tree prefers well drained soils on an annual rainfall of 600 mm.

The tree is considered to be attractive, the trunk is very striking. It is more or less ornamental and suitable for parks and pleasure grounds. Like all Eucalyptus the species does shed limbs and should be avoided close to buildings and structures. Branch shedding is occasional and is usually limited to older trees that develop brittle wood as they age. Once established the trees need to be inspected annually by an arborist to assess storm damage, dieback & deadwood, inclusions and the like.

Eucalyptus rossii once established is a hardy and durable small to medium sized tree indigenous to the Canberra - ACT region and once established and maintained should require minor annual maintenance.

In conclusion Eucalyptus rossii is one of the species recommend for the Northbourne Avenue – Capital Metro project as per our 'Review of Planting Species' report dated November 2014.

[redacted]
Registered Landscape Architect
Horticulturist / Consultant Arborist
March 31-2015

Attachment 8

Memo – Norcue P/L memo for *Eucalyptus mannifera* (13th April 2015)

Capital Metro – Canberra ACT

Northbourne Avenue Tree Planting Recommendation

Eucalyptus mannifera – *Red spotted gum*

April 2015

Introduction

This report addresses the use of a suitable street tree for planting along Northbourne Avenue as part of the Capital Metro project. Tree selection is based on the use of a local indigenous species that are adaptable to the local growing conditions, environment and landscape amenity.

After much consideration and evaluation Eucalyptus mannifera - *Red spotted or Manna Gum and Brittle Gum* is the preferred species

Description

Eucalyptus mannifera – Commonly known as *Red spotted or Manna Gum and Brittle Gum*

A small to medium sized open crowned erect evergreen tree growing between 10 -20m. in height at maturity. The tree's trunk is generally erect, clean, the bark is smooth, white in colour with plum – coloured patches decorticating in curly flakes

Eucalyptus mannifera Captain Cook Crescent - Griffith ACT

Typically the species is found growing on rather poor soils, especially those which contain large amounts of clay, but extends both to lighter podsolics and to shallow and rocky soils.

The bark is smooth and white, or sometimes partly persistent and somewhat flaky.

The species is naturally distributed throughout the Central and Southern Tablelands and their western slopes. Plantings are naturally found around Canberra with significant planting along road verges and the public open space of The Australian National Botanical Gardens located on the lower aspects of Black Mountain

Eucalyptus mannifera's natural soil habitat is low-nutrient, dry, rocky, skeletal soils on a variety of substrates including sandstone, granite and mudstones. The tree is known to occasionally grow on flats and valley bottoms. The tree prefers well drained soils on an annual rainfall of about 650 mm.

As one of the common names implies, 'Brittle Wood' (of which I believe indicates its lack of hardness, rigidity and little tensile strength) confirming that it is not considered as useful structural timber.

It should be noted that all eucalypts trees have an efficient (self pruning) method for shedding limbs. Eucalyptus mannifera's branch drop and limb shedding does not appear to be worse than any other locally grown eucalyptus species. The species has a graceful form and branching habit making it an excellent shade or specimen tree

Eucalyptus mannifera along with other eucalyptus species should be avoided where they are likely to overhang structures and the like.

Timber from this Eucalyptus tree is typically hard, close grained and moderately heavy. It is only reasonably durable being only useful for fencing material and fuel. When it comes to rigidity and tensile strength for building structures it is known to be brittle.

Following planting all trees in public locations and in the interest of safety need to be inspected annually by an arborist to assess deadwood, die back, inclusions and the like to reduce failing, wayward, poor and storm damaged limbs and the appropriate pruning actions need to be addressed immediately.

Once established long term pruning may comprise crown clearing and raising, crown thinning and over time crown reduction to reduce hazards.

All pruning procedures shall be carried out strictly in accordance with AS4373 the Pruning of Amenity Trees by an AQF Level 4 Arborist.

Principally this species is grown for its ornamental value and fine examples can be seen in many towns and cities, including Canberra where several of the older avenues were planted with this graceful eucalyptus. The attractive appearance of well grown specimens, combined with its tolerance of rather poor soil and its ability to withstand moderate drought conditions make it very suitable for both private and public plantings. The species is also fairly easy to establish

Eucalyptus mannifera was overlooked as one of the original species recommended for the Northbourne Avenue – Capital Metro project as per my 'Review of Planting Species report dated November 2014. This was because of the planting soil considerations which have now changed.

However in reflection, further research and subject to the abovementioned qualities this naturally occurring indigenous species has adapted well to Canberra's built and streetscape environment.

It is recommended that trees for the project should be specifically grown to ensure that they are well formed, upright and clear of inclusions, free of structural imperfections and wayward branches so as to avoid future problems as they mature. Once planted an Arborist should inspect the trees annually to ensure that they are retained in good condition, healthy and free from structural imperfections and hazards.

In conclusion I have no hesitation in recommending Eucalyptus mannifera , if it is managed as I have indicated to be used for the Northbourne Avenue - Capital Metro project.

[redacted]

Registered Landscape Architect / Horticulturist / Consultant Arborist.

References

- Forest Trees of Australia - Hall, Johnston & Chippendale 1970
- A Key to the Eucalyptus – W.F.Blakely 1972
- Native Trees & Shrubs of South –Eastern Australia – Leon Costermans 1981
- Trees of South-eastern Australia K.J. Simpfendorfer 1992
- Garden & Landscape Trees in Australia – Harry Oakman 1979

Attachment 9

SESL Report – Northbourne Avenue soil testing results (9th April 2015)

Our Ref: C5365.Q4306.B34041.FC.docx

9 April 2015
Hassell Studio
Level 2, 88 Cumberland Street,

Sydney, NSW 2000

Re: SOIL REPORT - Northbourne Avenue, Light Rail Corridor Project

Introduction

SESL Australia has been commissioned by Hassell Studio (the Client) to conduct an investigation into the physical and chemical characteristics of the soil along the median at Northbourne Avenue, Canberra (London Circuit to Antill Street, Dickson) (the Site). A Light Rail corridor has been proposed along the median and the investigatory section covers the area, 10m away from each side of the kerb and approximately 3.5km long.

The objective of this assessment is to characterise the soils present and provide advice and specifications for soil improvement works necessary to support the growth of *Eucalyptus rossii* (Scribbly gum) for planting within the existing soils of the median. The assessment will provide recommendations in regards to the suitability of the soil material, or if extensive modification may be required. The project includes a benchmarking exercise examining soil conditions at Mt Ainslie under existing natural stands of *E. rossii* to inform this process.

Eucalyptus rossii is native to the Canberra region and is distributed on poor shallow, stony soils on rises and ridges in undulating country with dry soil conditions and well-drained shallow sandy soils. They are not found in lower slope positions where deep clay soils tend to be periodically waterlogged. As an indigenous species they have adapted to grow in nutrient poor, acidic and well-drained soils. Only occasionally are they found on flats and valley bottoms (NSW DPI 2010).

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In our experience and trial work performed on the related *E. haemastoma,* the scribbly gums show one of the strongest edaphic associations on poor sandy soils and at even the Sydney Scribbly Gum has difficulties to grow on some other soil types, particularly clay soils rich in Manganese (Mn). Thus it may be crucial that the soils along the corridor match the conditions of the wild grown stands and have well drained soils and a low content of Manganese of around 20-25mg/kg. In contrast, good agricultural soils have a Mn content of 80 to 140mg/kg. The similar species *E. haemastoma* has a tendency to uptake Manganese readily and as a consequence show reddening around the leaf edges (Leake 2014).

Site assessment

Kelly Lee of SESL Australia conducted an in-situ walk over inspection and in-situ sampling on Friday 13th March 2015 and Monday 17th March 0215. Soil sampling locations were chosen from twenty-two (22) boreholes at the representative areas illustrated on the sampling plan (Appendix B). Twenty-two (22) soil profiles were inspected and samples were obtained to determine soil chemistry. Laboratory analysis were conducted on the samples at SESL Australia's NATA accredited analytical laboratory for the following:

- Topsoil chemistry – pH in H_2O, pH in $CaCl_2$, Nutrients: Nitrate (NO_3), Phosphate (PO_4), Potassium (K), Sulfate (SO_4), Calcium (Ca), Magnesium (Mg), Electrical Conductivity, Cation Exchange properties and exchangeable cation, Trace elements: Fe, Mn, Zn, Cu B and organic matter.
- Organic matter.
- Subsoil Chemistry.

Field Observations

Northbourne Avenue median strip soils do not compare physically to the poor shallow soils of Mt Ainslie. The soil at Mt Ainslie is yellow, grainy, sandy soil with orange clay lumps. The soil was difficult to auger due to the compacted, dry and friable texture with little structure. Overall the soil has a similar light to medium brown appearance and a loamy sand texture. In most boreholes at 150mm+ the soil contained aggregates and orange clay lumps. Between holes 15 - 22 fine white aggregates were found in the soil. Bore holes 1 and 2 showed some variation where the organic content appeared to be higher as the soil was darker, less friable and more cohesive. Within the regions of boreholes 13, 14 and 18 the grass was either yellowing or had limited growth.

Table 1. Field observations

Location / Street	Bore Hole	Depth (mm)	Texture, Structure, Colour	Observations
Alinga to Cooyong	BH 1	0-150	Brown sandy loam and organics.	
		150-300	Lighter brown sandy soil.	
		300-500	Mixed light brown and pale brown, sandy soil with aggregates.	
	BH 2	0-200	Dark brown sandy loam with organics.	
		200+	Light brown, yellowish light clay.	
	BH 3	0-300	Brown sandy soil, including rocks.	
		300+	Unable to auger due to the looseness of the soil, too sandy and rocky.	
Cooyong to Elouera	BH 4	0-30	Dark brown loamy sand.	
		30-300	Brown sandy soil including small aggregates.	
		@ 400	Bit refusal.	
	BH 5	0-30	Brown loamy sand.	
		30-300	Light brown sandy soil.	
		300+	Lighter brown, orange sandy soil.	
Elouera to Girrahween	BH 6	0-20	Dark brown loamy sand.	
		20-250	Fine brown sandy with small aggregates. Very compacted.	
	BH 7	0-150	Dark brown loamy sand.	
		150+	Medium brown with clay lumps. Progressively dry with depth.	
Girrahween to Condamine	BH 8	0-150	Brown loamy sand.	
		150-300	Brown sandy soil with orange mottling and lumps.	

		300+	Brown with orange mottling clayey sand.	
	BH 9	0-200	Brown sandy soil with orange lumps, very compacted.	
	BH 10	0-200	Brown sandy soil, very compacted.	
		200+	Brown sandy soil with orange lumps. Very compacted.	
Condamine to Macarthur	BH 11	0-30	Dark brown sandy loam soil.	
		30-150	Light brown sandy soil, compacted.	
		150-300	Light brown sandy soil with orange clay lumps.	
	BH 12	0-200	Brown sandy soil, very compacted.	
		200+	Brown sandy soil with orange clay lumps. Lighter coloured material.	
	BH 13	0-200	Friable sandy light brown soil.	Dry and yellow grass area, disturbed grass patch on right side of median. Left is green.
	BH 14	0-50	Friable brown sandy soil.	Yellow and dry grass on both sides of median
		50-150	Orange brown sandy soil. Small orange aggregates	
Macarthur to Morphett	BH 15	0-30	Dark brown loamy sand.	
		30-200	Light brown sandy soil with orange clay lumps.	
		200-300	Yellowish brown sandy soil with fine white aggregates.	
	BH 16	0-100	Brown loamy sand with organics.	
		100-300	Yellowish brown sandy soil with fine white aggregates. Very fine sand.	
	BH 17	0-100	Brown loamy sand with organics.	

		100-300	Yellowish brown sandy soil with fine white aggregates.	Aggregates larger with depth.
		@350	Bit refusal.	
	BH 18	0-250	Brown and light brown sandy soil with white aggregates.	Bald grass patch.
		250-300	Light brown sandy soil with white aggregates and some orange clay lumps.	
		@350	Bit refusal. Some orange clay.	
Morphett to Antill	BH 19	0-200	Mixed brown and light brown sandy soil with a number of large white rocks.	Colour progresses to darker shade as depth goes.
		200-300	Orange brown sandy soil with small clay lumps.	
	BH 20	0-300	Light brown sandy soil with white aggregates. Grainy material.	
		300-400	Darker light brown sandy soil.	
	BH 21	0-150	Brown sandy soil with aggregates.	
		150-350	Orange brown sandy soil. Fine material.	
	BH 22	0-100	Brown sandy soil.	
		100-300	Light brown sandy soil with orange clay lumps.	
Mt Ainslie		Topsoil	Yellow grainy sandy soil with orange clay lumps.	

Laboratory Test Results

Soil Chemistry

Laboratory analysis was conducted at various locations along Northbourne Avenue in order to chemically characterise the soil. It was determined that the soil overall has very similar properties aside from BH1. The soil has moderate acidity and desirably low salinity levels and the cation exchange is dominated by

high levels of hydrogen. The effective cation exchange capacity (eCEC) is low, indicating poor nutrient retention and holding capacity. Nutrient levels are low to moderate, which is adequate to support the growth of *Eucalyptus rossii* (Scribbly gum). The phosphorus levels are high at BH3, 4 and 5. *Eucalyptus* have some phosphorus tolerance however is too high at 60 - 111mg/kg. Manganese at Mt Ainslie is 18mg/kg whereas along the median the manganese levels range from 42mg/kg – 92mg/kg which is significantly higher.

The soil at BH1 is slightly richer and is not acidic in comparison to the other bore holes. It has slight acidity and desirably low salinity levels. The cation exchange is highly calcic. The effective cation exchange capacity (eCEC) is low, indicating poor nutrient retention and holding capacity.

Table 2. Northbourne average, minimum and maximum statistics compared against Mt Ainslie.

Sample Name	TOPSOIL AVERAGE	MINIMUM	MAXIMUM	Mt Ainslie
pH in H_2O	5.7	5.5	6.2	5.6
pH in $CaCl_2$	4.9	4.7	5.3	4.6
EC dSm	0.0	0.0	0.0	0
Cl mg/kg	50.5	43.8	75.5	33.07
Na % CEC	0.7	0.5	1.6	0.3
K % CEC	3.9	2.0	7.7	1.5
Ca % CEC	50.2	40.9	80.3	22
Mg % CEC	12.7	9.6	15.9	37
H % CEC	32.3	0.0	42.7	38.8
Al % CEC	0.0	0.0	0.0	0.1
eCEC meq/100g	0.1	0.0	0.1	0.03
NO_3 mg/kg	11.3	5.7	21.0	0.5
PO_4 mg/kg	38.1	12.5	111.1	14.6
K mg/kg	197.3	51.7	466.0	92
SO_4 mg/kg	17.4	11.0	28.0	7.2
Ca mg/kg	1211.9	780.0	1581.0	702
Mg mg/kg	189.5	112.0	284.0	716

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Fe mg/kg	346.3	285.2	541.8	182.5
Mn mg/kg	60.2	42.0	92.0	18
Cu mg/kg	1.3	0.6	2.6	2.5
B mg/kg	0.1	0.1	0.3	0.1
Zn mg/kg	10.2	4.9	22.0	0.65

Foliage Analysis

Young and mature foliage was analysed from *E.rossii* at Mt Ainslie. This analysis was primarily performed to measure the Manganese levels. It was determined that the Manganese levels are higher in the foliage than in the soil. The younger foliage contains less Manganese (46mg/kg) in comparison to the mature foliage, which has accumulated 152mg/kg.

The soils at Mt Ainslie are low in Manganese at 18mg/kg in comparison to the Northbourne Avenue average manganese levels of 60.2mg/kg.

The Calcium:Magnesium ratio is low in the foliage at 0.74 (young *E rossii*) and 1.08 (mature *E.rossii*). The ideal Ca:Mg ratio is 2:1. The soil at Mt Ainslie also shows a similar low Calcium ratio at 0.6. The average Ca:Mg ratio at Northbourne Avenue is much higher at 3.9 (min = 3.2, max = 5.2) which is close to meeting the target range of 4.1-6.0.

Table 3. Tabulated data of the foliage and soil.

	Young *E.rossii* Foliage	**Mature *E.rossii* Foliage**	**Mt Ainslie Soil**	**Northbourne Ave Soil Average**
Manganese (mg/kg)	46	152	18	60.2
Calcium	0.17%	0.27%	702 mg/kg	1212 mg/kg
Magnesium	0.23%	0.25%	716 mg/kg	189.5 mg/kg
Ca:Mg ratio	0.74	1.08	0.6	3.9

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Discussion and recommendations

The soils of Northbourne Avenue are significantly more fertile than the soils of the native *Eucalyptus rossii* at Mt Ainslie, both physically and chemically. The landscape is also significantly different to the poor shallow soils that *E. rossii* typically grows on. The most notable differences between the Mt Ainslie soil and the Northbourne Ave soil are the Mn, P and Ca levels.

The issues of most concern are listed below:

- High Manganese levels, in particular the soils located from BH3 to BH6 are quite high. SESL has previously encountered Manganese toxicity through growth trials of a similar species, *E.haesmastoma*. It is likely since they are in the same genus that *E. rossii* may also be susceptible to Manganese toxicity;
- The Manganese levels are higher in the older foliage than in the younger which supports the view that *E.rossii* is a Mn accumulator and may suffer in high Mn soils.
- Ca:Mg ratio is much lower in the Mt Ainslie soil and foliage in comparison to the Northbourne Avenue soils.
- High phosphorous levels around BH3, 4 and 5. Eucalyptus have some phosphorus tolerance but levels up to 111mg/kg are considered high even for phosphorus tolerant species; and
- The soil landscape is quite different between the shallow stony of Mt Ainslie soil and the deep loam to clay loam of Northbourne Ave reconstructed soils.

Given this information, it is not possible to provide certainty as to whether *E. rossii* will tolerate the soil conditions found along Northbourne Ave. Without providing any implied guarantee of success, the following actions may be required to ameliorate the soil conditions in order to encourage better chances of success and good growth of *E.rossii.* The purpose of the recommendations is to alter the soil chemical and physical properties to be more similar to the soils of Mt Ainslie.

1. Remove all topsoil from the planting trench to a depth of 150-200mm avoiding the inclusion of subsoil clay. Stockpile and reserve.
2. Remove all subsoil from an area at least 3 x 3 m in the location of a tree planting. Stockpile and reserve.
3. Install deep subsoil drainage to a depth of around 1-1.2m along the entire length of planting trench.

4. Using the reserved subsoil, make a mix of 40% by volume medium/coarse quartz sand and 60% reserved subsoil screened to 50mm and install in each planting location to 250mm.
5. Excavate sufficient depth of subsoil to locate the tree such that the final level of the top of the rootball is 150mm above the surrounding level.
6. Using the reserved topsoil screened to 50mm make a mixture of 60% by volume medium/coarse quartz sand and 40% reserved topsoil.
7. Add to this mix **250g/m^3 of dolomite** to make the soil less acidic, which will lock up some of the Manganese. Around BH3 - BH6, BH18 and BH19 we suggest being a little more liberal and adding **300g/m^3** as the Manganese levels are much higher.
8. Phosphorus levels are high around BH3, 4 and 5. We suggest adding **iron sulfate at 100g/m^3** to help lock up the phosphorus.
9. Place the topsoil around the planted specimen trees bringing the final level at the trunk to 150mm above the surrounding soil level.
10. Along the rest of the trench apply **dolomite at 100g/m^2** and incorporate with a tyne implement loosening the subsoil and removing rocks >100mm in size at the same time.
11. Replace topsoil using the mix described in 6 and 7 above.
12. No phosphorus containing fertiliser should ever be used on these plantings or on turf within 3m of the trunk.

Ideally some trials would be performed using techniques such as recommended above to ensure conditions are suitable for healthy growth of this species using soil recycled from site. Without the benefit of such trials it is not possible in our view to provide any greater level of certainty.

Conclusions

E.rossii typically grows in nutrient poor, shallow and stony soils on rises and low ridges (NSW DPI 2010). It is our conclusion from the work that Northbourne Avenue does not match this soil landscape type. However *E.rossii* is said to grow occasionally on flats and valley bottoms, which may indicate that the soils could be adequate providing that drainage is good. We recommend either following through with a trial to see if *E.rossii* can grow in the Northbourne Avenue soils before landscape works are undertaken, or attempt to locate some well grown specimens growing on more fertile soils for the Canberra area in

lower landscape positions and some sampling of soil and foliage to confirm its tolerance of these conditions.

Alternatively a similar species that is more environmentally adaptable to lower slope positions, such as *E. mannifera* could be used as a substitute.

SESL is pleased to present this report and recommendations. We will be pleased to answer any further questions during the progress of the development therefore please do not hesitate to contact us with any questions or clarifications.

SESL AUSTRALIA

[redacted]

[redacted]

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[redacted]

[redacted]

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Appendices

Appendix A: SESL Results

Appendix B: Site Map

Attachment 10

Record of Meeting – Northbourne Avenue Tree Selection (15th April 2015)

Record of Meeting

Northbourne Avenue Tree Selection

Date of Meeting – 4pm, 15th April 2015
Location – CMA Office

Attendees:

Emma Thomas (ET) – CMA	
Steve Allday (SA) – CMA	
Melanie Taylor (MT) - CMA	
Gary Byles (GB) - TAMS	
Fleur Flanery (FF) - TAMS	
Dorte Ekelund (DE) - EPD	
[redacted] – Arup	
[redacted] –Arup	
[redacted] - HASSELL	
[redacted] - HASSELL	
[redacted] – Norcue	

Notes:

Item	Note	Action	Date
1	ET introduced the meeting explaining the purpose of this meeting was to discuss and agree the way forward on the tree selection for the Northbourne Ave median – given recent publicity and the outcome of soil investigations.		
2	RD and [redacted] tabled a report written by HASSELL (as sub-consultants to Arup) to provide the history and decision making process on the tree selection process for the Northbourne Avenue median, titled: *CAPITAL METRO – TREE SELECTION MEMORANDUM* (14th April 2015). [redacted] introduced [redacted], an eminent arborist (47 years' experience), whom HASSELL have collaborated on many projects and who is currently advising HASSELL and Arup on the Canberra Light Rail project and also working on the Barangaroo headland park in Sydney for the BDA. [redacted] referred to the 6 stage process that was undertaken through the tree selection process.		

Item	Note	Action	Date
	Throughout this process, there has been extensive liaison with relevant ACT agencies and specialist advisors including: TAMS; EPD; nurseries; ANBG; NCA; dsb Landscape Architects; and Norcue P/L [redacted] [redacted] explained the multi-criteria analysis that was carried out on tree species, the shortlisting process that was carried out which informed the recommendations for the tree species.		
3	[redacted] explained the soils analysis that was carried out (Step 6: verification of the selection process) and which identified that there were elevated levels of Manganese and Phosphorous in the existing soils within the Northbourne median. This analysis has been carried out by SESL. ET asked if this soils analysis was consistent for the whole corridor. AC confirmed 22 samples were taken from Alinga Street to Antill Street. Of these samples SESL determined that the soil overall "has very similar properties". SESL has benchmarked the Northbourne soils analysis against that of a sample taken at Mt Ainslie, which is one example of a natural growing area of the *E.rossii*. [redacted] explained that SESL's conclusion to the soils analysis was that they were concerned with the higher levels of Manganese and Phosphorus (in comparison to that of the benchmarked sample) and there was therefore a potential risk associated with the successful growth of the *E.rossii*. SESL was not prepared to guarantee the successful growth of the *E.rossii*, and recommended additional soil modification to that already included in the tender documentation (by the addition of dolomite and iron sulphate to lock up the Manganese and Phosphorus in the existing soils, and the addition of coarse sand to assist drainage).		
4	[redacted] stressed that from the very beginning of the design process there has been a requirement for substantial soil modification/reconstruction and inclusion of sub-soil drainage – the further additions of dolomite, iron sulphate and sand to		

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	support *E.rossii* would be a modest additional cost to the project		
5	However, in response to SESL's concerns over the compatibility of the *E.rossii* tree with the reconstructed soils, HASSELL and Norcue P/L (SP) had reviewed as a final step, in the tree selection process, whether an alternative Eucalyptus species would guarantee successful growth . This design verification concluded that *E.mannifera* would be a suitable alternative Eucalypt and would satisfy the project design criteria.		
6	ET referred to concerns over the *E.rossii* in John Gray's letter to the Canberra Times. ET then asked FF to discuss some of her concerns. It was also noted that John Gray was the designer of the current tree species on Northbourne Avenue.		
7	FF queried the height of the proposed trees (irrespective of *E.rossii* or *E.mannifera*), however acknowledged that the direction and decision on this was probably thoroughly documented well before now.		
8	[redacted] explained that the comprehensive tree design brief for the project is documented in the *CAPITAL METRO – TREE SELECTION MEMORANDUM* (14th April 2015), and includes that it be a 'Eucalypt' (specific mandate from the NCA). The agreed design criteria for the tree species from the beginning of the project and endorsed by all parties was for a tree 15 – 20m in height – a scale commensurate to the grand scale of Northbourne Avenue as a major boulevard in the National Capital.		
9	FF accepted this and noted that the aspirations above limits the list to 4 or 5 Eucalyptus species.		
10	ET further explained that the brief was also to have a tree that had a single trunk and other factors etc. [redacted] explained these agreed criteria are documented in the *CAPITAL METRO – TREE SELECTION MEMORANDUM* (14th April 2015).		
11	[redacted] advised that the *E.rossii* and *E.mannifera* were actually considered to be medium sized trees that grow in close association to each other and stressed		

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	that the entire growing, installation and ongoing maintenance of the trees was absolutely critical to the trees success. [redacted] also noted that today's standards of tree and soil reconstruction techniques are substantially in advance of those that have been carried out in the past e.g. existing Northbourne trees. As a result, the expectation is that the new *E.mannifera* trees would be a graceful tree, have an outstanding trunk and with comparatively less litter on the ground than the *E.elata* trees on Northbourne Ave at the moment.		
12	FF endorsed the use of *E.mannifera* and confirmed that this species is actually the best performing Eucalyptus species in Canberra, (>80,000 trees recorded) based on the recent TAMS audit of trees in Canberra.		
13	DE noted that she also likes the *E.mannifera*, in that this species already existed on the verge along the corridor, and that its use in the median would add to cohesion in the landscape setting.		
14	ET asked why was it that the *E.rossii* had been preferred originally over the *E.mannifera*. [redacted] explained that, at that preliminary design stage, the *E.rossii* was considered to be marginally the more beautiful tree. It is a common misunderstanding that the *E.mannifera* has 'brittle' limbs (an understanding arising from its common name), but this is erroneous as *E.mannifera* does not pose any greater maintenance regime or risk than other native Canberra Eucalyptus species. The soils analysis and results had also not been performed during the earlier multi-criteria analysis of tree species. [redacted] explained that there was very little visual difference between the *E.rossii* and the *E.mannifera* and to most people there would not be a discernable difference. In fact, the only people who could probably tell the difference would be an arborist or related horticultural professional		
15	GB noted he agreed that you can't tell the difference between the two tree types from the photos in the HASSELL report.		

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16	There was then a discussion around the 'common names' for the *E.mannifera* – which is sometimes called the 'Brittle Gum'. There was concern that this name might paint a picture to the general public of a tree that loses limbs, etc.		
17	[redacted] advised that the reference to 'Brittle' is actually in the structural properties of the wood/timber, not to the tree dropping limbs greater than any other Eucalypt. (i.e. the tree timber is not suitable for structural or architectural use,) In fact, *E.mannifera* was in this respect (both limb dropping and bark shedding) no worse than other Eucalyptus species in Canberra. [redacted] also noted that *E.mannifera* was also known by other common names including 'Red Spotted' or 'Manna' gum.		
18	GB asked if there were any other species that came close in consideration to the *E.rossii* and *E.mannifera*. [redacted] noted that there are some hybrid eucalypts around (or designer trees) but he did not have faith in these.		
19	FF noted that examples of *E.mannifera* were along Captain Cook Drive and also along the Northbourne Avenue verges. It was considered that those along the Northbourne Ave verges were not being maintained as well as they could be – and newly planted trees using today's techniques (from nursery growing, through installation and ongoing maintenance) would perform much better.		
20	With the existing Northbourne verge trees being *E.mannifera*, the consensus of the meeting was that there would be a desirable consistency in street appearance with *E.mannifera* used in the main central median.		
21	ET raised again the issues with John Gray's letter to the Canberra Times. [redacted] suggested one interpretation of John Gray's concerns in the article as read were more to do with the overall scale of the tree (i.e. the avenue requires		

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	a significant tree to match the scale of the street) – this would not be undermined at all by the *E.mannifera*.		
22	DE asked whether the flowers and ground planting proposed will be adversely affected by the growth of the *E.mannifera* trees above. [redacted] explained that this would not be the case and that the trees and ground cover would be complementary.		
23	In conversations to be had with the Minister, DE noted that there were strong reasons for both *E.rossii* and *E.mannifera*, however it would appear that *E.mannifera* may be better suited to the existing soil conditions along Northbourne Ave. There would also be a consistency of street experience with those *E.mannifera* currently on the Northbourne verges. (It was noted that the selection and placement of verge trees is not part of CMA scope but consideration of median and verge tree selection and existing / proposed verge treatments was important).		
24	ET questioned how prescribed the trees and their installation should be – because the current scope and performance requirements for the trees is very prescriptive.		
25	DE advised that it was better to be more prescriptive, and the *E.mannifera* should be prescribed as the sole species for Northbourne Avenue. The meeting endorsed this position.		
26	ET asked for a final note and recommendation from the HASSELL and Arup team.	HASSELL/ARUP	24 April 2015
27	SA asked whether early procurement of trees was back on the agenda on the basis of the *E.mannifera*. Agreed to be discussed separately.		
28	[redacted] again reiterated that the most important factors to the success of the tree planting is how they are propagated and grown in the nursery, how they are planted, the importance of continued arborist and		

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	soils scientist advice and ongoing monitoring and maintenance throughout the operational period. [redacted] explained how new standards in this respect had been set in the current Barangaroo project in Sydney, where, for example, the trees had been nursery grown in exposed wind swept conditions and had been carefully monitored, irrigated, regularly trimmed and widely spaced to achieve optimal form, etc. [redacted] can arrange a visit to Barangaroo for those who are interested.		
29	[redacted] noted that it was correct to grow the Northbourne trees in Canberra or comparable climatic conditions e.g. with frost and cool temperatures.		
30	FF asked whether the whole of the existing Northbourne trees are required to be removed. SA confirmed that yes this was the case, not just for the light rail tracks but for CMA utilities work in particular. The planting of the new trees would probably be one of the later items in the program.		
31	Confirmation of Actions:		
	• Final recommendation from HASSELL / Arup team	HASSELL / Arup	24April 2015
	• FF/ET to meet and speak with John Gray.	FF	
	• DE to progress with Northbourne verge schemes including tree selection– and liaise with TAMS and CMA accordingly.	DE	
	• FF to consult with [redacted], [redacted], and [redacted].	FF	
	• SA to send tree procurement paper to FF.	SA	
	• [redacted] and [redacted] are reviewing CMAs SPR 10 for Public Realm and to involve HASSELL / Arup in finalizing this. Intention to send to bidding consortiums the week after next.	CMA / Arup / HASSELL	

CAPITAL METRO – TREE SELECTION MEMORANDUM

This memorandum outlines the process undertaken by the Advisory Team for selecting the replacement tree for the *Eucalyptus elata* (River Peppermint) trees in the Northbourne Avenue median, and how the Advisory Team arrived at the initial selection of the *Eucalyptus rossii* tree species.

Background

The selection of a suitable replacement for the *Eucalyptus elata* (River Peppermint) trees in the Northbourne Avenue median is significant. It represents the fourth major tree planting within the median of Northbourne Avenue since c1913. The previous tree plantings failed due to a number of factors including pest infestation, and in the case of the *Eucalyptus elata* trees it was the poor establishment and over dependency on irrigation.

Process for tree selection

The selection of the replacement tree was a rigorous process that included the review of the previous tree plantings within the median, including the current trees, to understand the local conditions and environmental requirements. This was combined with consideration of the specific constraints for trees in close proximity to light rail infrastructure.

The process was undertaken within the following steps, which are outlined below:

1. Assess existing trees, physical condition and life expectancy.
2. Assess site conditions and identification of specific requirements.
3. Establish key design requirements and performance criteria for the appropriate tree.
4. Review suitable tree species based on local research, specialist advice and site investigations.
5. Develop short list of suitable trees and select preferred species.
6. Finalise tree selection following site specific soil structure and chemical analysis and final arboriculture advice.

1. Assess existing trees, physical condition and life expectancy

The failure of the existing planting of *Eucalyptus elata* trees, as well as the combined effects of the construction impacts of the light rail corridor was investigated in the Scoping Design stage. The findings of this investigation were documented in the memo *Capital Metro – Preliminary assessment of tree impacts and opportunities* (14th May 2014) refer attachment 1.

2. Assess site conditions and identification of specific requirements

The existing site conditions of the Northbourne Avenue median was reviewed, through advice received from and meetings held with representatives of dsb Landscape Architects and TAMS. This advice identified that the existing conditions of the Northbourne Avenue median was of a very shallow top soil layer of approx. 300mm, with an underlying clay layer. This was documented in the memo *Capital Metro – Preliminary assessment of tree impacts and opportunities* (14th May 2014), refer Section 2.3 Local soil and environmental condition, attachment 1 below.

3. Establish key design requirements and performance criteria for the appropriate tree.

An important consideration in the tree selection was the overall form and scale of the tree, so that it represented a tree that is commensurate to the grand boulevard character of Northbourne Avenue, as the primary approach corridor in to the city. A primary consideration (National Capital Authority) is that the replacement trees are to be Eucalypts.