RESILIENT EAST

Climate Ready Eastern Adelaide

24 February 2023

Parliamentary Officer
Environment, Resources and Development Committee
Parliament House
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RE: Response to Inquiry to the Urban Forest

Resilient East appreciates the opportunity to contribute to the Parliament of South Australia's Environment, Resources and Development Committee's **Inquiry into the Urban Forest** (Inquiry).

As the current Chair of the Resilient East Steering Group, I want to take the opportunity to introduce the Committee to our partnership and our priorities which focus heavily on urban green spaces as a key priority and action area in responding to climate change.

Resilient East

Resilient East is a regional climate partnership between state and local government organisations in eastern Adelaide, including Campbelltown City Council, the Cities of Adelaide, Burnside, Norwood Payneham and St Peters, Prospect, Tea Tree Gully, Unley, the Town of Walkerville, and the Government of South Australia. Resilient East coordination and initiatives are jointly funded by the eight partner councils and the Green Adelaide Board.

Resilient East's Adaptation Plan is implemented under a Climate Change Sector Agreement with the South Australian Government that was signed on 23 March 2017 (established under section 16 of the *Climate Change and Greenhouse Emissions Reduction Act 2007)*. A renewed Sector Agreement for 2020-2025 was signed by Minister Speirs (July 2020), and will expire in January 2025. A Resilient East Project Steering Committee oversees the implementation and includes membership from all eight partner councils and State Government staff.

The following infographics *(Figure 1 and Figure 2*) summarise the climate change actions and community vulnerability facing the eastern region of Adelaide.

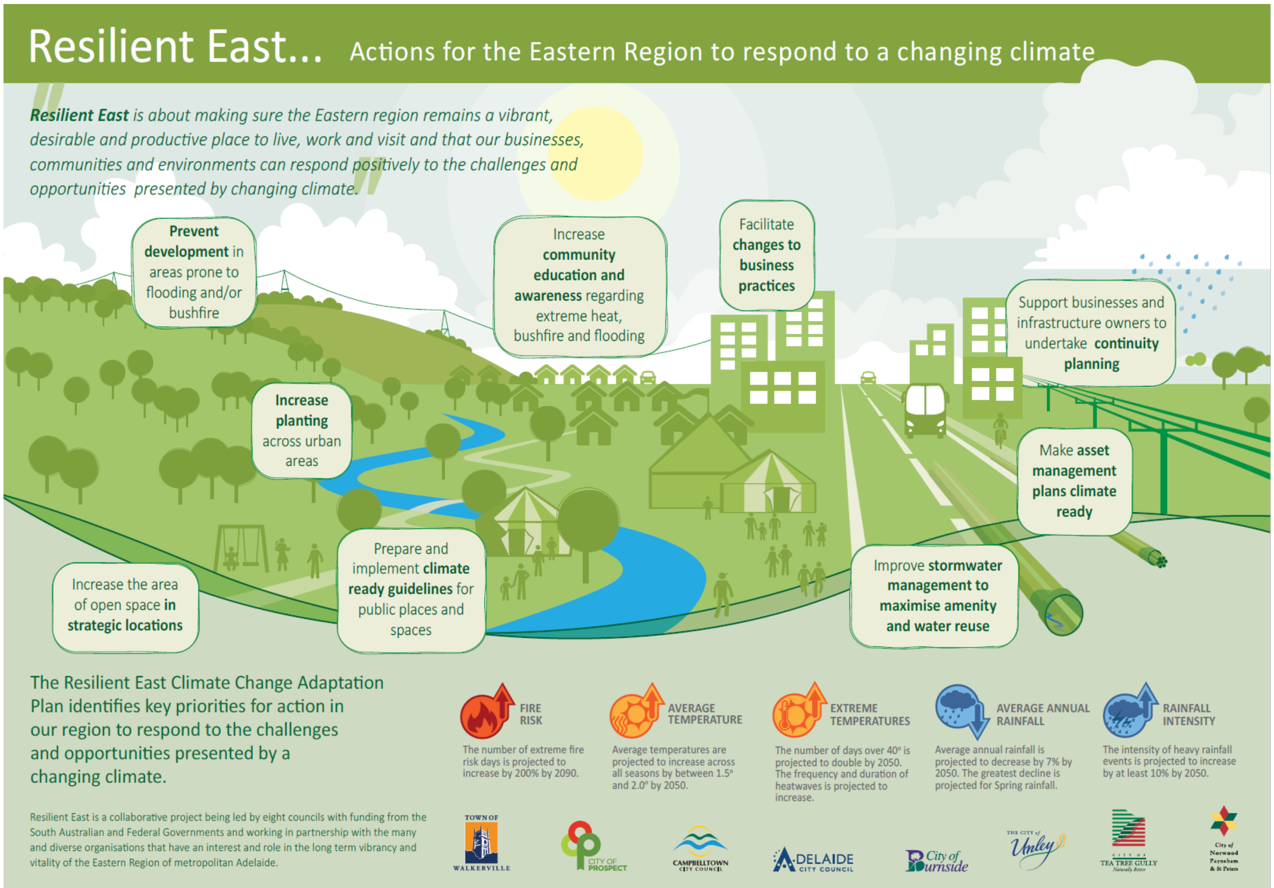

Figure 1: *Resilient East Climate Change Adaptation Plan: Actions for the Eastern Region to respond to a changing climate*

Figure 2: *Resilient East Climate Change Adaptation Plan: Understanding the eastern region's vulnerability to a changing climate*

Resilient East partners are committed to our priorities of:

- Cooling, greening and enhancing biodiversity on our streets and natural assets,
- Mainstreaming water sensitive urban design (WSUD),
- Actively addressing councils' and businesses' risks and opportunities in relation to climate change,
- Building resilience in our communities,
- Delivering a monitoring and evaluation framework, and
- Contribute to ongoing planning and policy reform opportunities.

These priorities align with the delivery of key state government priorities and strategies, including (but not limited to):

- 30 Year Plan target for 20% increase in urban green cover by 2045
- Planning and Design Code Reviews
- Regional Planning for Greater Adelaide
- Green Adelaide Regional Landscape Board Strategy
- Urban Greening Strategy (in development)
- Water Security Statement (related to the Water Industry Act 2012)
- Urban Water Directions Statement
- South Australia's Climate Change Actions
- Stronger Together – South Australia's Disaster Resilience Strategy
- State Public Health Plan

Resilient East and greening priorities

Resilient East is pleased to see a recognition of the importance of trees and canopy in the urban environment, and noting of the various challenges and contradictions that exist between development and environmental outcomes. It has been a priority of Resilient East partners to build strategies and actions in order to further maintain, grow and protect our urban forest.

The Resilient East partnership has advocated for positive urban greening outcomes through various parliamentary and governmental submissions over the last few years, including publicly available responses to the State Planning Commission Phase Three Planning and Design Code for SA's Urban Areas – first draft (October 2019), second draft (late 2020), the Natural Resources Committee's Parliamentary Inquiry into Urban Green Spaces (July 2020). **This latter response will be re-submitted as part of this response, as it is valid background information to your current inquiry.**

More recently the Coordinators of the Regional Climate Partnerships were invited to make a deputation to the Expert Panel for the Planning System Implementation Review (December 2022).

Resilient East partners are actively engaged in the development of Adelaide's first metropolitan Urban Tree Strategy, and in the re-collection of urban heat and canopy mapping, which is part of forming the evidence base from which to set a new benchmark.

Collectively and individually Resilient East partners demonstrate ongoing commitments, research, capacity building, data collection, monitoring, trials and incentives to maintain, enhance, grow and future proof our urban forests. The benefits of the Regional Climate Partnerships, like Resilient East, are to mainstream, scale up and showcase the challenges and the solutions to ensure we are well equipped for the changes in climate we are experiencing and will continue to experience, regardless of commitments to reduce emissions.

Climate science and impacts

The Resilient East Climate Change Adaptation Plan was completed in 2016. Under the [then] current high emissions trajectory (aligned with the IPCC RCP 8.5 scenario[1]), it was projected that the climate in the Eastern Adelaide Region will experience considerable changes – generally an overall drying and heating with more extreme weather. These include increased rainfall intensity but decreased overall average rainfall, increased overall average temperatures, increased extreme temperatures and numbers of days over 35°C and 40°C and increased fire risk days.

The recently updated [Guide to climate projections for risk assessment and planning in South Australia] confirms these trends, however it also notes the observed trends have outstripped the data being used. Observed data in the last 10 years demonstrates that the rate of increase in very hot days is greater than projected for central Adelaide.

The most recent IPCC reports released throughout 2021 and 2022 highlight three key messages that are relevant:

- Predominantly the same messages and trends as before – but all with **greater certainty**
- There is **greater variability of extremes** and there is now the ability to assess **compounding effects**
- There is less time to drastically reduce emissions, but there is a lot of the tools and "will" to do so.

Adelaide's climate is shifting from a Mediterranean climate (characterized by hot, dry summers and cool, wet, winters) to a semi-arid climate (characterized by very hot, dry summers and warm winters with limited rainfall). In addition to these trends, climate projections have indicated an increase in frequency and intensity of extreme weather events (droughts, heatwaves, and storms), and increasingly variable rainfall.

To note about this submission

While the full suite of improvement options for modern urban forest management is long, this submission response is kept within the framework of the focus inquiry questions set out in the Terms of Reference.

This submission does not reflect formal Council endorsement by any of the constituent Councils. This input complements feedback from contributing Councils and provides a perspective from the Local Government members of the Resilient East Steering Group.

Attachments:

- **NRC Parliamentary inquiry into Urban Green Spaces (2020)**
- **Creating More Space for Trees report (2021)**

[1] See the Resilient East Climate Projections report for detail and references. https://www.resilienteast.com/s/Climate-Projections-Report

1. Best practice and innovative measures to assist in the selection and maintenance of site appropriate tree species to improve the resilience of the urban forest, with a focus on trees for urban infill developments.

The urban forest includes trees and plants planted on both private and public land. Three major pressures to improving our combined urban forest include:

- Removal of trees on private land due to urban infill development;
- Limitations in planting opportunities on public land due to limited space and significant encumbrances from utilities (overhead powerlines, buried pipes and cables, and the legislation surrounding service assets), and
- Climate change impacts reducing the suitability of commonly planted tree varieties due to long-term drying, warming and extreme weather events

The pressures and impediments to increasing greening in the private realm are not independent of the limitations of planting in the public realm. A mixture of the challenges and innovations are presented here for both, to demonstrate how learnings from the public realm can apply to increasing trees in urban infill developments.

Retention of street trees on public land

Tree retention is the most important part of maintaining our urban forests. Councils are responsible for managing street trees, maintaining safe and pleasant places to live, work and play. In the eastern region, there is a strong drive from elected bodies and communities to maintain and expand the existing green spaces and canopy cover. This is evident in the consistent range of governance levers in strategy, values, policy, and targets to support the retention and expansion of canopy cover in strategic ways. Many have both targets for public realm street tree plantings, management programs to enhance the health and longevity of the urban forest, and many have a range of incentives and educational initiatives to encourage the planting of trees and understorey on private property as well.

The eastern region historically had more native vegetation due to the location of foothills, creeks and the settlement of Adelaide, and the areas are described typically as fairly 'leafy' and 'green'. Many of the originally planted street trees are reaching their natural end of life, or an earlier end of life due to human disturbances impacting their survival. Councils are working on replacement schemes over the coming years which will greatly impact the leafy nature of many of our streets, and the valuable shade falling on private property.

The removal of street trees due to development impact has been mitigated somewhat by some councils adopting a price on the removal of street trees. This cost is measured typically using a recognised valuation method of the tree (i.e. the Burnley Method, Melbourne method or Maurer-Hoffman Formula), plus the cost of the valuation report, the removal and replacement of the tree. This provides an estimation as to a more realistic valuation of the tree and acknowledgement that a new tree will take many years to reach the same level of value and benefits provided. Currently Cities of Adelaide, Burnside, Unley, Campbelltown City Council and Town of Walkerville have a calculation tool used to value the cost of a street tree to the applicant.

An opportunity to dis-incentivise council tree removals for driveways and developments could be to formalise process for valuing trees using City of Melbourne method or Burnley Method so that the full value is captured and paid if trees are to be removed. This formular for calculating this cost needs to be agreed and applied more consistently across Councils.

Retention of trees on private land

In many cases the most site appropriate tree species for urban infill developments is the existing tree(s) already established on the site. Best practice should be first and foremost to retain existing greening as a higher priority than planting new and/or finding alternate spaces nearby and decision makers and urban forest management practitioners should reflect this, so we don't end up with this stark difference (*Figure 3*).

15 dwellings *31 dwellings*

Figure 3: *Photos before (2013) and after (2022) a 9-year period, in Hectorville clearly showing the impact of urban infill on vegetation, tree canopy cover and shade for these homes. (Campbelltown City Council Urban Forest Strategy, 2022).*

Greater emphasis and expectation should be placed on improving design-led solutions that complement existing trees, including the State-led planning and design of the built form through the Planning and Design Code (the Code), and the engineering of footings and structures to take into consideration proximity to the tree (below ground).

Whilst there is a policy in the Urban Tree Canopy Overlay of the Planning and Design Code to discourage the practice of completely clearing blocks of all vegetation prior to redevelopment, since the introduction of the Code in March 2021, there are no recorded incidents of this being followed and some Councils have investigated the achievement of this policy option and found it has not been utilised by applicants, since the Code's introduction. This whole-block clearance "efficiency" often includes excellent specimens of trees by the back fence which could have been retained as a feature garden for the finished new homes. An audit should be undertaken of the effectiveness of this new policy, introduced by the State Planning Commission, into the Code. Learnings of why this policy incentive is not working to save existing vegetation on house blocks, should be used to inform changes to the Code.

A review of the effectiveness of tree policies in the Planning and Design Code, should also include an extension of the spatial application of the Urban Tree Canopy Overlay into higher density and Urban Corridor Zones and non-residential zones and a review of the 1 tree per 10m2 in carparks, to determine whether urban development is delivering on strategic greening.

The retention of existing trees is important to the re-sale (a key driver of 2-for-1 infill development), as well as the activation and shading of outdoor spaces and help reduce the ongoing heating and cooling costs of new buildings.

Outside of urban infill developments, ongoing maintenance support options for private land can help retain trees. For example, City of Burnside, City of Prospect and City of Unley offer financial assistance to community members for the maintenance of Significant and Regulated Trees on their land.

For non-legislated trees (the majority of trees in the private realm), other than the Code policy which appears to have limited application, there are currently no incentives or disincentives to retain existing trees on the property you live in or move into, let alone are subdividing. The mechanisms recently implemented in the Code, which only applies in some locations, to address trees on private land (the one-tree policy or the tree offset scheme) may be easier financially and logistically rather than clearing the land of trees and starting from scratch.

City of Unley's unique investigation into incentivising ratepayers to maintain 'all' trees to reach a minimum level of canopy cover is being watched with keen interest by the other Resilient East partners.

New trees on public land

When councils plant new trees it is done so that the trees to have the best chance of survival and in a way that works with the surrounding urban infrastructure, both existing and future. This requires holistic planning and considerations of growing conditions. Fit-for-purpose solutions can be used to ensure that we have trees on our streets to provide a range of functions for nearby properties and passers by – especially shade and cooling.

With contested space above and below ground, a factor to improve the survivability rate of urban trees can include engineered and innovative approaches that result in additional up-front costs, but with significant long-term benefits: the value of a tree increases as it grows and a well-planned tree can help the infrastructure around it through shading and soil stability.

Innovation and accountability can drive greater building and engineering solutions to minimise the perceived impact of trees adjacent to buildings. In addition, horticultural industry innovations are continuing to advance new technology which can minimise the impact of trees or make it more affordable to integrate trees.

Root barriers *(Figure 4*) can provide a simple and cost-effective solution when a non-permeable barrier is required adjacent to services. Alternatively, **honey-comb like 'strata cells'** (*Figure 5A and B*) can support effective root management in confirmed spaces, limiting paving lift and supporting above ground loads from adjacent vehicles without soil compaction.

More on root barriers: SA Water are [trialling tree root barriers](#) as a new approach to prevent tree roots impacting wastewater connections and protect the natural environment. As part of the innovative pilot, a thin layer of high-density plastic liner made from 100 per cent re-used material has been installed two metres below ground between problematic trees and a wastewater connection. The trial (in its second year) is targeting properties which have experienced higher than average wastewater blockages, caused by tree root intrusion. The tree root barrier aims to restrict roots from moving towards pipes, without removing the tree or impacting the tree's health, retaining tree canopy coverage. The barriers are being trialled in locations where the wastewater asset is still in good condition and doesn't need replacing, rather it has tree root intrusion. This initiative ensures the wastewater asset is retained and its asset life extended rather than replacing an asset that isn't broken. The barriers are also less than 1/3 the cost of re-lining or replacing the connection.

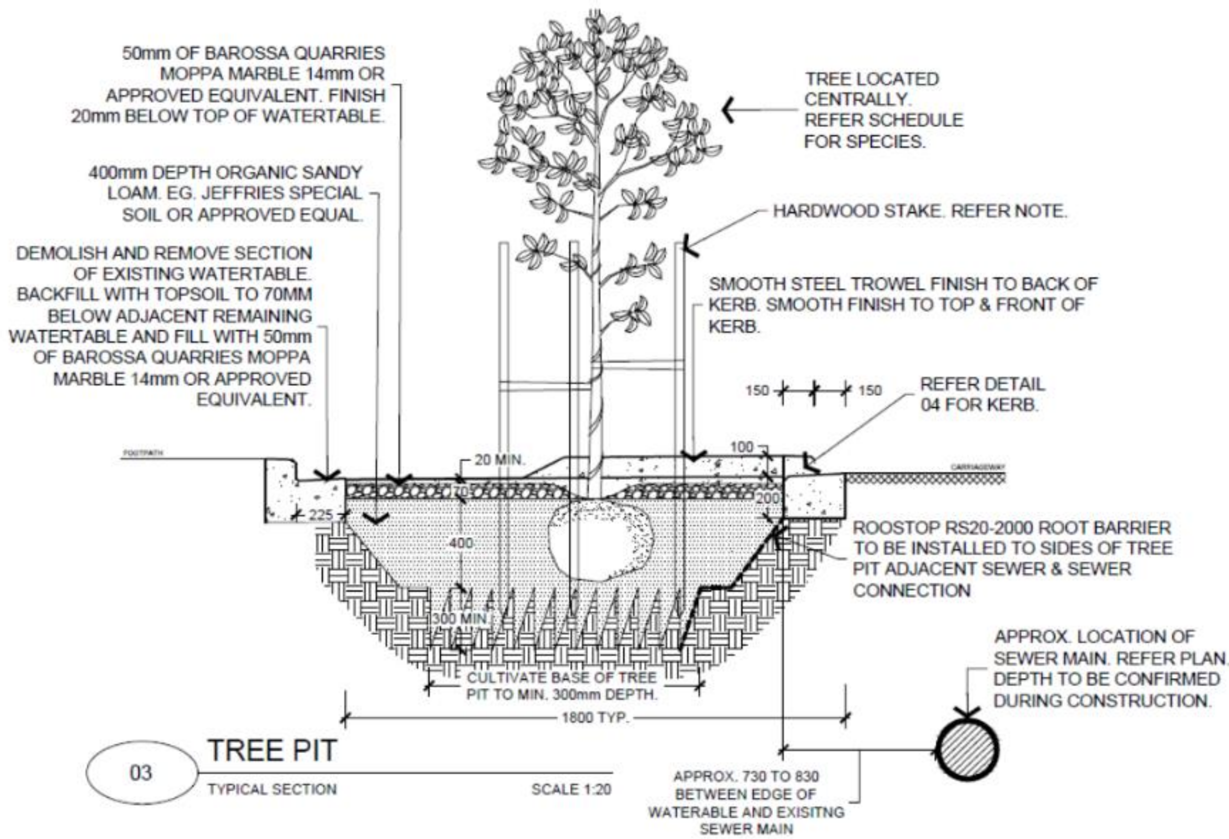

Figure 4: *Example root barrier location. Designed in collaboration between SA Water and City of Adelaide*

(A) *(B*

Figure 5: *Examples of how the councils create more space underground for trees in contested environments to help support the growth of a tree. (A) Cutting into the road space to put a tree strata cells that support stabilization of the soil when -(B) bitumen goes on the top, and therefore leaving space for car parking either side of the tree;*

Where the infrastructure underground is dated, critical or cost prohibitive to dig around, trees in **planter boxes** and **green infrastructure** such as **arbours** and **tree-like structures planted with climbing vines** (*Figure 6*), are being increasingly used in dense urban environments around the world to provide quick shade, create ambience and for city activation.

Figure 6: *Examples of trees in planter boxes, lifting above contested underground space on busy footpath and dining areas and an artificial structure which aims to grow vine type plants fast and create shade and cooling quickly*

Water Sensitive Urban Design

Water sensitive urban design (WSUD) enhances the overall liveability of communities and can help to keep trees healthy and reduce cost of tree management while also making your home, streets and neighbourhoods cooler, more comfortable and more walkable.

Water sensitive urban design (WSUD) techniques can counter extra run-off due to the increase in impermeable surfaces by capturing water and using it onsite for fit-for-for purpose solutions. Resilient East councils have over 1,915 different WSUD devices (see *Figure 7*), and are constantly improving internal capacity and ability to install, record, and maintain these assets.

More than half of councils' WSUD devices are small 'verge soakers' (or 'leaky well') type devices that catch water from either the street (street tree inlets) or the roof gutters of private property (B-Pods). The water soaks slowly into the verges, providing water for the street trees. This water would otherwise run down the street, enter the stormwater system and end up in rivers, creeks and the ocean, if not into a constructed wetland or similar filtration process. The benefits of verge soakers are most relevant in prolonging the life, health and resilience of Adelaide's urban tree canopy during the summer months as slowly filtering water out and encouraging plant growth.

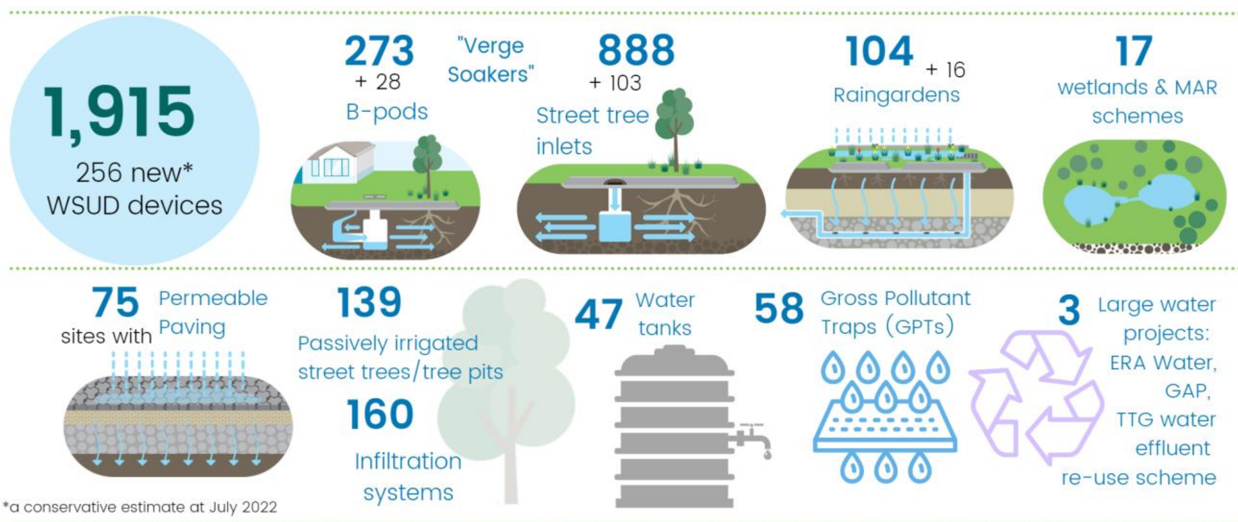

Figure 7: *Tally of water sensitive urban design features within the Resilient East Councils - approximately 256 new devices were installed within the 2021/22 financial year.*

When placed directly around trees, permeable and porous paving allows water to seep down to the tree's roots (see *Figure 8 for examples*). This means roots are less likely to grow close to the surface in search for water. Overall this can reduce tripping hazards on the pavement, encroachment into the road, maintenance costs, and ultimately increase the survivability of the tree because surrounding soil can absorb water that falls on the site, rather than it running off.

(A) (B)

Figure 8: *An example of (A) permeable paving, where the water seeps directly into the tree root zone below, and (B) porous paving, which is porous aggregate and has a similar function. Here it surrounds and protects a significant gum tree in Prospect.*

There are 75 sites within the eastern region that have permeable paving, mostly located in carparks. This WSUD approach used by councils is suitable for many urban infill driveways and carpark situations, which are a major factor in increasing run-off to the street. Increased run-off or stormwater in streets can contribute to more pollutants entering waterways, localised flooding issues, and overall exacerbation of the urban heat island effect.

Of note, a 1970s Strata Corporation in the City of Unley, recently used a small section portion of permeable paving in their driveway upgrade to remove potholes and cracked surfaces, and overcome some of the challenges of water pooling. The above linked video documents the process, from the decisions at the strata committee level, to the technical details. It is a perfect example of the benefits of incorporating a small amount of permeable paving into new developments for a fit-for-purpose engineering solution: reduce the potential for future water ponding and pothole issues, and enhanced watering of trees and greenspaces on the property, which keeps the roots from searching for water elsewhere.

Water Sensitive SA provides a comprehensive range of useful information for both community and developers, including demonstrating a range of WSUD methods for home and shared carpark and driveway situations. The Adelaide Garden Guide for New Homes is a recently completed guide for increasing green and pervious space as per the Planning and Design code requirements, prepared by Green Adelaide and State Planning Commission. This is an excellent resource and should be used by community and developers as more than just a 'guide'.

Visit www.resilienteast.com/watersmart to view more videos about the benefits of WSUD, and many examples of WSUD in the eastern Adelaide region.

Opportunities for best practice:

- Water Sensitive SA have been partnering with SA Water, Green Adelaide, Plan SA and LGA planners on developing a standard set of water sensitive urban design technical drawings to support stormwater re-use on both private and public land.
- Councils are also working with WSSA to train Development Assessment planners and Developers in incorporating WSUD into designs.
- Improving the deemed to satisfy requirements for WSUD in the Code is paramount to ensuring effective stormwater management in urban infill and support the growth and resilience of our urban forest.

Spatial mapping

Innovative spatial software systems to map have been adopted by many Resilient East councils that identify and locate public realm trees. There are a raft of benefits to the integration of spatial tree data into multiple departments across councils, including planning. Councils arborists can identify future spaces to plant street trees as part of upcoming tree planting programs. There is an opportunity for Assessment Planners to access this information when integrating tree data and development applications. If Assessment Planners know where the potential spaces are to plant trees, they can make approvals regarding the future tree in alignment with placement of infrastructure and driveway crossovers, preserving deep root zone in the verge - therefore the space is retained. This can also trigger the tree to not be planted until the development is finished, to ensure best results for the tree's survival.

There is also potential to use spatial mapping across departments and service providers for streamlining processes, approvals, and visibility of current and future trees. Not all councils have GIS capabilities in house, and this is a real barrier to linking tree software systems, LiDAR, heatmapping and other good datasets in with their regular decision-making requirements – both in planning approvals and public realm.

There is an opportunity to support building the capacity and consistency across local and state government of access to contemporary tree mapping software tools that integrate with other GIS systems, including across departments (like SA Water) so that efficiencies can be made.

Creating more spaces for trees

Standards and guidelines for planting in proximity to underground and overhead infrastructure such as utilities are often blunt, prescriptive instruments that can conflict with other strategic outcomes such as increasing greening and may be outdated.

Within a typical streetscape, councils can consider placement of street trees within the verge, within the road (kerbside, see *Figure 9*) or within the centre of wider roadways. In each of these locations, the historic alignment and separation of below ground services and the previously conservative offsets from services for tree planting has resulted in limited opportunities for additional trees to be located.

Figure 9: Tree pits dug into the road (kerbside) created on narrow roads with narrow footpaths.

Above ground, tree pruning activities to trees interfering with overhead powerlines has had a detrimental effect to the canopy cover and performance of the urban forest and the beauty of individual trees and local streetscapes.

In 2021, Resilient East and the City of Adelaide led the **Creating More Spaces for Trees project**, as part of a University of Adelaide *Industry Engaged PhD Internship Project* that looked at underground space available to plant urban trees and influencing challenges, such as utility services and planning regulations., The report is attached as part of our submission. Key recommendations from the report included: legislation to support the preservation of existing trees and urban forest development, planning for trees in the long-term, developing of decision-making standards for trees in Adelaide, and collaborative and well-informed decision making.

Further works could be explored with SAPN to consider ways to better consolidate and manage the overhead wires, underground all new electricity infrastructure, the clearances required, and extent of pruning undertaken to established canopy.

Current research project with SA Water and Resilient East Councils

Initiated by the Resilient East Canopy & Heat working group, SA Water hosted a workshop between Council planners and arborists together with SA Water technical standards and development services team to determine how we can between share the road verge to make more room for trees during urban-infill developments. Local Councils have shared that SA Water and other utilises new services make it difficult to plant a tree after new essential services have been installed. This results in councils either not being able to plant a tree or planting a tree in the incorrect location causing a problem for SA Water and the customer when the tree matures. We look forward to being able to share the outcomes of this work, and recommending practical suggestions of improvements to the processes of council, SA Water, and the planning portal system to better support all in achieving greening outcomes for our state.

Species selection, urban forest diversity and climate impacts

The greater Adelaide region is moving into unprecedented territory with weather, and it is unknown how certain tree species will respond to heat and drought thresholds. Tree health and resilience can be improved with having complementary and ideally native biodiverse understorey plantings. While the focus is on urban forest, ground covers, midstorey, increasing native biodiversity and other effective urban greening options such as vines and green walls should not be overlooked.

Resilient East councils are acutely aware of the potential that climate change directly has on its urban forests, i.e. more extreme weather events, as well as greater indirect risks such as pathogens and plant parasites which can further harm trees under climate stress. There is a wealth of collective knowledge across the Resilient East councils which continues to grow through trialing new strategies and reviewing the probable causes or poor tree health and mortality.

There's a range of different considerations, evidence and opportunities when it comes to selecting species – to both improve urban biodiversity and prepare for future climate impacts:

- **Street Tree Species Guideline:** In 2019 a Resilient East working group of arborists developed a climate ready street tree species guideline for council staff to consider in their planting programs. This guide assist councils to select from a range of tree species, suitable to our regions changing climate. The guide lists over 115 species trees existing in the region and considers attributes like: useful life expectancy, watering requirements and resilience to droughts, pests and severe weather events. This is a 'living' document which can be updated as we increase and gain more knowledge.

- **<u>CoA, Street Tree Resilience Study:</u>** In 2021 CoA worked with DeBill Environmental in collaboration with the University of Adelaide in a street tree resilience study. A December 2019 heat stress study by DeBill of Ginkgo biloba had found the trees were unable to cool their leaves after multiple hot days. A small study was undertaken in February 2021 to investigate the heat resilience of four CoA commonly planted street tree species (London Plane Tree, Ornamental Pear, Common Hackberry and Desert Ash). All were found to have a reduced capability for water to move through the tree during warmer temperatures. Additionally, they experienced increased evapotranspiration when ambient temperatures were above 35°C, increasing loss of water. These studies indicate that some tree species may not be able to cool their leaves during longer and hotter heatwaves. Further research is required. This was intended to be phase one however with LaNina changing our summer weather we put this work on hold.

- Throughout 2022 the University of Adelaide have been working on building the literature and research using the starting point of Resilient East's Street Tree Species guide, and this is a working progress to enhance this as a tool to use in conjunction with the Botanic Plant Selector Tool, adding in more parameters that are influenced by climate change and increased frequency and severity of natural hazards. There is still a lot of work to be done in this space, as there were many unknown impacts of existing or future trees to the impacts of climate change.

- The costs and resourcing required for councils post-storm clean-up is likely to increase. After the extreme storm on 12 November 2022, neighbouring council arborist crews were pitching in to assist with the safe clean-up of trees. If storm incidences are more prevalent, extreme, cumulative and widespread, the ability to be flexible and assist other councils may be lessened. Some councils are investigating resourcing for better veteran tree management – extra care for trees more susceptible to be damaged in storms to both protect the tree, and reduce their risk to property and humans by limb dropping.

Resilient East councils are participating in further collaboration with University of Adelaide, State Government and many other Councils on the **Future Trees project** to identify an increased range of species and potential new cultivars suitable for planting adjacent to existing infrastructure and suitable for future climatic conditions.

- Pre-liminary analysis of the tree inventory data from across greater Adelaide shows a predominance of a handful of heavily planted tree varieties of street trees. Callery Pears and Jacarandas make up more than 20% of Adelaide's public urban forest. Other common trees planted are the Queensland Brush Box (although several councils are no longer planting this species), Golden Rain Trees and Claret Ash. Recent years have also seen a rise of Crepe Myrtles and Chinese Pistachios.

- The above-mentioned trees are also heavily planted on private property, including in gardens and as street or park trees in new developments. These tree species are popular because they are proven performers with relatively few major pest issues, are well-known to developers and gardeners and have well-developed propagation techniques, allowing them to be readily grown locally or interstate. These advantages have led to them being heavily grown and promoted by the nursery industry, who are reluctant to invest in growing stock that may not be of interest to a conservative market.

- Adelaide’s shifting climate means that several popular tree varieties, including some native species, are moving outside of their climatic envelope and are becoming more difficult to establish and maintain. For example, Callery Pears are native to the humid subtropical to temperate zones of eastern Asia and Jacarandas are native to subtropical South America. While moderately drought tolerant, both species (and many other heavily planted exotics) are on the edge of their climatic range in Adelaide. As Adelaide’s climate becomes increasingly semi-arid, with increasing drought periods and heatwaves, commonly planted species are likely to have reduced health and useful life expectancy and lower success in establishment. Eventually, widespread cultivation of some currently common species in Adelaide will not be possible.

The best way to bolster the urban forest against direct climate impacts and climate-mediated threats (like disease) is through diversification of the trees we plant. Higher diversity ecological communities are more resilient, and there is more redundancy in place should we pass the climatic threshold or experience the introduction of a pest or disease which heavily impacts one or more tree species.

Determining which varieties to plant in the place of currently popular tree varieties that are overrepresented in the urban forest is not straightforward and will require coordination between local governments, state government and nursery industry, to ensure (species and genetic) diverse stock are available for purchase by urban forest managers.

Current opportunities include:

1) Benchmarking Adelaide’s urban forest
(i.e. mainstreaming the Future Trees project to ensure the process is ongoing and improved over time)

2) Integrating trees on private land into spatial data capture
(i.e. train the LIDAR analysis to identify tree species)

3) Identification of new tree varieties to prioritise planting
(i.e. from dry Mediterranean or semi-arid climate zones)

4) Relax regulatory impediments to planting new and existing street tree varieties
(i.e. relating to trees planted in relation to powerlines and SA Water pipes)

5) Develop new cultivars to suit Adelaide’s current and future conditions
(i.e. investment in local horticultural industry to safeguard and diversify our supply)

6) Improving species selection in large housing developments
(i.e. good opportunity for improved tree selection for shade and mainstreaming services)

Research and development of new cultivars would be a long-term project and would benefit from multi-year funding, and is relevant for the transition and/or updating of service infrastructure.

The State Planning Commission Open Space and Trees Project is a positive initiative. The supporting reports released on 1 September 2022, including ‘*Open Space and Tree Project – Part 1A (Arborist Review)*’, ‘*Urban Tree Protection in Australia: Review of Regulatory Matters*’ and ‘Adelaide *Home Garden Guide for New Homes’*, provide valuable research and tools to improve species selection.

Whole of life costs and maintenance

Urban tree management funding should fundamentally account for whole of life costs and the community benefit that will be gained by trees in more constrained environments, rather than the total cost per tree.

With the increasing aridity and extreme heat events, there may be greater requirements to water trees that normally weren't watered in order to improve chances of survival. Councils watering regime is already in higher demand and some insistence stretched to capacity due to increasing the number of trees planted on council land and roads each year. Budgeting for watering can vary due to seasonal unpredictability – if upfront costs are increased enabling the installations of compatible forms of WSUD or other irrigation, plants and trees are likely to survive longer. The last few years with La Nina has brought milder summers however we need to be prepared for the flux between this and the extremes of El Nino summers which require more maintenance, watering, and potentially encouraging residents to water street trees.

This will result in councils requiring additional water trucks, investment in WSUD and irrigation, pruning crews, and general arboriculture staff to maintain trees and ensure required clearances to roadways are maintained.

Consideration needs to be reinforced for trees in private realm as well, if trees are being planted as part of a development, for example, and are part of the common land – the maintenance and support for the longevity of these trees is an important consideration. If the trees are to become the responsibility of councils, adequate supports should be included to ensure the trees have best chance of survival with minimum maintenance requirements or additional costs to be borne by councils.

Communication

Advocating the importance and value of the urban forest through communication, education and clear messaging all contributes to a greater collective appreciation for trees in our urban areas and the benefits they provide. This values shift could take a long time, but is essential to the growth of our urban forest if the community have a stronger desire and expectation for urban trees and willingness to deal with the maintenance requirements.

Resilient East council arboriculture staff spend a significant amount of time talking residents out of removing a tree on public land that causes said residents 'nuisance'.

Councils have worked on a range of initiatives to support public perception of trees and greening in both the public realm and private property. For instance:

- City of Unley has recent success with promoting a competition to win an $80 tree voucher
- City of Norwood Payneham & St Peters has for a second year a Tree Incentive Program which provides an $80 tree voucher to private property owners with selection criteria for species that provide shade and cooling outcomes – program includes offering double vouchers to properties with lower canopy, or within a heat island
- Cities of Burnside, Norwood Payneham & St Peters, Tea Tree Gully and Prospect offer seasonal a native plant (shrub) giveaway or discount

- To encourage a diversity of tree plantings, City of Burnside, City of Tea Tree Gully, City of Unley have created a selection of tree or plant information cards and suggestions to suit their local areas

Green Adelaide has been bolstering communications to suit a contemporary market – bite size and easy to read, as well as more detailed planting guides that help people learn about why, how and when to plant different plants. This communication needs to met by people in the market for buying a new property, and creating demand for it in new builds.

Many Resilient East councils and organisations have been altering how they pitch language on 'valuing trees' – whether that be for public or private realm to suit their demographics and values of their constituents. **A broad scale campaign that touches on a range of key values would be beneficial across Adelaide, and ideally led by a State Government Department** – i.e. Wellbeing SA – Healthy Parks and Healthy People, with Green Adelaide. Resilient East has engaged several intern students through various university programs to assist and have some good learnings and ideas around approach.

Research, Collaboration & Innovation

Best practice and innovative methods have been either driven or greatly supported through collaborative networks including but not limited to - regional adaptation (e.g. Resilient East), Water Sensitive SA, TreeNet, Healthy Parks Healthy People and Universities. Continued funding and support of these collaborative networks and research bodies by State Government is recommended for their contributions towards research, peer to peer knowledge sharing and increasing awareness and education on the urban forest.

Some good examples of research and collaboration have been discussed throughout this submission so far – **Creating more Space for Trees** and **Future Trees**, **Tree Root Trials** as some examples.

Important to mention is that Resilient East and the other RCP partnerships were instrumental in facilitating an Adelaide-wide benchmark of tree canopy cover, which is an improved and updated methodology from previous canopy cover baseline set for Adelaide in the 30-year Plan. Resilient East partners are financial partners in the second capture and analysis project led by Green Adelaide, which is recapturing LiDAR canopy and heat mapping across metropolitan Adelaide. This project will create a shared resource to understand the challenges, track progress and prioritise, Resilient East councils are currently awaiting these results. The data capture needs to be done at regular intervals, centrally coordinated for evaluation and longitudinal comparisons for the 5-yearly State of the Environment Reports.

2. Legislative and regulatory options to improve the resilience and longevity of trees comprising the urban forest

Green Cities and Suburbs

Despite local and State governments having a shared goal to grow canopy cover (for example, the 30-Year Plan for Greater Adelaide target to increase canopy by 20% from a 27% baseline by 2045), Adelaide's net tree canopy is declining. For this reason, we strongly support State Government commitments to examine tree protection laws as part of the Planning and Design Code reform.

It is noted that the State Government is already considering strengthening greening policy and funding, including by:

- Extending the ‘One Tree Rule’ into master-planned developments
- Increasing the fees payable under the Urban Tree Canopy Offset Scheme to better reflect the actual cost to local governments of planting trees off-site
- Changing the protection exemption for trees located within 10m of an existing dwelling or existing in-ground swimming pool
- Exploring funding options available to councils for public realm tree planting and maintenance, to encourage the planting of more substantial trees.

Resilient East councils agree that the above are all important issues, and commends and supports these being explored by the State Government. However, major obstacles to achieving canopy growth are still present even with the above considerations. For example:

- **There is not enough funding to achieve canopy targets**: Proposed increases to the Offset Scheme to cover costs would be a great start. However, the majority of our tree canopy comes from mature trees, and there is either no or negligible (for Regulated trees) fee payable to the community to compensate the community for the loss of tens of thousands of dollars of annual benefits each tree provides. Diverse financial options to both minimise tree loss and incentivise and fund tree planting and maintenance on both public and private land are required.
- **Canopy targets cannot be achieved by solely planting trees on public land**: State and local government have planted tens of thousands of trees since the last urban forest LiDAR flyovers in 2018 and 2019. Despite this work, there is evidence that Adelaide’s canopy has declined over this period due to tree removal on private land. Public land within suburbs is limited and much of what is not already planted is encumbered by infrastructure clearance regulations that limit any further tree planting. In order to arrest and reverse decline across greater Adelaide, regulations or incentives to plant and retain trees on private land will be required.
- **All trees are not equal**: while the ‘One Tree Rule” is a move in the right direction, there is an economic incentive for developers to plant compact, short-lived trees with minimal cooling and amenity value rather than larger, long-lived trees which will deliver greater community and environmental benefit. A similar trend towards replacing existing larger trees with smaller trees to make way for public infrastructure will see an ongoing shrinking of our canopy. Consideration should be given to stipulating minimum canopy levels within developments in order to ensure community benefits from trees are met.

There are further examples of where the current Planning and Design Code does not currently support good greening outcomes:

- **Only elderly, girthy trees are protected**: Under the current planning system, trees become ‘Regulated’ (protected) once they reach a two-metre stem circumference. Protecting only the very thickest trees, with no other size-based protections (such as height or canopy spread), effectively protects mainly ‘elderly’ trees (with a potentially limited remaining lifespan), while allowing all ‘adolescent’ and most ‘adult’ trees to be removed. This blunt trigger also fails to protect species that do not reach a two-circumference at maturity.
- **Tree protection triggers are the weakest in the nation**: All comparable jurisdictions in Australia protect much smaller trees by girth, with some also protecting a tree based on its height and canopy spread. If we are to have any hope of achieving adequate canopy cover, we must consider adjusting the protection triggers to protect more trees (i.e. as documented in Conservation Council SA *Comparison on Australia’s Tree Laws*)

- **Most trees are exempt from protection**: There are many exemptions from tree protections, including the aforementioned 10m distance exemption, and exemptions based on land use (for example, land occupied by a school or transport corridor). Under the Code PO 1.3 and 1.4, even trees that are not exempted under other provisions may be damaged or removed where "development might not otherwise be possible" and "all reasonable development options and design solutions have been considered". Effectively, these cumulative exemptions mean that very few trees are actually protected.
- **Tree lists are subjective, complex to administer, and don't support adaptation**: The list of tree species currently excluded from protection under the Regulations complicates implementation of the Act. The list fails to allow for changing climatic conditions, and is drafted (and has been recently assessed under the Open Space and Trees Project) based on subjective values and opinions on amenity value and climatic suitability. Instead, we suggest removing the tree list and instead triggering protections based on circumference, height, and/or canopy spread.
- **Policy to discourage completely clearing blocks doesn't work:** Whilst there is a policy in the Urban Tree Canopy Overlay of the Planning and Design Code to discourage the practice of completely clearing blocks of all vegetation prior to redevelopment, since the introduction of the Code in March 2021, there are no recorded incidents of this being followed and some Councils have investigated the achievement of this policy option and found it has not been utilised by applicants, since the Code's introduction. This whole-block clearance "efficiency" often includes excellent specimens of trees by the back fence which could have been retained as a feature garden for the finished new homes. An audit should be undertaken of the effectiveness of this new policy, introduced by the State Planning Commission, into the Code. Learnings of why this policy incentive is not working to save existing vegetation on house blocks, should be used to inform changes to the Code.

There are many options available in the *Planning, Development and Infrastructure Act & Regulations and Planning and Design Code* to improve the resilience and longevity of trees comprising the urban forest:

- Greater protection for established trees.
- Design policy for increased provision of new trees in new developments, including front and rear of property.
- Review of Regulated and Significant Tree protections – broadening criteria for trees to include height, area of canopy and rare species. Exemptions should be avoided including the ten metres on an existing dwelling and increasing the fee for approved removals.
- While protecting existing Regulated and Significant Trees, care should be taken to avoid creating a dis-incentive to retain trees approaching Regulated and/or Significant status.
- Minimum tree number, tree size and area around buildings for planting obligations all need to be increased to be effective to meet canopy cover targets and form an expected and beneficial component of all development. For example, under the current policy, a 450-square metre block would require one medium tree, which, even at its mature age, would only achieve a four to eight-metre canopy spread, which would produce between 3 to 11 per cent of canopy cover over that block.

- Monitoring and compliance mechanisms need to be in place to ensure removal of the tree(s) and/or change to the allocated space to support the tree(s) should not be feasible.
- Urban tree offset scheme should only be available in exceptional circumstances and with increased fees to dis-incentivise this option.
- Funding options to councils for public tree planting and maintenance to encourage planting more substantial trees in the built-up urban areas.
- Increasing and strengthening requirements to reduce building footprints and increase setbacks, open-space, areas of soft landscaping and tree number, size, and canopy.

It is critical that Tree protections in our Development Act, Regulations and Planning and Design Code are strengthened in order to arrest and reverse tree canopy decline.

Services and Planning Decisions

The intersection between the needs for services and infrastructure is always going to compete with tree space – above, below and on ground. The 2021 report Creating More Space for Trees (2021), supported by Resilient East, documents the challenges and opportunities within this space. Since then, a lot of discussion and a greater intent to allow for trees has occurred, especially through working groups with SA Power Networks and SA Water updating a range of guidelines.

Service Authorities do not have to be assessed under the Planning and Design Code, so there may be a conflict of interest from the start with conflicting priorities and reducing risk of future problems. There is much more that can be done in this space.

Therefore Resilient East proposes the following to be investigated:

- **Regulate in the design phase positioning of service connections and driveway placement**: It is too late by the time an application (i.e section 222) gets put in to reduce the decision-making for the developer / applicant, the various service authorities, and the councils, for greater outcomes for a variety of important outcomes (i.e. reducing emissions, using water effectively and maintaining trees on private realm and streets). There is much more that can be done, especially from a planning regulatory level, that reduces the need for ongoing conversations between council planners and services, when the Development Assessment team has 20 days to provide all the feedback and approvals per assessment. This would assist with making sure services are not in the way of the deep root zone required for the front yard tree, as well as the street tree and/or WSUD and landscaping on the verge.
- **Common Trench Design**: Services are placed in a common trench under driveways, so as to limit access points and minimum distances from trees. Planning services need to avoid the need for multiple trenches which is both inefficient and creates problems with current and future trees. This would also reduce the risk for dial before you dig issues.
- **Electrify everything**: Reducing access to gas (especially in new suburbs) would remove one subterranean service with associated trenching, reduce the health impacts of incomplete combustion of natural gas in the home, reduce use of fossil fuels, and remove community exposure to rising gas prices.

In order to create more spaces for trees and provide the best possible growing conditions, reduce the risk to households in the future, and lower ongoing costs for all involved, additional strategic and higher-level regulations about the positioning of underground services need to be created, given the speed and touchpoints at which the new planning system requires information.

State Government Collaboration - General

Better integration and clarity is needed in terms of the roles of the Stormwater Management Authority, Green Adelaide, the Department for Environment and Water, the Department for Infrastructure and Transport, and other key stakeholders involved in the funding and implementation of urban forest management.

Summary

The inquiry into the Urban Forest presents a valuable opportunity for deeper analysis to address some of the complex issues around urban tree management and a focus on urban infill.

While there are many areas for further improvement, Resilient East believes the key opportunities at a state level are:

- Focus all urban forest improvements on outcomes for the protection and retention of existing trees as a higher priority than planting new.
  - Recommend improvements to the Regulated and Significant Tree policies for purpose of improving the extent of tree retention on private land - including increasing the fee for approved removal of regulated and significant trees.
  - Ensure the Planning System Implementation Review supports improved measures to retain and enhance trees (and other greening) on private land.
- Use of LiDAR analysis to report on delivery of the 3*0 Year Plan for Greater Adelaide* tree canopy targets, with information used to inform the revised 30 Year Plan (Discussion Paper due May 2023) and drive policy change through the Planning and Design Code.
- Audit of the effectiveness of the spatial application and policy content of the Urban Tree Canopy Overlay in the Planning and Design Code, to apply learnings of when applicants have used the whole-block vegetation retention option, where and how many trees have been planted, use of money paid into the Urban Tree Offset Fund and the extension of the Urban Tree Canopy Overlay into other locations (higher density, commercial and other non-residential land)
- Enhance the required tree number, tree size and area around buildings for tree and other complementary soft landscaping planting options for an effective green outcome for new development as a key part of planning policy.
- Ensure planning policy requires urban greening to the front yards as well as backyards of properties.
- Future proofing urban forest to replace for climate- ready rather than ‘like for like’ species, planning what we do well and raising minimum standards – rapidly diversifying our urban forest.
- Treat trees as an asset, not a risk, or canopy decline will not stop. Engage the community on the benefits of trees.

- Support and lead the coordination of standards and guidelines for below ground and above ground services, to support increases in urban forest.
- Continue to fund existing collaboration networks to support ongoing innovation, research, knowledge sharing, and urban forest education.
- Leadership of mapping to coordinate information to track collective efforts, and strategically plan for increasing urban trees.
- Leadership around a campaign valuing all trees to improve understanding of their vast benefits, and encourage 'living with trees' rather than removing them.
- Work together more than we have before – the Urban Greening Strategy being led by Green Adelaide presents a good opportunity for this, and their submission will highlight a lot of the key themes, strategies, and outcomes that Resilient East councils have been part of shaping.

Thank you again for the opportunity to contribute to the Parliament of South Australia's Environment, Resources and Development Committee's Inquiry into the Urban Forest.

If you would like further information on Resilient East or would like to arrange a meeting please don't hesitate to contact myself, or the Resilient East Coordinator, Bec Taylor on (08) 8273 8718 or btaylor@unley.sa.gov.au.

Kind Regards,

Maria Zotti

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Attachments:

- **NRC Parliamentary inquiry into Urban Green Spaces (2020)**
- **Creating More Space for Trees report (2021)**

RESILIENT EAST
Climate Ready Eastern Adelaide

RESILIENT EAST

Climate Ready Eastern Adelaide

29 July 2020

Mr Josh Teague MP
Presiding Member
Natural Resources Committee
Parliament of South Australia
NRC.Assembly@parliament.sa.gov.au

Re: Resilient East Submission on the NRC Inquiry into Urban Green Spaces

Dear Mr Teague,

Resilient East welcomes the opportunity to provide input into the Parliament of South Australia's Natural Resources Committee's Inquiry into Urban Green Spaces (Inquiry).

As the Coordinator of the Resilient East partnership, I want to take the opportunity to introduce the Committee to our partnership and our priorities which focus heavily on urban green spaces. Our submission is guided by the challenges we face and the opportunities presented in resource constrained environments. The benefits will be touched on briefly, as they are well documented elsewhere.

The Resilient East partnership has advocated for urban greening outcomes through Its recent submissions to the State Planning Commission on Phase Three Planning and Design Code for SA's Urban Areas, State Planning Policies and a letter to the Planning Commission following the release of the 'what have we heard report' in June (**Appendix 1**). Please read these as part of our submission to this inquiry.

This submission does not reflect formal Council consideration by any of the constituent Councils. This input complements feedback from contributing Councils and provides a perspective from the Local Government members of the Resilient East Steering Group.

Introduction – Resilient East

Resilient East is a partnership between the Government of South Australia and eight eastern councils working together to deliver practical actions that build climate resilience at a landscape level.

The goal of Resilient East is to improve the resilience of communities, assets and infrastructure, local economies and natural environments so we can manage and prepare for the challenges and opportunities of climate change. We collectively build resilience in our communities through collaborating, capacity building and joint delivery of on-ground action. Green urban spaces is a crucial element to this work.

The Resilient East Climate Change Adaptation Plan was completed in 2016. Under the current high emissions trajectory (aligned with the IPCC RCP 8.5 scenario[1]), it is projected that the climate in the Eastern Adelaide Region will experience considerable changes – generally an overall drying and heating with more extreme weather. These include increased rainfall intensity but decreased overall average rainfall, increased overall average temperatures, increased extreme temperatures and numbers of days over 35°C and 40°C and increased fire risk days.

Our Adaptation Plan is implemented under a Climate Change Sector Agreement with the South Australian Government that was signed on 23 March 2017 (established under section 16 of the *Climate Change and Greenhouse Emissions Reduction Act 2007)*. A renewed Sector Agreement for 2020-2025 was prepared with support of the draft from all parties and has been signed by Minister Speirs this week (July 2020). A Resilient East Project Steering Committee oversees the implementation and includes membership from all eight partner councils and State Government staff.

The following infographics *(Figure 1 and Figure 2*) summarise the climate changes and community vulnerability facing the eastern region of Adelaide.

[1] See the Resilient East Climate Projections report for detail and references.
https://www.resilienteast.com/s/Climate-Projections-Report

Figure 1: Resilient East Infographic Stage One

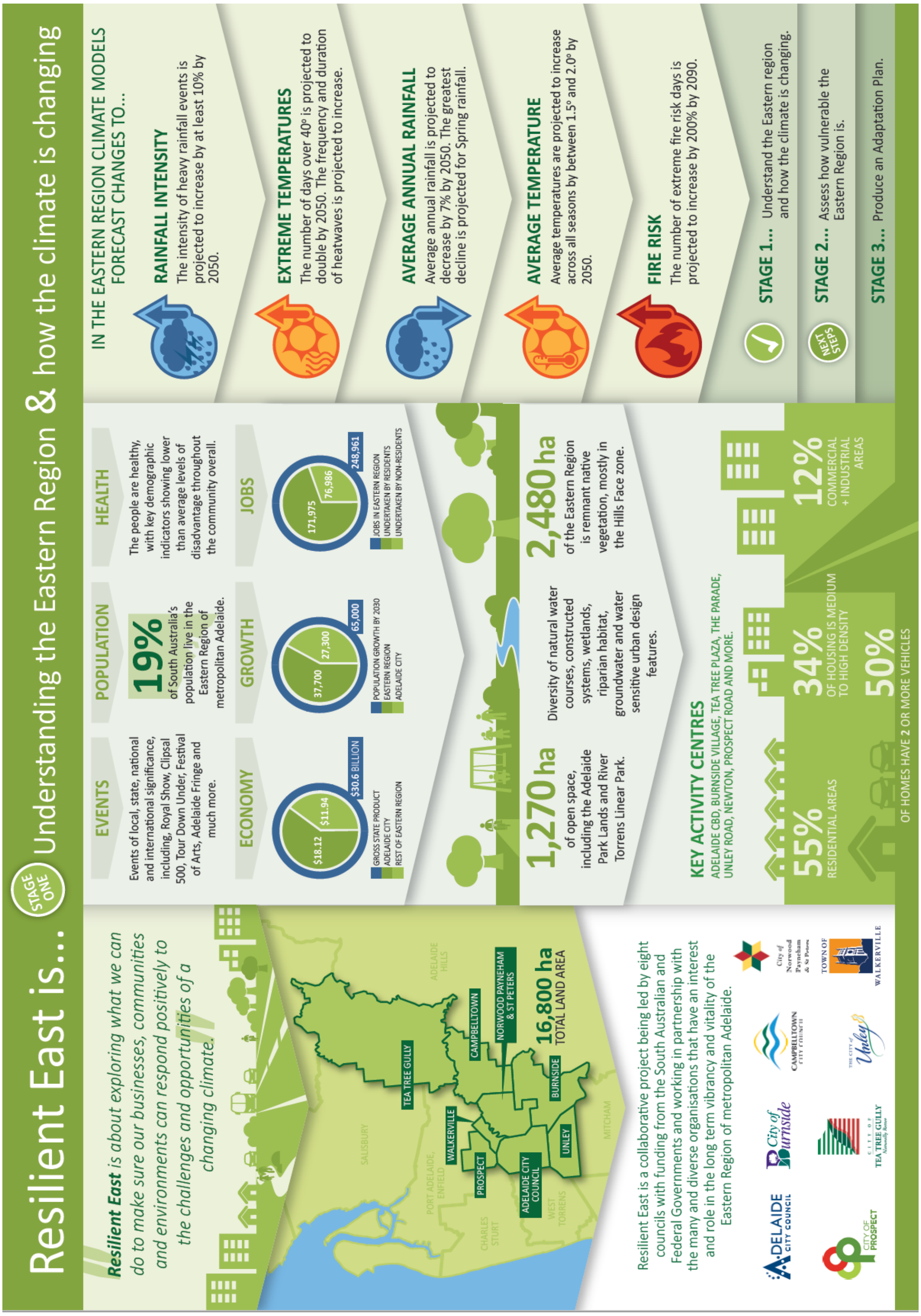
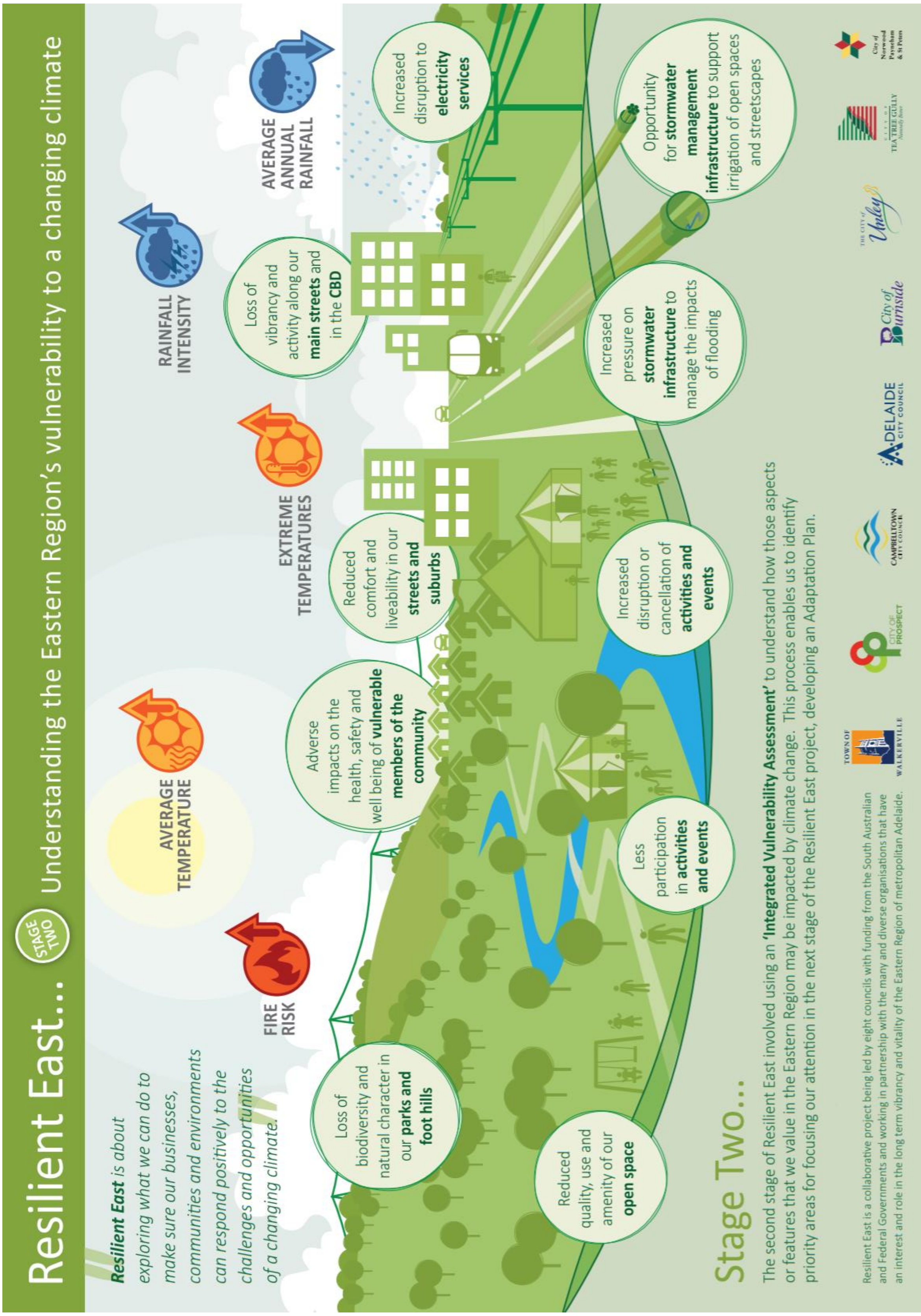


Figure 2: Resilient East Infographic Stage Two



We are committed to continue working as part of our renewed Sector Agreement on a 4-year action plan which prioritises:

- Cooling, greening and enhancing biodiversity on our streets and natural assets,
- Mainstreaming water sensitive urban design (WSUD),
- Actively addressing councils' and businesses' risks and opportunities in relation to climate change,
- Building resilience in our communities,
- Setting up a monitoring and evaluation framework, and
- Contribute to ongoing planning and policy reform opportunities.

These priorities align with the delivery of key state government priorities and strategies, including (but not limited to):

- Landscape South Australia Act and the establishment of the Green Adelaide Region
- Directions for a Climate Smart South Australia
- Across-agency climate change strategy (in development)
- Stronger Together – South Australia's Disaster Resilience Strategy
- State Public Health Plan
- 30 Year Plan target for 20% increase in urban green cover
- Phase 3: Planning and Design Code.

Resilient East – the benefits and challenges associated with urban greening:

Urban Greening

Background

Resilient East Councils have greening targets to align with the *30-Year Plan for Greater Adelaide (2017 update)* target to increase urban green cover 20% by 2045. The eastern regional community is proud of our association with being leafy and green, which is reflected as a strong feature in our Council Strategic Plans and through direct action, budgets and resourcing.

Creating more canopy and green cover, as well as introducing more WSUD infrastructure and water capture, will play an important role in creating cooler microclimates to help communities cope with temperature and rainfall changes in a denser urban form.

Benefits of urban greening

The benefits of trees, urban greening and open space are widely documented. We know higher canopy cover and improved water management has multiple benefits for councils, our environment, our community and our economy including:

- Increasing canopy and green cover is a proven strategy to cool our microclimates significantly. Our greenest suburbs are the coolest places on hot days, particularly in the absence of a sea breeze. (Our Collaborative Heat Mapping for Eastern and Northern report demonstrates this - tree lined streets were found on average to be 4.5 degrees Celsius cooler than the average land surface temperature).

- Cooler microclimates mean that households and businesses using air conditioners can save money and reduce greenhouse gas emissions, as the units don't need to work as hard.
- Property prices in greener suburbs and greener streets are higher in value because of their positive cooling, amenity and biodiversity benefits.
- Increased canopy cover in streets and open spaces supports people to be more active, to be able to walk in shade and enjoy our parks and gardens.
- Increased canopy and shrub cover supports our urban biodiversity which is rich in diversity and an important part of living in Eastern Adelaide suburbs. We are conscious that not all cities are able to keep biodiversity to such levels.
- Increased capture of surface stormwater runoff by trees, plants and soil, which reduces pollution to creeks and streams.
- A growing number of studies are recognising the links between trees and human health and mental health[2].
- Trees not only produce oxygen and absorb carbon dioxide but also act as air filters to remove dust, fine particulates and other pollutants from air in our urban environment.
- Trees as part of our leafy green eastern suburbs are becoming recognised as significant natural assets in a changing climate.

Barriers to increasing urban greening

There are many barriers to increasing green cover and green space in our region, especially in existing built up areas, and those experiencing high urban infill as required by urban infill targets of the 30 Year Plan. Here are some of the key reoccurring and emerging issues (but by no means an exhaustive list).

Tree canopy loss

Our tree canopy, along with the 30-Year Plan target, is at risk. A nationwide study in 2017 (*Greener Places Better Spaces)* found that metropolitan Adelaide experienced a decrease in canopy cover from 21.5% to 19.5% between 2013 and 2016. Hard surfaces have increased, with inner urban areas such as Norwood, Payneham & St Peters, and Prospect now recording hard surface cover in excess of 60% (*Greener Spaces Better Places*, 2014), which increases risks of urban heat and excess stormwater runoff. A Conservation SA report (June 2020) has highlighted key findings from recent tree loss analyses by Councils, and has amplified existing strong interest in this issue from the media and community.

[2] https://www.huffingtonpost.com/2013/01/21/trees-linked-with-human-h_n_2505267.html
http://ec.europa.eu/environment/integration/research/newsalert/pdf/trees_in_urban_areas_may_improve_mental_health_410na2_en.pdf

There is some evidence that urban infill has been the main contributor to this. An in-depth study by City of Unley analysed differences in canopy on public and private land over a 38-year period, using data from 1979, 1997, 2007 and 2017. Key findings are that:

- Canopy cover decreased from 34% to 28% while building cover increased from 29% to 36% – despite Council significantly increasing its tree planting on public land.
- Every suburb lost canopy cover in the private realm, with suburbs losing between 30% and 51% of their private canopy cover.
- Potentially plantable private space decreased from 18% to 13%, which was typically due to it being paved or built over.
- The City of Unley would need another 5% of its land area to be covered by tree canopy in order to meet the 30-Year Plan for Greater Adelaide target. With only 2.9% of the LGA's total area being public open space (and much of this already dedicated to recreational uses), significant contributions on private land will be needed. Planning policy through the State's Planning and Design Code is critical to setting the development expectations to achieve these outcomes on private land.

Lack of space prohibiting reaching canopy targets

Built up areas are contested landscapes with competing priorities and increasing competition for space, including:

- Above and below ground services (electricity, sewer, gas, telecommunications).
- On-street parking and vehicle crossovers into properties - especially where subdivision is occurring, on narrow streets and most of the city.
- Footpath widths and accessibility requirements.
- Preference for large building footprints with low maintenance landscaping.
- Demand for double and triple car garaging – forfeiting garden space for driveways and causing loss of street trees (i.e. through widened crossovers)
- Reduced open space on private land through urban infill.
- Increased appetite for whole block vegetation clearing for new development.
- Larger tree removals being replaced typically with smaller specimen trees or not replaced at all.

As a network we have often noticed a community sentiment that public land will be able to compensate for private green space loss. The State Planning Commission in its *Natural Resources and Environment Policy Discussion Paper* outlined a planning system of "offset schemes" as the means to deliver both green cover and stormwater management. However in terms of tree attrition, even if adequate planting funding was available, **mapping research is increasingly demonstrating that there is simply not enough public space to offset the loss of trees from private land.**

Standards and guidelines for planting in proximity to this infrastructure are often blunt, prescriptive instruments that can conflict and may be outdated. Following all existing standards could result in a sparse, low diversity canopy that is vulnerable to climate change. In Planning & Design Code consultation, the development industry groups provided submissions against the 'one tree per house' guideline with an argument that higher costs for tree-resilient house footings would undermine housing affordability objectives. Engineers Australia also argued against trees in backyards, under a zero-tolerance stance for potential public liability implications. We counter that minimum build standards should include footings that are robust for existing or future planted trees and that there are more public health risks in a future Adelaide without urban trees compared to neighbourhoods with trees. The health benefits of trees and green space are well documented. It Is understood the State Planning Commission Is finalising the Planning and Design Code policies through Its Residential Infill Advisory Committee, which Is due to meet on 7 August 2020 to consider reports on building implications for the proposed stormwater and urban tree canopy measures.

Funding Shortfalls for Purchase and Improvement of Open Space

Through the levying of a charge on land divisions through the Open Space Contribution Scheme, Councils are able to apply to the State Government for monies held from this Scheme in the Planning and Development Fund. Typically, the Planning and Development Fund is unable fund all open space applications it receives from local government, resulting in some land acquisitions or open space upgrades unable to be implemented.

Recent regulation changes have occurred to enable these funds, collected for the purposes of open space, to be used for government administration of the planning system. Any reduction in the amount of funds available to support the provision of open space in urban areas, will reduce the ability of Councils to deliver community well-being and tree canopy objectives through parks and reserves.

Ongoing tree survival in changing climate

Urban green spaces are an essential asset and shared aspiration of State and local government. However, it would be naive to invest in green spaces without factoring in survivorship with a changing climate.

Reduced rainfall and hotter temperatures exacerbate challenges in providing and maintaining healthy trees and vegetation. Climate change is also likely to impact on the prevalence and distribution of pests and diseases that affect trees, requiring greater consideration of climate in species selection and tree management approaches.

Soil moisture across the region has declined as urban areas have become increasingly sealed and paved. Even after wet periods, soil moisture across many areas may still be low and plants and trees then struggle to survive in these harsh environments. These conditions will be exacerbated by reduced rainfall and higher temperatures caused by climate change.

When South Australia last had enforced water restrictions due to a drought, the first thing to stop being watered were lawns in private and open green spaces. More recent evidence demonstrates that irrigated grass provides a cooling benefit to surrounding buildings and communities. Trees and green spaces have more chance of survival through a hot summer if they are intentionally watered before heatwaves. Adelaide will experience longer, more severe heatwaves, increase in average temperature and overall less rainfall, so it is a challenge to capture enough water to keep our cities green, and therefore cool.

Species selection tools

Tools used for selecting species of trees for planting in Adelaide are out of date (for example the Botanic Gardens Plant Selector Tool) – and require resourcing to update. Excellent work is underway in the eastern states on similar challenges, however the interstate tools must be applied in SA with caution as the weather conditions are so different which means tree species respond and grow differently in our drier, Mediterranean climate.

Loss of protections for Significant and Regulated Trees

We understand there is currently a shortfall in the Planning and Design Code around protecting Significant Trees, compared to current Development Plan controls introduced by the Planning Minister in 2012. Protection of both Significant and Regulated Trees must have clarity of policy outcomes in the Planning and Design Code which are not a reduction of the current statutory protections.

Mature trees provide the most inherent value to our communities and neighbourhoods, because trees are appreciating assets that gain value over time. Mature trees also deliver the most canopy cover, which can take decades to grow. This appreciating asset value of trees is generally not considered in financial systems and is certainly not reflected in costs associated with removing trees along with their inherent community value.

There is currently a $94 fee for removing a Significant or Regulated tree on private land. This nominal fee falls well short of covering the costs of planting and maintaining a replacement tree – not to mention the lost benefits to the community, which have been estimated in a City of Burnside study to be in the range of several thousand dollars for small mature trees through to tens of thousands or more for large mature trees. This gross under-valuing of mature trees causes significant economic barriers in ensuring adequate urban green space.

Having access to the best information

Planning, decision making and tracking progress on urban green spaces at landscape scale relies on accurate data and spatial information. Until recently this was disparate, expensive and often statistical/representative at best.

What are some things we doing?

Resilient East is trying to increase the understanding and use of the best practices for urban greening, how we increase awareness and understanding of trees in relation to climate change for both staff and communities. Here's an example of some projects:

- Creation of Mission and Strategies to support Councils with the principles behind greening to incorporate into their policies.
- We have compiled a tree species list for internal Council use to support a range of attributes enables better decision making in species selection. This work supports the national research by Which Plant Where and could contribute to updating the existing Botanic Gardens Plant Selector Tool which is used state wide and publicly available.
- In the last 5 years most of the metropolitan councils had thermal imagery heat mapping captured at day and night to Identify hotspots and vegetation Index.
- Currently we are analysing the latest LIDAR canopy data which will give us accurate data that tells us where we have trees at a certain point in time. Repeats of this LIDAR capture will give us greater potential to do longitudinal studies and Identify exactly where and when trees are being lost, which will give good oversight into what is happening in the private realm and progress of our collective actions on public land.
- A 'Trees R Cool' education package was developed by DEW in 2019 with financial support from LGAs and is being used to support our campaigns to Increase understanding and awareness of the benefits of trees.
- Advocacy for trees in P&D Code submissions - you can read our February 2020 submission as linked on *Page 1.*

Water management and Water sensitive urban design (WSUD)

Background

Eastern Adelaide is changing. Increases to population, house sizes and housing densities are putting pressure on open space and water management. These changes present challenges in meeting resident needs and expectations for attractive and liveable suburbs. Water Sensitive Urban Design (WSUD) can play an important part in addressing these challenges. WSUD presents enormous opportunities to secure long-term local water resources, mitigate the effects of floods, protect natural waterways and support green infrastructure.

Traditionally, stormwater has been considered a nuisance in urban areas, directed quickly into drains and discharged into watercourses. This approach sees a costly loss of the valuable water resource and results in much drier soils. This loss will be exacerbated as the climate dries and more water is needed to maintain open space and green infrastructure. There are also downstream impacts, with organic debris, pollutants and litter entering creeks and marine environments. Further, with more intense and severe weather events predicted, the costs of managing a traditional stormwater network will increase. WSUD can assist in managing these issues.

Benefits of WSUD

WSUD utilises proven and emerging techniques and technologies to manage rainwater, stormwater, groundwater, wastewater and mains water. In practice, WSUD can be as simple as installing rainwater tanks to collect water or swales to slow water flow and allow it to infiltrate into the soil. At the other end of the spectrum, WSUD can be complex and involve multiple treatments, such as the construction of artificial wetlands to clean water for aquifer storage and subsequent use.

Increasingly, small to medium WSUD projects are being integrated with street upgrades, tree planting and replacement programs and kerbside repair activities. Resilient East has over 1000 examples of WSUD installed. These deliver multiple benefits including:

- Greater infiltration of water onto ground and soil for trees and vegetation to be healthier, greener and cooler,
- Creating new areas of cooler and climate resilient places,
- Utilising opportunities for managed aquifer recharge systems which can then provide water for irrigation of parks and gardens,
- Reduced runoff and slower rates of runoff into stormwater systems thereby reducing flood risk,
- Reduced pollution loads, such as oils, chemicals and organic pollutants, and
- Improved habitat for urban biodiversity.

WSUD presents enormous opportunities to secure long-term local water resources, mitigate property risks from floods, protect natural waterways and support green infrastructure. Residential and commercial property owners and developers can and should play a role in WSUD for stormwater management, water conservation and tree protection.

Barriers for WSUD

There are a range of challenges and barriers that Councils face with making our cities more water sensitive. For example:

- Becoming water sensitive cities requires collaboration across council in understanding data management, upskilling, training, better spatial mapping, and having good governance leading with the financial commitment to back it up. Most councils don't have much capacity for internal collaboration on such projects.
- The benefits of WSUD are still not widely translatable into financial terms.
- There might be a desire to incorporate more WSUD into projects for flood mitigation, as part of traffic calming, to assist with watering trees etc, however the funding for the project does not always allow for it.
- WSUD features are not often put on the asset register, and similarly on a maintenance scheme.
- Lack of studies to test ultimate maintenance regime (may also depend on rainfall, leaf litter and range of other factors). This can form hesitancy about trusting their effectiveness and understanding of how to maintain them, or that it's too hard or not enough time to do it.
- Incorrect design or installation.
- Local governments are responsible for managing stormwater drainage networks in their Council area. The cost of stormwater drainage upgrades needed to

manage higher peak flows (due to more intense storms and infill development) will need to be borne by our communities, through higher Council rates, unless another funding mechanism can be found to manage stormwater onsite with rainwater tanks or offsite with local water sensitive urban design (for example, tree wells, raingardens and wetlands).

What are some of the things we are doing?

Resilient East is trying to Increase the understanding and effectiveness of WSUD for our streets and communities by doing a range of Initiatives, which can be expanded upon. For example:

- Creation of Mission and Strategies to support Councils with the principles behind incorporating WSUD into their policies.
- Supporting staff training and skill-sharing (for example assets staff went onside at Burnside recently and looked at how their B-Pod design works In comparison to TREENET Inlets). Training with experts can come at a cost, and the time for skill-sharing needs to be supported by managers and the organisation.
- Water Sensitive SA Is a key partner in capacity building activities and through the CRC to do research and develop design guidelines. Resilient East has many examples highlighted on their online interactive map demonstrating how mainstream WSUD is.
- Resilient East tested the effectiveness of 30 kerbside infiltration units installed in our region. Positive results found that they were blockage free and fully functional with organic matter breaking down naturally after 5-10 years of use.
- Resilient East received a grant to commission a study which used a South Australian State Government[3] monetised benefits tools to assess different types and sizes of WSUD treatments. In summary, these are the calculated benefits into monetary terms over 30 years (see *Table 1*) below for a summary. This tool assessed some of the benefits of WSUD, including water quality, runoff attenuation, neighbourhood character and health benefits. This possibility to monetise benefits of WSUD will greatly help justify more WSUD projects and therefore assist cities with understanding the value behind valuing water. For the full report '*Monetising the benefits of water sensitive urban design and green infrastructure features*', please see **Appendix 3**)

[3] *The benefits were calculated using the Excel-based WSUD/GI Monetised Benefits Tool ('the tool'), developed by Martin Allen, Principal Policy Officer at the Water Sensitive Towns and Cities section of the Department for Environment and Water (DEW).*

Table 1: Monetised benefits calculated in 2019 for five WSUD projects in the Resilient East region

WSUD System	**WSUD Monetised benefit calculation (value over 30 years)**
Gray Street (7 trees + 2 rain gardens, City of Adelaide)	$98,283
Bell Yett Reserve car park and swale (City of Burnside)	$57,949
Felixstow Wetlands (City of Norwood, Payneham & St Peters, ERA Water)	$5,269,736
Florence Street (3 Rain gardens + 3 bioretention filters, City of Unley)	$64,100
Way Avenue (water inlet wells for 31 trees, City of Unley)	$300,520

Urban strategic planning – Planning and Design code

Building on the evidence and key points presented above, Resilient East strongly encourages the State Planning Commission to at least retain, but ideally build upon, the draft Planning and Design Code policy in relation to:

- Requiring minimum one tree per dwelling.
- Maintaining or increasing the requirement for a 7% deep soil area.
- Minimum 15-25% soft landscaping space (and defining this as 'living green landscaping').
- Increased provision of landscaping within common driveways and public realm.
- Onsite rainwater tanks.
- Quantification of the protection of street trees.
- Provision of site permeability.
- Retention and protection of Regulated and Significant Trees.
- Introduction of mechanism to ensure trees planted in accordance with proposed Planning and Design Code requirements, are maintained and not removed.

Resilient East supports the proposed new minimum tree requirements and look forwards to supporting DPTI in its implementation. However, it is considered this does not go far enough to meet the overall green cover targets. For example, under the proposed P&D Code, a 450m^2 block would require 1 medium tree (4-8m spread) which at maturity would only produce 3-11% cover on that block. With most Councils having far more private land than public, if this is the minimum approach applied across the state we will not have enough collective cover to build resilience to climate change.

For our full understanding of Issues with urban planning policy please refer to our response to the draft Phase Three Planning and Design Code for SA's Urban Areas.

Barriers

The task of increasing canopy and green cover amidst urban consolidation can be particularly challenging. Resilient East councils not only understand the need to protect and increase canopy and greening on public land, but also to reduce the loss of trees and vegetation on private land.

These barriers include but are not limited to:

- Planning regulation and guidelines which provide little incentive to protect and enhance canopy and green cover outcomes on properties under development.
- Limited scope for engaging with developers and architects on finding ways to enhance canopy and green cover and recognise the commercial benefits.
- Limited diversity in housing options for consumers that provide developments with more canopy and green cover.
- Changing consumer behaviours and lack of recognition of the benefits of urban greening.
- The persistence of new buildings which do not include green roof cover, green walls or better use of open property space.
- Lack of financial or related incentives for developers to incorporate greater levels of greening.

Opportunities for improving urban greening

Here are a few key pressing and timely opportunities that we see arising for work, research, collaboration and action in relation to urban greening, water management and urban planning:

Update standards and guidelines for planting in proximity to infrastructure

We can do this by building the evidence on actual costs, risks and co-benefits. There is a need to better understand which species are most likely to impact other infrastructure, how soil type influences this, and what treatments (e.g. root barriers, watering regimes/infrastructure) should be used to mitigate any impacts. This will create more space for trees, addressing one of the leading barriers to achieving canopy cover targets. Preliminary work has begun on some of these Issues, for example:

- City of Adelaide is leading a project with SA Water (water, sewer) and APA (gas) to correlate tree information (location, species, height, width, age) and planting treatments against fault data to identify low-risk approaches
- City of West Torrens received 2019/20 DEW Greener Neighbourhoods Grant to prepare standards for trees and infrastructure
- SAPN recently produced an updated guide on planting under overhead powerlines.
- Through the Planning Reforms, DPTI has made substantial efforts to improve standards on trees in proximity to house footings and driveways, but lacks the evidence base to support these changes.

There is a gap in the coordination of research across service providers and Councils, and of development of agreed standards (e.g. species lists, Design Standards under the PDI Act) that are applied by and understood by relevant stakeholders across South Australia.

Best available data - state-led collaborative hazard mapping

Councils want to have the best available best available data and science to inform decision makers and achieve the greatest impact in reducing urban heat islands and identifying where the best opportunities are to increase tree planting. Best information includes:

- Aerial thermal imagery across the day and night time cycle will assist in prioritising decisions and investment that is targeted towards achieving the best return for canopy and cooling outcomes.
- Review of Landsat thermal imaging will assist the councils to understand longer term trends and changes in urban heat over the past three decades.
- Multispectral analysis of vegetation will assist councils in the heath of existing vegetation, the rates and extent of canopy loss and opportunities for canopy and green cover restoration.
- Heat mapping and canopy datasets will be open data that encourages participation and collaboration with research organisations, non-government organisations and interested community members.
- A five-yearly review of progress and data update will ensure that progress and changes can be monitored and quantified through time.

Increase large scale WSUD and WSUD on private land

While there has been a focus on public WSUD, there is also a need to consider the potential for WSUD on private land. There has been limited attention to private work thus far, but there is growing community interest. Encouraging and documenting examples of private WSUD systems has been identified as an area for future work, engaging with residents and developers to expand the potential of WSUD.

There is also potential to develop new large-scale WSUD systems and expand existing ones. Aquifer storage of stormwater is working at numerous sites and could be developed at additional sites. New developments could be stand-alone or constructed to augment existing WSUD infrastructure, such as the ERA Water network.

The ongoing utilisation of WSUD will assist local and state governments in meeting commitments to protect natural environments and develop a liveable and sustainable region.

Ensure the planning policies and building codes do not increase climate risk

The South Australian Government has had great success in moving towards its *30-Year Plan for Greater Adelaide (2017 update)* target of 85% of new housing being within the existing urban footprint. It is now time for the South Australian Government to commit the same degree of attention and leadership to meet its goal of a green liveable city, including by taking tangible steps towards its target to increase green cover by 20% - a target that is currently at significant risk.

By strengthening the policies as listed in the previous section and supporting with capacity building, regulation and incentives, there is an opportunity to manage zoning and development that does not increase climate risks for the people that will live, work and play in these areas and properties. Including hazard mapping and canopy mapping as overlays In the Planning and Design Code will assist with this.

Collaboration on a Complex Issue

The Resilient East collaboration provides strategic support to Green Adelaide and the integrated delivery of the state government's landscape reforms and climate change policy frameworks in an efficient and coordinated manner. We were early stakeholders with Green Adelaide and State Government in forward business planning and provided an established group for discussion of potential collaborative projects to meet both local and State Government objectives for data collection, Greener Neighbourhoods Grants and a range of projects that would enable more on-ground greening.

Different projects require different sorts of funding approaches, and depends on how opportunistic it is:

- Fully grant funded - i.e. Monetised Benefits of WSUD research project (**Appendix 3**)
- Grant with matched funding – with contributions just from Resilient East project budget or co-contributions from individual councils, i.e. – Coordinator Position
- Co-contributions from Councils – i.e. *Collaborative Heat Mapping for Eastern and Northern Adelaide* 2018 – regional heat mapping project – an equitable contribution was made for each council proportionate of its size.
- Choose to opt in projects – i.e. participation in the Urban Microclimate Citizen Science Study, analysis of 2018 /2019 LIDAR canopy data
- Led by individual councils on behalf of the network – i.e. City of Adelaide funded and ran the *Feeling Hot Hot Hot!* public community forum in 2019 on behalf of Resilient East
- Resilient East project funding – i.e. participation in Climate Ready Communities
- In-kind – Coordinator and PSG staff led – i.e. Mission Statement and Strategies; Street Tree Species review for greening and Climate change

Most require in-kind support from PSG members and council staff. They must balance this on top of their individual Council priorities, and not each Council has set aside discretionary budget to participate in these regional projects for matched funding opportunities.

A strategic approach to future heat mapping and vegetation / canopy mapping is being explored with the State Government for the efficient collection and comparison on a cycle that ideally aligns with State of the Environment reporting. This approach would be designed to reduce duplication of effort across the councils, reduce costs, and share costs with other agencies and organisations that seek to access the same data. The costs associated with resourcing this mapping, analysis, interpretation and communications work would need to be factored in for the whole of metropolitan Adelaide.

In-kind resourcing and capacity building for urban green spaces

Resilient East councils are responding to the mounting moral and legal pressures from various levels to act on climate change – both reducing emissions and their own contribution to the problem, and the ability to prepare and respond to the inevitable impacts. Many of the Resilient East Councils have only one core sustainability officer, linked to a manager in a planning, infrastructure or assets related role. Within those roles they deliver on both community and corporate sustainability initiatives – including data collection and interpretation, low-carbon transition, climate change adaptation, influencing greening and biodiversity policy and sometimes waste as well.

Staff involved in Resilient East see the worth in being part of something bigger, and the value in sharing and learning together to create the changes required to fully prepare our councils for climate change. Even if the information or will is there, there is not always time, priority or finances to properly engage all required and create systemic business as usual changes. In terms of resourcing for the topics listed in the inquiry – to do better and make the most of the information and networks that already exist, extra staff resourcing for each council could go a long way – as well as Coordinated support by the State Government, the LGA, the Regional Coordinators and other networks.

Networking, capacity building and upskilling is a very important part of being able to achieve better outcomes for our urban environments. For example, there are tools being developed (including by DEW and Water Sensitive Cities among others) to help practitioners understand, articulate and apply the benefits of urban greening, biodiversity and WSUD. This is useful to explain in monetary values or otherwise the longer-term benefits in language more palatable to some, as well as communicate to the public. It is important to build the base of staff that have key understandings about the solutions, and then empowering them to trial and incorporate these solutions into usual business practices.

COVID-19 has presented both a challenge and opportunity with networking and sharing of knowledge. Whilst many of our working groups, networking events and shared learnings were done face-to-face – and face-to-face is still preferred for certain types of hands-on activities and workshops – it has forced Councils to network effectively online together – and this means we have expanded our skills and ability to quickly connect, with shared platforms for accessing information.

There is an ongoing need to develop a targeted capacity building initiative or decision-support tools that detail and compare streetscape treatments that mitigate urban heat, and thus spend our on-ground grant money more effectively. This will improve the capacity of Councils to make site-specific, evidence-based decisions while accelerating uptake of best practice approaches for urban greening.

Appendix 2 highlights some of the organisations that do (or have) provided excellent capacity building opportunities for staff and community.

Conclusion and State Opportunities

We are very pleased to provide this information on such an important topic of green urban spaces and that the NRC is seeking to learn more.

While there are many areas for further improvement, we believe some key opportunities at a state level are;

- Assist to highlight importance and value of urban green spaces, only increased by recent heat waves and pandemic restrictions.
- Encourage the new Green Adelaide board to focus on green urban spaces as a priority action and the understanding between species susceptibility to climate change.
- Ensure the Planning Policy Reforms support measures to retain and enhance green infrastructure on private land including the one tree policy as a minimum and deep soil zones.
- Recommend immediate review of the Significant Tree policies for purpose of Improving tree retention on private land - including increasing the fee for approved removal of regulated and significant trees.
- Support and continue to fund existing collaboration networks including but not limited to - Regional adaptation, Water Sensitive SA, Healthy Parks Healthy People
- Support and lead the coordination of standards and guidelines for underground and overground services, to support urban green spaces.
- Advocate for the National Construction Code to better address heatwave impact through material choice, energy efficiency, passive design/orientation, permeable surfaces, deep root zones and green infrastructure.
- Using the evidence base of thermal heat and canopy mapping to underpin increased Planning and Design Code requirements for onsite trees, deep soil areas and living green landscaping.
- To direct DEW and DPTI to continue collecting this data for evaluation and longitudinal comparisons for the 5-yearly State of the Environment Reports. (I.e. metropolitan LIDAR analysis undertaken every 3 years to measure canopy levels, and A metropolitan Heat Mapping assessment should be done every 5-6 years to measure progress in cooling strategies implemented and further work required).

- Support Local Government, Community groups and volunteers to increase the quality and quantity of green infrastructure on public land through access to funding.
- Develop a broader communication and awareness campaign based on the existing 'Trees R Cool' library (this is a set of images developed to promote the benefits of trees and canopy).
- Showcase concepts and ideas that provide 'easy wins' to transition to greener streets and incorporate WSUD design in day to day practices.

The Resilient East Project Steering Group would welcome opportunity to discuss this submission in person and how we work together to green greater Adelaide.

Kind Regards,

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List of Appendices

- **1:** Letter to Chair of State Planning Commission Michael Lennon in relation to the 'What we have heard report' for Phase 3 of the Planning and Design Code (July 2020)
- **2:** External climate adaptation resources and arising opportunities
- **3:** 'Monetising the benefits of water sensitive urban design and green infrastructure features' (November 2019)

RESILIENT EAST

Climate Ready Eastern Adelaide

APPENDIX 1: Letter to Chair of State Planning Commission Michael Lennon in relation to the 'What we have heard report' for Phase 3 of the Planning and Design Code (July 2020)

RESILIENT EAST

Climate Ready Eastern Adelaide

3 July 2020

Mr Michael Lennon
Chairperson
State Planning Commission
By email: saplanningcommission@sa.gov.au

Dear Mr Lennon and Commission Members,

Re: Resilient East supports inclusion of onsite tree and rainwater tank policies in the Planning & Design Code

As the Commission deliberates on finalising the Phase 3 Planning and Design Code, the Resilient East Steering Group's Local Government members urge the Planning Commission to retain and enhance the draft policy for new development to provide trees, landscaping, water tanks and water sensitive urban design (WSUD).

Resilient East is a partnership between the Campbelltown City Council, the Cities of Adelaide, Burnside, Norwood Payneham & St Peters, Prospect, Tea Tree Gully, Unley and the Town of Walkerville and the South Australian Government, a regional alliance tackling climate change. Resilient East seeks to ensure the eastern region remains a vibrant, desirable and productive place to live, work and visit, and that our businesses, communities and environments can respond positively to the challenges and opportunities presented by a changing climate.

Our partners are about to re-commit with the Minister for Environment and Water to work together, under the *2020-2025 Resilient East Regional Sector Agreement* (under section 16 of the *Climate Change and Greenhouse Emissions Reduction Act 2007)*, to implement action that prioritises:

- Cooling, greening and enhancing biodiversity on our streets and within our natural assets,
- Mainstreaming water sensitive urban design,
- Actively addressing councils and businesses risks and opportunities to climate change,
- Building resilience in our communities,
- Setting up a monitoring and evaluation framework, and
- Contribute to ongoing planning and policy reform opportunities.

This letter does not reflect formal Council consideration by any of the constituent Councils. This input complements the specific planning feedback from participating Councils and provides a perspective from the Local Government members of the Resilient East Steering Group.

Resilient East strongly supports including green infrastructure and water sensitive urban design provisions in the Planning and Design Code.

The Resilient East partnership submitted a response to the draft Phase Three Planning and Design Code for SA's Urban Areas, which had built on a number of earlier submissions made for the various State Planning Policies and Technical Discussion Papers. You can read our full response here.

We note that the *What We Have Heard* report (17 June 2020) addresses many of the points Resilient East has made, which appear to be sentiments echoed by many other Councils, organisations, industry groups and community members.

In particular, the Steering Group notes the strong community feedback that supports further change by the Commission in the Phase 3 Code including:

- The extent of the Native Vegetation Overlay including within residential areas and townships
- Council and community members seeking stronger policy to reduce further loss of tree canopy, and to increase requirements for more and linked landscaped areas
- Concern about the inadequacy of policy to combat urban heat from infill development
- Concern regarding the loss of existing policies and protection of significant and regulated trees
- Concern about the lack of policies to prepare developments for climate change, particularly over the life of the development
- Further policy development around stormwater management with increased infill development being more prevalent.

We therefore strongly encourage the State Planning Commission to at least retain, but ideally build upon, the draft Planning and Design Code policy in relation to:

- Requiring minimum one tree per dwelling
- Maintaining existing 7% deep soil area
- Minimum 15-25% soft landscaping space (and defining this as 'living green landscaping')
- Increased provision of landscaping within common driveways and public realm
- Onsite rainwater tanks
- Quantification of the protection of street trees
- Provision of site permeability
- Retention and protection of Regulated and Significant Trees.

Resilient East are very pleased about the proposed new minimum tree requirements and look forward to supporting DPTI in its implementation. However we feel they do not go far enough to meet the overall green cover targets. For example, under the proposed P&D Code, a 450m^2 block would require 1 medium tree (4-8m spread) which at maturity would only produce 3-11% cover on that block. With most Councils having far more private land than public, if this is the minimum approach applied across the state we will not have enough collective cover to build resilience to climate change.

The South Australian Government has had great success in moving towards its *30-Year Plan for Greater Adelaide (2017 update)* target of 85% of new housing being within the existing urban footprint. It is now time for the South Australian Government to commit the same degree of attention and leadership to meet its goal of a green liveable city, including by taking tangible steps towards its target to increase green cover by 20% - a target that is currently at significant risk.

The importance of trees in the Resilient East region

Resilient East Councils have greening targets to align with the *30-Year Plan for Greater Adelaide (2017 update)* target to increase urban green cover 20% by 2045. The eastern regional community is proud of our association with being leafy and green, which is reflected as a strong feature in our Council Strategic Plans and through direct action, budgets and resourcing. We know higher canopy cover and improved water management has multiple benefits for councils, our community and our economy including:

- Increasing canopy and green cover is a proven strategy to cool our microclimates significantly. Our greenest suburbs are the coolest places on hot days, particularly in the absence of a sea breeze.
- Cooler microclimates mean that households and businesses using air conditioners can save money and reduce greenhouse gas emissions, as the units don't need to work as hard.
- Property prices in greener suburbs and greener streets are higher in value because of their positive cooling, amenity and biodiversity benefits.
- Increased canopy cover in streets and open spaces supports people to be more active, to be able to walk in shade and enjoy our parks and gardens.
- Increased canopy and shrub cover supports our rich urban biodiversity, which is an important part of living in Eastern Adelaide suburbs.
- Increased capture of surface stormwater runoff by trees, plants and soil, which reduces pollution to creeks and streams.
- A growing body of research recognises the links between trees, human health and wellbeing.
- Trees not only produce oxygen and absorb carbon dioxide but also act as air filters to remove dust, fine particulates and other pollutants from air in our urban environment.
- Trees as part of our leafy green eastern suburbs are becoming recognised as significant natural assets in a changing climate.

Towards 2045, the climate in the Resilient East region will continue to change. There are likely to be significantly more hot days above 35°C in any given year. Under a high emissions concentration pathway, the trend of increasing hot days will likely see the frequency rise from 20 days per year over 35°C (on average) to 47 days per year by 2090 (CSIRO & BoM 2015). There will be a decline in spring rainfall and more heavy rain when it does fall. Creating more canopy and green cover, as well as introducing more WSUD infrastructure and water capture, will play an important role in creating cooler microclimates to help communities cope with these changes in a denser urban form.

Tree canopy loss

Our tree canopy, along with the 30-Year Plan target, is at risk. A nationwide study in 2017 (*Greener Places Better Spaces)* found that metropolitan Adelaide saw a decrease in canopy cover from 21.5% to 19.5% between 2013 and 2016. Hard surfaces have increased, with Norwood, Payneham & St Peters, and Prospect now recording hard surface cover in excess of 60% (*Greener Spaces Better Places*, 2014), which increases risks of urban heat and excess stormwater runoff. A Conservation SA report (June 2020) has highlighted key findings from recent tree loss analyses by Councils, and has amplified existing strong interest in this issue from the media and community.

There is some evidence that urban infill has been the main contributor to this. An in-depth study by City of Unley analysed differences in canopy on public and private land over a 38-year period, using data from 1979, 1997, 2007 and 2017. Key findings are that:

- Canopy cover decreased from 34% to 28% while building cover increased from 29% to 36% – despite Council significantly increasing its tree planting on public land.
- Every suburb lost canopy cover in the private realm, with suburbs losing between 30% and 51% of their private canopy cover.
- Potentially plantable private space decreased from 18% to 13%, which was typically due to it being paved or built over.
- The City of Unley would need another 5% of its area to be covered by tree canopy in order to meet the 30-Year Plan for Greater Adelaide target. With only 2.9% of the LGA's total area being public open space (and much of this already dedicated to recreational uses), significant contributions on private land will be needed. Planning policy is critical to achieving these outcomes on private land.

Resilient East recently collaborated with other metropolitan Regional Climate Partnerships and the South Australian Government to procure LIDAR analysis of the tree canopy across metropolitan Adelaide. This will provide, for the first time, a three-dimensional map of the height and extent of tree canopy across the whole city. This data will be more accurate and detailed than before, and will enable us to develop even more targeted and nuanced policies. The Resilient East partnership urges the Commission to consider this new evidence base to underpin increased Planning and Design Code requirements for onsite trees, deep soil areas and living green landscaping.

The initial evidence from this new LIDAR analysis **indicates that the State Government canopy cover target cannot be met on public land alone.** It demonstrates there is far greater potential to increase tree planting on private land. In the more built up urban areas, finding space for trees is becoming increasingly difficult. Public land is increasingly contested, with space for trees constrained by:

- Underground services and overhead powerlines
- Increased crossovers and carparking resulting from infill development
- Increased demand for grassed public recreation space to compensate for diminishing backyards.

It will also get harder to increase canopy cover on public land as it is anticipated that the ageing tree stock, climate change and the increased potential for disease could all affect the health of existing mature trees, which provide the greatest canopy coverage. It must be emphasised that mature trees are one of our best defences against a changing climate, and they should be protected on every front. The services gained from a century old tree take a century to grow back, but can be taken away from the community in an instant.

All of this points towards us being at significant risk of not meeting the 30 Year Plan target, and therefore not being able to deliver the goal of a green liveable city. Without strong leadership on this front, including strong Planning and Design Code policy, we will see our neighbourhoods become hotter, less walkable, less liveable, less resilient to a changing climate, and ultimately, less economically prosperous.

The Code has further work to do in terms of mechanisms not just for planting new trees in infill developments, but in retaining mature vegetation, ensuring post-establishment compliance and incentivising greening on private land.

Beyond the commencement of the new Code, the Steering Group is particularly interested in understanding the monitoring and feedback loops for measuring the on-ground effects of the new infill and greening policies and the timeframes for future Code Amendments to respond to any identified issues.

Regulated and Significant Trees

We understand there is currently a gap in the Planning and Design Code around protecting Significant Trees. Protection of both Significant and Regulated Trees must be enshrined in the Planning and Design Code for statutory protections to take effect.

Mature trees provide the most inherent value to our communities and neighbourhoods, because trees are appreciating assets that gain value over time. Mature trees also deliver the most canopy cover, which can take decades to grow. This appreciating asset value of trees is generally not considered in financial systems, and is certainly not reflected in costs associated with removing trees along with their inherent community value.

There is currently a $94 fee for removing a Significant or Regulated tree on private land. This nominal fee falls well short of covering the costs of planting and maintaining a replacement tree – not to mention the lost benefits to the community, which have been estimated in a City of Burnside study to be in the range of a few thousand dollars for small mature trees through to tens of thousands or more for large mature trees. This gross under-valuing of mature trees causes significant economic barriers in ensuring adequate urban green space.

Water sensitive urban design

The impact of urbanisation and infill development typically increases hard impermeable surfaces – in some case up to 90% of allotments – which increases runoff and flood risk to property, requiring upgrades to stormwater infrastructure that are funded by the community via increased Council rates. Water Sensitive Urban Design (WSUD) can play an important part in addressing these challenges. WSUD presents enormous opportunities to secure long-term local water resources, mitigate property risks from floods, protect natural waterways and support green infrastructure. Residential and commercial property owners and developers can and should play a role in WSUD for stormwater management, water conservation and tree protection.

Some of the benefits of WSUD include:

- Greater infiltration of water onto ground and soil for trees and vegetation to be healthier, greener and cooler
- Creating new areas of cooler and climate resilient places
- Reduced runoff and slower rates of runoff into stormwater systems thereby reducing flood risk
- Reduced pollution loads, such as oils, chemicals and organic pollutants
- Improved habitat for urban biodiversity, and
- Improved amenity and attractiveness of a place.

Onsite contributions to stormwater management, using retention and detention tanks, are critical to the overall stormwater management system, especially when allotments have significant hard cover. There are often significant restrictions on Councils' ability to manage localised flooding issues in built up areas, especially when there is no undeveloped space available to install water sensitive urban design infrastructure.

We understand the Commission has received significant feedback on the issue of flood mapping and hazard risk in the Planning and Design Code and Overlays. In fulfilling the Commission's obligation to ensure the Planning and Design Code meets State Planning Policy 15 to "*identify and minimise risk to people, property and the environment",* changes are required in the Code's approach to flood mapping and policy expression. The Steering Group reiterates the need for removal of outdated mapping and replacement with accurate mapping. The Department for Planning, Transport and Infrastructure should be an active contributor to a coordinated hazard mapping framework for the state, to ensure we have up to date and fit for purpose flood mapping available for all developed areas. Enhanced policy for Deemed to Satisfy and Performance Assessed pathways is also required to align the Planning and Design Code with the requirements of State Planning Policy 15.

Transforming residential neighbourhoods into liveable neighbourhoods

Increased urban infill and the Code's proposed 'transformation of residential neighbourhoods' must keep as a central priority that those neighbourhoods be liveable. The individual and cumulative effects of urban infill should not be at the expense of existing canopy cover, effective stormwater management, and opportunities to deliver urban green space.

At the local and neighbourhood scale, the negative cumulative and incremental effects of increased infill development can only be addressed if the urban design standards expressed through the Planning and Design Code effectively address the need for healthy, safe neighbourhoods with shady streets and large treed private open spaces complemented by public open space and improved water and energy use. Given our recent experiences with Covid-19 it is clear our recovery needs to factor in the importance of open green spaces for health, wellbeing and feelings of connectedness.

Our councils are increasingly aware of our imperative to mitigate urban heat and increase green cover to reduce impacts to our communities, lifestyle, and environment. These responsibilities are strategically and operationally embedded into our organisations. We are willing to work with developers and community to continue to build understanding of the multiple benefits that trees, greening and decreased water runoff can have in the short- and long-term for their homes, their health and lifestyle.

The Resilient East Steering Group would welcome the opportunity to brief the Commission on the work and challenges of the Resilient East partnership, to assist the Commission's deliberations as it finalises the Phase 3 Planning and Design Code. If you would like further information or would like to arrange a meeting, please do not hesitate to contact me.

Kind Regards,

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APPENDIX 2: External climate adaptation resources and arising opportunities

Program / website	Description and Resourcing (if known)	Opportunity
Water Sensitive SA (WSSA) https://www.watersensitivesa.com/	WSSA is a capacity building program that provides government, industry and the community with the support they need to deliver greener, more liveable communities sustained by water sensitive urban design. **Funded by State Government, each member Council and other partners.**	Strong links to supporting the viability of urban greening, collaboration and finding engineering solutions to ensure green infrastructure works with rather than against the built form.
TREENET https://treenet.org/	The national urban tree **research** and education cluster, and originates from the University of Adelaide's Waite Arboretum. TREENET operates as an independent, not-for-profit, environmental organisation, **funded by voluntary membership subscriptions**.	Great opportunity for our staff and leaders to learn at the Urban Forest Festival 21st National Street Tree Symposium 3rd - 24th September 2020 (online).
National Climate Change Adaptation Research Facility (NCCARF) https://www.nccarf.edu.au/	NCCARF worked to support decision makers throughout Australia as they prepare for and manage the risks of climate change and sea-level rise. Based at Griffith University on the Gold Coast, NCCARF had a national focus across Australia to build resilience to climate change in government, NGOs and the private sector. **Not funded**	The 2017 federal budget cut funding for this program. https://theconversation.com/the-2017-budget-has-axed-research-to-help-australia-adapt-to-climate-change-77477. Opportunity to Advocate for re-establishment of funding at Federal level,
NRM Education https://landscape.sa.gov.au/hf/education/for-educators	Natural Resources AMLR's education program (NRM Education) works with school and preschool communities to embed sustainability principles into their learning and management practices, linking them to the Australian Curriculum. In the last few years the NRM Education team has grown involvement in incorporating teaching resources and professional development around climate change mitigation and adaptation, rather than the traditional managing of natural resources.	This has been welcomed and aligns with our priorities in terms of increasing community awareness and understanding of climate change impacts. There is a great opportunity with being able to grow the relationship with NRM Education across our region to communicate the challenges, solutions and link priorities.

APPENDIX 3: 'Monetising the benefits of after sensitive urban design and green infrastructure features' (November 2019) *(attachment).*

CREATING MORE SPACES FOR TREES

University of Adelaide IEP Internship Project Report

Supported by the City of Adelaide and Resilient East

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List of Acronyms:

APA	Australian Pipeline Association
CoA	City of Adelaide
DBYD	Dial Before You Dig
DEW	Department of Environment and Water
DIT	Department of Infrastructure and Transport (from mid-2020)
DPTI	Department Planning Transport and Infrastructure (until mid-2020)
GDP	Gross Domestic Product
GIS	Geographical Information System
IEP	Industry Engaged PhD
LiDAR	Light detection and ranging
NDVI	Normalised difference vegetation index
PM	Particulate Matter
PVC	Polyvinyl Chloride
SA	South Australia
SAPN	South Australia Power Networks
UHI	Urban heat island
US	United States
USDA	US Department of Agriculture
WIR 2012	Water Industry Regulations 2012
WSUD	Water Sensitive Urban Design

List of Legislation Referenced

Australian Standard: AS4970-2009 Protection of Trees on Development Sites

Electricity Act 1996

Gas Act 1997

Gas Regulations 2012

Planning, Development and Infrastructure Act 2016

Planning, Development and Infrastructure (General) Regulations 2017

Telecommunications Act 1997

Water Industry Act 2012

Water Industry Regulations 2012

Executive Summary

This report is the outcome of a University of Adelaide Industry Engaged PhD (IEP) Internship Project that was supported by the City of Adelaide and Resilient East and presents a study into the factors at play in determining underground space to plant urban trees. The information contained in this report is applicable to all of greater metropolitan Adelaide (Adelaide), with a particular focus on and examples from the City of Adelaide council area. The efforts to increase tree canopy in Adelaide have been hindered by inefficiencies with long-term planning for planting trees and collaborating with the multiple interests to find underground space to plant trees. The study aimed to provide insight into the broader issues and find opportunities relating to city and urban green infrastructure development within the context of utility services and planning regulations. The study involved a qualitative analysis of academic literature, government and utility policy and legislation, and stakeholder consultations to establish the overriding factors and ascertain possibilities for resolving the problems with the congested and contested underground space in city and urban spaces.

The literature review examined the broad values of trees in cities and urban spaces that inform government tree canopy plans and targets (e.g., their role in climate change mitigation, reduction of the urban heat island (UHI) effect, their role in urban ecology and biodiversity, and the health and economic benefits). The review also reflected the complexity of urban forest development by focusing on governance processes, the costs for infrastructure development, the consequences for tree health and survival, including examples of planning, development, and engineering solutions.

The report then presents the complex processes involved in putting trees into the ground in Adelaide. The processes for site determination, including negotiating approvals with utility authorities, costly site investigations and the consideration of the many development and utility related laws and regulations. These processes underscore the crowded and contested underground space that make finding the space available for trees challenging, if not impossible. To provide some clarity of this often-convoluted process, the report consolidates these processes into a series of steps and brings together the different industry and government protocols, acts and regulations that affect the decision-making processes and outcomes.

A series of stakeholder consultations, including with landscape architects in private business, academics working in engineering, horticulture, and arboriculture, TREENET representatives, local government landscape architects, arborists and asset managers, and utilities representatives, revealed eleven key subject themes relating to the issues in planting urban trees. They include: (i) that there is a problem; (ii) viewing trees as risk; (iii) the value of trees; (iv) inadequate knowledge in decision-making processes; (v) the prioritisation of assets; (vi) the old utility infrastructure in Adelaide; (vii) the costs of putting trees into the ground; (viii) community understanding; (ix) the political influence in decision-making; (x) the problems associated with tree planning, development, and management; and (xi) opportunities for tree planning, development, and management.

The qualitative data presented in this report underscores the difficult process of finding space to plant trees in a metropolis. Despite these issues, seven recommendations are made that reveal a range of opportunities for future decision-making and research regarding tree canopy targets to resolve some of the problems with finding space to plant trees in Adelaide. The recommendations include: (i) legislation to support the preservation of existing trees and urban forest development; (ii) decision-making standards for trees in Adelaide; (iii) research and development into urban forest development; (iv) collaborative and well-informed decision-making; (v) funding to support research and development and to cover the costs of planting and managing urban forests; (vi) planning for trees in the long-term; and (vii) expanding this study.

Introduction

Trees provide metropolitan spaces a range of services, including, ecosystem services by mitigating the urban heat island (UHI) effect (Lanza & Stone 2016). Trees are also associated with providing social and economic services by creating beautiful spaces that people seek to live and work in, by increasing community cohesion and by reducing rates of crime (Kirkpatrick et al. 2013). As such, treed urban and metropolitan spaces symbolise the liveability and climate resilience of an urban space (Kirkpatrick et al. 2013). Because of this range of benefits, governments globally seek to increase the number of trees in cities and urban spaces.

Planting trees in urban and city environments, however, is not a simple task. The very nature of a tree means that they interact with a range of other planning considerations, above and underground, including utility services, human perceptions, and political dynamics (Elmendorf et al. 2003; Jim & Chan 2016; Kirkpatrick et al. 2013). Trees are also not governed by singular standards and rules like other services, such as, electricity, gas, water, and telecommunications. Therefore, finding places to plant trees is difficult because the spaces are often filled with these essential services and contested with often conflicting service and government policies and regulations (Jim & Chan 2016). Moreover, the harsh environment of many metropolitan spaces makes it difficult for trees to thrive and survive. The perceived risk in planting close to other infrastructure – house footings, local and State roads, footpaths, driveways, and underground and overhead services – frames rules and regulations about planting trees and limits plantable space (Slater & Chalmers 2020). Indeed, it is widely accepted that a lack of plantable space because of these constraints is a leading barrier to achieving canopy cover targets set by governments.

The City of Adelaide, other councils and Resilient East (with the support of the South Australian State Government through the 30 Year Plan for Greater Adelaide) are seeking to establish a way through all of these complexities to improve the conditions for planning and executing tree planting in urban spaces.

The City of Adelaide and Resilient East have developed this research project with the University of Adelaide's Industry Engaged Placement PhD internship scholarship program to start the process of researching, documenting and finding solutions for planting trees in city and urban spaces in order to create a greener and more liveable Adelaide. This internship project is the first part of this process and seeks to pull together the complex frameworks that influence tree planting. The result of this study is the documentation of the broader issues in relation to urban tree planting and the presentation of possibilities to work with the various stakeholders to increase the number of trees in Adelaide's urban areas.

Resilient East is a regional climate initiative between state and local government organisations in eastern Adelaide. It is about making sure the eastern region remains a vibrant, desirable and productive place to live, work and visit, and that our businesses, communities and environments can respond positively to the challenges and opportunities presented by a changing climate.

This partnership includes Campbelltown City Council, the Cities of Adelaide, Burnside, Norwood Payneham and St Peters, Prospect, Tea Tree Gully, Unley, the Town of Walkerville and the Government of South Australia.

Resilient East is one of 12 South Australian Regional Climate Partnerships.

Project Background

This project sits within a range of government actions to improve Adelaide's sustainability and adaptability to the effects of climate change. Increasing the number of trees in Adelaide is a goal for most metropolitan councils, guided by the 30 Year Plan targets. For example, the City of Adelaide 2020-2024 Strategic Plan positions planting trees as a way to mitigate the urban heat island (UHI) effect and the effects of climate change more broadly:

> *Council and the South Australian Government have a joint commitment to make Adelaide one of the world's first carbon neutral cities. However, the achievement of carbon neutrality requires the efforts of citizens as well as governments.*
>
> *Climate change and increased frequency of adverse weather events calls for systems to prepare our city, community and businesses. Enhancing biodiversity in the City and Park Lands will help to mitigate some of the effects of climate change on the community and the environment. The planting of trees and other greenery increases canopy cover and reduces the urban heat island effect, which can potentially diminish the amenity of the City for its users (City of Adelaide 2020, p. 22).*

The South Australian State Government's 30 Year Plan target to make Adelaide a "green liveable city" (see Box 1) similarly sees planting trees as a key factor in mitigating climate change and to improve the liveability of metropolitan Adelaide. Increasing the city's tree canopy in all available spaces, including street verges and parklands is viewed to have a range of benefits, including to biodiversity, reducing heat island effect, management of air quality and storm water, and improve the visible amenity and public health within the region.

Box 1: Target 5 of the South Australian State Government's 30-Year Plan for Greater Adelaide (DPTE 2017, p. 150)

Urban tree cover refers to trees and shrubs located in street verges, parks and backyards. Such vegetation in urban landscapes is known to provide multiple economic, biophysical and social benefits including:

- maintenance of habitat for native fauna, which can include vulnerable or threatened species in fragmented urban landscapes
- reduction of the urban heat island effect
- air quality improvements
- stormwater management improvements through reductions in the extent of impervious surfaces
- provision of spaces for interaction, amenity and recreation, which improve community health and social well-being
- increased level of neighbourhood safety
- positive visual amenity for urban residents
- productive trees that can contribute to local food security.

Particular focus will be placed on ensuring that urban infill areas maintain appropriate levels of urban greenery.

This target will support the work being done by councils through their tree strategies which address biodiversity and quality of vegetation.

How this target will be measured

The target will be measured using software consistently applied to local council areas across the Adelaide metropolitan area. It is recognised that councils currently have varying amounts of tree canopy cover.

Therefore, the following is proposed:

- For council areas with less than 30% tree canopy cover currently, cover should be increased by 20% by 2045.
- For council areas with more than 30% tree canopy cover currently, this should be maintained to ensure no net loss by 2045.

In recent years the metropolitan Regional Climate Partnerships undertook land surface heat mapping which has highlighted hotspots of urban heat. These hotspots often correlate with low tree canopy and greenspace, as evident by tree canopy mapping using LiDAR (Light Detection and Ranging) and NDVI (normalised difference vegetation index). Councils are now referring to this evidence to plan and prioritise future planting programs.

There are a range of projects, research and initiatives being undertaken across metropolitan Adelaide at various scales that contribute to increasing the number of trees and addressing the challenges and barriers to putting this into action:

- City of Adelaide has worked with SA Water (water, sewer) and the Australian Pipeline Association (APA) (gas) to correlate tree information (location, species, height, width, age) and planting treatments against fault data to identify low-risk approaches.
- City of West Torrens received a Greener Neighbourhoods Grant to develop tree specifications for challenging spaces, this is close to completion.
- SA Power Networks (SAPN) produced an updated guide on planting under overhead powerlines and are still engaging with their stakeholder groups on this.

- Through the Planning Reforms, the Planning Commission made substantial efforts to improve standards on trees in proximity to house footings and driveways.
- Councils have trialled numerous treatments which enable trees to be closer to services and footpaths (e.g., root barriers), but there is not a standardised approach.
- Resilient East produced a report which looks at Monetised Benefits of water sensitive urban design (WSUD) treatments, including tree inlets, raingardens and wetlands.
- The Botanic Gardens Plant Selector tool is due for an update – there is an opportunity for information on species suitability in proximity to infrastructure to be included.

The City of Adelaide has adopted a ‘green infrastructure’ approach to the city’s development. Green infrastructure refers to “greening elements that support a city such as street trees, community gardens and Water Sensitive Urban Design” (City of Adelaide 2016, p. 258). This policy requires increasing the number of trees planted in the city. To do so, however, also requires consideration of the underground service utilities that also accommodate the space.

The identified heat mapping ‘hotspots’ often correspond with highly developed spaces such as state and large main roads and within central business districts that also have little to no tree canopy. These spaces are contested with the range of utility services and policies that protect them above and underground. Finding space is in these areas is expensive because it involves substantially more background and on-the-ground work. Background work includes often extensive and time-consuming liaising and negotiating with utility service providers. It also requires substantial effort excavating sites to navigate spaces in amongst the utility services that conform with all of their policy requirements whilst at the same time ensuring the tree's survival. As a result, finding funding to fulfill the greening Adelaide policy is fraught because of complicated and expensive proposals.

Within this context there are a range of factors that need to be better understood. For example, the best suited tree species for Adelaide city/urban conditions, the influence of various soil types, and what treatments (e.g., root barriers, watering regimes/infrastructure) best mitigate any impacts. There are gaps in the coordination of research and its findings across service providers and the development of agreed standards (e.g., species lists, design standards under the *Planning, Development, and Infrastructure Act 2016*) that are recognised by relevant stakeholders across South Australia. As a result, long-term planning for planting trees is inefficient, particularly in relation to accommodating the requirements of utility services below ground. Addressing these inefficiencies and improving collaboration across sectors will reduce costs and time and increase opportunities to find spaces to plant trees for improved liveability.

Research Aims

This study is the start of a larger research engaged by the City of Adelaide through Resilient East that seeks to increase the understanding of the broader issues, find opportunities, and establish best practice relating to green infrastructure and services, planning regulations and species diversity within the urban context, with a specific focus on service authorities. Within this context, the aim of this study is to determine the range of issues in relation to allocating spaces for trees in urban environments.

Specifically, this study seeks to:

i. Consolidate the range of regulations imposed by services that frame the planting of trees within the urban environment.
ii. Establish the range of design, physical and development issues that relate to planting trees within the urban environment.
iii. Ascertain a range of possibilities and solutions for creating space for planting trees within the urban environment.

Project Scope

The scope of this project was to find insights into what modes may be available to ensure the planting and survival of more trees in a changing climate. To do so the study addresses and presents recommendations on one of the leading barriers – finding places to plant trees in the contestable space belowground.

The study includes an extensive literature review and consultation with Service Authorities, Councils, and other stakeholders to consider these issues. The literature review explores the academic and grey literature regarding the broader issues of planting trees in city and urban spaces. The study also consolidates the current service authority standards and guidelines, and the current legislative requirements.

Consultation with council staff provided insights into the processes and pathways, and barriers and opportunities for councils to plant trees. Consultation with other key stakeholders that work within this space also provided an understanding of the processes of working with various services.

This information will lay the groundwork and document what is happening on the ground in planning and implementing tree planting in Adelaide. This work will contribute to the overarching goal of developing central standards and guidelines for planting trees in Adelaide and provide some next steps towards achieve successful growth of more trees in proximity to infrastructure and create a greener and more liveable Adelaide.

Research Method

The method of research included an extensive desktop study which analysed a range of secondary data including academic research, acts and legislation, and government and utility service documents. The academic literature provided the data for a comprehensive literature review, enabling an extensive understanding of the subject matter. The inclusion of acts and legislation and service utility policy documents provided the overarching legislated framework which frame decision-making around trees. All desktop searches related to planning and planting trees in cities and urban spaces and the benefits and challenges pertaining to trees within the contexts of planning and development. Analysis of City of Adelaide and Government of South Australian reports and strategic plans provided essential contextual information.

A range of stakeholders relevant to the study were also consulted through informal interviews. The stakeholders included landscape architects in private business, academics working in engineering, horticulture and arboriculture, TREENET representatives, local government landscape architects, arborists and asset managers, and utilities representatives. The data, summaries of each of these consultations, was thematically analysed using the NVivo qualitative analysis program. All data contributed to the overall analysis and findings of the report.

Conclusion

This report documents the result of the internship study which seeks to find ways to improve tree planting in Adelaide. An analysis of the literature and other relevant documents, and insights from stakeholder consultation, document the processes and challenges and presents opportunities and recommendations for planting trees with consideration of underground utility service infrastructure. By improving the understanding of these realities and the opportunities the study establishes the next steps to enabling the goals for increasing the number of trees in metropolitan Adelaide and creating a greener and more liveable Adelaide.

Literature Review

There is substantial evidence of the value of trees in relation to human wellbeing, economic benefits, and the positive environmental impacts. These understandings substantiate government policy agendas to increase the number of trees within city and urban spaces. However, the way these agendas are put into practice vary, as do the results. The literature reflects this complexity in a range of ways, including, with focuses on governance processes, the repercussions for infrastructure development and the implications for the survival and health of trees, planning development and engineering solutions for urban forests.

The Value of Trees to Cities and Urban Environments

Trees hold a range of values to human and natural systems. For cities and urban spaces, trees provide a plethora of ecosystem services, such as, improved air quality, energy conservation and carbon storage, and changing climate conditions by reducing air temperature and providing shade to infrastructure and open spaces, all of which alleviate the impact of UHI effect (Lanza & Stone 2016). Trees also provide human and economic services. The social impact of trees in urban spaces include improved human wellbeing and public health as well as perceptions of a place's liveability (Beatley 2016). Economic values include improved property value (Donovan & Butry 2010) and energy saved by reducing heating and cooling costs from shading buildings and reduced wind speeds (Fisher 2016).

The term, urban forest, came from the US in the 1960s, and originally focused on woodlands close to urban areas, however, in recent decades, has come to include parklands, green spaces and even single tree or small groups of trees in city spaces (Sanesi et al. 2011). Representing this contemporary understanding, urban forest is defined in the Urban Forest of New York Report, 2018, as:

> *all trees in the city including street trees, trees in public parklands, as well as trees on private properties (Nowak et al. 2018).*

A narrative centred on sustainable cities emerged in the 1990s has brought the significance of the ecological integrity of urban environments into the centre of urban planning. This narrative considers urban development without deteriorating the quality of the environment, the effects on the quality of life for urban residents, and the impacts of urban development on the wider regional and even global environment (Sanesi et al. 2011). Consequently, urban policy has shifted to take into account externalities, such as climate change adaptation and mitigation, and our improved insights into the complex relationships between urban and natural environments (Sanesi et al. 2011).

Reflecting this trend, urban forest strategies are increasingly being developed by governments globally to improve tree populations in cities and urban spaces and demonstrate the growing recognition that increasing the number of trees have substantial benefit for the future of these spaces. The London Plan includes a policy to network London's green infrastructure because the benefits include:

> *biodiversity; natural and historic landscapes; culture; building a sense of place; the economy; sport; recreation; local food production; mitigating and adapting to climate change; water management; and the social benefits that promote individual and community health and well-being (Greater London Authority 2017).*

The UN's Food and Agriculture Organisation (FAO) similarly promotes trees within urban and city spaces because of the range of benefits trees offer (*Figure 1*). The range of benefits include filtering pollution in the air, providing food, improving physical and mental health, supporting building infrastructure energy efficiency, and providing vital habitat and biodiversity.

Figure 1: The Benefits of Urban Trees produced by the UN Food and Agriculture Organization (FAO)
http://www.fao.org/resources/infographics/infographics-details/en/c/411348/

Tyrväinen et al. (2005) similarly argue that benefits of trees in urban spaces is extensive and includes social, aesthetic, climate and physical, ecological, and economic (summarised in *Table 1*). Trees are also prominent features in urban landscapes because of their size, shape, colour and seasonal changes (Tyrväinen et al. 2005).

Table 1: Benefits and uses of urban forests and trees taken from Tyrväinen et al. (2005, p. 82)

Social Benefits	Recreation opportunities, improvement of home and work environments, impacts on physical and mental health. Cultural and historical values of green areas
Aesthetic and architectural benefits	Landscape variation through different colours, textures, forms, and densities of plants. Growth of trees, seasonal dynamics and experiencing nature. Defining open space, framing, and screening views, landscaping buildings
Climatic and physical benefits	Cooling, wind control, impacts of urban climate through temperature and humidity control. Air pollution reduction, sound control, glare and reflection reduction, flood prevention and erosion control
Ecological benefits	Flora and fauna habitats in urban environments
Economic benefits	Value of market-priced benefits (timber, berries, mushrooms etc.), increased property values, tourism

The literature demonstrates the examination of the broad-ranging benefits of trees in cities and urban spaces from varying research fields and are explored below.

The Environmental Services Provided by Trees in City and Urban Spaces

There are a range of ways that trees provide environmental services to city and urban spaces, particularly in their capacity to store carbon, clean the air and mitigate the effects of climate change. However, various challenges in defining, classifying, and valuing ecosystem services impact decision-making (Bodnaruk et al. 2017). Predominantly, the studies about the value of trees and their ecosystem services demonstrate that trees in cities make a difference (Hecht et al. 2016). Nonetheless, despite this knowledge there continues to be a decline in urban tree numbers globally. Hecht et al. (2016) argue that this is because trees are more often viewed regarding their aesthetic or landscaping attributes and therefore overlooked in terms of their function as ecosystems and providing environmental services or calculated as carbon emission and sink entities. There is also a perception that because urban areas are heavily modified by humans that urban ecosystems have limited ecological value. However, with the growth of urbanisation, the ecology of towns and cities is increasingly relevant to urban planning and development (Davies et al. 2011).

The impacts of trees' ability to store and sequester carbon have been known for decades. Rowntree and Nowak (1991, p. 274), for example, documented the role trees have in reducing atmospheric carbon dioxide particularly by "maintaining existing trees and by planting and maintaining trees in the future" thirty years ago. Davies et al. (2011) quantified the above ground carbon storage capacity of vegetation in Leicester, UK, found Leicester demonstrated that cities are capable of storing a substantial amount of carbon, and that trees provided a 97.3% greater carbon pool than other forms of vegetation. Bjorkman et al. (2015), in a study of urban forests in Canada found that the estimated amount of CO_2 stored totalled 102,995,988 metric tonnes, that 7,225,191 metric tonnes of CO_2 were sequestered, and 1,300,883 metric tonnes of CO_2 were avoided annually. Similarly, Nowak et al. (2013) found that planting trees in potential available space in urban areas in the US could increase carbon storage capacity, whilst noting that the trends of declining tree cover in urban areas corresponded with a decline in carbon storage capacity.

Trees also provide environmental service through their role in removing air pollutants (Bodnaruk et al. 2017) and as a by-product of photosynthesis in their ability to absorb some gases, including Nitrogen Dioxide (NO2). Polluting particulate matter (PM) is captured in the process of dry deposition, on leaf and bark surfaces (Willis & Crabtree 2011). The particulate capture occurs when air passes and retains on the rough plant surfaces. This is dependent on both the density and leaf form of the foliage and the spacing and surface topography of trees (Willis & Crabtree 2011). Bark-shedding also give trees the ability to remove PM from the air (Willis & Petrokofsky 2017). Tree types differ in ability to capture air pollutants (Willis & Crabtree 2011) and as such specific species can be strategically planted in optimal locations to effectively manage locations with high levels of air pollution (Bodnaruk et al. 2017).

Trees, along with other vegetation, are also vital in providing the biodiversity required for habitat for wildlife (Beatley 2016). Trees are part of what is known as novel ecosystems:

> *human-modified ecosystems that have been irreversibly altered by intense impacts on abiotic conditions or biotic composition. … As such they include non-native vegetation assemblages, consisting of native, spontaneous, naturalized, and invasive species (Itani et al. 2020, p. 2).*

Despite the contrived nature of urban habitats, Itani et al. (2020) demonstrate that cities have the capacity to provide suitable habitats for species of conservation interest. For example, diversity of tree species and numbers and groupings provide important ecological value (Bell et al. 2005). Additionally, cities are spaces in which multiple species, flora and fauna have converged. Crawley (2011) explores this phenomenon in London which has seen the decline of native species since Roman occupation. He argues that it is important to note that this decline has been matched with the increase of alien species that have created new dynamic plant communities (Crawley 2011) which in turn support new ecological systems.

Trees also mitigate surface water runoff. One way they do this is by intercepting water flow during rain events from the disruption of tree leaves, branches, and bark. Another way is through the infrastructure that is put in place to plant the trees within can also capture and therefore passively water the trees, which results in savings for water treatment and runoff control costs (Nowak et al. 2018).

Mitigation of the Urban Heat Island (UHI) Effect

UHI is “the phenomenon through which cities are warmer than nearby rural areas” (Lanza & Stone 2016, p. 75). The problem of UHI has been demonstrated in US studies of large cities where their warming was found to be at twice the rate of adjoining rural districts (Lanza & Stone 2016). This trend is attributed to decreased vegetation, dark building materials, and the escalating waste heat emissions occurring in cities (Lanza & Stone 2016). Santamouris (2013, p. 225) argues that UHI is the most documented climate change related phenomenon and relates it to “positive thermal balance created in the urban environment because of the increased heat gains like the high absorption of solar radiation and the anthropogenic heat, and the decreased thermal losses”.

There are two ways in which trees provide cooling; (i) by providing shade on infrastructure, and (ii) through evaporation. The effect of these two impacts directly blocks solar radiation reducing the UHI intensity and removes heat from the urban environment (Speak et al. 2020; Willis & Petrokofsky 2017; Yuan et al. 2017). Transpiration converts water to vapour and reduces the air temperature within the trees canopy and cools the leaf surface temperatures (Speak et al. 2020). The tree canopy also intercepts sunlight (radiation) preventing it from reaching, and heating, adjacent urban surfaces as well as reducing reflected and re-radiated heat from urban surfaces (Speak et al. 2020). Nowak et al. (2018) found that these reductions in air temperature reduce building energy usage and subsequent emissions from power plants and other pollutant sources and latent heat from building air conditioners.

One of the approaches to mitigating UHI is by increasing localised albedo (surface reflectivity) of which urban forest strategies are a feature. Albedo is achieved by increasing the reflectivity of city surfaces to reduce the absorption of local radiation to offset local warming effects (Pearl 2019). Plants contribute to the albedo effect by both reflecting and absorbing the radiation through their process of photosynthesis (Pearl 2019). Lanza and Stone (2016) describe the significance of trees in mitigating UHI has been demonstrated in New York City where the Regional Heat Island Initiative (2006), in which urban forestry, living roofs and light reflective surfaces have effectively decreased urban temperatures.

Box 2 demonstrates how the City of Melbourne presents a range of environmental benefits from urban forests that reflect the examples from the literature above in their Urban Forest Strategy 2012-2032.

Box 2: City of Melbourne Urban Forest Strategy 2012-2032, (2012, p. 12)

Urban forests are described as the “engine room” for urban ecosystems in that they transformative and provide oxygen, clean air, shade and habitat. The environmental benefits of urban forests are that they:

- **Provide shade and cool our cities:** trees and other vegetation mitigate the urban heat island effect. Through the process of transpiration and by providing shade, trees help reduce urban temperatures. Whilst shading streets and footpaths, their leaves reflect more sunlight and absorb less heat than built materials, reducing the absorbed heat of the built environment. Transpiration releases moisture into the air from plant leaves.
- **Reduce stormwater flows and nutrient loads:** tree canopies and root systems reduce stormwater flows and nutrient loads in waterways. Tree canopies intercept and mitigate the impact of heavy rainfalls. Healthy tree roots help reduce the nitrogen, phosphorus, and heavy metal content in stormwater. Green roofs retain rainwater, filter the water that does run off, and delay the time at which runoff occurs, resulting in decreased stress on sewer systems at peak flow periods. Wetlands and raingardens trap stormwater, improve water quality, and reduce nutrient loads.
- **Reduce air pollution, air-borne particulates, and greenhouse gas emissions:** vegetation ameliorates air pollution and reduces greenhouse gases. Photosynthesis removes carbon dioxide, nitrous oxides, sulphur dioxide, carbon monoxide and ozone from the atmosphere. By reducing temperature, trees help improve air quality by reduced emission of pollutants that are temperature dependant. Trees sequester and store carbon and therefore mitigate atmospheric carbon dioxide. Studies show a typical mature tree can store as much as 10 tonnes of carbon.
- **Provide habitat and enhance levels of biodiversity:** a healthy urban forest contributes to biodiversity and habitat provision. Urban forests support a wide range of species, even endangered animals, and other species of high conservation value. By planting and managing different age strata, biodiversity and wildlife habitat values can be enhanced. Green roofs and walls can also provide habitat for wildlife.

The Social and Human Value of Trees in Urban Spaces

A range of literature also demonstrates the ways in which urban forests have positive social and human wellbeing effects (Sander 2016). These range in terms of public health and well-being and the promotion of good social cohesion, even to the extent of reducing levels of crime. Poverty is often associated with higher levels of pollution, unhealthy living and unsafe neighbourhoods (Suzuki et al. 2008). Greening a city is one way in which to address issues of public well-being and create a safe and stable environment for its citizens, businesses, and urban ecological assets (Suzuki et al. 2008).

People are also more likely to be emotionally connected to spaces that have higher tree canopy (Tzoulas et al. 2007). Holtan et al. (2015, pp. 503-504) lists the ways in which green spaces benefit and are valued by society:

- decreased hospital patient recovery times
- increased feelings of peace
- escape from distraction
- neighbourhood satisfaction
- walking in forests reduce levels of stress hormones, heart rate, and blood pressure
- regulates the effects of environmental stress
- people are drawn to green space for mental health benefits
- meeting other people seeking the same relaxation and restoration
- creates space for social ties

Tree canopies also facilitate increased levels of social capital by a range of mechanisms. Social capital is associated with the way that trees make spaces more welcoming and hospitable, making them important features in shared public spaces, such as footpaths and parks (Kelcey & Müller 2011). Moreover, trees drive increased use of footpaths and outdoor spaces, in part because they create a feeling of freedom "that is essential to mental restoration or increase the sense of mystery that draws walkers around the corner to the next block to meet their neighbours" (Kelcey & Müller 2011, p. 517).

The way that trees affect the way that people feel about the spaces they are in is also described as *biophilia*. This term refers to the subconscious connection that people seek with other life and life-like systems (Van Herzele et al. 2011). The idea is that people have an inherent drive to connect with other forms of life such as plants, animals, and natural landscapes (Van Herzele et al. 2011). Trees provide these natural systems and allow the connection in urban spaces (Van Herzele et al. 2011). The elements of a biophilic city, according to Beatley (2016) include green alleys, parklets, footpath gardens, waterfront promenades, all of which create spaces that permit socialising, intermingling and strengthen social networks that enhance the publics resilience and cohesion.

These benefits can also be seen in term of positive public health outcomes. The greater levels of physical and outdoor activity in relation to proximity of green spaces are associated with improved public health and wellbeing (Maller et al. 2009; Nowak et al. 2018; Sanesi et al. 2011; Tzoulas et al. 2007). Trees are also associated with protection from the harmful effects of UV radiation. Trees absorb approximately ninety percent of UV radiation therefore reducing the amount that reaches the ground, protecting people from the harmful effects of sunshine (Nowak et al. 2018). Moreover, in their absorption of carbon dioxide and release of oxygen, trees also support overall public health (Suzuki et al. 2008). Connection with natural systems, such as with trees is also perceived to be fundamental to personal fulfilment and psychological wellbeing (Maller et al. 2009; Tzoulas et al. 2007). Moreover, in a recent citizen science study on connections between green spaces and public health in Adelaide, green spaces were attributed to community health and wellbeing because the spaces brought about a sense of calm and relaxation and desire to exercise (Barrie et al. 2020).

The Economic Value of Trees in Urban Spaces

From an economic lens trees have a range of benefits in urban and city spaces. Indeed, many cities are quantifying the value of trees in economic terms to shift the focus of the value away from perceived ethereal or unfounded human values to sound and indisputable and more accepted economic values. These benefits summarised in Box 3, include: property value, the value of improved energy efficiency and lowering costs of power use, reduced costs because of improved water and storm water management, and the economic value of healthier and happier communities.

Box 3: Economic wellbeing benefits arising from connection with nature in parklands (Maller et al. 2009, p. 69)

- Views of nature from detention centres and prisons have the potential to reduce the incidence of illness (particularly stress related illness) in inmates, reducing health care costs in prisons.
- Views of nature from hospitals and other care facilities (such as nursing homes) have the potential to reduce recovery time (number of days spent in hospital). reduce the quantities of medication required to treat patients and reduce incidences of post-operative surgery in patients.
- Contact with nature improves job satisfaction, overall health, and reduces job stress in the workforce as well reducing number of sick days and employee absences.
- Parks and natural features attract businesses.
- Trees in urban streets attract consumers and tourists to business districts and are seen to increase appeal.
- Tourism is the third largest industry worldwide, with growth occurring particularly in wilderness or nature-based tourism.
- Parks and nature tourism generate employment in regional areas.
- Significant natural features, including parks and gardens, raise real estate values.
- Contact with nature can potentially reduce the burden of disease on the current health care system. For example, for pet ownership alone preliminary estimates of savings to the health care system are between AUD$790 million to AUD$1.5 billion annually (Headey and Anderson, 1995).
- Interaction with nature encourages a holistic/ecological approach to health, giving people a sense of control over their own health and wellbeing which may lead to less reliance on health care services.

In relation to property value, tree lined, or ‘leafy’ streets are known to increase the value of properties (Staats & Swain 2020). In 1988 Anderson and Cordell (1988), for example, found that house prices in Athens, Georgia in the US were increased by five percent when they were within treed, leafy streets. Donovan and Butry (2010) found in their research valuing the street trees in Portland in the US that street trees fronting properties positively influenced house sales price, on average, adding USD$8870. Pandit et al. (2013) similarly found that a broad-leafed street tree in Perth, Australia, but not on the property, increased the average house price by approximately AU$16,889 (4.27%). Plant et al. (2017) revealed that the homebuyer’s willingness to pay for leafy streetscapes demonstrates that there is strong support and informs a business case for local footpath tree canopy cover targets.

However, house prices are just one factor that is used to measure the economic benefit of street trees. The introduction of the i-Tree program integrated a range of economic benefits to quantify the benefits of trees into monetary value and has been used by researchers to assess the value of trees in cities across the globe. i-Tree is a peer-reviewed program developed in 2006 by the US Department of Agriculture Forest Service and quantifies urban and rural forestry benefits (USDA 2020). Measures are derived from calculations using the direction and distance of the tree from housing, as well as tree height and condition, and in conjunction with a range of state data, such as, savings in residential energy costs, State average costs for natural gas, heating season fuel costs, and residential costs for electricity and wood (Nowak et al. 2018).

McPherson et al. (2016) estimated the monetary value of street trees in California in the US, using measures on function and value (energy; carbon dioxide; air quality; rainfall interception; property values and other benefits; total annual benefits; replacement value):

> *Despite decreasing street tree densities in California, the state's street trees are an infrastructure asset valued at USD$2.49 billion. The annual value of all street tree services is USD$1.0 billion (USD$58.3 millions), or USD$110.63 per tree (USD$29.17 per capita). Given an average annual per tree management cost of USD$19, USD$5.82 in benefit is returned for every USD$1 spent. These findings indicate that investing in the long-term health of municipal forests can provide positive returns (McPherson et al. 2016, p. 113).*

In China, Wang et al. (2018, pp. 12-13) similarly found trees to be of significant economic value.

> *The structural value of Dalian's street trees was approximately USD$130 million, with a value of USD$4.5 million for carbon storage. The annual functional benefits of Dalian's street trees were USD$4.9 million (USD$85/tree). Street trees increased property value with an estimated annual value of USD$1.5 million (USD$25/tree). The annual energy saving benefits from all street trees in Dalian was USD$1.7 million (USD$29/tree). The net carbon dioxide reduction benefit was valued at USD$0.9 million (USD$16/tree). Smaller benefits resulted from air quality (USD$0.4 million or USD$7/tree) and stormwater runoff (USD$0.5 million or USD$8/tree). However, city managers should also consider the management costs of street trees. The municipality of Dalian spent approximately USD$1.5 million (USD$26/tree) annually on tree management. The annual net benefits were USD$3.4 million, an average of USD$59/tree. City residents received USD$3.2 in benefits from every USD$1 invested in management costs of street trees.*

Another consideration in relation to the economic value of street trees is via the improvement of citizen health through increased exercise and sense of wellbeing. Providing and maintaining nature spaces is considered a relatively cheap method to reduce the significant economic burden of the public health system (Goodenough & Waite 2019). Nature-based interventions, such as focusing on developing greener spaces within cities and urban spaces are estimated to contribute to significant savings (Goodenough & Waite 2019). The economic savings is through saving the public health system with more people engaging in increased physical activity and changing sedentary behaviour over the long term (Willis & Crabtree 2011).

Underground Service Utility Infrastructure in Cities and the Conflicts About Trees – Varying Perceptions

The conflicts regarding the interaction between trees and underground service utility infrastructure are well known (Jim & Chan 2016; Randrup et al. 2001a; Slater & Chalmers 2020). Trees are seen as problems because their root systems are perceived as invasive, particularly with sewage, storm water drains, other water supplies, building infrastructure, footpaths, streets, curbs and parking lots (Randrup et al. 2001a). Much of the problems are framed around the species selection of street trees and infrastructure construction (Randrup et al. 2001a). Compounding the problem is the fact that trees have not been part of street and townscape planning leading to a lack of consideration and adequate planning for how trees interact with infrastructure (Randrup et al. 2001a).

In relation to tree function, their ability for supporting the tree roots to grow within the physical conditions available for street trees is a significant issue. Research into the geotechnical/physical specifications needed to prevent tree root extension has seen the development of a range of construction techniques and base materials that promote optimum growth responses within a confined urban context for street tree species (Jim 2012; Randrup et al. 2001a). Trials have assessed the interaction between tree roots and infrastructure, soil moisture regimes under a different paving systems and soils mixtures (Jim 2012; Randrup et al. 2001a).

One of the fundamental problems with this area of research is the language of arboriculturists and engineers is different and therefore they describe the conditions within tree root zones from different biases and using different terms and measures. As a result, trees fail to establish and thrive, and street and footpath paving fail to last (Blunt 2008). Blunt (2008) argues that the constraints put on tree selection (trees of small stature and considerable drought tolerance) are because of engineering design parameters that must be achieved. Additionally, most of the available information concerning planning and managing trees and underground utilities derives from industry standards and guidance, rather than targeted and independent research (Slater & Chalmers 2020).

One study by Kirkpatrick et al. (2013) explored the different attitudes of tree professionals in relation to trees and urban forestry in Australia, found that there were contrasting attitudes between those who work within and outside of government agencies. Those working in planning and strategy were more likely to regard trees as green infrastructure, whilst those working on-the-ground with tree management were more emotionally engaged with the trees (Kirkpatrick et al. 2013). Indeed, the range of biases and perceptions that exist in relation to trees (i.e., residents, planners and architects, tree professionals, engineers, and politicians) is at the heart of many of the conflicts and problems associated with urban trees (Kirkpatrick et al. 2012).

The varying biases and perceptions around trees have meant that conflicts relating to trees and underground services and urban infrastructure are well ingrained, even chronic, in urban development (Jim & Chan 2016). The utility infrastructure dominates urban and city underground spaces because cities have evolved with much of the utility services placed underground in direct competition with tree roots. In Hong Kong, they have reduced this problem as the service and redevelopment of the significant utility service lies underneath roads, not footpaths, resulting in the elimination of damage to existing trees (Jim & Chan 2016). The task of convincing governments to invest in common utility ducts requires building business cases demonstrating that it is cheaper than the substantial monetary and social costs of maintaining the existing systems (Jim & Chan 2016). For example, repeated trenching to reach or install underground utilities causes severe root damages reducing the lifespan of existing trees (Fini et al. 2020; Jim & Chan 2016; Slater & Chalmers 2020). In the UK, underground utilities consist of approximately 3.5 million kilometres of underground cables and pipes, of which, the highest density is in urban areas (Slater & Chalmers 2020). Excavation relating to management of utility trenches results in tree root damage and affects the trees lifespan (Fini et al. 2020; Slater & Chalmers 2020).

The impact of this type of tree root damage is substantial and Fini et al. (2020) suggests that root severance be reclassified from an inciting factor (a factor directly causing tree mortality) to a predisposing factor (a contributing, but indirect factor of tree mortality) in the Manion Mortality Spiral (*Figure 2*). The Manion Mortality Spiral is the result of research that found root damage from excavation for the installation and repair of belowground infrastructure reduces the long-term capacity of trees to survive the constrained and disrupted urban environments by decreasing carbon availability for growth and defence (Fini et al. 2020). The implication of this redefinition is that the management of utilities needs to take into consideration the long-term effects of damaging a tree's roots

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Figure 2: Manion's spiral of tree decline (1981) taken from Amoroso et al. 2017

The solutions for conflict are undoubtedly found in the way the different government, utility service agencies, and private developers interact and make priorities for urban tree planting and management. The review above demonstrates a clear need for trees to survive and thrive in cities, and it is therefore beholden upon constructive relationships to find solutions for this to happen (Slater & Chalmers 2020). Moreover, as Randrup et al. (2001a, p. 222) argues, rather than focusing on specific solutions, there "needs to be a broader spectrum and multi-disciplinary approach" with research that is site specific and uses methods of "controlled experiments and in situ testing".

Trees Viewed in Relation to Risk

The evidence discussed so far demonstrates a range of perceptions about the value and function of trees in urban spaces from which urban greening strategies are framed. The range of benefits of having trees in cities drives the decision-making to promote greening strategies, but trees often struggle to thrive and coexist with the infrastructure which define urban spaces. This problem relates to the fact that trees are most often not part of the planning in urban development which means that the development and management of infrastructure and services utilities do not take into consideration their interaction with trees

(Randrup et al. 2001a; Ridgers et al. 2006). The result is that trees are viewed in terms of risk and the problems occurring because of the interactions between trees and infrastructure, with the tree being the problem.

Evidence of this viewpoint is found in the framing of research focused on the problems between trees and infrastructure. For example, there is much discussion in the literature about the problems associated with tree roots penetrating sewage pipes (known as root intrusion) because the substantial financial costs resulting from this problem are an ongoing concern for municipalities (Ridgers et al. 2006; Torres et al. 2017). This area of research focuses on the typical entry points for tree roots (the often "not completely tight" joints in pipes) and the 'susceptibility' of pipes to 'root intrusion' (Ridgers et al. 2006, p. 269). Kuliczkowska and Parka (2017) for example, explore the frequency and size of 'root intrusion' into sewers frequency as well as root size to develop methods for determining risks associated with root and the probability of structural defects. Östberg et al. (2012) examined data on 'root intrusion' to determine the ability of different plant species to intrude into urban sewer pipes. Torres et al. (2017) similarly identified pipe characteristics and tree species most responsible for 'root intrusion' to establish the characteristics that facilitate the damaging interfaces between pipes and tree roots.

Although root damage to sewer systems is likely to occur in old systems and cracked pipes (Randrup et al. 2001b), these studies describe trees as the problem. Indeed, tree root damage does present a considerable problem for service providers, with their underground utilities, particularly water and sewage. Problems associated with roots include partial and total flow blockages that cause leaks into the surrounding soil and groundwater, consequently contamination them (Kuliczkowska & Parka 2017). These flooding and pollution incidents can also occur in a range of places including residential housing and local communities (Kuliczkowska & Parka 2017). The blockages attributable to roots are estimated to represent about 50% of the total number of sewer blockages (Randrup et al. 2001b). *Table 2* shows the different types of sewer system failures found in an American study by (Randrup et al. 2001b).

Table 2: Types of sewer system failures, taken from Randrup et al. (2001b, p. 28)

Sewer Failure Types	Reason for Failure
Collapse	• difficult ground conditions • large wastewater flow • adjacent utility impacts • traffic congestion • deep excavation
Structural	• roots • corrosion • soil movement • inadequate construction combined
Blockage	• sediment • roots • intrusions (connections or foreign bodies) • grease or encrustation or both

It is also important to note that trees in urban spaces are expected to grow in conditions that are far from ideal and they are attracted to the moist and fertile environment existing from leakages from sewage pipes (Bühler et al. 2016; Grabosky 2001; Moore et al. 2019). The growing environment for urban trees is more often in compacted soils that have limited drainage and oxygen diffusion which limits tree root growth capacity (Moore et al. 2019). The opportunistic tree roots go to the more suitable environment provided by backfill around pipes which is often less compacted and provides opportunity for them to penetrate pipes where cracks are larger than the root tips (Moore et al. 2019).

The resulting conditions mean that sewers are not constructed in a way to prevent root intrusion and are therefore more susceptible to root intrusion compared to other types of urban infrastructure (Torres et al. 2017). The joints in pipes (whether they be old clay and concrete pipes which have joints every metre, or new PVC pipes which have joints up to 8 metres) continue to be the main entry point for roots (Moore et al. 2019; Östberg et al. 2012). However, root penetration also occurs because the infrastructure is old and not repaired (through breaks, loose joints, or failed rubber gaskets, and smaller pipes) and when the pipes are embedded in sandy soils (Moore et al. 2019).

Trees are also viewed in terms of risk in relation to powerlines, particularly in more forested areas. The primary cause of power outages is attributed to trees, principally from trees falling on powerlines during severe weather events (Fenrick & Getachew 2012; Freeman et al. 2019; Glass & Glass 2019). In the US, trees are estimated to cause approximately 25 percent of all electric service interruptions annually (Freeman et al. 2019). Fire is also a significant risk in particular where the climate is dry and warm (Ma et al. 2020). Given the considerable social, economic (the total annual cost of fire in Australia amounts to approximately 1.15% of GDP) and environmental costs of wildfires, the risks are substantial (Ma et al. 2020). Trees are managed to mitigate these risks. Right-of-ways and roadside tree pruning and removal have become the go-to forms of risk management.

There is a debate about placing power lines underground as a way of mitigating these risks. The arguments for and against undergrounding are framed around cost and risk. On one hand, putting these serviced underground shifts the risks away from trees above ground. However, the financial costs of doing so are considerable (Freeman et al. 2019). Freeman et al. (2019, p. 10) argue that the risks associated with weather are not eradicated by undergrounding: "flooding, insects, roots of trees, and decomposition are just a few issues that affect undergrounding". However, the argument for and against undergrounding is more nuanced; the pros and cons of each relative situation needs to be considered to evaluate the costs and benefits (Fenrick & Getachew 2012). Glass and Glass (2019) argue that when you take into consideration the total costs of having powerlines above ground, including those not related to trees such as damage from wildlife, and fires caused by faults in the lines and transformers, there is a case for undergrounding those services.

However, there is little evidence in relation to trees' interactions with underground powerlines. Despite this, service providers remain cautious and regulate tree planting space around the utilities. For example, the South Australian Power Network (SAPN) has regulated that if planting within three metres of an underground powerlines the tree must only have a mature height of less than 2 metres (South Australian Government 2020). In the UK, the British planting standards streamline the planting regulations for all underground services with drains (BSI 2005). As there is an absence of literature, particularly substantive empirical research regarding the effects of tree roots on underground powerlines, it appears that such regulations are not necessarily evidenced-based, but rather put in place through a risk-averse approach to decision-making.

Engineering Solutions for Planting Trees in Urban Spaces

The risks explored above have been predominantly managed by either tree removal or increasing the zones around infrastructure that trees cannot be planted in. These approaches, however, have resulted in the depletion of the number of trees in urban areas as well as a reduction in the available space for planting trees. New research has shifted its focus away from seeing the tree as the problem, but rather finding ways to have both trees and utilities sharing the space. Much of this research has focused on finding engineering solutions for protecting underground utility services from ‘root invasion’. There is a growing area of research that incorporates engineering and arboricultural research to find ways to improve the growth conditions for trees in urban spaces so that they do not seek the nutritious moisture of leaking sewer pipes and utility trenches, including passively watering trees from rain runoff, and planting trees within contained spaces that provide them with all their growth needs. There is also research exploring measures to control stormwater aimed at reducing the environmental damage and financial costs caused by impervious runoff (Grey et al. 2018).

Grey et al. (2018), for example, explore the effects of water infiltration differences in various tree pit designs (*Figure 3*). This study found that street trees with access to stormwater runoff have the capacity to double their growth rates compared to conventional street tree planting techniques (Grey et al. 2018). However, the study also found that waterlogging was the key issue with the pits, thus measures to avoid waterlogging conditions is necessary to promote tree growth (Grey et al. 2018).

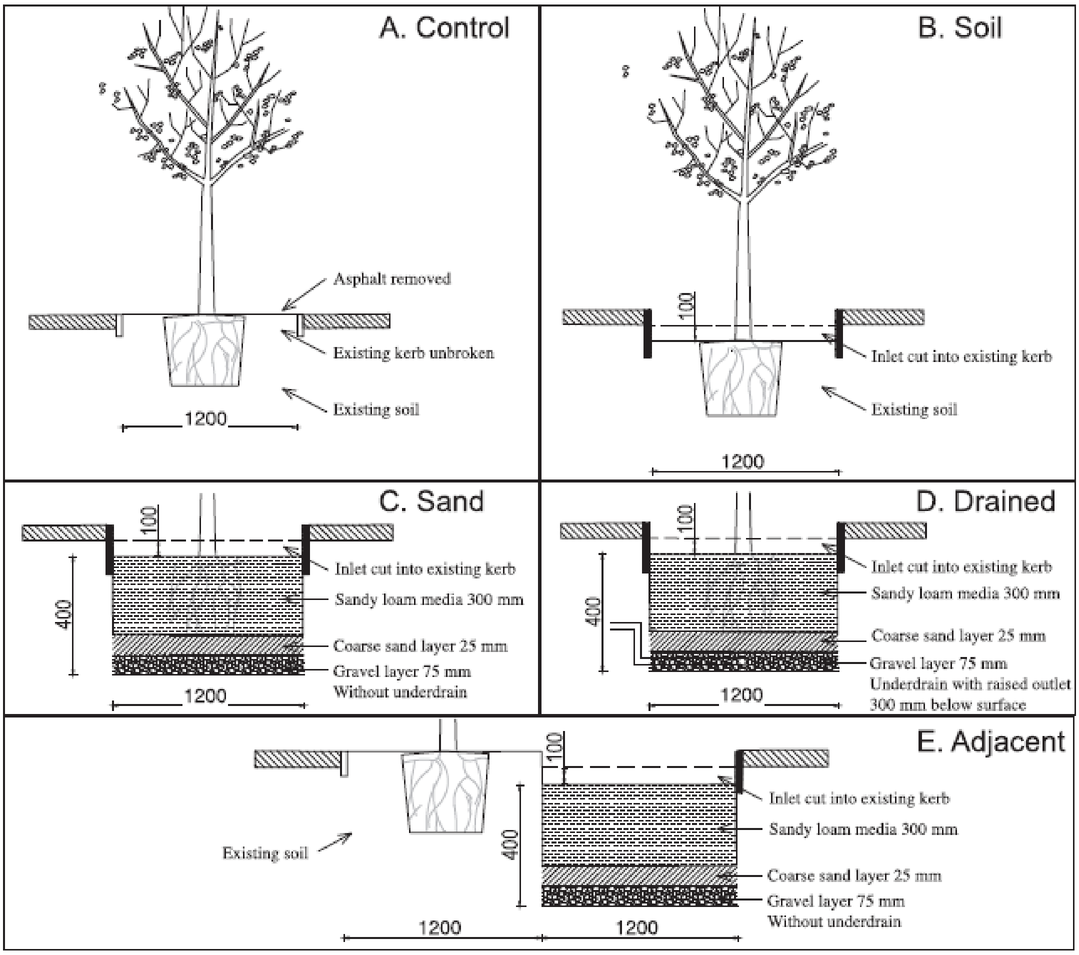

Figure 3: Cross section drawings of study sites with different inlet locations, soil/substrate types, drainage connections and tree locations. Image taken from (Grey et al. 2018)

Another area of research focuses on finding ways to reduce stormwater flows through pervious forms of paving (Beecham et al. 2012; Boogaard et al. 2014; Chandrappa & Biligiri 2016; Kuruppu et al. 2019). The problems associated with stormwater flows include flooding, erosion and pressure on sewer and drainage infrastructure capacity (Boogaard et al. 2014). This problem has been mitigated in the past through engineered infrastructure built to rapidly deliver the stormwater to collection points, but which was often inadequate to treat the quantities of water (Kuruppu et al. 2019). Permeable pavements reduce the pressure on stormwater infrastructure by enabling stormwater to infiltrate on site without disrupting aboveground land use, particularly pedestrian and vehicular traffic (Beecham et al. 2012). Research has found that there is no runoff from minor rainfall events and the peak flows from large rainfall events are substantially delayed and reduced (Johnson et al. 2020). Additionally, the in-situ infiltration effectively removes nutrients, suspended solids and some heavy metals (Beecham et al. 2012; Chandrappa & Biligiri 2016; Liu & Armitage 2020; Mullaney & Lucke 2014).

There are different systems of permeable paving (*Table 3*), monolithic (porous concrete/ asphalt), and modular types (interlocking porous pavers or grid systems) (Kuruppu et al. 2019).

Table 3: Types of permeable pavements, taken from Kuruppu et al. (2019, p. 326)

Pavement type	**Construction**	**Applications**
Porous concrete/asphalt	Open-graded concrete or asphalt with no or reduced fines mixed with a special binder that create voids when cured to allow water to infiltrate	Commercial parking lots, perimeter/overflow parking, perimeter/light commercial, driveways, patios/other paved areas, sporting courts, industrial storage yards/loading zones
Interlocking concrete paving systems	Paving stones installed with keeping gaps between stones to allow water to infiltrate	Commercial parking lots, perimeter/overflow parking, perimeter/light commercial, driveways, patios/other paved areas, industrial storage yards/ loading zones, parking pads (e.g., caravan parks)
Grid systems/ reinforced turf	Plastic or concrete grids filled with aggregate, sand or grassed soil that water can infiltrate through	Commercial parking lots, perimeter/overflow parking, parking pads (e.g., caravan parks)

Each of the permeable paver types are found to be high performing in relation to infiltration rates (Mullaney & Lucke 2014). All paving types will clog with sediment over time, however, can be managed with maintenance procedures, such as high-pressure hosing, sweeping and vacuuming (Mullaney & Lucke 2014). Much of the debate about permeable paving relates to the design, particularly in relation on whether or not to include geofabric between the aggregate layers (Mullaney & Lucke 2014). Research on permeable paving based in South Australia has included systems where geofabric has been used to line the sides and base of the gravel base layer but was not used between the base and bedding layers (see *Figure 4*). Johnson et al. (2020) argues that this type of design allows the water to freely drain into surrounding soil.

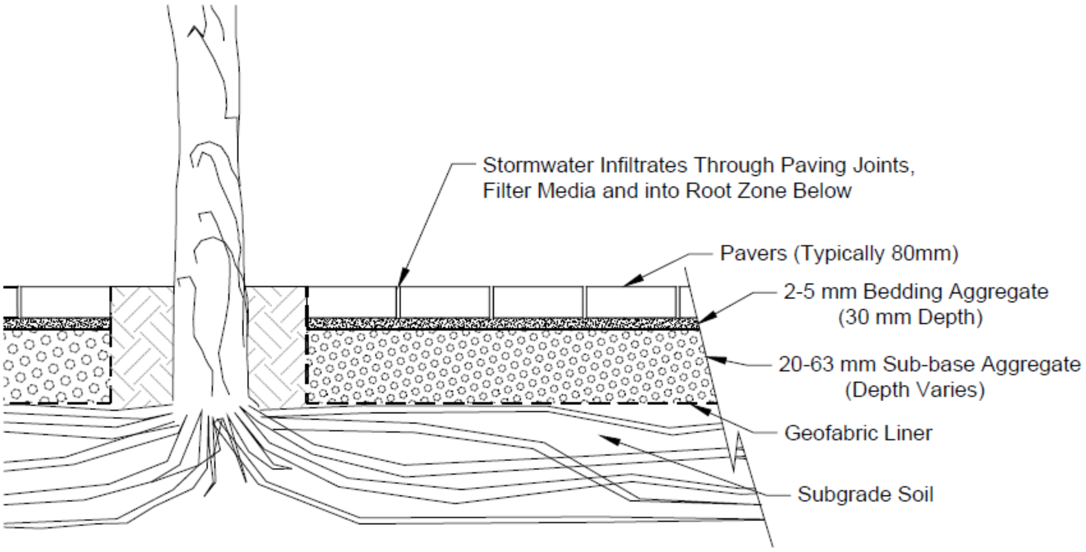

Figure 4: Cross section of street tree with permeable paving design (Beecham 2012)

Figure 5 also shows the different base designs using gravel on a level uncompacted subgrade ('perm-level') and on uncompacted subgrade formed into a swale beneath the footpath ('perm-swale'). Existing impermeable paving laid on a coarse sand bedding layer on compacted subgrade served as the control.

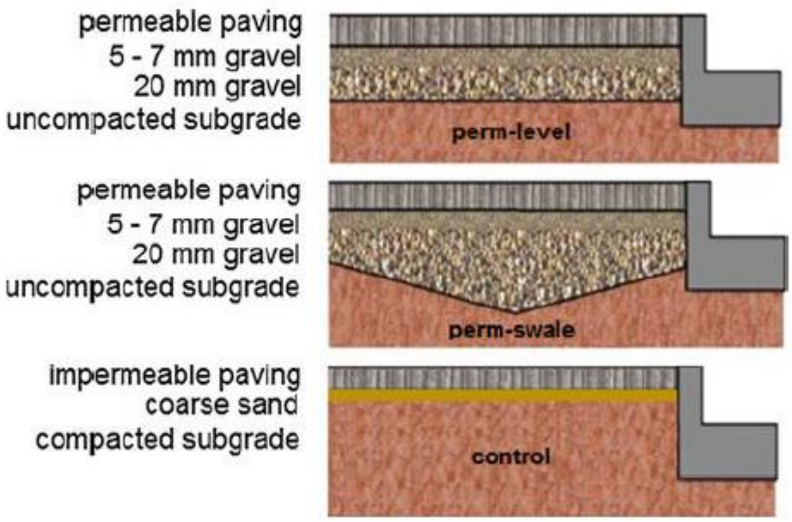

Figure 5: Examples of permeable paving base designs. Image taken from Johnson et al. (2019, p. 2)

As described above, impermeable surfaces that predominate city and urban spaces make it difficult for trees to get the required water they need to grow. Permeable paving has the added advantage of passively watering street trees which is vital to supporting better growth rates (Beecham 2012; Johnson et al. 2019). Permeable paving and passively watering trees also lead to reduced damage of other infrastructure damage, such as raising and cracking footpaths and roadways (Johnson et al. 2020) Trees instead provide soil stability when grown near pervious paving (Johnson et al. 2020). The uncompacted soils (*Figures 4 and 5*) also allow faster growing, deeper and healthier tree roots to grow compared to trees growing in streets where the traditional practice of compacting soils beneath paving has been used (Beecham 2012; Lucke & Beecham 2019). The aggregate layers prevent large roots from growing under the paving, providing a buffer to footpath damage (see *Figure 6*) (Beecham 2012; Johnson et al. 2019; Lucke & Beecham 2019)

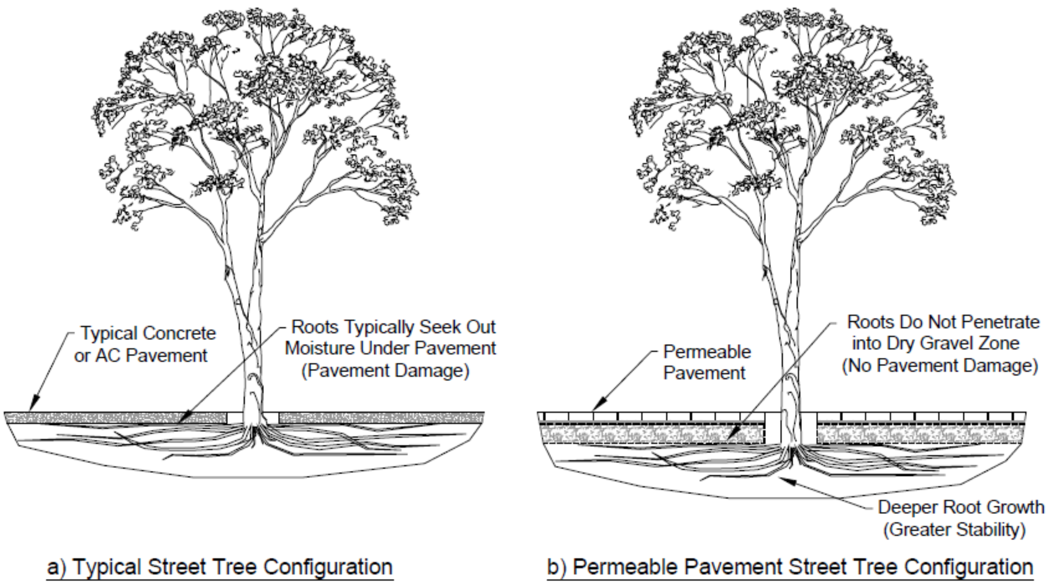

Figure 6: Comparison of impermeable and permeable paving with street trees,
Image taken from Beecham (2012, p. 3)

An example of permeable paving occurred at an intersection in an Adelaide suburb with a history of flooding during heavy rain events. Permeable paving was constructed at the intersection and used as a case study for research supported by TREENET, the University of South Australia and Mitcham Council. The project used 500 m^2 of permeable paving at the intersection (*Figure 7*) and also included the construction of soakage trenches to drain the runoff into nearby parkland where it irrigated existing River Red Gums (*Eucalyptus camaldulensis*) (*Figure 8*). The result of the project was that no ponding occurred at the intersection during heavy rain events. The cost for construction was one sixth of the cost of the alternative traditional pit and pipe drainage upgrade to increase the stormwater holding capacity (Lawry et al. 2017).

Figure 7: Example of permeable paving at Mitcham Council, South Australia.
Image taken from (Lawry et al. 2017)

Figure 8: Example of permeable paving above underdrains that direct storm water into the adjacent reserve and into the road subgrade. The construction is laid close to mature trees with no damage to paving surface. Image taken from Lawry et al. (2017, p.6)

Another emerging water sensitive urban street design to passively water trees is a cut kerb connected to a leaky well or trench. South Australian research has been conducted on a locally produced version of this system (Sapdhare et al. 2018; Sapdhare et al. 2019). The TREENET street kerb inlet (*Figure 9*) harvests road runoff for passive irrigation of street trees.

Figure 9: TREENET Inlet. Image taken from Johnson et al. (2016)

This inlet, coupled with a leaky well infiltration pit (*Figure 10*), is emerging as a system that can be installed into existing roadside infrastructure instead of directing stormwater flows into drainage, water is directed into the leaky well infiltration pits that filters water into the surrounding soils (Johnson et al. 2016). The leaky well infiltration pit is enclosed in filter media which acts to filter heavy metals, nutrients and organic matter to improve the quality of stormwater (Sapdhare et al. 2018).

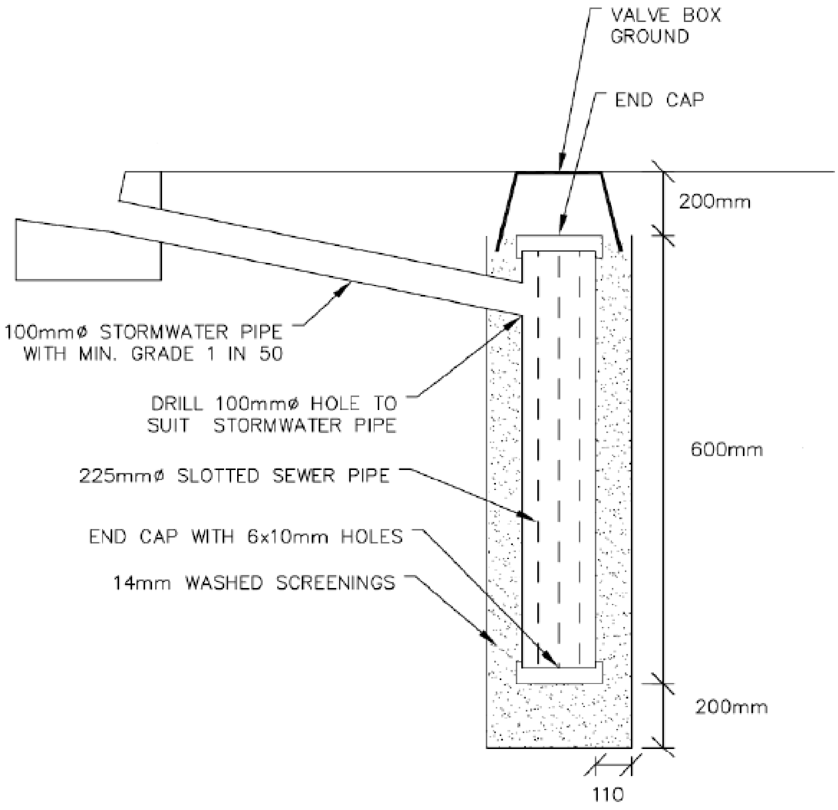

Figure 10: Cross-section of a leaky well with a TREENET inlet. Image taken from Johnson et al. (2016, p. 66)

Storm water harvesting systems are successfully functioning in local councils in metropolitan Adelaide with no operational failures or problems and provide a cost-effective opportunity to improve the conditions for trees in urban spaces (Johnson et al. 2016). In providing street trees with water, these systems also potentially provide systems for planting trees in otherwise difficult/ congested cityscapes through their ability to curb root growth (due to layers of gravel) in areas that protect and insulate service utilities. This is an area yet to be fully explored in the literature.

Planning and Development for Urban and City Trees

The planning implications of all the considerations above, particularly in relation to the growing trend of governments to pursue urban greening and city tree planting programs is complex. This review demonstrates the challenges in finding space to plant trees because of the extent and complexity of underground utility networks in urban spaces and the constraints that they bring (Slater & Chalmers 2020). On one hand, changing the status quo and pursuing, or even facilitating, new and innovative approaches to roadside planning and development is a major challenge for decision-makers. On the other hand, divergent political interests and agendas, perceptions of risk, and operational standards and practices of different stakeholders make it difficult to find a shared vision for urban development (Elmendorf et al. 2003; Kirkpatrick et al. 2013). Needless to say, there is a case for improving government planning frameworks and decision-making regarding urban trees.

Improvements may include improvements to processes that incorporate broader regional strategies that protect trees and increase tree canopies (Kirkpatrick et al. 2012; Kirkpatrick et al. 2013; Pincetl 2010). Pincetl (2010) argues that it is important to resource and establish coordinated systems that sufficiently manage and maintain urban forests because of ecosystem services they provide, and because they are alive:

> *Nature's services infrastructure also suggests coordination and cooperation among traditionally separate departments such as planning, transportation, sanitation and other utility providers, and new biological knowledge about soils and microbes and their pollution filtration potential, which trees are the most appropriate for bioregion, climate, and desired function. Finally, unlike grey infrastructure that is generally hidden underground, in pipes, or else made inaccessible in concentrated facilities, nature's services infrastructure is in plain sight, it takes up real physical space, and if it is not regularly maintained, (gardened) it will look unattractive, may not work and/or it will die. This implies a different knowledge and maintenance regime from the networked modern city to one more akin to parks (Pincetl 2010, p. 47).*

Slater and Chalmers (2020) also found that a lack of coordination between stakeholders is a problem and contributes to the conflicts that evolve around urban trees which are now more highlighted because of the only very recent acknowledgement of the value of urban forest. They argue that better communication and collaboration and the facilitation of knowledge development and innovation would improve the chances of successful urban forest outcomes (Slater & Chalmers 2020).

The known attributes of thriving, long-lived trees that contribute the range of ecosystem services demonstrated above are in jeopardy when there is premature tree decline, physiological pressure and stunted growth (Fini et al. 2020). Conventional measures to address poor performance through maintenance and replanting regimes considerably reduces the benefit to cost ratio of urban trees (Fini et al. 2020). Continuous damage to trees because of the precedence given to utilities is a stress of increasing importance for trees in the urban environment (Fini et al. 2020; Jim 2003). Therefore, ensuring the conditions for trees is optimal, such as with the required soils, irrigation and space will ensure urban trees survive (Grabosky 2001; Jim 2012).

Jim (2001) lists a range of considerations for planning and managing trees in Hong Kong:

- the confined space of narrow pavements is keenly contested both above and below ground.
- the aboveground confinements that restrict trees performance (planting sites are often narrow, usually only 2–4 m) which limits the types of trees that will fit the space.
- safety clearance for pedestrians and vehicles (particularly double-decker buses and trucks) make for unyielding restrictions on roadside planting.
- the soil component is essential for the very fact that half of a tree dwells below the ground (from which water, nutrients, and anchorage are acquired), and that urban soils in most urban areas are inferior as a medium for plant growth.
- the high-density underground utilities located at shallow depth below the paving often congregate in the upper 2 m of the substrate; hence they are in direct conflict with tree roots.
- the lack of a separate conduit or tunnel to accommodate the profusion of service lines, and their placement is often haphazard, and there is little concern or awareness about their adverse impacts on trees, even though it is one of the most limiting physical constraints to tree planting in the city.

- the frequent trenching to repair defective utility lines, to install new ones, and to make connections or disconnections results in the repeated root damage and decline of trees.
- a lack of an official guideline on working with or near trees.
- community involvement is a way to connect residents with the open spaces they are otherwise divorced from.
- the unclear demarcation of responsibilities and authority concerning trees is unhelpful.
- recommendations include:
    - demonstrate the priority to greening by providing strong leadership and community and establish a coordinating body to oversee and integrate planting activities.
    - initiate in-depth, long-term, and visionary policy that is metropolitan-wide to effect widespread tree planting.
    - allocate adequate resources.
    - shift from a predevelopment to a sustainable-development strategy.
    - encourage private developers and citizens to participate.
    - raise the professional standard of urban forestry practice and readily adopt new techniques and materials.

Alternatively, Bell et al. (2005) offers a range of urban forest design principles:

- incorporate non-woodland habitats such as grassland, wetland, open water, or heath, where ecological values are important as well as recreational spaces, such as paths, picnic areas, play spaces or viewpoints.
- consideration should be given to the aspect of the trees (i.e., either on the sunny side or the shady side of the street, depending on species or desired design effect).
- considering different species but with care to maintain the design integrity.

Conclusion

This review highlights that quality urban greening into the future lies in addressing the problems of, and making changes to, conventional measures for planning, and planting trees in city and urban spaces. However, the ecological pressures on urban forests are not always obvious to the public and politicians (Ottitsch & Krott 2005). Therefore, it is up to decision-makers and managers to make the case for innovation, research and development to ensure the greening and canopy targets are achieved. To do so new and innovative (and often more cost effective) processes, such as the ways of passively watering trees described above, will need to be incorporated into urban planning and development whilst simultaneously investing in the research and development of better systems. There is also opportunities for thinking outside the square to increase spaces to plant trees, such as developing brown sites (urban sites that are derelict, underused or contaminated and require intervention to be returned to beneficial use) can provide additional space to preserve existing and support new trees (Jim & Chan 2016). The costs for not addressing the issues today will only prolong the problems and financial costs into the future (Ottitsch & Krott 2005).

The Planting Trees Framework in Adelaide

Overview of the Process of Getting Trees into the Ground

Putting trees into the ground in metropolitan Adelaide, as with any metropolis, is a complex system of considerations and negotiations. Primarily there are a range of laws and regulations applying to state and local government development, and each utility service, that need to be taken into consideration. The city is a contested landscape as depicted in *Figure 11*.

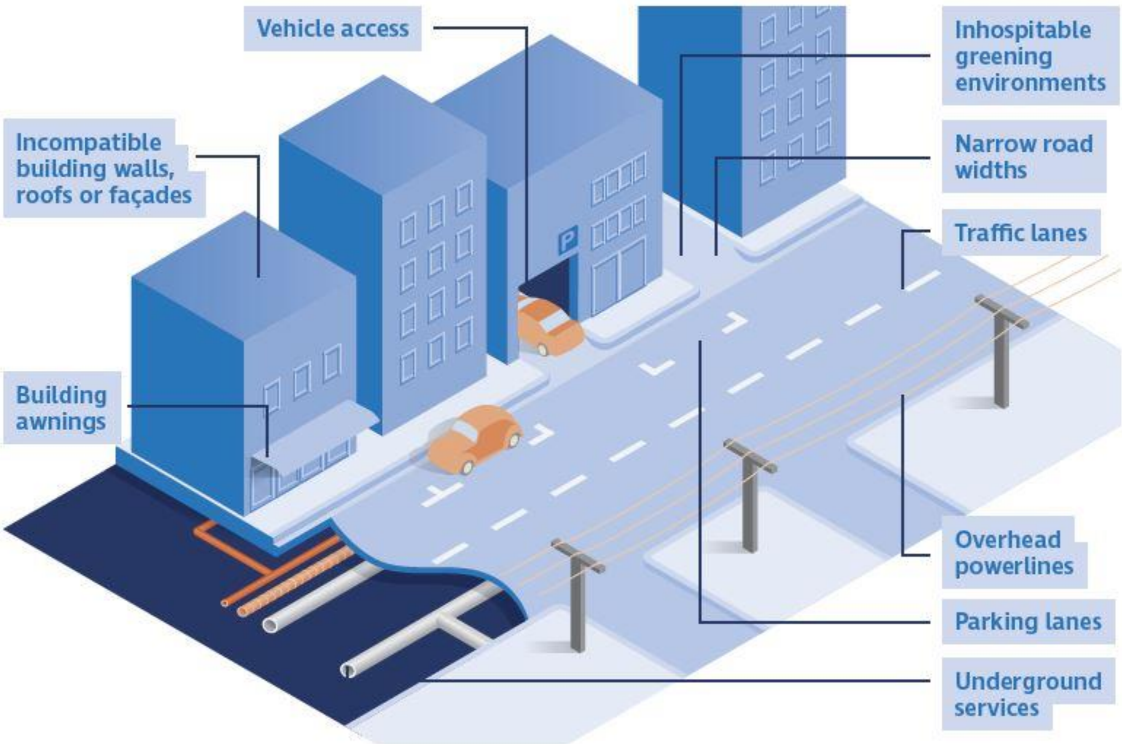

Figure 11: A contested landscape creates barriers to greening in the urban environment
(City of Adelaide)

Each of the utility services also need to be negotiated with independently, including the often-difficult process of establishing and documenting the location of their infrastructure and then attaining planning approvals before any form of construction/planting can take place. All of this occurs within the highly contested and overcrowded underground space (*Figures 12 and 13*) and finding the space available for trees is often difficult, if not impossible.

Figure 12: Example 1 of the extent of services in a city underground space, Bank Street Adelaide.

Figure13: Example 2 of the extent of services in a city underground space, Bank Street Adelaide.

The planning and implementation of planting trees on public land for local councils, therefore, is an extraordinarily convoluted process and includes a range of steps. *Figure 14* illustrates these steps and highlights this process is far from straight forward. At several stages through the process, obstacles are identified, negotiations are undertaken, and at times the site is found to be unviable which forces the process back to the beginning – identifying a possible location to plant trees. The jurisdiction of planning and development relating to planting trees and other vegetation in the city most often falls on local council. As such, they are responsible for the costs to identify the location of utilities and for any damage to utility infrastructure at all stages of a tree planting project and across the lifespan of the tree.

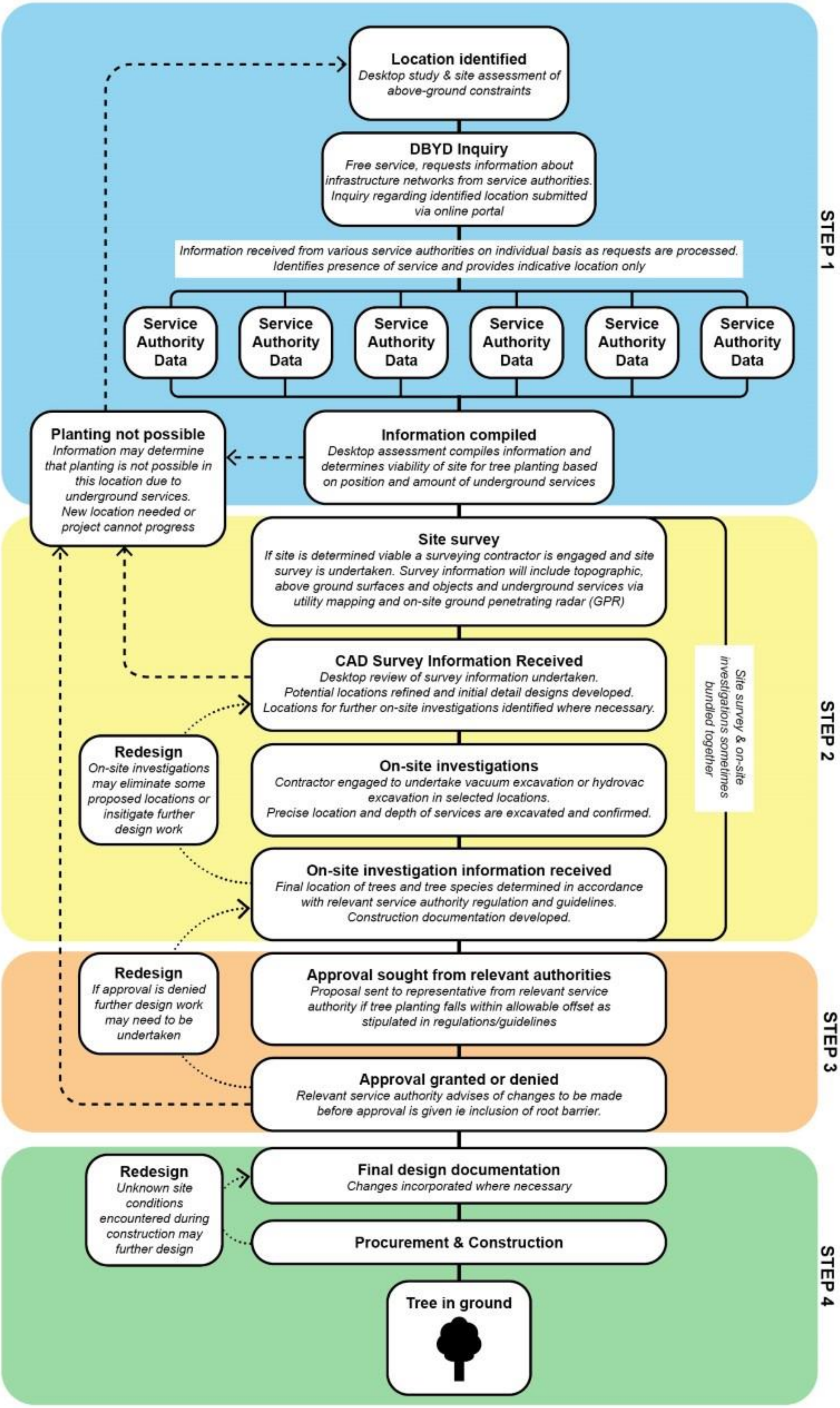

Figure 14: Flow chart illustrating the process of planting tree in Adelaide. (S.Rogers, B Meyer-Mclean) **
Note, this figure number was incorrectly labelled and this is the only change in Version 3

Step 1. Establish site details

Once a potential site is identified the process of establishing the details of the site begins. A desktop study establishes the aboveground constraints of the site. Lodging an inquiry to Dial Before You Dig (DBYD) initiates establishing the belowground constraints. Contact with the utilities from this point is then on an individual basis.

DBYD is a not-for-profit organisation that provides a free single point of contact to request information about the infrastructure networks at the planned project site without the need to contact utility organisations individually. The DBYD requested information is them provided from each service authority from their asset databases. This information generally comes with a disclaimer from each service authority, explaining that the location information provided about their assets is not guaranteed to be accurate, therefore necessitating that Council undertake their own verification of these assets before any works commence.

Step 2. Site surveys and onsite investigations

If the site is considered viable, site surveys are then undertaken by a surveying contractor. Information such as, topographic survey information, above and belowground surfaces, objects and services are located using utility mapping and onsite ground penetrating radar (GPR). Desktop investigations also review existing survey information in order to locate and refine detail drawings.

This is the time where more specific locations within the identified street are determined for onsite investigations to establish the precise location of underground utilities. To do so, **vacuum excavation** (*Figure 15*), otherwise known as ‘pot holing’, uses a high-pressure vacuum to remove soil to locate services under roadways, footpaths or areas that have limited access, removing the risk of damaging the infrastructure. **Hydrovaccing**, uses high-pressure water for the same purposes. These processes are also used to expose and determine the extent of tree roots around significant trees and to assess tree ‘root intrusion’ damage to utility infrastructure without damaging the tree or the infrastructure. Figures 15, 16 and 17 illustrate how vacuum excavation exposes utilities and tree roots without damage to the infrastructure or the trees.

Figure 15: Vacuum excavation to expose utility services in the city. Image: https://www.newcastlelocatingservices.com.au/vacuum-excavator-hire

Figure 16: Utilities exposed by vacuum excavation. Images: http://www.statewidehydrojet.com.au/sa/shj/main/hydro-excavation-adelaide/

Figure 17: Vacuum excavation used to expose tree roots next to a footpath. Image: https://southvac.com.au/hydro-excavation/

The process of vacuum excavation is expensive but vital because the utility infrastructure locations are not necessarily accurately documented on building or construction plans, making utility location a primary and expensive exercise for decision-making regarding where trees can be planted. Finding space in the often-congested space underground is further complicated when disused and unidentifiable infrastructure is found. This disused/unidentifiable infrastructure is unable to be removed because of the lack of knowledge about its potential network and the unidentifiable risks, such as leaks and contamination, therefore planting constraints continue to apply.

The information correlated in this step determines the site's suitability for planting trees ready for the next stage.

Step 3. Negotiation and Approvals

Proposals are developed with documentation of the accurate locality of utilities which are submitted to the appropriate utility authorities (i.e. up to 4 different utilities) where necessary. The process of negotiation with each utility authority begins. The section below outlines the different utility service requirements, demonstrating the complex environment in which these decisions and negotiations are determined. Whether proposals are approved or denied determines whether the process moves to the next step or goes back previous steps of onsite investigations or even ending the process altogether.

Step 4. Final design and tree planting

When there is approval from all the relevant service authorities, the final design is drawn, and the processes of procurement and construction are instigated.

Overview of the Utilities and Development Regulations Relating to Trees*[1]

Each of the utility services have different legislated and non-legislated requirements for planting trees near their infrastructure. These differences summarised below, *Figure 18* and Table 4, highlight the complexity of the process for finding space to plant trees according to utility protocols. SA Water sewerage (wastewater) assets and SAPN have an associated legislated plant species list of approved trees if planted at a specified distance (See Appendix 1: Schedule 2 and 3). *Figure 18* illustrates the different required distances (offsets) measured from the different utility infrastructures and the centre of the tree trunk. When trees have multiple tree trunks the measurement is taken from the central trunk.

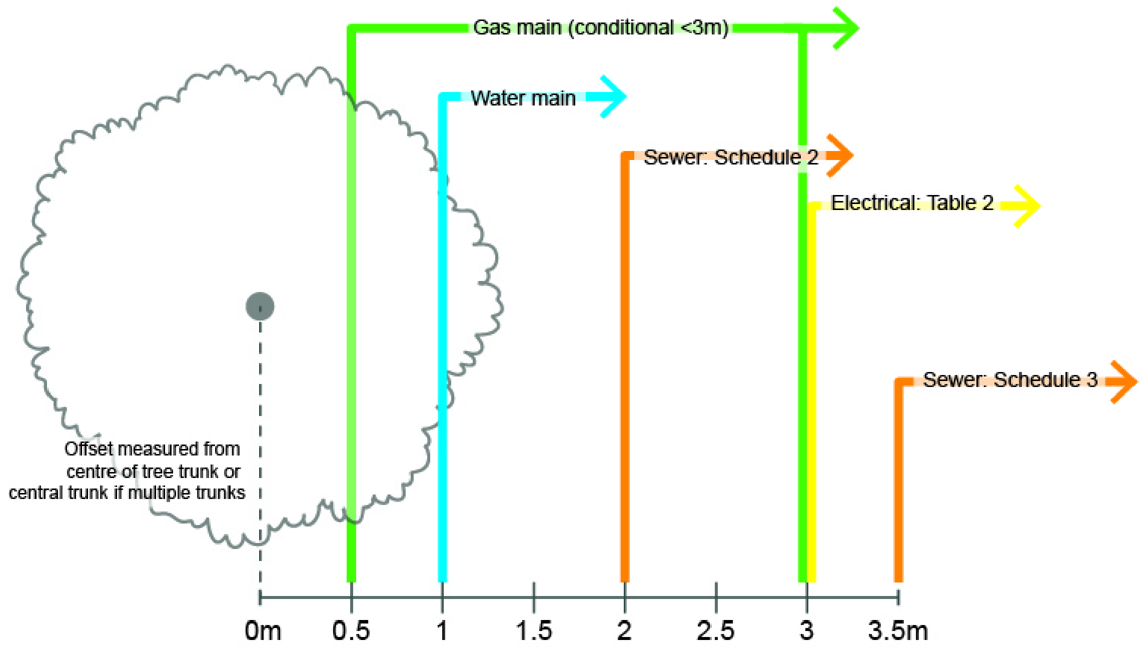

Figure 18: Underground utility tree planting requirements – offset between tree and utility service.
(S Rogers & B Meyer-Mclean 2021)

Table 4 provides details of the each of these utility requirements.

[1] **Note, this section has had minor reviews on 1 June 2021 to make this Version 2*

Table 4: Utility tree planting regulations

<table>
<tr><th>Utility</th><th>Distance of utility from tree centre (m)</th><th>Regulations</th></tr>
<tr><td rowspan="4">Gas (APA Group)</td><td colspan="2">No specific regulations regarding planting trees near their assets, however, this is their policy:</td></tr>
<tr><td>>3</td><td>There are no restrictions</td></tr>
<tr><td>0.5 - 3</td><td>Trees cannot be planted within 0.5 to 3 metres of a transmission pressure gas asset without approval.
Root barriers of robust permeable polyethylene or nylon sheeting or concrete cylinders are required and installed with specifications for approval</td></tr>
<tr><td>Minimum 0.5</td><td>No trees permitted to be planted</td></tr>
<tr><td>Water mains (SA Water)</td><td>Minimum 1</td><td>Approval is required for any trees planted closer than 1 metre to water infrastructure</td></tr>
<tr><td rowspan="3">Sewerage (SA Water)</td><td colspan="2">Written approval for any trees and shrubs (except those listed in Schedule 2 and Schedule 3) planted on public land that may affect any sewerage</td></tr>
<tr><td>Minimum 2</td><td>Trees and shrubs listed in Schedule 2 in the Water Industry Regulations 2012</td></tr>
<tr><td>Minimum 3.5</td><td>Trees and shrubs listed in Schedule 3 in the Water Industry Regulations 2012</td></tr>
<tr><td rowspan="3">Underground Power Infrastructure (SAPN)</td><td colspan="2">Any party intending to undertake civil works to a depth more than 300 mm below ground level shall contact Dial Before You Dig, and/or an equivalent on-site infrastructure location provider to have all cables and other infrastructure located</td></tr>
<tr><td>Minimum 3</td><td>Species listed in Table 2 in the Electricity Act 1992 and exempt vegetation</td></tr>
<tr><td colspan="2">Near an underground power line of 66kV or more, only trees with a mature height of less than two metres can be planted within three metres of the centre of the underground power line</td></tr>
<tr><td>Aboveground Power Infrastructure (SAPN)</td><td colspan="2">There are no restrictions for planting distances from infrastructure. There are 2 zones with tree height requirements. In bushfire risk areas or areas where lines are uninsulated – trees can only have a mature height of 3 m or less. In non-bushfire risk areas or areas where lines are insulated – trees can only have a mature height of less than 6 m.</td></tr>
<tr><td>Telecommunications (includes Telstra, Optus, Vocus Group, Nextgen Group, Primus Telecom, PIPE Networks, NBN)</td><td colspan="2">No specific regulations regarding planting trees near their assets, however, decisions are made on individual risk assessments.</td></tr>
</table>

APA Gas

APA Group, Australia’s largest natural gas company operations are underpinned by legislation that gives the utility the discretion to remove trees to protect or maintain their assets. This legislation effectively allows APA to remove or damage public trees without consent or assessment by a qualified arborist. According to the Gas Act 1997, APA can access and work on their infrastructure, including via excavation and removal of obstructions (including trees and vegetation) without prior notice or agreements for the purposes of an emergency or for maintenance, repairs, or minor extensions. Vegetation is viewed in terms of risk and the restrictions are based on the view that:

> *Vegetation may limit line of site, access and passage along an existing gas asset alignment, while the associated roots may damage existing buried pipe, coating or other ancillary equipment (e.g. cables). Above ground gas infrastructure may also be exposed to hazards from falling vegetation and increased fire risk (Gas Regulations 2012).*

SA Water

SA Water also requires approvals for planting trees within the vicinity of their infrastructure. In the case of water mains, tree or shrub planting within 1 metre of infrastructure is not permitted unless written approval are obtained prior. There are no planting restrictions for shrubs and trees planted more than 1 metre from water mains.

Sewage is more likely to encounter problems associated with tree roots finding joints and leaks and as a result have greater restrictions regarding planting near sewer infrastructure. There are two legislated tree and shrub species lists, the first (Schedule 2 in the *Water Industry Regulations 2012* – Appendix I) lists those species that can be planted minimum 2 metres from sewer infrastructure. The second list (Schedule 3 in the *Water Industry Regulations 2012*– Appendix II), lists those species that can be planted minimum 3.5 metres from sewerage infrastructure.

The *Water Industry Act 2012* similarly gives power to SA Water to excavate any land and remove or use any earth, stone, minerals, trees or other materials or things located on the land for the purposes of maintaining and developing their infrastructure. The *Water Industry Regulations 2012* also provide the framework for the planting restrictions on sewage infrastructure. The regulations are specific to the protection and use of infrastructure, equipment and water and gives powers in relation to installations and access to infrastructure and inhibits the planting of trees and shrubs on public land without approval.

SA Power Networks

SA Power Networks (SAPN) similarly requires approvals for planting within proximity of their infrastructure. For underground powerlines, planting trees is restricted to 3 metres offset. In relation to trees, the underground requirements only relate to their underground powerlines, however *The Electricity Act 1996* also legislates the power for the provider (SAPN) to acquire land and carry out work on public land for the purposes of installing, operating, maintaining, repairing, altering, adding to, removing, or replacing electricity infrastructure on public land and to carry out other work for the purposes of generation, transmission, distribution or supply of electricity. This includes excavation and the clearance of vegetation from and around powerlines.

For above ground powerlines they have restrictions associated with zones according to the fire risk of the area. In bushfire risk areas or in areas where the powerlines are uninsulated, trees can only have a mature height of 3 metres or less. In non-bushfire risk areas or areas where powerlines are insulated, trees can only have a mature height of less than 6 metres. SAPN has established the Appropriate Tree Species Lists which are focused on tree height and form and trees’ responses to pruning (they are not at all related to the root systems). Each zone above has a tree species list.

Telecommunications

The *Telecommunications Act 1997* is not specific about tree, or vegetation planting within the vicinity of their infrastructure, however, provide guidelines on a case-by-case basis from the DBYD process. The *Act* does legislate utility carriers to do anything necessary or desirable on, over or under the land, for those purposes of accessing, installing, and maintaining facilities, including, felling, and lopping trees, clearing, and removing other vegetation and undergrowth, and clearing land. The *Act* also gives power to providers (carriers') access to enter on, and occupy, any land, and the right to remove and dispose of soil, vegetation, and other material for the purposes of installing and maintaining telecommunication facilities.

Figure 19 depicts a plan view of the constraints that exist in relation to implementing trees in the urban context, where both above ground elements, such as footpaths, parking, roadways and street lighting, and the numerous underground utilities, and their required setbacks, must be considered.

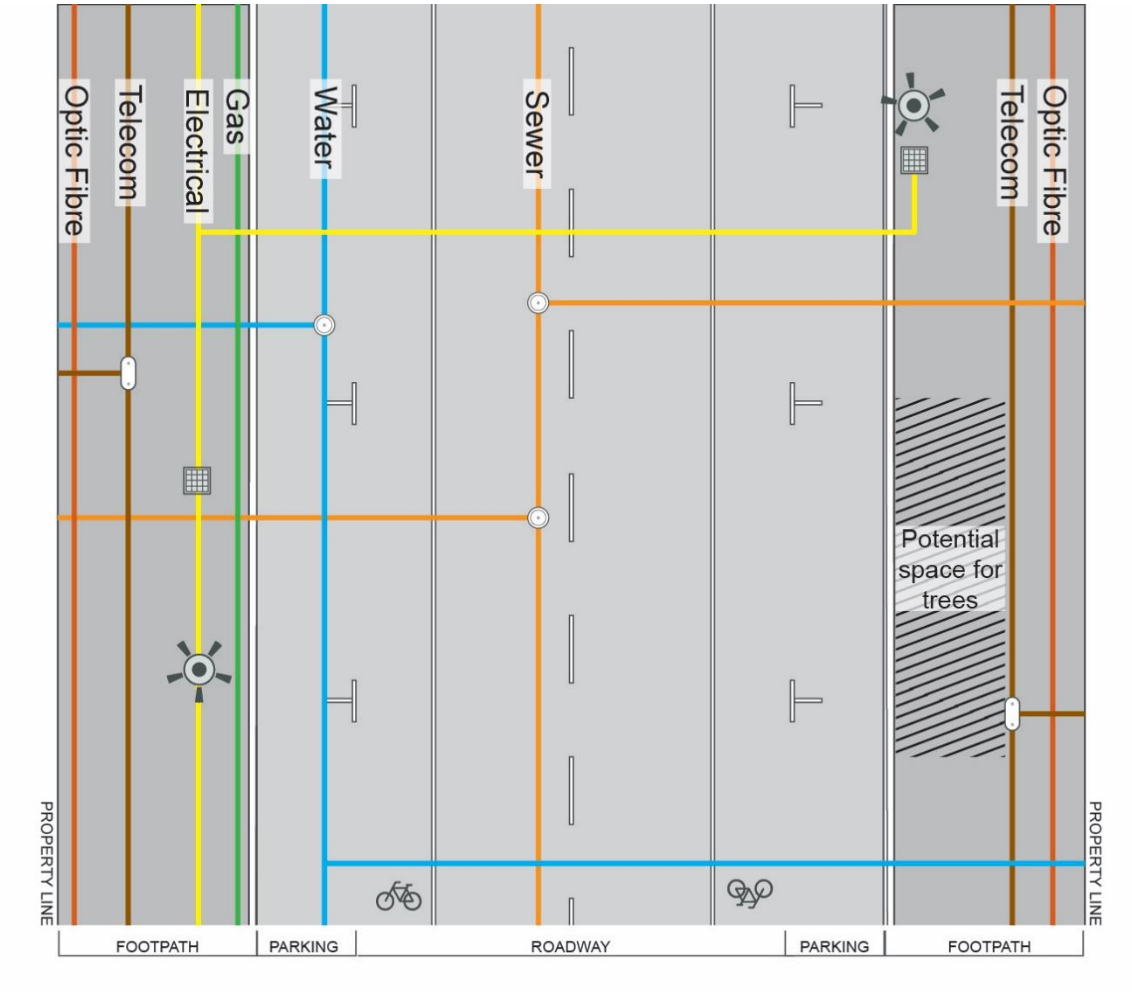

Figure 19: Diagram of typical underground services arrangement in roadways and footpaths with potential space for tree planting highlighted after all service authority regulations and guidelines have been considered.
(S Rogers & T Roe)

Protection of Existing Trees

There is no specific legislated framework to fully protect all existing trees from development or utility activities, and urban/city tree planting ratios or quotas, or tree canopy ratios are also not legislated in South Australia. However, the *Planning, Development and Infrastructure Act 2016* does provide statutory provisions for the preservation of 'significant trees':

> *(i) it makes a significant contribution to the character or visual amenity of the local area; or*
>
> *(ii) it is indigenous to the local area, it is a rare or endangered species taking into account any criteria prescribed by the regulations, or it forms part of a remnant area of native vegetation; or*
>
> *(iii) it is an important habitat for native fauna taking into account any criteria prescribed by the regulations; or*
>
> *(iv) it satisfies any criteria prescribed by the regulations; or*

Or a significant stand of trees:

> *(i) as a group they make a significant contribution to the character or visual amenity of the local area; or*
>
> *(ii) they are indigenous to the local area, they are members of a rare or endangered species taking into account any criteria prescribed by the regulations, or they form, or form part of, a remnant area of native vegetation; or*
>
> *(iii) as a group they form an important habitat for native fauna taking into account any criteria prescribed by the regulations; or*
>
> *(iv) as a group they satisfy any criteria prescribed by the regulations,*
>
> *(and the declaration may be made on the basis that certain trees located at the same place are excluded from the relevant stand).*

The definition of a significant tree according to the *Planning, Development and Infrastructure (General) Regulations 2017* is a tree that:

> *has a trunk with a circumference of 3 m or more or, in the case of a tree with multiple trunks, has trunks with a total circumference of 3 m or more and an average circumference of 625 mm or more, measured at a point 1 m above natural ground level.*

The *Act* does, however, give power for the removal of any trees (including significant trees) to protect buildings and persons, so far as is reasonably practicable, be undertaken to cause the minimum amount of damage to the tree and have received the appropriate development authorisation. Also, the powers given to the developers and utility services to remove trees and vegetation, and excavate land for the purposes of development, and the development of utility services outlined above, are used to remove existing trees, including significant trees.

There is also the Australian Standard: AS4970-2009 Protection of Trees on Development Sites which:

> *provides guidance for arborists, architects, builders, engineers, land managers, landscape architects and contractors, planners, building surveyors, those concerned with the care and protection of trees, and all others interested in integration between trees and construction.*

This document provides best practice standard framework for planning and protection of significant and regulated trees on development sites and is an effective means of protecting space for trees in Australia. The document provides advice on planning and the tree management processes, including determining tree protection zones and other tree protection measures, and planning, construction, and post-construction tree protection strategies. This is not a compulsory standard and therefore is not consistently applied for all trees. For example, SA Water has adopted the standard for regulated trees, but not any other utility providers (to the knowledge of the authors at the time of writing).

Summary of Stakeholder Consultations

Consultations were conducted with a comprehensive range of stakeholders. The stakeholders included landscape architects in private business, academics working in engineering, horticulture, and arboriculture, TREENET representatives, local government landscape architects, arborists and asset managers, and utilities representatives (SAPN, SA Water, APA gas). The stakeholder consultations showed a willingness to better understand the issues in finding underground space for trees in city and urban spaces. Table 5 presents eleven key subject themes produced from these discussions; (i) that there is a problem, (ii) viewing trees as risk, (iii) the value of trees, (iv) inadequate knowledge in decision-making processes (v) the prioritisation of assets, (vi) the old utility infrastructure in Adelaide, (vii) the costs of putting trees into the ground (viii) community understanding, (ix) the political influence in decision-making, (x) the problems associated with tree planning, development, and management, and (xi) opportunities for tree planning, development, and management.

Table 5: Key themes of discussion from stakeholder consultations

There is a problem • All stakeholders identified that there is a problem with trees and utilities and planting urban trees. The divergences from this point of view related to each stakeholder's position. • The utilities representatives saw trees as risk to their assets, and the problem therefore was the tree (and tree roots). They all commented on how City of Adelaide plants trees close to their assets without consultation and then there are problems, and the trees must then be managed. Council, therefore, causes the problem by planting the tree in the first place. • Council representatives presented the problem as relating to the confusing and inconsistent restrictions for planting trees (navigating the approvals of multiple players), as well as the individualistic approach to utility development. • Trees are primarily seen in terms of risk, therefore efforts to preserve and support planting of trees aims to minimise risk in planning and development rather than accommodate for existing and new trees. • There is no foundational legislated framework to support an urban forest. • Trees are not valued in the same way as other utilities. • Arborists represented the problem from the trees point of view and saw the problem is more about the lack of consideration of trees in planning and development. • Trees are seen as a way of solving problems and expected to perform in a space that is not meant for trees. The space needs to be made better for trees to survive and then they will perform – they will not solve the problem on their own. Urban, especially city spaces, are harsh environments for trees to survive in and so they are doomed because there is little investment into their survival and therefore their ability to perform. Given the harsh environments, trees will seek the nutrients and moisture to survive and that often coincides with utilities which consolidates the thinking that they are the problem.
Trees viewed in terms of risk • Trees were often framed in terms of risk, or risk-related terminology, particularly that they cause damage.   o Tree roots grow where they want and do significant damage to infrastructure. • When the utilities go to fix/work on their infrastructure, they risk damage to trees (here the trees are in the way).

• Termites from nearby trees affect infrastructure (it has been found that termites are attracted to and have in some instances begun to eat through the poly coating around the steel pipelines and so exposing the pipes to the elements) • A lack of diversity in street trees – smaller varieties or species creates risk of pest and disease – ideally there should be no one tree species over 10% of the total tree population. The risk is loss of a large number of trees at one time which would create a significant challenge to replace. • Asset strike –when people start digging into a site and strike and damage a utility asset. • Fundamentally, trees are a risk, but we need to put that into context – that we have risks all over the place. Tree risks, therefore, need to be put into perspective and we should work harder at saving trees and reducing those risks. • There is a lack of evidence supported by data regarding infrastructure failure caused by tree roots.
The value of trees • There was a consensus that trees are important. All stakeholders recognised the values of trees – particularly in relation to the UHI effect, habitat and biodiversity and water management. • For the utility representatives, this level of importance, however, did not surpass the value of their assets. • In contrast, one stakeholder argued that they are fundamental for life; if you do not have vegetation you do not have planet earth and that humans have evolved with a close association with plants (of which Indigenous people have a better understanding). We absolutely need them for the quality of life that we aspire to. • Another comment (particularly those stakeholders that are speaking from a horticultural or arboriculture background) is that trees are not valued within the Australian culture like they are in other cultures. Two people used Spain, as an example of the way trees can be valued differently within cityscapes – for example, care and maintenance required to have them well pruned and looking great to enhance the cityscape whilst also performing as cooling agents within the city. • Trees in the city and built-up areas have a greater impact because they affect a greater number of people.
A perceived lack of knowledge about trees in decision-making • There is a lack of knowledge about trees and their interaction with infrastructure within the context of growing conditions in cities. • Many of the problems associated with Adelaide's trees are because the trees are old as is the infrastructure. Any knowledge about trees in Adelaide is limited to the age of the tree within the urban spaces and there have been limited tree species used in Adelaide. Therefore, the knowledge is constrained to those tree species. As the trees grow older, so too the problems arise because of their interactions with services which gives rise to the views of certain species as problems. There is really no longitudinal research in Adelaide into the impacts of trees with infrastructure because you need to do that research over an extended timeframe – decades. • A tree's expected performance is based on optimal growing conditions. However, urban and city tree growing conditions are principally below optimal and trees will therefore not perform in the same way. For this reason, species lists are not helpful, because they are all based on optimum growing conditions. Many examples of this exist within in Adelaide, such as Fraxinus trees (Ash) planted in North Adelaide. These trees are approximately 100 years old and if they had been planted in ideal conditions they would be double the size they are currently.

- Multiple comments were made about the various levels of decision-making not having appropriate knowledge in relation to trees:
    - Many decisions about trees given to arborists are appropriate when the decision relates to a tree's biological/physical condition, however they are not necessarily qualified to make decisions based on their environmental/habitat/biodiversity impact.
    - Landscape architects don't necessarily have an in-depth knowledge of tree species, and their appropriateness within a certain space/conditions.
    - Overall decision-making needs to be flexible and adaptable, not require black and white answers (i.e., specific lists of species that are perfect for all conditions, as there'll be 0) (but more often than not it is not flexible)
    - Engineers are often the primary advisers behind utility asset requirements and arborists are not necessarily consulted at all – however, SA Water and SAPN have made improved.
    - The challenge for local governments is that it's often the number crunchers (accountants and business managers) that make the final decisions about trees, but they don't have the knowledge to be making the decisions.
- With proper expertise there can be the necessary understanding to be able to have some flexibility with decision-making so that good decisions about what trees/where can be made.
    - Some of the service provider representatives noted the benefits of expertise that have informed changes and improved their business operations.
- The representatives from SAPN and SA Water demonstrated their company's efforts to improve their business operations by consulting with a range of experts:
    - Over the past 7 years SAPN has engaged in efforts to improve public relations in terms of vegetation management. To do so they have set up advisory groups, the Arborists Advisory Group to bring expertise to improve the company's decision-making regarding trees, a Local Government Working Group to advise on improved relations with local councils, and a Customer Consultative Panel to improve customer and stakeholder relations.
    - To improve relations with local councils, SA Water has adopted the AS4970-2009 Protection of Trees on Development Sites and is investing in working trials with councils when the pits are open to put in root barriers and water inlets to protect their infrastructure, and trials where they are looking into tree species and how they interact with the pipes by cross-referencing species with the damaged pipes. They have also developed a tool to provide council planners a reference guide to their service locations to quickly choose locations for trees without needing specialised GIS experience or software.
- Trees are considered invasive by utility providers, but trees do not naturally grow in isolation and in compacted polluted soils. For a tree to survive in an urban (street) environment, it must be invasive. To plant less invasive trees there needs to be a more concerted effort to consider and provide more ideal space for them to grow in. Because of this, the idea then of suitable species lists is a misconception (either they need more nurturing/management to perform as expected, or they need to be 'invasive' to survive) and also highlights the importance of preserving and improving space for trees.
- Blanket rules regarding trees are a problem and are not a solution. There are so many variables and there is not enough knowledge about trees in Adelaide to be able to make long-term effective decisions.

• Trees are not the baddies! But trees go to the place of less resistance and there is a lot of sand and water to access in services trenches. Therefore, there is no one tree that is not going to be a problem.
The prioritisation of assets • Each of the utility service provider representatives (gas, water, and electricity) spoke about the importance to them about protecting infrastructure, which they described as their assets. They approach each development/tree planting proposal from the perspective of protecting their assets. All of them expressed a keenness to work to improve working with councils and an extension of this project if it means they can help to protect their assets. • At this point Dial Before You Dig is regarded as the go-to for asset protection for utilities. • Council representatives were frustrated that the utilities are not necessarily adequately restoring work sites, the cost of which is placed on Council; a principal that also applies to trees. When trees are damaged/removed by the utilities, it is still up to Council to replace that tree, which is often impossible. • The guidelines regarding trees are written by the Institute of Public Works Engineers Australia which only see trees as risks. Therefore, with the asset management systems, the trees are not valued as other infrastructure is, and all the other range of values from trees are not measured when considering them as assets. • There is no obligation for the utilities to consider or put in infrastructure to protect their services – the expectation is that Council will pay for it all. • It is a one-way street – services only looking after their own assets; however, council must consider it all (i.e., all the assets underground, above ground, water runoff, pedestrian access, creating public amenity, greening, lighting, safety etc). • Trees were also described as assets by City of Adelaide representatives; they are costed and viewed as an attribute to the city (i.e., trees are used to draw people to spaces – particularly in 'target spaces' where people can move in amongst them). Notable, although trees are spoken of as assets, they are not thought of in the same regard as hard infrastructure assets.
Old infrastructure in Adelaide • The old and often failing infrastructure is seen as a problem across the board. This is particularly so with sewage, there has not been a consistent and cohesive system for the placement of utilities, therefore the utility infrastructure in Adelaide is dense and complicated. The cost to address this problem is viewed as incomprehensible.
The costs of putting trees into the ground in the city • You can't just dig a hole in the city. The cost of putting trees into the ground is a principal issue that applies to the city - the fact is that it is more costly to plant trees in the city, predominantly because of the processes involved in establishing the space availability at any given site (finding, negotiating, and actually physically getting the space that caters for all of the requirements and considerations within that space, including the expensive and often numerous onsite investigations and onsite surveys) but that makes it hard to find funding to plant trees (a lot less trees for a lot more money). • People don't necessarily fully understand these costs in relation to planting a tree in the city or reconcile that cost with the full value of the tree. • Councils always have problems with tree maintenance – irrigation, filters, pruning, regulation assessments – all of these create points of opposition that are driven by finance. The economic benefit and the long-term benefit and costs are lost in these points of opposition because they are not as quantifiable.
Community understanding about trees

• There are reasons for making decisions around trees and the development of tree species lists (massive trees under a powerline is not going to work) however, people need to understand why certain decisions/management approaches are made and they need to have access to that information. Getting that information out to the community is really important to gain public acceptance about tree management. • People oppose trees for a range of reasons but often it's generally a situation of yes, we want more trees, just not in my street/back yard. Humans respond to trees from their own biases, and therefore, trees will be a problem from a range of different perspectives.
The political influence in tree-related decision-making • Politically, there is motivation to plant the trees, but then it is all too hard because it is so difficult and expensive. There is no funding through the acts and regulation spent on R&D but there is a lot that can be developed in this space, if there was that would improve the longevity of infrastructure, management of storm water, and greening cities. • Principally, there is nothing that will protect trees in the long-term because of the political nature that trees exist in. The governing and decision-making is often political and also often driven by public opinion. • The issues around trees become political and whoever is making the decisions at the time determine the outcomes. • Trees are impacted by humans and the problems with trees are framed by humans.
Problems associated with planning, development, and management • The management of utility services is inefficient and there should be an effort to converge and manage our services underground. In this context, the use of trenching was also referred to as archaic and instead, existing tunnelling technology could be used to tunnel underneath tree roots. Therefore we should be able to pull together all services in a common utility box or tunnel. Hindering this progression is an attitude about using the trenching from the engineering infrastructure side– that it has always been done this way. • It is astonishing that development projects still engineer with the assumption that there are no trees. Engineering standards need to evolve. There are different approaches being developed and so there are ways forward. • Drought management is a problem because trees are not looked after during extreme and long dry periods – such as the millennium drought, where many street trees were cut down because there was a perceived concern about water requirements and that they would be a strain on water supplies, which was argued to be a misperception. • A key reason street trees are lost is due to the increase of subdivision within urban spaces (such as dual occupancies) which means that street trees are cut down to make way for the increased number of driveways. • Utilities felt that their assets are not thought of initially in development designs and that developers/designers are less inclined to allow for their spatial requirements and as a result, problems occur with the trees – hence the need for their removal. Considering the requirements in the planning phase reduces the need for the utilities to step in and manage the situation. • Trees are not necessarily considered in the development of utilities. • Infrastructure is built to fail, especially when trees aren't taken into account in the planning, but trees are blamed for it. Trees go where the water is and that is often

where the sewer chokes (blockages) are – work needs to be done to work out solutions for these problems, not just blame trees.

- Utility services rarely collaborate, and are rarely on site at the same time, instead work independently.
- Asset management timelines are not coordinated. For example, the NBN know when they are rolling out their asset operations – but that information is not necessarily shared with council to be able to coordinate other operations in line with those timelines.
- When coordination does occur, utilities may contract the work out to private companies and undertake work that go against agreed plans (private contractors are not necessarily informed) and changes may be made onsite without informing council.
    - There are no consequences for these irregularities and therefore the utilities do not care.
- Council planners/designers are willing to design around all of the utility infrastructure and make sure that everyone is happy but feel that services are always the complexity in any situation, and that it is up to council to fit in with everyone else.
- Designing to fit in with utility requirements is often expensive.
- The rapidity of development and the influence of developers has led to trees being at risk.
- The focus is wrong – trees are not seen as something to be preserved for the long term and are therefore dispensable. Trees should be seen as part of the project that needs to be worked around (a given) and therefore the problems around trees will be worked out because you have to. When they are dispensable, they are not taken into consideration.
- Growing canopy and achieving targets first requires the protection of existing trees due to high mortality rates and the recognition of their conservation value to protect intergenerational assets. Large, long lived trees provide the greatest environmental services and carbon sequestration, but they are being replaced by smaller trees with a life expectancy of less than 30 years – the replacement value is uneven.
- Many projects are approached by landscape architects and developers with a mindset that trees are replaceable – North Terrace and Adelaide Oval are good examples. Landscape architects decide to remove 100+ year old trees from projects because of their aesthetic (looking scrappy).
- Trees affect every government department, and in that way, they are a wicked problem.

Opportunities for planning, development, and management

- The use of plant boxes that raise the level of the planting space above the road/path surface, something that is not done so much anymore, but used to be used much more in Adelaide. This increases the amount of medium, increasing the space available for trees to grow in.
- Using climbing plants on buildings, which has been found to not cause structural issues in buildings but have the same cooling effect on buildings.
- Incorporate, or incentivise the incorporation of passive watering systems into road/footpath infrastructure. Using alternative forms of paving and passive watering, storm water flows, and the effects of flooding are reduced because water is taken away from floodways, as well as the benefit of improving groundwater levels and providing water for trees.

- Using gravel medium as a buffer/ barrier for tree roots – new research
- The use of pruning trees, such as espaliering, pleaching or pollarding[2] so that they fit in the confined spaces, but still provide the cooling effect needed. The problem with these approaches is they require a higher level of management with regular pruning.
- Rooftop gardens. A critical note regarding rooftop gardens in Adelaide is that there is no incentive for developers to design buildings in the city that accommodate rooftop gardens and then retrofitting is expensive, so they do not get done.
- Being innovative/experimental with tree selection. This will increase the number of tree species in the city, but also increase the understanding of what species do and do not work.
- Watering systems for trees to establish in the first few years.
- Use the Waite Arboretum as a resource for trees in Adelaide. The trees here are not watered and live in relatively difficult conditions.
- Ensure collaborative process are used – don't make decisions in a hurry. Time should be taken to make decision and discussions with those that have the knowledge should happen before decisions are made. Tree planting and removal decisions are often made in haste without consultation.
- Council landscape architects seek dispensations with the utilities so that they can design systems to protect the utility, and at the same time, create more space for the tree to grow successfully. The idea is that with individual projects, some flexibility can enable the creation of space.
- If the tree is given the right conditions, they are not likely to cause problems. Service authorities see the tree roots as 'out of control', but we can control them by giving the tree the right conditions to grow.
- An Adelaide Tree Advisory Board which would provide the required expertise for decision-making about trees in Adelaide. It would provide an informed view and an unbiased view and consist of tree professionals, horticulturalists, arborists.
- City of Melbourne is doing particularly well because there is good leadership and great quality of staff. The urban forest strategy is good and influential with other metropolitan councils. The Council has a strong position because the land they manage is significant and they are not scared to take on the utilities which sometimes leads them to going to court. The importance of that is that although they do not always win, the issues they are bringing to the fore become public issues which is a good thing.
- Places that have embedded strategies for trees have increased tree canopies. New York and Vancouver are good examples of cities with good policies in place

[2] Pollarding, pleaching, and espaliering: pruning systems used widely in Europe that promote the growth of a dense tree canopy foliage and shape branches and to maintain trees at a determined height and frame and which enable a range of trees to be grown in more contained spaces.


Pleaching


Pollarding


Espaliering

regarding trees. New York has costed each tree in the city which has meant that each tree has a monetised value (in terms of all the benefits) which then affects development decisions regarding trees in that city. Vancouver has a tree strategy that involves a mandated volume of soil per tree so that each tree that is planted has sufficient soil for it to survive in which has been complied with well by developers etc and it seems to work well.

- Need to consider what is real in terms of long-term benefits, not just in terms of budgets, because that will always result in cheaper, short-term outcomes.
- There was an expressed willingness by the utility providers to work with councils in a positive way to make sure that trees get planted and collaborate to work out how trees can be planted when near their infrastructure rather than just plant and then have a problem later down the track. SA Water for example, is in the process of rolling out an online tool to help planners establish where their assets are. They are also starting trialling working with councils when the pits are open to put in infrastructure to protect their infrastructure by putting in root guards and inlets to passively water the trees, and other research into tree species and how they interact with the pipes – cross referencing species with the damaged pipes.
- Add trees to the DBYD process – i.e., contact the council and see if they had earmarked a streetscape for new/replacement trees, and looking at existing trees

Discussion: The Challenges and Opportunities for Finding Spaces for Trees

The challenges related to planting trees in Adelaide’s urban and city spaces listed by the stakeholders in this project are testament to the extent of the problem. Many of the problems relating to trees and infrastructure identified are widely known and anticipated in metropolitan developments worldwide (Jim 2003; Jim & Chan 2016; Randrup et al. 2001a; Randrup et al. 2001b; Slater & Chalmers 2020), such as tree roots interactions with sewer pipes (Kuliczkowska & Parka 2017; Randrup et al. 2001b; Ridgers et al. 2006; Torres et al. 2017). However, many of the problems are site specific (Randrup et al. 2001a), and using the example of Adelaide, is an opportunity to highlight specific problems to achieve local tree canopy targets.

Examining South Australia’s legislative framework highlighted the complex landscape shaping any planning for an urban forest in Adelaide. Despite the policy goals and targets, backed up by the well-understood values of trees in cities (demonstrated in the literature review), it is evident that there is no robust framework to specifically support those goals and targets coming into fruition. The value of the utility services, fundamental to supporting expectations of contemporary society, is underpinned by the strong legislated frameworks which support their management and development. However, within those legislations, there is little to consider trees outside of them as a risk concern. Furthermore, because trees are framed as ultimately expendable, there is no incentive for the utility providers to either protect or consider trees within their development or management operations. Any work by the utilities to consider the protection of trees is driven by their own motivations to protect their assets, not because there is a need or that they are required to by law to support the planting of trees in the city/urban public spaces. Moreover, the policy targets and goals have no regulatory provision for the development of tree planting in Adelaide.

Without robust regulation the policy targets and goals can be seen as tokenistic, because with no such framework, putting them into action is a very difficult exercise, and as such, a disincentive. For example, the convoluted process of finding space to plant trees in Adelaide, illustrated above (*Figure 14*), is a central challenge for the City of Adelaide (and other similar built-up local government areas) meeting the canopy targets. The fact that so much time, effort and cost go into establishing a site’s viability is a real barrier to getting trees into the ground. The excessively high costs involved in finding spaces to plant trees in the city compared to metropolitan councils is a hard sell in grant applications and adds to the financial strain on council to meet targets. Also, the vast range of problems identified in the stakeholder consultations underscore the multifaceted scale of why the tree canopy in Adelaide is at risk, and why reaching the canopy targets is increasingly challenging.

Needless to say, trees have risk associated with them, which not only require consideration, but as highlighted strongly in the stakeholder consultations, require better understanding, particularly in the Adelaide context. This project has revealed a concern that decision-making systems do not sufficiently use existing knowledge or seek to expand what is known. The recent work by SA Water and SAPN, driven by their own business bottom-lines, emphasise that having adequate understanding and expertise about trees makes business sense. In this way, the utility providers are demonstrating a concerted effort to improve their knowledge, and thus their operations concerning trees. The problem here lies with the fact that knowledge building is framed by industry desire to preserve their assets rather than focus on solving the problems of preserving trees and supporting tree canopy growth within city and urban spaces per se.

At the moment, in South Australia, there is no overarching research initiative or funding to develop a better understanding of how to find ways to support the preservation of existing trees and increase the tree canopy in Adelaide. Any research progress, such as the vital work exploring engineering solutions for passive watering trees being undertaken in Adelaide, is supported in an ad hoc way by individual local councils and university research institutes. There are therefore missed opportunities impacting the broader metropolitan area more comprehensively. The limited literature demonstrating working governance mechanisms and planning, and design possibilities resolving existing underground spatial and contested interest issues further highlights that there is no silver bullet to roll out city/metropolitan tree canopy targets.

This project also highlights that there is a highly political aspect to planting trees in cities and urban spaces. Trees are at the centre of decision-making that is based on a range of perceptions and biases. In general terms, governments focus on cost, engineers on hard structures, utilities are biased towards their assets, landscape architects focus on public amenity, and arborists on a tree's biological and physical attributes. Public opinions vary between appreciation of the aesthetic of trees, fears of risk and the mess they make, conservation of indigenous species, and urban biodiversity. Moreover, there is an overarching view that trees are dispensable which has meant that many trees have unnecessarily been cut down.

The decision-making that affects trees often fails to consider appropriate species that suit the limited space. In regards to preservation of existing trees especially, it can often fail to consider the full range of their value and benefits, such as carbon sinks, habitat value, or public health benefits. Despite some protections for significant and regulated trees, these can be overridden, and there is nothing in place to protect trees under a 200 mm trunk circumference, with only certain species capable of reaching this size. Therefore, it would be beneficial to review who is making and why decisions are made regarding trees, and whether those decisions support or inhibit Adelaide's urban forest.

But despite the long list of problems, the consensus that there is a problem and the willing participation by a wide range of stakeholders in this project denotes that there is interest to engage in and find solutions. Importantly too, the stakeholder consultations also presented a range of possibilities to address those problems and find ways and means to increase Adelaide's tree canopy.

Fundamentally, many of the problems presented above have foundations in the fact that the tree canopy targets have no legislated backing. Trees as a legitimate urban structure / asset is also not legislated. The only legislated protection for trees relates to 'significant trees in the *Planning, Development and Infrastructure Act 2016.* Although an important legislation, it affects a limited number of trees and there are ways that can be found around it to still cut down and remove significant trees for urban development and utility related projects. There are examples of successful legislated structures which could inform ways in which to put in such a framework. The limited timeframe of this study meant that case studies of other examples of city's tree canopy efforts were not analysed. Further study into case studies, such as the examples highlighted in the stakeholder consultations, New York, and Vancouver, would provide a range of possible strategic frameworks that could incentivise problem solving abound finding space in which to plant trees.

The issues around knowledge highlighted in the stakeholder consultations related to decision-making systems and community understanding, but above all, there was a strong perception that there is not enough known about trees specific to Adelaide. The perceived need to improve knowledge extends to all aspects of putting trees into the ground, including developing systems to allow for and support trees within hard infrastructure and to include trees within utility development. Creating incentives to problem solve leads to significant opportunities in research and development to create new and improved ways and means to support urban tree planting. These opportunities lie in both new and existing understandings. The existing research and development into passive watering and water management development described above is a great example of what could be supported by a legislated framework and fostered more broadly across metropolitan Adelaide. Existing planning and design possibilities already adopted in Adelaide and in cities worldwide also provide a plethora of options to inform decision-making.

Conclusions and Recommendations

The qualitative data presented above demonstrates that finding space to plant trees in a metropolis is a difficult undertaking. This report provides an opportunity to present the multifarious issues at play in undertaking planting trees in the city and broader metropolitan Adelaide. For the city, the space underground is physically congested and contested by numerous and often conflicting interests. Moreover, the number of factors that inhibit and complicate decision-making are made more difficult because of a lack of overarching frameworks that support the planting of trees. In presenting these issues, the opportunities are also highlighted and provide potential ways to resolve the problems at hand. The following recommendations provide ways to consider the range of issues raised in this study in future decision-making regarding tree canopy targets to resolve some of the problems with finding space to plant trees in Adelaide.

Key Recommendations

Legislation supporting the preservation of existing trees and urban forest development

It is recommended that the tree canopy targets be strengthened by legislation. Legislation that places trees as assets and specifically directs urban tree protection and planting trees in urban public space would provide a foundation to protect and promote urban forest development in Adelaide. Legislation would also provide the impetus for urban and utility development to include measures for trees and incentivise research into solutions that enable planning and development that takes trees into account.

Decision-making standards for trees in Adelaide

Another recommendation is for the development of standards for decision-making concerning all trees within the city/urban public spaces that can be universally adopted by councils, developers, and utilities. The standards would guide decision-making in relation to city and urban development, and utility management and development. Moreover, establishing a site-specific framework for Adelaide would not only give substance to the tree canopy targets in place, but also be an exemplar for successful rollouts of those targets. These standards should be a coordinated and collaborative effort, informed by all key stakeholders, including, tree experts proficient in horticulture, arboriculture, and conservation and biodiversity; hard structure experts (engineers, architects, landscape architects, planners); representatives from all utilities and developers; and government (state and local).

Research and development into urban forest development

Support for multi-disciplinary local research and development into the range of issues relating to trees is imperative to ensuring strong frameworks can be put in place, decision-making is properly informed, and trees can grow and perform in the way intended when they are planted. The success of planting trees hinges on their planting environments and so it is important to support research into how to better provide adequate water, nutrients, and enough space for them to grow within the Adelaide environment.

Other important research areas include:

- Creating best practice standards for urban planning and design that considers trees.
- How to improve engineering and architectural design to consider trees.
- Engineering solutions for utility development that considers trees and retrofitted solutions to protect existing infrastructure.

Collaborative and well-informed decision-making

Decision-making should reflect the range of stakeholders that affect and are affected by decisions made regarding trees. This report shows that the range of issues related to trees tap into different stakeholder interests and knowledge. The many different voices that affect trees calls for a multidisciplinary collaborative approach to tree management. The stakeholder consultations revealed a range of methods undertaken by the utilities to improve their dialogue with councils, demonstrated that maintaining productive, collaborative dialogue between stakeholders results in better outcomes for all parties. However, it is important that decisions about trees are not driven by one agenda. Equally, it is important that decisions are appropriately and expertly informed. Protecting and managing existing trees and planting trees that will thrive and perform requires specific knowledge capabilities. Moreover, problems solving around issues between trees and infrastructure requires certain knowledge and capabilities. The idea of an Adelaide Tree Advisory Board broached in the consultations is one way that may provide unbiased tree related expertise into decision-making. Whatever approach, adopting a more consultative and informed approach to decision-making allows for those broad spectra of ideas and expertise to be considered in planning and development.

Funding to support research and development and to cover the costs of planting and managing urban forests

The above recommendations require funding. If urban forests are to be valued, they need to be invested in. This includes funding management and development of city and urban treescapes and in research and development. This project identified many of areas relating to trees that should be better understood, but for a concerted effort to fill those knowledge gaps (particularly to finetune these understandings to Adelaide) they will need to be funded. Moreover, anecdotal evidence has been given that suggests that the City of Adelaide requires substantially more funding than the metropolitan councils.

Planning for trees in the long-term

Long-term planning for trees is an imperative. Preserving what exists and looking to the future when planting new trees will address the risks to tree canopy in Adelaide. Many of Adelaide’s street trees are relatively short lived (30 years), contingency plans will need to take the renewal of these trees into account.

Expanding this study

This study was a small step towards better understanding the issues relating to putting tree canopy targets into action by exploring the spatial problems for planting urban/city trees. The small scope of the study had several limitations, particularly, that there was not time to undertake case study analyses of other cities that have successfully rolled out tree canopy targets, and/or put into place legislation for trees. Another limitation to this study, is that there was no scope to examine the value and culture relating to urban trees in Adelaide. Such an examination would help to inform tree canopy strategies and areas to shift cultural expectations to support urban forest development. The first three recommendations also provide an opportunity to expand this study into possible legislative frameworks and the collaborative development of an Adelaide specific standard for urban forest development.

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Appendix I: Table of Tree Species that are listed under the Water Industry Regulation 2012 and the SAPN Vegetation Around Powerlines Protocol

Latin name	Common name	WIR 2012 Tree List Schedule 2	WIR 2012 Tree List Schedule 3	Bushfire Risk Zone Tree List 1	Bushfire Risk Zone Tree List 2
***Abelia* species**				v	
***Abutilon* species**				v	
Acacia acinacea	Gold Dust Wattle			v	
Acacia acuminata	Raspberry Jam Wattle		v		v
Acacia anceps				v	
Acacia aneura	Mulga				v
Acacia argyrophylla	Golden Grey Mulga				v
Acacia brachybotrya	Grey Mulga			v	
Acacia calamifolia	Wallowa Wattle				v
Acacia cardiophylla	Wyalong Wattle			v	
Acacia cultriformis	Knife Leaf Wattle	v			v
Acacia cyanophylla	Orange Wattle		v		
Acacia cyclops	Western Coastal Wattle	v			v
Acacia dodonaeifolia	Hop-leaved Wattle				v
Acacia drummundii	Drummond Wattle			v	
Acacia glandulicarpa	Hairy Pod Wattle			v	
Acacia glaucoptera	Flat Wattle			v	
Acacia gracilifolia					v
Acacia hakeoides	Hakea Leaved Wattle				v
Acacia howitii	Sticky Wattle	v			
Acacia iteaphylla	Flinders Range Wattle	v			v
Acacia ligulata	Umbrella Bush				v
Acacia longifolia	Sallow Wattle				v
Acacia microbotrya		v			
Acacia microcarpa	Manna Wattle			v	
Acacia myrtifolia	Myrtle Wattle			v	
Acacia notabilis	Notable Wattle				v
Acacia oswaldii	Umbrella Wattle				v
Acacia pendula	Weeping Myall		v		
Acacia pycnantha	Golden Wattle				v
Acacia retinodes	Wirilda	v			
Acacia rigens	Nealie				v
Acacia rotundifolia	Round Leaf Wattle			v	
Acacia salicina	Broughton Willow or Wattle		v		
Acacia sclerophylla	Hard-leaf Wattle			v	
Acacia sophorae	Coastal Wattle	v			v
Acacia sowdenii	Western Myall	v			
Acacia spectabilis	Mudgee Wattle				v

Acacia suaveolens	Sweet Wattle				v
Acacia terminalis (A. elata)	Cedar Wattle		v		
Acacia trineura	Hindmash Wattle	v			v
Acacia verniciflua	Varnished Wattle	v			v
Acacia vestita	Hairy Wattle				v
Acacia victoriae	Elegant Wattle	v			v
Acer buergerianum	Trident Maple				v
Acer ginnala	Amur Maple				v
Acer grosseri					v
Acer japonicum	Full-moon Maple				v
Acer negundo	Box Elder		v		
Acer palmatum	Japanese Maple				v
Acer pennsylvanicum	Striped Maple				v
Acer sieboldianum					v
Acokanthera oblongifolia				v	
Actinostrobus pyramidalis	Swan River Cypress	v		v	
Aesculus pavia	Red Buckeye				v
Agonis Flexuosa	W.A. Willow Myrtle or Peppermint		v		
Alberta magna					v
Albizia julibrissin	Silk Tree		v		
Aleurites fordii	Tung-oil Tree				v
Allocasuarina muelleriana				v	
Allocasuarina nana	Stunted Sheoak			v	
Allocasuarina paludosa	Scrub Sheoak				v
Aloysia triphylla	Lemon-scented Verbena				v
Alyogyne species	Desert Rose			v	
Alyxia buxifolia	Sea Box			v	
Amelanchier andrachne					v
Amelanchier asiatica					v
Amelanchier laevis					v
Amelanchier sanguinea				v	
Amygdalus pollardii	Flowering Almond		v		
Angophora cordata	Dwarf or Scrub Apply Myrtle		v		
Angophora cordifolia (syn. A. hispida)	Dwarf Apple-Myrtle				v
Angophora costata	Smooth-barked Apply Myrtle		v		
Anigozanthos species	Kangaroo Paw			v	
Annona species	Custard Apple				v
Anopterus glandulosus	Tasmanian Laurel				v
Arbutus unedo	Strawberry Tree		v		v
Aristotelia serrata	Makomako				v
***Arundinaria* (cultivars) (except those in List 2)**	Ornamental Bamboos			v	
Arundinaria hindsii	Kanzan-Chiku				v
Arundinaria japonica	Metake				v
Arundinaria linearis	Narrow-leaf Bamboo				v
Arundo donax	Danubian Reed				v

Atriplex species	Saltbush			v	
Azara lanceolata					v
Azara microphylla	Box-leaf Azara				v
Baccharis halimifolia					v
Bambusa multiplex	Hedge Bamboo				v
Banksia ashbyi	Ashby's Banksia				v
Banksia baueri	Possum Banksia				v
Banksia baxteri	Birds-nest Banksia				v
Banksia brownii	Brown's Banksia				v
Banksia burdettii	Burdett's Banksia				v
Banksia caleyi	Caley's Banksia			v	
Banksia collina	Hill Banksia				v
Banksia dryandroides	Dryandra-leaved Banksia			v	
Banksia hookeriana	Hooker's Banksia			v	
Banksia media	Golden Stalk				v
Banksia nutans	Nodding Banksia			v	
Banksia ornata	Desert Banksia			v	
Banksia speciosa	Showy Banksia				v
Banksia sphaerocarpa	Round-fruited Banksia			v	
Bauhinia carronii	Queensland Bean or Ebony Tree		v		
Bauhinia species	eg Orchid Tree				v
***Bauhinia variegata* and forms**	Orchid Tree, Bauhinia	v			
Beaufortia sparsa	Swamp Bottlebrush			v	
Berberis species	Barberry, Berberis		v		
Betula pendula (B. alba)	Silver Birch		v		
Betula pendula 'Youngii'	Weeping Birch				v
Boronia muelleri	Tree Boronia				v
Boronia species* (except *B. muelleri)				v	
Brachychiton acerifolium	Flame Tree		v		
Brachychiton acerifolium x populneum (B. Hydridum)	Hybrid Flame Tree		v		
Brachychiton discolor	Queensland Lace Bark		v		
Brachychiton populneum	Kurrajong		v		
Brachyglottis repanda 'Purpurea'					v
Brahea armata	Blue Palm				v
Buddleja colvilei					v
Buddleja davidii	Butterfly Bush				v
Buddleja madagascariensis					v
Butia capitata	Wine Palm				v
Butia yatay					v
***Buxus sempervirens* (cultivars)**				v	
Calliandra portoricensis					v
Callistemon "Harkness"	Gawler Hybrid Bottlebrush	v			
Callistemon 'Burgundy'					v
Callistemon cirtrinus (C. Lanceolatus)	Crimson Bottlebrush	v			

Callistemon citrinus	Red Bottlebrush				v
Callistemon 'Harkness'					v
Callistemon lilacinus (C. violaceus)	Lilac Bottlebrush	v			
Callistemon macropunctatus (C. rugulosus)	S.A. Red Bottlebrush	v			
Callistemon phoeniceus	Fiery Bottlebrush	v			v
Callistemon polandii					v
Callistemon rigidus	Stiff-leaved Bottlebrush	v			v
Callistemon salignus	Willow Bottlebrush	v			
Callistemon species* (except those in List 2 and *C. salignus)	Bottlebrush			v	
Callistemon viminalis	Weeping Bottlebrush	v			v
Callitris columellaris	White Cypress Pine		v		
Callitris drummondii					v
Callitris oblonga	Tasmanian Cypress Pine				v
Callitris preissii	Slender Cypress Pine		v		
Callitris verrucosa	Mallee Pine				v
Calothamnus aspera	Rough-leaved Net Bush	v			
***Calothamnus* species**	Netbush			v	
Calpurnia aurea	African Laburnum				v
***Calytrix* species**	eg Snow Myrtle, Fringe Myrtle			v	
Camellia sasanqua				v	
***Camellia* species**	Camellias				v
Carissa bispinosa				v	
Carissa grandiflora	Natal Plum			v	
Caryota mitis	Fish Tail Palm				v
Casuarina cristata	Black Oak, Belah		v		
Casuarina stricta	Weeping Sheoak		v		
Casuarina torulosa	Rose Sheoak		v		
***Ceanothus* species**	Californian Lilac	v			v
Celtis australis	Southern Hackberry, Celtis		v		
Celtis occidentalis	American Hackberry, Celtis		v		
Cephalotaxus harringtonia	Japanese Plum-Yew			v	
Cercis siliquastrum	Judas Tree		v		
Chamaecyparis lawsoniana 'Allumii'					v
Chamaecyparis lawsoniana 'Darleyensis'					v
Chamaecyparis lawsoniana 'Ellwoodii'				v	
Chamaecyparis lawsoniana 'Fletcheri'					v
Chamaecyparis lawsoniana 'Lutea'	Golden Lawson Cypress				v
Chamaecyparis lawsoniana 'Olbrichi'				v	
Chamaecyparis lawsoniana 'Pottenii'				v	
Chamaecyparis lawsoniana 'Stewartii'					v

Appendix I: Table of Tree Species that are listed under the Water Industry Regulation 2012 and the SAPN Vegetation Around Powerlines protocol

Chamaecyparis lawsoniana 'Tamariscifolia'				v	
Chamaecyparis lawsoniana 'Westermanii'					v
***Chamaecyparis obtusa* (except dwarf cultivars)**					v
***Chamaecyparis obtusa 'Aurea'* (and other dwarf cultivars)**				v	
Chamaecyparis pisifera 'Argentea'					v
***Chamaecyparis pisifera 'Filifera'* (and other dwarf cultivars)**				v	
Chamaecyparis pisifera 'Squarrosa'					v
Chamaecyparis thyoides 'Glauca'					v
Chamaecytisus proliferus	False Tree Lucerne				v
Chamaerops humilis	Mediterranean Palm			v	
Chamelaucium species	Esperance Wax			v	
Chamelaucium uncinatum	Geraldton Wax				v
Chionanthus retusa					v
Citharexylum fruticosum	Florida Fiddlewood				v
Citharexylum species	Fiddlewood		v		
Citriobatus pauciflorus				v	
Citrus aurantifolia	Sweet Lime				v
Citrus limon	Wild Lemon				v
Citrus limon 'Variegata'	Variegated Lemon			v	
Citrus medica	Citron				v
Citrus reticulata	Mandarin Orange				v
Colletia paradoxa				v	
Coprosma repens	Mirror Bush			v	
Cordyline stricta	Erect Palm-Lily			v	
Cordyline terminalis	Ti-Port				v
Cornus mas					v
Corokia macrocarpa					v
Cortaderia rudiuscula	N.Z. Pink Pampass-Grass			v	
Corylus avellana	European Hazelnut				v
***Corymbia ficifolia* 'Dwarf'**	'Summertime' Grafted Red Flowering Gum				v
Cotinus coggygria	Smoke Tree				v
Cotinus obovatus					v
Cotoneaster 'Cornubia'					v
Cotoneaster Frigida	Himalayan Cotoneaster	v		v	
Cotoneaster glaucophyllus (C. serotinus)					v
Cotoneaster serotina	Cotoneaster		v		
Cotoneaster 'Watereri'					v
Crataegus chrysocarpa					v
Crataegus coccineoides	Kansas Hawthorn				v
Crataegus crus-galli	Cockspur Thorn				v

Crataegus durobrivensis					v
Crataegus ellwangeriana					v
Crataegus lavallei (C. carrieri)	Lavalle Hawthorn	v			
Crataegus orientalis	Silver Hawthorn				v
***Crataegus oxyacantha* and forms**	Hawthorn, May Tree	v			
Crataegus phaenopyrum	Washington Thorn	v			v
***Crataegus pinnatifida* var. major**					v
Crataegus prunifolia	Plumleaf Hawthorn				v
Crataegus pubescens (C. mexicana)	Mexican Hawthorn	v			
Crataegus x grignonensis					v
Crataegus x lavallei	French Hawthorn				v
Crinodendron hookeranum	Red Lantern Tree				v
Cupressus glabra	Arizona Cypress		v		
Cupressus glabra 'Hodginsii'					v
Cussonia spicata					v
Cuttsia viburnea					v
Cycas media	Baveu				v
Cycas revoluta	Sago-Plum			v	
Cyperus papyrus	Papyrus			v	
Cyphomandra betacea	Tree Tomato			v	
Cytisus battandieri					v
Cytisus multiflorus					v
Cytisus species* (except those in List 2 and *C. scoparius)				v	
Dahlia imperialis				v	
Dais cotinifolia	Pompon Tree				v
Datura arborea					v
Datura cornigera (Brugmansia knightii)				v	
Datura sanguinea				v	
Datura suaveolens (Burgmansia)	Angels Trumpet				v
Deutzia species				v	
Dicksonia antarctica	Soft Tree-Fern				v
Dodonaea species* (except *D. viscosa)	Hop Bushes			v	
Dodonea viscosa	Hop Bush				v
Dombeya natalensis				v	
Dombeya tiliacea				v	
Doryanthes species	Spear Lily			v	
Dracaena species	eg Dragon Tree				v
Dracaena umbraculifera				v	
Dryandra formosa					v
Duboisia hopwoodii	Pituri			v	
Duranta repens	Sky Flower, Duranta	v			
Duranta species	Sky Flower				v
Elaeagnus species	Russian Olive				v
Elaeodendron australe	Scarlet Olive-Wood				v

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Entelea arborescens	Whau				v
Eremophila fraseri	Turpentine Bush			v	
Eremophila mackinlayi	Desert Pride			v	
Eremophila maculata	Spotted Emu Bush			v	
Eremophila species	Emu Bush				v
Erica arborea	Tree Heath				v
Erica species (except E. arborea)	Heath			v	
Eriostemon species	Native Daphne, Waxflower			v	
Erythrina "Indica"	Hybrid Indian Coral Tree		v		
Erythrina acanthocarpa	Tambookie Thorn Tree			v	
Erythrina 'Blakei'	Coral Tree			v	
Erythrina fusca					v
Erythrina hendersonii				v	
Erythrina humeana	Coral Tree				v
Erythrina parcellii	Variegated Coral Tree				v
Erythrina phlebocarpa	Veined-pod Coral Tree				v
Erythrina senegalensis					v
Erythrina speciosa					v
Erythrina x bidwillii					v
Escallonia 'C F Ball'				v	
Escallonia 'Edinburgh'				v	
Escallonia 'Fretheyi'				v	
Escallonia 'Iveyi'				v	
Escallonia macrantha				v	
Escallonia 'Slieve Donard'				v	
Escallonia species					v
Escallonia x langleyensis				v	
Eucalyptus "Augusta Wonder"		v			
Eucalyptus "Ericoides"			v		
Eucalyptus "Pterocarpa"			v		
Eucalyptus "Torwood"	Hybrid Coral gum		v		
Eucalyptus "Urrbrae Gum"			v		
Eucalyptus angulosa	Ridge Fruited Mallee				v
Eucalyptus behriana	Broad-leaved Box		v		
Eucalyptus brachycalyx	Gilja or Chindoo Mallee				v
Eucalyptus caesia	Gungunnu	v			
Eucalyptus caesia 'Silver Princess'					v
Eucalyptus calycogona	Square-fruited Mallee	v			
Eucalyptus calycogona 'Jubilee'	Jubilee Gum				v
Eucalyptus campaspe	Silver Gimlet		v		
Eucalyptus Cinerea	Mealy Stringybark, Argyle Apple		v		
Eucalyptus cneorifolia	Kangaroo Island Narrow-leaved Gum		v		
Eucalyptus conglobata	S.A. Coastal Gum		v		
Eucalyptus cosmophylla	Cup Gum	v			v
Eucalyptus crucis	Southern Cross Mallee	v			v

Eucalyptus decipiens	Limestone Marlock				v
Eucalyptus dielsii	Cap-fruited Mallee	v			v
Eucalyptus diversifolia	S.A. Coastal Mallee	v			
Eucalyptus dumosa	White Mallee				v
Eucalyptus dundasii	Dundas Blackbutt		v		
Eucalyptus eremophila	Tall Sand Mallee	v			
Eucalyptus erythrocorys	Red-capped Gum	v			
Eucalyptus erythronema	Lindsay Gum	v			v
Eucalyptus Ficifolia	W.A. Scarlet Flowering Gum		v		
Eucalyptus flocktoniae	Merrit		v		
Eucalyptus foecunda (E. lepto-phylla)	Slender-leaved Mallee	v			
Eucalyptus forrestiana	Fuchsia Gum	v			v
Eucalyptus gardneri	Blue Mallett		v		
Eucalyptus gillii	Curly Mallee				v
Eucalyptus gracilis	Yorrell		v		
Eucalyptus grossa	Coarse-leaved Mallee				v
Eucalyptus incrassata	Ridge-fruited Mallee		v		
Eucalyptus intertexta	Smooth-barked Coolibah		v		
Eucalyptus kingsmillii	Kingsmill Mallee				v
Eucalyptus kruseana	Bookleaf Mallee			v	
Eucalyptus lansdowneana	Pt. Lincoln Gum & Crimson Mallee		v		v
Eucalyptus lansdowneana albopurpurea	Port Lincoln Gum				v
Eucalyptus lansdowneana lansdowneana	Crimson Mallee				v
Eucalyptus le souefii	Le Souef's Blackbutt		v		
Eucalyptus lehmanni	Bushy Yate		v		
Eucalyptus leucoxylon "Rosea"	Pink-flowering Blue Gum		v		
Eucalyptus leucoxylon 'Magnet'	'Euky Dwarf'				v
Eucalyptus macrandra	Longflowered Marlock				v
Eucalyptus macrocarpa	Mottlecah				v
Eucalyptus megacornuta	Warty Yate		v		
Eucalyptus nutans	Red-flowered Moort		v	v	
Eucalyptus oleosa	Red Mallee		v		
Eucalyptus orbifolia	Round-leaved Mallee	v			v
Eucalyptus pachyphylla	Thick—leaved Mallee			v	
Eucalyptus pauciflora 'Frosty'	Edna Walling 'Little Snowman'				v
Eucalyptus pileata	Ravensthorpe Mallee		v		
Eucalyptus platypus	Round-leaved Moort		v		
Eucalyptus preissiana	Bell-fruited Mallee	v		v	
Eucalyptus pulverulenta	Silver-leaved Mountain Gum		v		
Eucalyptus pyriformis* (not *E.p.youngiana)	Pear-fruited Mallee				v
Eucalyptus pyriformis* subspecies *youngiana	Ooldea Mallee	v			
Eucalyptus redunca	Black Marlock				v
Eucalyptus rhodantha	Rose Mallee	v		v	
Eucalyptus rugosa	Kingscote Mallee	v			v

Appendix I: Table of Tree Species that are listed under the Water Industry Regulation 2012 and the SAPN Vegetation Around Powerlines protocol

Eucalyptus salubris	Gimlet Gum		v		
Eucalyptus sargentii	Salt or Sargent's Mallet		v		
Eucalyptus sideroxylon	Manna Red Ironbark, Mugga		v		
Eucalyptus socialis	Red Mallee, Morrel	v			
Eucalyptus spathulata	Swamp Mallee		v		
Eucalyptus steedmanii	Steedman's Gum		v		
Eucalyptus stoatei	Scarlet Pear Gum	v			v
Eucalyptus stricklandii	Yellow-flowering Gum		v		
Eucalyptus tetragona	Tallerack				v
Eucalyptus tetraptera	Four-winged Mallee	v			v
Eucalyptus torquata	Coral or Coolgardie Gum		v		
Eucalyptus viridis	Green Mallee		v		v
Eucalyptus websterana	Webster's Mallee	v			v
Eucalyptus woodwardii	Lemon-flowering Gum		v		
Eucryphia glutinosa					v
Eugenia aggregata	Rio Grande Cherry				v
Eugenia smithii (Acmena smithii)	Lilly Pilly		v		
Eugenia uniflora	Surinam Cherry				v
Euonymus alata	Cork Tree			v	
Euonymus fortunei	Spindle Tree				v
Euonymus hamiltoniana* var *yedeonsis				v	
Euonymus japonicus	Evergreen Spindle Tree	v			v
Euonymus latifolia					v
Euonymus pendula					v
Euphorbia species* (except *E. candelabra)				v	
Eupomatia laurina	Copper Laurel				v
***Exochorda* species**	Pearl Bush				v
***Feijoa sellowiana* and forms**	Pineapple Guava	v			v
Ficus rubiginosa "Variegata"	Variegated Rusty Fig		v		
***Fortunella* species**	Cumquat			v	
Fraxinus excelsior "Aurea"	Golden Ash		v		
Fraxinus ornus	Manna Ash		v		v
***Fraxinus 'Raywood'* on ornus root stock**	Dwarf Claret Ash				v
Fremontodendron californicum	Flannel Bush				v
Garrya elliptica					v
Gastrolobium bilobum	Poison Pea				v
Geijera linearifolia	Sheep Bush			v	
Geijera parviflora	Wilga	v			v
Genista aethnensis	Mt. Etna Broom				v
Genista species* (except *G. aethnensis, G. virgata* and *G. monspessulanus)				v	
Goodia lotifolia	Golden Tip			v	
Gordonia axillaris				v	
Gossypium barbadense	Sea Island Cotton			v	
Grevillea nematophylla	Silver Leaved Water Bush				v

Grevillea species (**except those in List 2 and** ***G. robusta, G. hilliana*** **and** ***G. striata)***				v	
Hakea elliptica	Oval-leaved Hakea	v			
Hakea francisiana	Bottlebrush Hakea			v	
Hakea kippistiana			v		
Hakea laurina	Pincushion Hakea	v			
Hakea leucoptera	Needle Bush			v	
Hakea muelleriana	Muller's Hakea			v	
Hakea nodosa	Yellow Hakea			v	
Hakea orthorrhyncha				v	
Hakea petiolaris	Broad-leaf Sea Urchin	v			
Hakea salicifolia (H. saligna)	Willow Hakea	v			
Hakea sericea	Silky Hakea			v	
Hakea **species**	eg Oval-leaved Hakea				v
Hakea suaveolens	Sweet Hakea		v		
Hakea sulcata	Furrowed Hakea	v		v	
Hakea undulata	Wavy-leaved Hakea	v		v	
Hamamelis **species**	eg Witch Hazel				v
Harpephyllum caffrum	Kaffir Plum		v		
Hebe diosmaefolia					v
Hedycarya angustifolia	Austral Mulberry				v
Hesperoyucca whipplei				v	
Hibbertia **species**	Guinea Flower			v	
Hibiscus **species**	Hibiscus	v		v	
Hoheria lyallii	Ribbonwood				v
Homalanthus populifolius	Queenslander Poplar, Bleeding-Heart Tree	v			
Hovea species				v	
Hovenia dulcis	Japanese Raisin Tree				v
Howea belmoreana	Curly Palm				v
Howea forsterana	Kentia Palm				v
Howittea trilocularis	Native Hibiscus			v	
Hydrangea **species**				v	
Hymenosporum flavum	Woolum, Native Frangipani		v		
Ilex cornuta	Chinese Holly			v	
Ilex crenata	Japanese Holly				v
Ilex paraguariensis	Paraguay Tree				v
Ilex purpurea	Java Holly				v
Ilex verticillata	Black Alder			v	
Illicium anisatum	Japanese Staranise				v
Illicium floridanum	Purple Anise			v	
Indigoferaspecies				v	
Itea ilicifolia					v
J. x media (hybrids)				v	
Jacaranda **species**	Jacaranda		v		
Jasminum fruticans				v	
Jasminum mesnyi	Primrose Jasmin				v

Jasminum multiflorum	Hairy Jasmine			v	
Jasminum nudiflorum	Winter Jasmin				v
Juniperus chinensis 'Aurea'	Golden Chinese Juniper				v
Juniperus communis 'Hibernica'	Irish Juniper			v	
Juniperus communis var. suecica	Swedish Juniper				v
Juniperus sabina	Savin Juniper			v	
Juniperus sheppardii var. pyramidalis ("J.africans")	Juniper		v		
Kalmia latifolia	Calico Bush			v	
Kerria japonica				v	
Koelreuteria paniculata	Golden Rain Tree		v		v
Kolkwitzia amabilis	Beauty Bush			v	
Kunzea ambigua	White Kunzea				v
Kunzea* species (except *K. ambigua)				v	
Laburnum species	Laburnum		v		v
Lagerstoemia indica all varieties	Crepe Myrtle				v
Lagerstroemia "Eavesii"	Mauve Crepe-Myrtle	v			
Lagerstroemia indica	Pink Crepe-Myrtle	v			
Lagunaria patersonii	Pyramid Tree		v		
Lantana camara	Common Lantana				v
Lantana camara 'cultivars' (except Common Lantana)				v	
***Lavatera* species**				v	
Lawsonia inermis	Henna				v
Leptospermum laevigatum	Victoria Coastal Tea Tree	v			
Leptospermum nitidum 'Copper Sheen'				v	
Leptospermum rotundifolium				v	
***Leptospermum scoparium* (dwarf varieties)**				v	
Leptospermum sericeum	Silver Tea Tree			v	
***Leptospermum* species**	Tea Tree				v
Leptospermum squarrosum	Pink Tea Tree			v	
Leucadendron argenteum	Silver Tree				v
Leucadendron salignum				v	
Leucopogon parviflorus	Coast Beard-Heath				v
Ligastrum ovalifolium 'Aureum'	Golden Hedge Privet			v	
Ligustrum amurense	Amur Privet			v	
Ligustrum delavayanum				v	
***Ligustrum japonicum* and forms**	Japanese Tree Privet		v		v
Ligustrum japonicum* var. *rotundifolium				v	
Ligustrum japonicum 'Variegatum'					v
***Ligustrum ludidum* and forms**	Glossy Privet		v		v
Ligustrum ovalifolium	Californian Privet				v
Ligustrum sinense	Chinese Privet				v
Ligustrum undulatum	New Guinea Privet			v	

Ligustrum vulgare	European Privet			v	
Linospadix monostachus	Walking-stick Palm			v	
Liquidambar styraciflua	Liquidambar		v		
Livistona chinensis					v
***Lonicera* species**	Honeysuckle			v	
Lophomyrtus bullata	Ramarama				v
Lophomyrtus obcordata					v
Luculia grandifolia					v
***Macrozamia* species**	eg Pineapple Palm			v	
Magnolia liliiflora					v
Magnolia salicifolia					v
Magnolia sieboldii					v
Magnolia stellata	Star Magnolia			v	
Magnolia x soulangeana (cultivars)	Saucer Magnolia				v
Mahonia lomariifolia					v
Maireana* species *(Syn. Kochia)	eg Blue Bush			v	
Malus 'Aldenhamensis'					v
Malus angustifolia					v
Malus 'Echtermeyer'				v	
Malus 'Gorgeous'				v	
Malus halliana 'Parkmanii'					v
Malus ioensis 'Plena'	Bechtel Crab				v
Malus 'John Downie'					v
Malus 'Robert Nairn'					v
Malus sargentii				v	
Malus sieboldii	Toringo Crab				v
***Malus* species**	Flowering Crabs and Apples	v			
Malus 'Veitch's Scarlet'					v
Malus x atrosanguinea	Red Japanese Crab Apple				v
Malvaviscus arboreus				v	
Maytenus boaria					v
Melaleuca acuminata	Mallee Honey Myrtle				v
Melaleuca alternifolia			v		v
Melaleuca armillaris	Bracelet Honey Myrtle		v		
Melaleuca bracteata	White Cloud Tree				v
Melaleuca brevifolia	White-flowered Paperbark			v	
Melaleuca coccinea	Goldfield's Bottlebrush			v	
Melaleuca decussata				v	
Melaleuca diosmifolia					v
Melaleuca elachophylla				v	
Melaleuca elliptica	Granite Honey Myrtle	v		v	
Melaleuca ericifolia	Swamp Paperbark				v
Melaleuca fulgens	Scarlet Honey Myrtle	v		v	
Melaleuca gibbosa				v	
Melaleuca glomerata	Inland Paperbark				v
Melaleuca Glomerata		v			

Melaleuca halmaturorum	Coastal Paperbark		v		v
Melaleuca hamulosa				v	
Melaleuca huegelii	Chenile Honey Myrtle		v		v
Melaleuca hypericifolia	Hillock Honey Myrtle	v		v	
Melaleuca incana	Yellow-Flowered Grey Honey Myrtle	v		v	
Melaleuca Lanceloata (M. pubescens)	Dry Land Tea Tree		v		
Melaleuca lateritia	Robin Redbreast Bush	v		v	
Melaleuca linariifolia	Flax-leaved Honey Myrtle		v		
Melaleuca megacephala				v	
Melaleuca micromera				v	
Melaleuca microphylla				v	
Melaleuca nematophylla	Wiry Honey Myrtle			v	
Melaleuca nesophila	Western Honey Myrtle	v			v
Melaleuca oraria	White-flowered Paperbark			v	
Melaleuca pentagona		v		v	
Melaleuca preissiana					v
Melaleuca pulchella	Claw Flower			v	
Melaleuca quadrifaria	Limestone Honey Myrtle			v	
Melaleuca radula		v		v	
Melaleuca scabra	Rough Honey Myrtle			v	
Melaleuca spathulata				v	
Melaleuca squamea		v		v	
Melaleuca steedmanii	Steedman's Honey Myrtle			v	
Melaleuca styphelioides	Prickly Paperbark		v		
Melaleuca thymifolia	Thyme Honey Myrtle			v	
Melaleuca trichophylla				v	
Melaleuca uncinata	Broombush Honey Myrtle			v	
Melaleuca wilsonii	Wilson's Honey Myrtle			v	
Melia axedarach	White Cedar		v		
Meryta sinclairii					v
Mespilus germanica	Medlar				v
Metrosideros excelsa (M. tomentosa)	New Zealand Christmas Tree		v		
Michelia figo	Port Wine Magnolia			v	
Microcitrus australasica	Native Finger-Lime				v
Mirbelia **species**				v	
Miscanthus sinensis				v	
Montanoa **species**	eg Mexican Tree Daisy			v	
Murraya paniculata				v	
Musa basjoo					v
Myoporum acuminatum (syn.M.montanum)	Water Bush				v
Myoporum floribundum				v	
Myoporum insulare	Boobialla		v		v
Myoporum laetum	Ngaio				v
Myoproum montanum	Water Bush		v		
Myrsine australis	Mapou				v

***Myrtus* species**	eg Common Myrtle				v
Neopanax arboreus	Five-Fingers				v
Neopanax colensoi	Orihou				v
Nerium oleander	Oleander		v		v
Nolina recurvata				v	
Ochlandra maculata	Mottled Bamboo				v
Olearia species	Daisy Bush			v	
Omalanthus populifolius	Queensland Poplar				v
Osmanthus aurantiacus				v	
Osmanthus 'Fortunei'				v	
Osmanthus heterophyllus (varieties except 'Ilicifolius')				v	
***Osmanthus* species**					v
Oxydendrum arboreum	Sourwood				v
Parkinsonia aculeata	Jerusalem Thorn		v		
Parrotia persica	Persian Witch Hazel				v
***Philadelphus* species**				v	
Phormium tenax	N.Z. Flax			v	
Photinia beauverdiana					v
Photinia glabra					v
Photinia glabra 'Rubens'	Red-leaf Photinia			v	
Photinia 'Robusta'				v	
Photinia serrulata	Chinese Hawthorn	v			
Photinia villosa					v
Phyllostachys castillonis					v
Phyllostachys nigra	Black Bamboo				v
Phyllostachys pubescens	Noble Bamboo				v
Picea glauca var. albertiana 'Conica'				v	
***Pimelea* species**	Rice Flower			v	
Pisonia umbellifera 'Variegata'					v
Pittosporum crassifolium and variegated form	Karo	v			v
Pittosporum eugeniodes 'Variegatum'	Silver Tarata				v
Pittosporum phylliraeoides	Native Apricot, Weeping Pittosporum	v			v
Pittosporum ralphii					v
Pittosporum revolutum	Brisbane Laurel				v
Pittosporum rhombifolium	Queensland Pittosporum		v		
Pittosporum tenuifolium	New Zealand Kohuhu	v			
Pittosporum tenuifolium "Pirpureum"		v			
Pittosporum tobira	Tobira				v
Pittosporum undulatum	Sweet Pittosporum		v		
Pittosporum undulatum "Variegatum"	Variegated Sweet Pittosporum		v		
Plumbago auriculata				v	
Plumeria rubra	Frangipani				v
Podocarpus lawrencei	Mountain Plum Pine			v	
***Polygala* species**				v	

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Polyscias balfouriana					v
Polyscias guilfoylei	Wild Coffee				v
Pomaderris **species**					v
Poncirus trifoliata					v
Populus x pseudo-grandidentata	Weeping Large-tooth Aspen				v
Prostanthera lasianthos	Victorian Christmas Bush				v
Prostanthera **species**	Mint Bush			v	
Protea **species**				v	
Prunus amygdalus	Almond				v
Prunus avium 'Pendula'	Weeping Gean			v	
Prunus cerasifera 'Nigra'					v
Prunus cerasus	Kentish Cherry				v
Prunus 'Elvins'					v
Prunus glandulosa 'Alboplena'	Bush Cherry			v	
Prunus ilicifolia	Islay				v
Prunus incisa	Fuji Cherry				v
Prunus japonica	Chinese Cherry			v	
Prunus lustianica	Portugal Laurel				v
Prunus mume 'Alboplena'	Flowering Apricot				v
Prunus mume 'Alphandii'	Flowering Apricot				v
Prunus persica (cultivars)	Peach				v
Prunus **species**	Flowering Almonds, Plums, Apricots, Cherries, Peaches	v			
Prunus spinosa 'Purpurea'	Purple-leaf Blackthorn			v	
Prunus tenella **var.** ***gesslerana***	Dwarf Russian Almond			v	
Prunus triloba	Bush Almond				v
Prunus triloba 'Plena'				v	
Prunus x blireiana	Cherry-Plum				v
Pseudocydonia oblonga	Quince				v
Pseudocydonia sinensis					v
Psidium guajava	Common Guava				v
Psidium littorale	Strawberry Guava			v	
Psoralea pinnata				v	
Ptelea trifoliata	Hop-Tree				v
Punica **species**	Pomegranate				v
Pyracantha angustifolia	Orange Firethorn			v	
Pyracantha atalantioides	Firethorn				v
Pyracantha coccinea				v	
Pyracantha coccines "Lalandei"	Lalande Firethorn	v			
Pyracantha crenulata	Nepal Firethorn	v		v	
Pyracantha fortuneana				v	
Pyracantha rodgersiana	Yellow-Berry Firethorn	v			
Pyracantha rogersiana				v	
Pyrus calleryana	Chinese Pear				v
Pyrus salicifolia	Silver Pear				v
Quercus ilex	Holm Oak		v		

Rhamnus alaternus 'Argenteovariegata'				v	
Rhaphiolepsis umbellata				v	
Rhaphiolepsis x delacourii				v	
***Rhododendron* species**					v
***Ribes* species**	Currant			v	
Robinia hillierii					v
Robinia kelseyi				v	
Robinia pseudoacacia 'Umbraculisera'	Robinia Mop Top				v
Sambucus nigra	European Elder				v
***Santalum* species**					v
Senna brewsteri					v
Senna species (except S. brewsteri)	eg Desert Cassia			v	
Sesbania grandiflora	Agati				v
Sophora japonica	Pagoda Tree		v		
Sophora tetraptera	Yellow Kowhai	v			
Sorbus aucuparia	Rowan, Mountain Ash		v		
Sorbus vilmorinii					v
***Sparmannia* species**				v	
Spartium junceum	Spanish Broom	v			v
Stenolobium alatum (Tecoma smithii)	Winged Yellow-Trumpet	v			
Stenolobium stans (Tecoma stans)	Florida Yellow-Trumpet	v			v
Stewartia sinensis					v
Styrax japonica	Snowbell				v
Syzygium Coolminianum	Blue Lilly Pilly	v			
Syzygium paniculatum	Brush Cherry		v		
Tamarix juniperina	Flowering Tamarisk		v		
Tamarix* species (except *T. aphylla)					v
***Taxus baccata* 'cultivars' (except Common Yew)**				v	
Telopea mongaensis				v	
Telopea species	eg Tasmanian Waratah				v
Telopea speciosissima				v	
Templetonia retusa				v	
Thevetia peruviana	Lucky Nut				v
Thryptomene species				v	
***Thuja orientalis* (cultivars)**					v
Thujopsis dolabrata 'Variegata'					v
Tieghemopanax sambucifolius	Elderberry Panax				v
Tristania conferta	Brush Box		v		
Tristaniopsis laurina (Tristania laurina)	Water Gum				v
Ulmus glabra 'Pendula'	Weeping Scotch Elm				v
Viburnum tinus	Laurestinus	v		v	
Virgilia divaricata					v
Vitex agnus-castus	Lilac Chaste Tree				v

Vitex agnus-castus	Lilac Chaste Tree	v			
Xylomelum angustifolium	Sandplain Woody Pear			v	
Yucca species	Yucca			v	