OPTIONS ANALYSIS:
Costs and Benefits of Urban Tree Canopy Options for Minor Infill Development in the Planning and Design Code

A Report to the Attorney-General's Department

September 2020

Prepared by BDO EconSearch
Level 7, BDO Centre, 420 King William Street
Adelaide SA 5000
Tel: +61 (8) 7324 6190
https://www.bdo.com.au/en-au/econsearch

ACKNOWLEDGEMENTS

This study was commissioned and project managed by the Attorney-General's Department (AGD) Planning Reform area. The development of this study was guided by an Across Agency Working and Steering Group which included representatives from:

- AGD (Planning Reform and Sustainability and Environment areas)
- Department of Environment and Water (Green Adelaide and Urban Water areas)
- Wellbeing SA.

A Stakeholder Reference Group provided feedback on the draft project scope and included representatives from the following organisations:

- Department of Treasury and Finance
- Housing Industry Association (HIA)
- Master Builders Association (MBA)
- Urban Development Institute of Australia (UDIA)
- Local Government Association of South Australia (LGA)
- Stormwater Management Authority
- Premier's Climate Change Council
- Water Sensitive SA
- Stormwater SA
- Australian Institute of Landscape Architects (AILA)
- Australian Institute of Architects (AIA)
- Conservation SA
- South Australian Council of Social Services (SACOSS)
- Property Council of Australia
- Community Alliance.

Project Manager:	Julian Morison
Principal Author:	Heather Bailey
Name of Client:	Attorney-General's Department
Name of Project:	OPTIONS ANALYSIS: Costs and Benefits of Urban Tree Canopy Options for Minor Infill Development in the Planning and Design Code
Document Version:	5
Job Number:	ES2001

#15766940

EXECUTIVE SUMMARY

Major Findings

To determine the most cost-effective way to balance urban tree canopy and infill outcomes, this study tested two policy options for the new Planning and Design Code:

- Option 1: Draft Planning and Design Code policy for one onsite tree per allotment
- Option 2: Offsite tree planting, via an offset scheme.

The 'One Tree Policy' proposed in the new Planning and Design Code is expected to deliver economic, amenity and liveability gains to the Greater Adelaide community valued at **$26.4 million** (**Benefit Cost Ratio 1.7**), and is therefore a worthwhile initiative for government to consider.

In the General Neighbourhood and Suburban Neighbourhood Zones, the majority of households can meet the proposed tree requirements without incurring any new costs to their house footings.

Consideration could be given to implementing more nuanced policy options to minimise upfront costs in the cases when a homeowner will incur a net cost as a result of tree policies i.e. in locations with highly reactive soils and small minimum set-backs. This may include introducing an optional offset scheme which, as formulated in this study, would deliver estimated gains to the Greater Adelaide community of $187.2 million.

Purpose of this Report

BDO EconSearch and Tonkin Engineering have been commissioned by the Attorney-General's Department, Department for Environment and Water, Department of Treasury and Finance, and SA Health to analyse the cost-effectiveness of the proposed Planning and Design Code policies for minor infill, in relation to:

- Tree canopy cover and the 'One Tree Policy' (*this report*)
- Stormwater management and rainwater tanks (*refer to separate report*).

The State Planning Policies give direction to improving urban greening outcomes in recognition of the multiple benefits they provide, especially in the context of minor infill. Draft Planning and Design Code (Code) policies have been prepared and consulted on in response to this direction.

Feedback received during the Code's consultation indicates there is a dichotomy of views in community and industry about whether the proposed tree policies for minor infill developments go too far, or not far enough. Concerns included, on one side, the potential impacts of tree planting on upfront housing affordability from higher footing costs, and on the other side, the potential negative impacts of tree loss on public health, urban heat, liveability, biodiversity and neighbourhood amenity. It is important to respond to these concerns with an independent and sound evidence base.

This report is intended to inform decision-making on the cost-effectiveness of proposed Code policy, alongside other feedback. It aims to improve understanding of all the upfront and long-term costs and benefits of the proposed policies to the individual household and the Greater Adelaide community, and ensure they can be weighed up objectively.

Balancing tree canopy cover and urban infill outcomes

Minor infill is now the single largest provider of new housing in Greater Adelaide, with a net annual increase of about 2,500 residential dwellings. *The 30-Year Plan for Greater Adelaide (2017 Update)* (the 30-Year Plan) has a target for 85 per cent of all new housing to be built within the existing urban footprint, because infill development helps to create walkable neighbourhoods, protect valuable farming and environmental land, and meet consumer demand for living close to jobs, shops, and services.

The 30-Year Plan also sets a target to increase urban green cover by 20 per cent by 2045. This target recognises the many benefits of green cover to urban cooling, the character, biodiversity and liveability of our suburbs, and our physical and mental health. This target is at significant risk, with tree cover reducing from 21.5 per cent to 19.5 per cent across metropolitan Adelaide between 2013 and 2016.

There is evidence minor infill has contributed to a significant reduction in green cover in many neighbourhoods. This is because infill development generally increases site coverage and driveway crossovers, and reduces space for gardens and tree planting, creating up to 90 per cent impervious surfaces. The opportunities for delivering additional green infrastructure on existing public land in the metropolitan area are insufficient to keep up with the loss of green cover on private land.

There are no provisions for landscaping in the current Residential Code, and landscaping provisions vary significantly in the current Development Plans. Therefore, to meet both desired policy outcomes – more infill and more canopy cover – improved policies need to be considered for inclusion in the new Planning and Design Code. It is important that Code policies find the best balance between upfront and long-term costs and benefits, for both individuals and the community.

Costs and benefits of urban tree cover

Benefits of urban tree canopy

Trees, beyond their amenity and biodiversity value, provide critical services that make cities healthier and more liveable. Tree canopy cover is now widely recognised for providing multiple benefits[1] including:

- **Urban cooling** - Reducing air temperatures by 4°C and household electricity consumption by an average 10,651kWh per year
- **Biodiversity and carbon capture**
- **Improved mental health** - Exposure to trees improves mental health more than physical health does - a 1 percentage point increase in vegetation cover above 20 per cent will reduce annual mental health costs in Adelaide by $8M
- **Placemaking and increased economic values** - Canopy cover can increase house values by over 5%
- **Stormwater management** - a Brisbane study priced the value add of stormwater services provided by trees at over $1.4 million per year
- **Protection from extreme weather**
- **Improved physical health** - Cleaner air, decreased mortality, decreased cardio metabolic conditions, lower risk of asthma development in children, enhanced motor skill development in children, increased physical exercise and sleep quality, and decreased UV exposure

[1] Refer to the full report for the list of references for these.

Given that trees are long-lived and provide a number of benefits, it is being increasingly recognised that trees should be considered as assets, the same way livestock, buildings and employees are considered assets. Trees should be considered appreciating assets, as their replacement value and the services they provide increase over time.

House footings and the tree effect

One of the concerns raised in consultation on the Code was the potential impact of tree planting on upfront housing affordability, as a result of higher footing costs. Addressing these concerns was a key focus of this report.

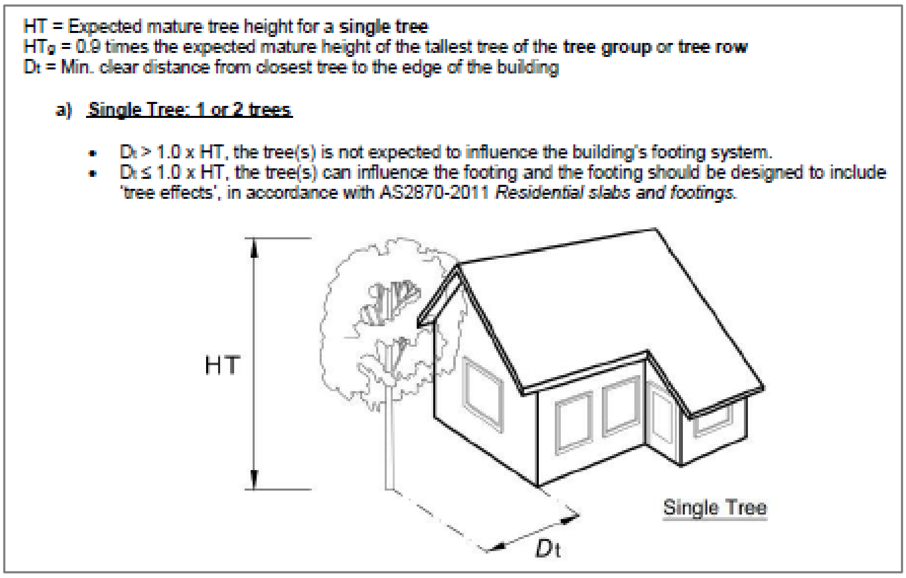
According to independent advice from several structural engineering firms, a single new tree will usually only impose a new cost on house footings if it is planted closer to the dwelling than its mature height (in the 'tree effect' zone[2], see diagram supplied by TMK Consulting (2019)).

In an established urban area, house footings often will already have to be designed to accommodate the impact of nearby offsite trees, regardless of the tree policy. Usually there is already a street tree and sometimes there is one or more neighbouring site trees within the 'tree effect' zone of the new dwelling. Adding the proposed new tree (to the front garden for example) will often not add an additional footing design cost as the new dwelling would have to already accommodate for a 'single tree effect' or 'group of trees effect' cost. Further, many households already choose to retain existing trees or plant new trees when undertaking infill developments. For example in our case study, **57 per cent of infill developments** retained or planted a tree anyway, regardless of the 'tree planting policy'[3].

Consequently, in the majority of cases, house footings will have to be designed to accommodate trees, regardless of the proposed 'One Tree Policy'. It is also recommended that developers seek advice from their structural engineer about the optimal location for the tree to minimise the effect on the footings.

It is also prudent for home owners to consider that new trees in the future may be planted on neighbouring sites or in the public verge outside their house (within the zone of effect on their footings), therefore it is recommended that their house footings are designed for this.

In cases where a tree is planted close enough to a footing to cause a 'tree effect', soil type can have a significant impact on the cost[4]. In Greater Adelaide there are five main soil types, ranging from sandy to highly reactive clay. The cost impact is also dependent on a range of other factors, including construction method, the mature height and number of trees, and the type and shape



[2] As per the Australian Standard 2870-2011 Residential Slabs and Footings. A single tree is classified as '1 or 2 trees'.

[3] Refer to the Glengowrie case study site within this report for further information. This case study includes developments occurring between 2007 and 2019 and is the best available information on household behaviour in relation to trees in minor infill settings in metropolitan Adelaide.

[4] See Table 3-3: Additional costs to footings from single tree effects by soil type

of footings. Therefore the cost impact on footings can be highly variable.

In the case studies tested in this analysis, additional house footing costs incurred under the 'One Tree Policy' ranged from $186 to $3,636 depending on the tree effect, the reactivity of the soil, and the dwelling type. This analysis used the 'single tree effect' costings as it will be the most likely outcome of the one tree planting policy.

Other costs

The cost of planting a tree and maintaining it for 25 years has been estimated in this study at $603 on private land and $1,165 on public land.

There can also be adverse tree impacts that need to be managed. For example, tree root growth can cause damage to kerbs, paving, foundations and other underground infrastructure; leaf litter can accumulate in gutters and drains; falling branches can cause risk to people, buildings and fences; and provision for trees may influence the footprint of buildings on small blocks. In many instances, adverse impacts reflect poor tree selection and/or poor site preparation and can be avoided.

Methodology

Which options have been analysed?

The cost benefit analysis tested two policy options under multiple scenarios, against the base case. The purpose of this approach is to test whether the Draft Code proposals stack up against the current South Australian policy requirements. Note that the tested policies are being considered for minor infill sites only, not for greenfield developments where the public realm (streetscapes and public open space) is usually designed together with new housing.

The base case and policy options analysed were:

- **Base Case Scenario - Current ('business as usual') scenario.**
  No tree planting provision. There are no provisions for landscaping in the current Residential Code. Landscaping provisions vary significantly in the current Development Plans but don't include a specific tree planting requirement for minor infill.
- **Option 1 - One onsite tree per allotment (Draft Code policy).**
  The proposed deemed-to-satisfy[5] provision for minor infill to provide one tree (or equivalent) on each allotment, which is small, medium or large depending on allotment size. Discounts apply for retaining existing trees and associated soil area.
- **Option 2 - Offset scheme.**
  Applicants can choose to meet the one tree provision on their own allotment, or have the same outcome achieved offsite on public land, funded by an offset scheme.

The two proposed solutions were compared against the 'base case' – that is, what happens with trees in minor infill developments now. To check if proposed policy options will add or subtract value, we needed to clearly define an accurate base case. This was a key part of this project. Based on a case study site[6],

[5] A deemed to satisfy policy is a measurable criteria which is one way of meeting a performance outcome in the Planning and Design Code. Applicants can instead choose alternative solutions that meet the relevant performance outcome.

[6] The case study site is the Frederick Street catchment area in Glengowrie within the City of Marion, which is the same area used as a case study for the separate Stormwater Management report.

we apportioned how many infill developments currently remove, retain and plant trees, and how many already have to factor the tree effect into house footing costs due to offsite trees.

Multiple scenarios were tested under each option to enable assessment of whether policies should be adjusted in specific scenarios. The scenarios covered various tree effects[7], two soil types[8] and two common infill dwelling types[9]. While this is not exhaustive, it does provide a reasonable indication of the potential impact of the proposed Code policy.

What is a cost benefit analysis, and why have we taken this approach?

A cost benefit analysis is undertaken to enable all quantifiable costs and benefits of various policy options to be considered on an even playing field. This includes testing the likelihood and significance of any net costs or benefits. The aim of using this approach is to ensure the Planning and Design Code uses the most cost-effective and beneficial solutions to meet the desired policy outcomes.

In determining the costs and benefits of the two policy options, it is important to distinguish between who is accruing the costs and the benefits. The analysis was therefore undertaken at two levels:

- **At the community level** – expected costs and benefits (both monetary and non-monetary) accruing to people (households, businesses and government) and the environment within Greater Adelaide, as a result of the proposed options.
- **At the individual household level** – expected cost and benefits (monetary only) accruing to the household undertaking the development, as a result of the proposed options.

A cost benefit analysis has limitations. It can only include costs and benefits that are quantifiable in dollar terms, backed by the best available, relevant and defensible information. It provides an indication of the likelihood and significance of costs and benefits, but due to the many variables at play, it is not possible to identify the exact net cost or benefit applicable to every individual household in every possible scenario.

The analysis was conducted over a 25-year period. Results were expressed in terms of net costs or benefits – that is, how each option compared against the base case, in real terms (i.e. 2020 dollars). The criteria measured were Net Present Value (NPV) and Benefit-Cost Ratio (BCR). Where NPV is a positive, this shows a net benefit, and where negative, a net cost. Where the Benefit-Cost Ratio is greater than 1.0, the option delivers a net benefit, and where it is less than 1.0, it delivers a net cost.

Which costs and benefits have been considered, and which have been excluded?

Monetary costs and benefits considered include those that are direct (e.g. paying an offset) and those that are indirect (e.g. electricity bill savings). Non-monetary costs and benefits were also considered (e.g. avoided healthcare costs from reduced air pollution).

The analysis captures only a conservative estimate of the benefits, due to the rigorous and transparent approach taken to quantify benefits in financial terms. We have preferenced South Australian and then best practice Australian data sources.

Many of the benefits attributed to tree cover in the research are not readily expressed financially, and as a result, often go unquantified in dollar terms. There are a multitude of studies that have identified the link between urban trees and social and environmental benefits (see Table 2-6), but it is a challenge to

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[7] Not causing a new tree effect, causing a new tree effect, and causing an additional tree effect.

[8] The type causing the smallest effect to house footing costs, and the type causing the greatest effect.

[9] A 200m^2 brick veneer detached single storey house and a 90m^2 two story townhouse, two common minor infill development housing types in metropolitan Adelaide.

find suitable studies from which to transfer values, without risk of misapplication. We have been careful and conservative in the values we have transferred from other studies to use in this study. Some well-researched benefits that could not be defensibly quantified have therefore been excluded. These include amenity values of onsite trees, biodiversity values, urban heat mitigation, and some physical and mental health benefits. Nuisance costs have also been excluded due to a lack of defensibly quantifiable evidence, and because nuisance effects are generally associated with larger trees than those required under the proposed Code policy.

	Individual Household	Community
COSTS	Tree effect on house footings (onsite trees) Planting & maintenance (onsite trees) Offset scheme payments (offsite trees)	Tree effect on house footings (onsite trees) Planting & maintenance (onsite trees) Planting & maintenance (offsite trees) Offset scheme development and management (offsite trees) Offset scheme payments (offsite trees)
BENEFITS	Electricity bill savings (onsite trees) Amenity (increased property value)	Amenity Improved air quality (avoided physical health costs) Removed carbon Avoided loss of stored carbon (retained trees) Avoided stormwater runoff Reduced household electricity use Avoided mental health costs Offset scheme receipts (offsite trees)
EXCLUSIONS	Nuisance effect (cost) Community benefits: Improved biodiversity Improved physical health Improved mental health Removed carbon Avoided loss of stored carbon Avoided stormwater runoff	Nuisance effect (cost) Improved biodiversity Unquantified health and wellbeing benefits Structural (replacement) value of trees

Key Findings of the Cost Benefit Analysis

Compared to the base case, introducing the 'One Tree Policy' is expected to deliver economic, amenity and liveability gains to the Greater Adelaide community valued at $26.4 million (BCR 1.7), and is therefore a worthwhile initiative for government to consider.

Consideration could be given to implementing more nuanced policy options to minimise upfront costs in the cases where a homeowner will incur a net cost as a result of tree policies (i.e. in locations with highly reactive soils and small minimum setbacks). This may include introducing an optional offset scheme which, as formulated in this study, would deliver estimated gains to the Greater Adelaide community of $165.1 million.

Option 1 - 'One Tree Policy' for one onsite tree per allotment (Draft Code policy).

This option would return $1.70 to the community for every $1 invested. The 'One Tree Policy' as described in the Draft Code is therefore a worthwhile initiative for government to consider.

This study tested a number of likely common infill development scenarios.

In the most likely scenario, a tree can be planted onsite without creating a new or additional tree effect (Scenario 1[10]). In this case, infill households will realise a significantly positive net benefit of $888 (BCR 2.5).

This study also tested the impact of infill developments planting a 6m tree 4m from the dwelling's footings, which will impose a new tree effect on house footing costs. The study found that where the soil has lower reactivity[11], the household will realise a net benefit, and where the soil has higher reactivity[12], the household will incur a net cost (BCRs range from 1.9 to 0.4 respectively).

There may be merit in identifying additional options for households to meet tree cover outcomes while minimising upfront costs, in the scenario they will incur a net cost.

This study has only included a limited sub-set of benefits that were able to be defensibly quantified in dollar terms. Other benefits likely to accrue to households with onsite trees include improved physical and mental health. We therefore expect the estimated benefits to be conservative for both individual households and the community.

Option 2 - Provision of an offset scheme.

This option would return $2.4 to the community for **every $1 invested**. Providing the option for infill households to have the same 'one tree' outcome achieved offsite on public land, funded via an offset scheme, is therefore a worthwhile initiative for government to consider.

As formulated in this study, providing an offset option would deliver gains to the Greater Adelaide community valued at an **estimated $165.1 million.**

Option 2 had a significantly higher return than Option 1 for three reasons:

- **Amenity value of offsite trees is significantly greater than onsite trees** - valued at $104.0 million in additional community benefits.
- **Most house footing costs would be avoided**, with some households choosing to pay an offset instead - valued at $26.3 million in avoided household costs compared to Option 1
- **More mature trees would be retained** (incentivised via avoided offset payments) - valued at $15.2 million in retained community benefits compared to Option 1.

For households choosing to pay an offset rather than meeting tree outcomes onsite, net costs were $1,165 if there was no existing tree onsite and $3,435 if an existing tree was removed. An offset may therefore be appealing where the cost is lower than amending house footings (e.g. on more reactive soils). In the case where an existing tree is removed, an offset payment may be attractive to households with other considerations external to this analysis (such as site configuration or particular house designs) they are prepared to trade off against the offset payment. Note the offset scheme in this cost benefit analysis is illustrative only and further investigation is needed.

[10] Scenario 1 covers cases where the new tree is planted outside the tree effect zone OR where there is already one nearby tree (causing an existing single tree effect on footings) OR where there is already a group of nearby trees (causing an existing group of trees effect on footings).
[11] See Scenario 2 and 4 in the Cost Benefit Analysis.
[12] See Scenario 3 and 5 in the Cost Benefit Analysis.

Key Policy Considerations

1. **Nuanced policy implementation for more reactive soils in denser zones**
   - A nuanced application of the policy could be considered for households expected to incur a net cost. This may occur in denser zones (with smaller lots and setbacks) with more reactive soils.
   - Distribution of more reactive soils is highly variable across Greater Adelaide.

2. **Putting a price on tree loss**
   - Retained trees, being more mature, provide relatively more economic, social and environmental benefits than newly planted trees.
   - There is currently a 3 x $150 fee for removing a Significant tree and 2 x $150 fee for removing a Regulated tree on private land. It is clear this nominal fee falls short of covering the costs of planting and maintaining a replacement tree ($603 on private land, $1,165 on public land) - not to mention the lost benefits to the community (estimated at $3,435 for an average unregulated tree).
   - Mechanisms could be considered for appropriately pricing removal of trees to reflect the true cost imposed on the community (e.g. lost carbon storage, lost urban heat mitigation, reduced house values, reduced health outcomes, etc.).

3. **Providing an offset scheme for trees to be planted offsite**
   - Option 2, as formulated in this study, does put a price on lost benefits and replacement costs when removing existing trees. This is expected to incentivise higher retention of existing trees.
   - An appropriately priced offset scheme may provide individual households with greater choice in how they fulfil their contribution to the desired policy outcome of improved tree canopy cover. For example, an offset payment may be attractive to households on sites with more reactive soils.
   - Individual households may have other considerations external to the analysis, such as site configuration or particular house designs, which they are prepared to trade off against the cost of payment into the offset scheme.
   - If an offset scheme is pursued, its design should consider the practicalities of replacing and maintaining a tree in the public realm (including space constraints), the loss of tree benefits where they are needed most, and the required administrative arrangements of an offset scheme.
   - Consideration would also need to be given to appropriately distributing offset payment receipts to equalise lost tree benefits, both by location (so tree benefits can be provided where they are needed most) and by sector (so the lost benefits can be provided by alternative means).

New infill development zones

The new **General Neighbourhood** and **Suburban Neighbourhood** Zones have a minimum 5m setback. Infill developments in these zones can usually meet the 'One Tree Policy' provisions without incurring any new costs to house footings.

The denser **Housing Diversity** and **Urban Renewal** Zones have a minimum 3m setback. In these zones, households could choose to avoid additional house footing costs by setting their house back further than the minimum, or they can choose to accommodate the 'tree effect' in their house footing design. Due to the small block size and minimum setback, it is likely that many of these developments will already have to consider some form of 'tree effect' from nearby street trees or neighbour's trees, regardless of the 'One Tree Policy'.

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ABBREVIATIONS

BCR	Benefit-cost Ratio
CBA	Cost Benefit Analysis
CPI	Consumer Price Index
DEW	Department of Environment and Water
AGD	Attorney-General's Department
DTS	Deemed-to-satisfy
GI	Green Infrastructure
LGA	Local Government Area
NPV	Net Present Value
SPC	State Planning Commission
WSUD	Water Sensitive Urban Design

1. INTRODUCTION

1.1. Background to this study

The progressive implementation of the *Planning, Development and Infrastructure Act 2016* will reach a major milestone in 2020, as the Planning and Design Code (the Code) is brought into formal operation across South Australia.

Introduction of the Code provides a valuable opportunity to refine and improve policies to meet the State's strategic directions, including those related to water sensitive urban design (WSUD) and urban greening in the context of increasing minor residential infill.

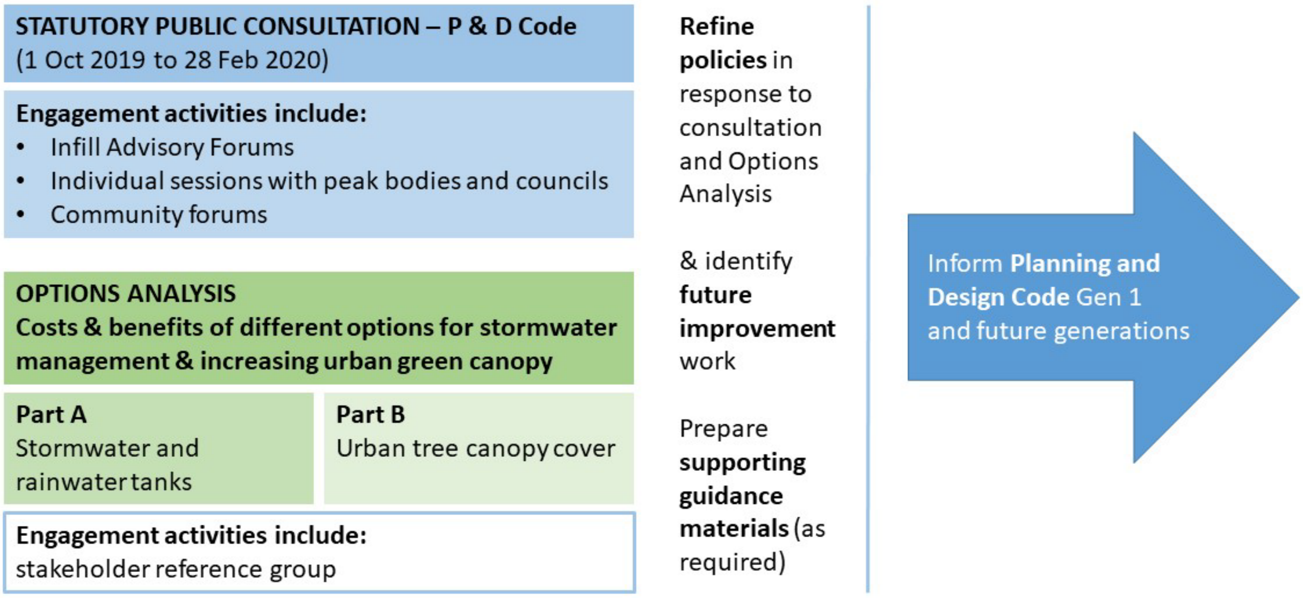
The State Planning Policies give direction to improving water sensitive urban design and urban greening outcomes, in recognition of the multiple benefits they provide. Draft Planning and Design Code (Code) policies have been prepared and consulted on (until 28 February 2020) in response to this direction.

BDO EconSearch and Tonkin Engineering have been commissioned by the Attorney-General's Department (AGD), Department for Environment and Water (DEW), Department of Treasury and Finance (DTF), and SA Health to analyse the cost-effectiveness of the proposed Planning and Design Code policies for minor infill, in relation to:

- Tree canopy cover and the 'One Tree Policy' (*this report*)
- Stormwater management and rainwater tanks (*refer to separate report*).

This work sits within the context of the public consultation process for Phase 3 (Urban Areas) of the Planning and Design Code as illustrated in -1.

Figure 1 Relationship of this Options Analysis to development of the Planning and Design Code



Stakeholder engagement

A stakeholder reference group with representatives from the following organisations provided feedback into the scope of this work:

- Department of Treasury and Finance
- Department for Environment and Water
- SA Health
- Housing Industry Association (HIA)
- Master Builders Association (MBA)
- Urban Development Institute of Australia (UDIA)
- Local Government Association of South Australia (LGA)
- Stormwater Management Authority
- Premier's Climate Change Council
- Water Sensitive SA
- Stormwater SA
- Australian Institute of Landscape Architects (AILA)
- Australian Institute of Architects (AIA)
- Conservation SA
- South Australian Council of Social Services (SACOSS)
- Property Council
- Community Alliance
- Engineers Australia.

Background evidence gathering

As a first stage to this work, AGD, sought to identify and review some of the likely costs and benefits associated with proposed Code policies, with funding from Green Adelaide. These efforts were informed by a number of stakeholder workshops and forums included members of the Stakeholder Reference Group as well as representatives from key government agencies, local councils and developers with experience in infill development. This options analysis used and built on this work (see **Appendix 1** for a summary).

1.2. Study objectives and scope

This report is intended to inform decision-making on the cost-effectiveness of proposed Planning and Design Code policy for minor infill in relation to tree canopy cover, alongside other feedback. It aims to improve understanding of all the upfront and long-term costs and benefits of the proposed policies, to both the individual household and the Greater Adelaide community, and ensure they can be weighed up objectively. Note that the tested policies are being considered for minor infill[13] sites only, not for greenfield developments where the public realm (streetscapes and public open space) is usually designed together with new housing.

The analysis was undertaken at two levels:

- **At the community level** – expected costs and benefits (both monetary and non-monetary) accruing to people (households, businesses and government) and the environment across Greater Adelaide, as a result of the proposed options.
- **At the individual household level** – expected cost and benefits (monetary only) accruing to the household undertaking the development, as a result of the proposed options.

The cost benefit analysis tested two policy options against the base case. The purpose of this approach is to test whether the Draft Code policies stack up against the current South Australian policy requirements. Multiple scenarios were tested under each option to enable assessment of whether policies should be adjusted in specific scenarios.

The base case and policy options analysed were:

- **Base Case Scenario - Current ('business as usual') scenario.**
  No tree planting provision. There are no provisions for landscaping in the current Residential Code. Landscaping provisions vary significantly in the current Development Plans but don't include a specific tree planting requirement for minor infill.
- **Option 1 - One onsite tree per allotment (Draft Code policy).**
  The proposed deemed-to-satisfy[14] provision for minor infill to provide one tree (or equivalent) on each allotment, which is small, medium or large depending on allotment size. Discounts apply for retaining existing trees and associated soil area.
- **Option 2 - Offset scheme.**
  Applicants can choose to meet the one tree provision on their own allotment, or have the same outcome achieved offsite on public land, funded by an offset scheme.

The study area covers the urban areas of the Greater Adelaide Capital City Statistical area[15]. Figure 2 shows a map of the study area for this analysis.

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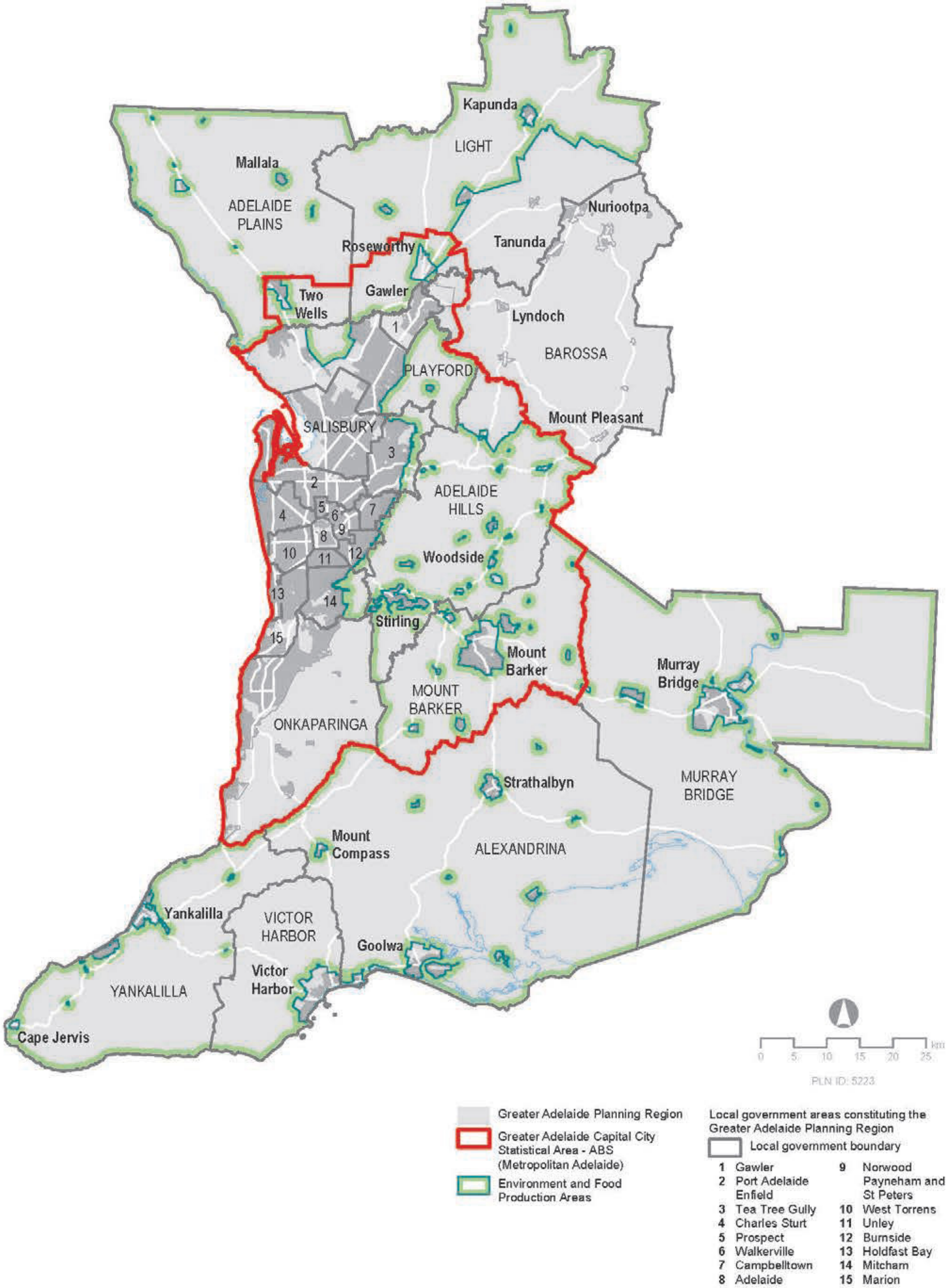
[13] Minor infill is defined as 'Development and adaptation of the existing housing stock, including demolition and subdivision, on sites less than 4,000m² and involving 10 dwellings or less. Minor infill is an important component of the overall land supply equation and makes a significant contribution (around 40 per cent) to the annual metropolitan housing supply growth within Greater Adelaide' (AGD 2019).

[14] A deemed to satisfy policy is a measurable criteria which is one way of meeting a performance outcome in the Planning and Design Code. Applicants can instead choose alternative solutions that meet the relevant performance outcome.

[15] Gawler, Port Adelaide Enfield, Tea Tree Gully, Charles Sturt, Prospect, Walkerville, Campbelltown, Adelaide, Norwood Payneham Dt Peters, West Torrens, Unley, Burnside, Holdfast Bay, Mitcham, Marion, Salisbury, Playford, Adelaide Hills, Mt Barker, Onkaparinga, Mallala (part of) and Light (part of).

Figure 2 Map of the study area (Greater Adelaide)



Source: AGD, The 30-Year Plan for Greater Adelaide – 2017 Update page 31

2. STUDY CONTEXT

This section provides a more in-depth discussion of the study context and describes urban infill and urban tree cover trends in Greater Adelaide, the policy context, and Draft Code tree planting requirements. It also provides a literature review of the costs and benefits associated with urban trees and highlights the limitations of this study.

2.1. Urban infill trends in Greater Adelaide

Target 1 of the *30-Year Plan for Greater Adelaide (2017 Update)* (the 30-Year Plan) is for 85 per cent of all new housing to be built within the existing urban footprint. This target recognises that infill development helps to create walkable neighbourhoods, protect valuable farming and environmental land, and meet consumer demand for living close to jobs, shops, and services. This target has facilitated a significant increase in the ratio of infill development compared to greenfield development in Greater Adelaide.

The 30-Year Plan for Greater Adelaide (2017 Update)

Containing our urban footprint and protecting our resources

85% of all new housing built in established urban areas by **2045**

In recent decades, a large amount of development has occurred at major infill broadacre sites such as Mawson Lakes and Northgate. Now the focus is shifting to identifying new opportunities within established suburbs. Currently, about 80 per cent of Greater Adelaide's new housing growth is in these established suburbs (AGD 2020).

Minor infill development[16] (see Figure 3 for an illustrative example) is now playing a significant role in delivering the 30-Year Plan target, contributing about 40 per cent of the overall housing supply each year (AGD 2019). From 2012 to 2018, minor infill produced an average annual net increase of about 2,500 residential dwellings (AGD 2019). Figure 4 gives context to the role played by minor infill in recent housing supply.

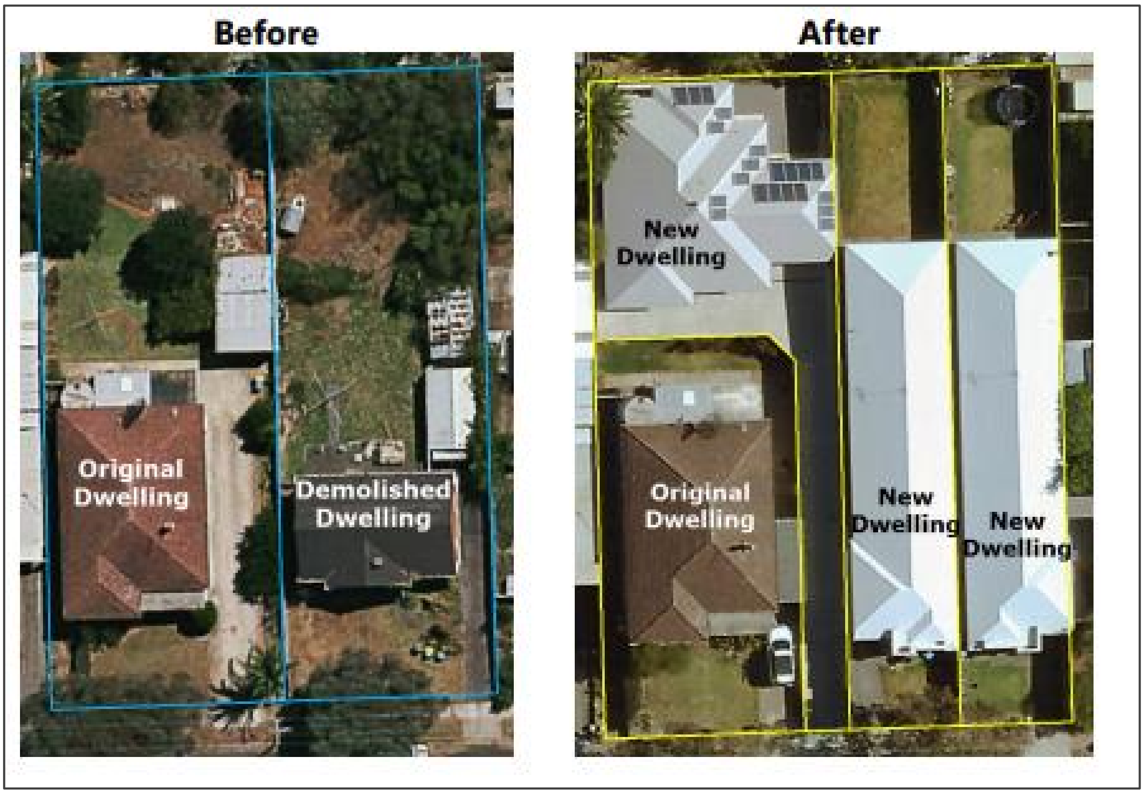
The median allotment size of new development across Greater Adelaide has reduced significantly in recent years. In 2018/19, the median size of new allotments (detached and semi-detached) was 361m^2, down from 518m^2 in 1999/2000.

It has been observed that minor infill development is generally not occurring in a way that addresses urban tree canopy objectives. This is because infill development generally increases site coverage and driveway crossovers, and reduces space for gardens and tree planting, creating up to 90 per cent impervious surfaces. The implications of these trends for urban tree canopy are discussed in Section 2.2.

Refer to the extract from AGD's People and Neighbourhoods Discussion Paper for further information about recent minor infill trends in Greater Adelaide (Figure 5 5).

[16] Minor infill involves the demolition of dwellings and/ or the subdivision of land to generate new housing at the same or greater densities (up to 10 dwellings) on sites less than 4,000m^2 (AGD 2019).

Figure 3 Examples of minor infill development



Source: AGD 2019a

Figure 4 Demand driven residential trends, Greater Adelaide

Source: AGD 2019a

Figure 5 Recent trends in minor infill development

Department of Planning, Transport and Infrastructure summary of minor infill activity in Greater Adelaide 2012-2018

Between 2012 and 2018, minor infill was the single greatest provider of new housing in Greater Adelaide, contributing 39% of the region's net dwelling increase compared with major / other infill (32%) and broadhectare (29%) sites.

Occurring within existing built up areas on sites of less than 4,000m², minor infill involves the demolition of dwellings and/ or the subdivision of land to generate new housing at the same or greater densities (up to 10 dwellings).

Example of minor infill created by a demolition and resubdivision

In the Greater Adelaide region between 2012 and 2018:

- The net dwelling increase from minor infill was 2,501 dwellings per annum (total 15,005).
- Demolition and resubdivision generated an average of 1,374 dwellings per annum.
- Vacant land parcels that were created through broadhectare land division, demolitions and resubdivsions prior to 2012, generated an additional 1,128 dwellings per annum.
- Marion LGA generated an additional 2,008 dwellings through minor infill, followed by Charles Sturt (1,988) and Onkaparinga (1,788).
- The rate of demolition increased steadily from around 1,765 dwellings per annum from 2008 - 2014, to the current 2,018 dwellings per annum. Charles Sturt LGA experienced the greatest number of demolitions, with a total of 1,909, followed by Port Adelaide Enfield LGA with 1,892.
- Resubdivision occurred on an average of 395 sites per annum (total 2,371). Onkaparinga LGA experienced the largest share of resubdivisions with 354 sites, which generated an additional 276 dwellings and 119 vacant lots. This was followed by Charles Sturt LGA, with 301 sites, generating an additional 289 dwellings and 53 vacant lots.
- The average replacement rate for demolition sites was 1:1.85. Onkaparinga LGA recorded the highest replacement rate of 2.4, followed by Marion and Gawler LGAs with 2.2. This is largely influenced by allotment size, planning policy and market demand.

Buoyed by a supportive policy framework provided within the 2017 update of The 30 Year Plan for Greater Adelaide, which both encourages the reduction of our urban footprint and the provision of more housing diversity close to public transport options, this steady increase in the importance of minor infill to the overall settlement pattern of metropolitan Adelaide is set to continue for the foreseeable future.

The full version of DPTI's Summary of Minor Infill within Greater Adelaide 2012-2018 can be downloaded from saplanningportal.sa.gov.au

Figure 3: Minor Infill Activity in Greater Adelaide 2012-2013

Source: State Planning Commission, 2019a

2.2. Urban tree canopy trends in metropolitan Adelaide

The evidence is that most metropolitan Adelaide councils have experienced a decline in canopy cover. Across 19 LGAs, a national report (Amati et al. 2017) found a loss of tree and shrub canopy and increase in hard surfaces from 2013 to 2016 (Table 2-1). The analysis, which used i-Tree Canopy, found that 17 of the 19 councils assessed had a loss of green cover across private and public spaces combined over the period 2013 to 2016. Overall, tree cover has reduced from 21.5 per cent to 19.5 per cent across metropolitan Adelaide between 2013 and 2016.

Table 2-1 Changes in land surface cover from 2013-2016, Metropolitan Adelaide

Land surface type	2013 (%)	2016 (%)	Change (%)
Tree canopy	21.37%	19.45%	1.92% loss
Shrub	5.92%	5.23%	0.69% loss
Grass	32.08%	32.10%	0.02% gain
Hard surface	40.63%	43.20%	2.57% gain

Source: Amati et al., 2017.

A number of metropolitan Adelaide councils have also undertaken more detailed analyses of changing tree canopy cover. For example, an i-Tree Canopy assessment of land cover was undertaken across the City of Charles Sturt (Seed Consulting Services 2016). Land cover was assessed at three points in time (1998, 2008, 2014) and across land tenures (private and public). Key findings include:

- Between 2008 and 2014, impervious surfaces across the City increased significantly (from 55.25 per cent to 60.16 per cent), plantable space decreased (from 23.63 per cent to 19.38 per cent), and tree cover decreased (from 15.51 per cent to 14.28 per cent).
- Changes in land cover across the City were driven primarily by changes on private land. For example, impervious surfaces increased by 6.5 per cent on private land, but only by 1 per cent on public land.

The implications of these combined results are that the rate of increase in green infrastructure on public land cannot keep up with the loss of trees and green cover due to infill development on private land. This trend is expected to exist in other council areas as reflected in the increase in hard surface area noted in Table 2-1.

2.3. Current policy framework

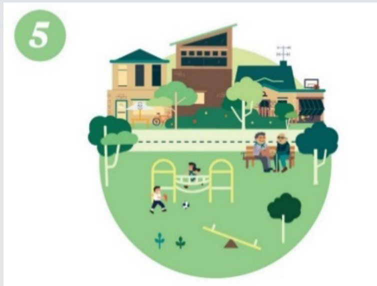
2.3.1. Urban green cover target and supporting policies

Target 5 of the 30-Year Plan is to increase urban green cover by 20 per cent by 2045. This target recognises the many benefits of green cover to urban cooling, the character, biodiversity and liveability of our suburbs, and our physical and mental health. This target is at significant risk, as outlined in Section 2.2.

The 2017 Update was the first time a target was introduced to measure progress in this area. The target includes the following detail:

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

The 30-Year Plan for Greater Adelaide (2017 Update)



A Green Liveable City

20% increase in urban green cover in metropolitan Adelaide by **2045**

The 30-Year Plan also contains the following policy to support investment in green infrastructure in areas subject to infill development:

- Promote permeable, safe, attractive, accessible and connected movement networks (streets, paths, trails and greenways) in new growth areas and infill redevelopment areas that incorporate green infrastructure (Policy 28).

Developing a new, more accurate baseline

AGD, DEW and the Regional Climate Partnerships have recently collaborated to develop a more accurate, finer grained baseline for urban tree canopy cover in metropolitan Adelaide. The tree canopy model uses high-resolution LiDAR laser surveying, rather than the i-Tree Canopy software. Due to the multiple spatial products LiDAR can produce, and the better accuracy of the results, it is likely that AGD will use this 2020 model as the new baseline for the 30-Year Plan target.

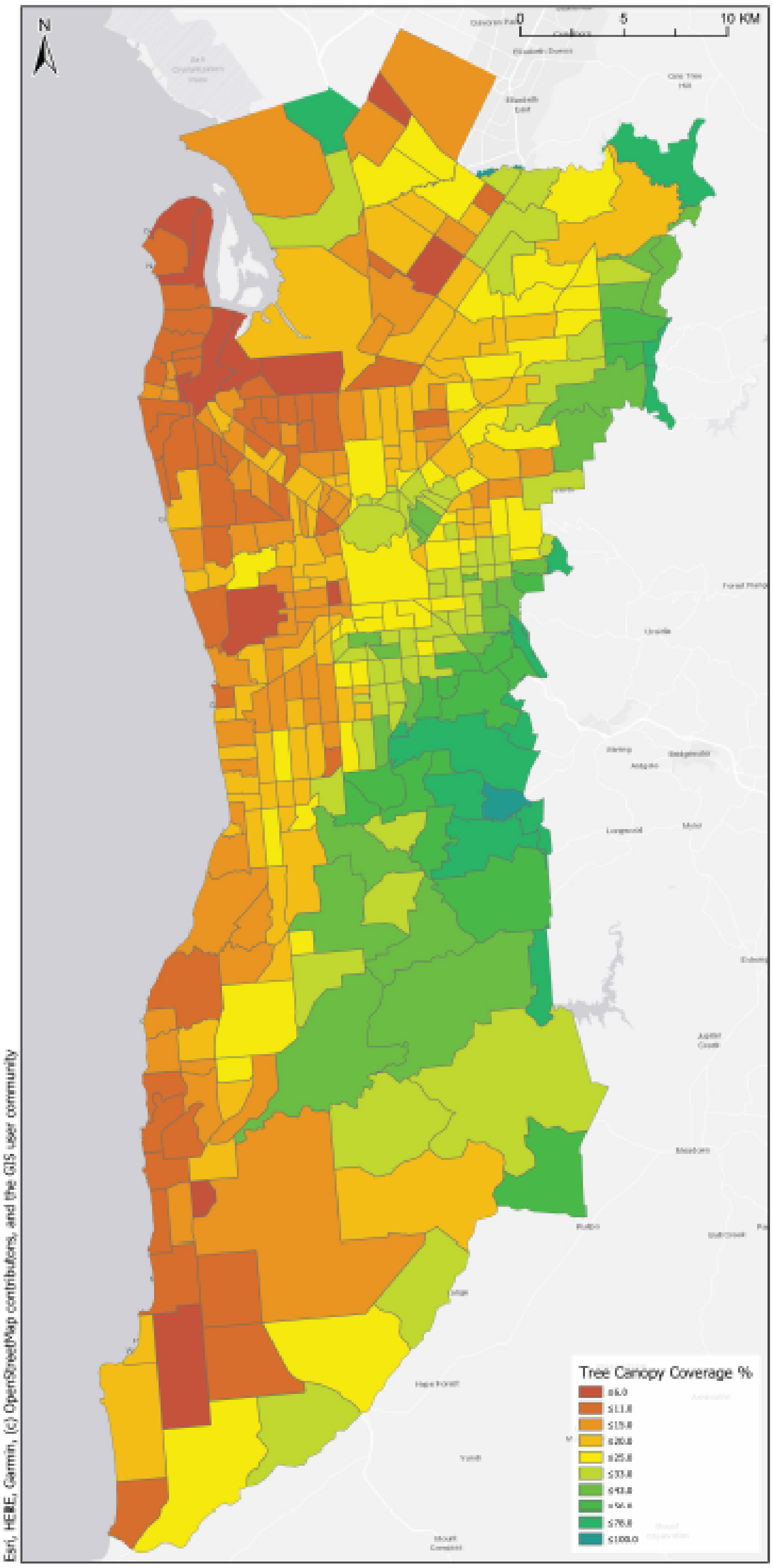
See Figure 6 for a snapshot of the new results, released in April 2020.

2.3.2. Current policy for tree canopy in minor infill development

In South Australia, where a proposed development meets certain criteria, it is assessed under the Residential Code. Otherwise, the development is assessed under the relevant Development Plan. There are no provisions for landscaping in the current Residential Code. Landscaping provisions vary significantly in the current Development Plans but don't include a specific tree planting requirement for minor infill.

Figure 6 New baseline data for tree canopy in metropolitan Adelaide (Aerometrex, 2020)

Canopy Coverage by Suburb - Metropolitan Adelaide



Ten Highest Suburbs

Upper Sturt	78.35%
Waterloo Corner	76.78%
Waterfall Gully	71.88%
Gould Creek	71.37%
Belair	71.26%
Pages Flat	69.79%
Ironbank	68.07%
Paracombe	67.08%
Houghton	66.66%
Lower Hermitage	64.66%

Ten Lowest Suburbs

Parafield	1.75%
Adelaide Airport	2.27%
Seaford Heights	2.29%
Gillman	2.75%
Outer Harbor	3.46%
New Port	3.72%
Direk	4.32%
Port Adelaide	4.33%
Mile End South	4.81%
Osborne	5.09%

Author: S.J. Holt, Aerometrex Pty. Ltd.
Date: 2nd April 2020
Coordinates: GDA 94 MGA54

2.4. Future policy framework

2.4.1. Overview of the South Australian planning reforms

The *Planning, Development and Infrastructure Act 2016* (the Act) is being progressively introduced to enable a more efficient, responsive and effective planning system.

Concerns about climate change, liveability, stormwater management, increasing health costs and declining biodiversity are driving an increased interest in green infrastructure and the many co-benefits it provides. Green infrastructure, particularly tree canopy, has been a significant area of interest for the State Planning Commission (the Commission), and the State Planning Policies on Climate Change and Design Quality reflect this.

State Planning Policies provide the high-level goals and requirements for the new planning system, which Regional Plans and the Planning and Design Code must respond to.

The 30-Year Plan has transitioned over as a Regional Plan.

The Code will replace the complex and at times inconsistent planning rules found within the 72 Development Plans currently in use. Establishing the Code presents an opportunity to refine and improve green infrastructure policies to meet the State Planning Policies and Regional Plan targets.

Draft policy directions were included in the Commission's *Natural Resources and Environment* and *People and Neighbourhood* Discussion Papers (released for consultation in August 2018 and September 2019 respectively). Draft Code policies were prepared in response, and were out for formal public consultation until 28 February 2020. These include both 'performance outcomes' and 'deemed-to-satisfy' provisions (see breakout box) for minor infill developments to provide tree canopy onsite.

Planning and Design Code
A performance-based planning system

Performance Outcomes (PO) are used in the Code to clearly describe the outcome being sought by the policy.

Deemed-to-Satisfy (DTS) provisions are clear and measurable criteria that have been assessed as one way to achieve a performance outcome. These criteria are designed to make policies easier to interpret and implement, but applicants can always choose to meet the performance outcome another way.

Source: DPTI 2019b

2.4.2. Draft Code policy for tree canopy in minor infill development

There is a Performance Outcome relating to tree planting (see below) included in the Draft Code for infill development (SPC 2019c).

The proposed Performance Outcome 21.2 for tree planting that:

- Contributes to shade and shelter
- Improves the outlook for occupants of buildings
- Reduces the mass of buildings
- Contributes to biodiversity
- Mitigates urban heat
- Improves the amenity and character of streetscapes and contributes to attractive vistas.

One way to achieve this Performance Outcome is for tree planting to be provided in accordance with the proposed DTS 21.2, which is essentially to provide one tree (or equivalent) on each allotment that is small, medium or large depending on allotment size. Discounts apply for retaining existing trees and associated soil area. Our analysis indicated that most potential minor infill developments would occur on allotments that are between 200m^2 and 400m^2 in size, so infill households are most likely to have a requirement to plant or retain one small tree, 4-6m in height.

In detail, the proposed DTS 21.2 provides for:

- Tree size and number required per dwelling according to allotment size (Table 2-2 and Table 2-3)
- Discounts apply for existing trees retained on the allotment and are not a species identified in Regulation 3F(4)(b) of the *Planning, Development and Infrastructure (General) Regulations 2017* which are invasive/nuisance species (Table 2-4)
- Smaller trees can be substituted for larger trees in accordance with equivalent planting rates (Table 2-5).

Table 2-2 Tree size and number required per dwelling, proposed DTS 21.2

Allotment size	Tree size[a] and number require per dwelling
Less than 450m^2	One small tree
450-800m^2	One medium tree
800m^2 and greater	One large tree

[a] Refer to Table 2-3 for tree size requirements.

Source: Draft Planning and Design Code, SPC 2019c.

Table 2-3 Tree size, proposed DTS 21.2

Tree size	Mature height	Mature spread	Minimum soil area
Small	4-6m	2-4m	10m^2 and minimum dimension of 1.5m
Medium	6-12m	4-8m	30m^2 and minimum dimension of 2m
Large	Greater than 12m	Greater than 8m	60m^2 and minimum dimension of 4m

Source: Draft Planning and Design Code, SPC 2019c

Table 2-4 Retained tree discounts, proposed DTS 21.2

Retained tree height	Retained tree spread	Retained soil area within development site	Discount applied
4-6m	Less than 4m	10m^2 and minimum dimension of 1.5m	Two small trees
6-12m	4-8m	30m^2 and minimum dimension of 2m	Two medium trees
Greater than 12m	Greater than 8m	60m^2 and minimum dimension of 4m	Two large trees

Source: Draft Planning and Design Code, SPC 2019c

Table 2-5 Tree size equivalents, proposed DTS 21.2

Tree size[a]	Equivalent planting
Medium	Two small trees
Large	Four small trees or two medium trees

[a] Refer to Table 2-3 for tree size requirements.

Source: SPC 2019c.

2.5. Research on the costs and benefits of urban trees

This analysis draws and builds on background evidence gathering work undertaken by AGD. See Appendix 1 for a summary of the relevant investigations.

2.5.1. Benefits of urban trees

Beyond its amenity and biodiversity value, green infrastructure provides critical services that make cities healthier and more liveable (Pittman et al. 2015). Tree canopy cover in particular is receiving increasing attention from urban planners and land managers nationally and internationally. This is due to trees now being widely recognised for providing multiple benefits (Natural Resources Adelaide and Mount Lofty Ranges 2018), including:

- Improved human physical, psychological and social health and wellbeing
- Enhanced liveability through improving amenity and air quality, and noise abatement
- Climate change mitigation through carbon sequestration in plants
- Climate change adaptation through reduction of the urban heat island effect by shading and transpiration, and providing protection from extreme weather events such as heatwaves and storms
- Buffering from exposure to extreme storms and winter weather
- Better water management, through reduced stormwater run-off and flooding, increased soil infiltration and groundwater recharge and improved water quality
- Healthy urban ecology conserving, creating and linking, habitat for flora and fauna
- Local food production e.g. private, school kitchen, verge and community gardens and urban orchards and farms
- Broader economic benefits from enhanced commerce and property values, health care and energy savings, and ecosystem services.

Further information on some of these benefits is presented in Table 2-6. A more detailed description of the broader benefits of green infrastructure is provided in the *Adoption Guidelines for Green Treatment Technologies* (Fowdar et al. 2018), in Pittman et al. (2015) and in Appendix 1.

Given that trees are long-lived and provide a number of benefits, it is being increasingly recognised that trees should be considered as assets, the same way livestock, buildings and employees are considered assets. Trees should be considered appreciating assets, as their replacement value and the services they provide increase over time.

Table 2-6 Examples of benefits of green infrastructure in cities

Benefit type	Description
Urban cooling	Trees have been identified as a highly effective mechanism for cooling the local environment through shading and evapotranspiration. The cooling effect of trees can benefit human health and general comfort either directly (e.g. direct shading or reducing solar radiation reflectance from pavements and buildings) or indirectly (e.g. reducing exacerbation or complication of existing illnesses) (Shashua-Bar, Pearlmutter and Erell 2011). A study in the City of Melbourne reported that every 10% increase in tree cover results in a 0.5-1°C cooling of land surface temperatures; and other studies have shown that tree shading can cool air temperatures up to 4°C (compared to unshaded areas), and cool soil surface temperatures by between 3-12°C (Coutts, Broadbent, et al. 2014, Lin and Lin 2010, Armson, Rahman and Ennos 2013). Coolstreets (LGNSW 2016) undertook a study with several neighbourhoods in Sydney and estimated that a neighbourhood of 40 houses on a street with trees reduced their electricity use (through less use of air-conditioning in summer) by 10,651kWh per year, compared to a similar street without street trees. A recent study in Western Adelaide assessed the effects of trees and other vegetation in people's yards at reducing day time and night time heat during an extreme heatwave event. Despite covering about 20% of urban land, people's yards contained more than 40% of the total tree cover. The number of private gardens, as well as the percentage of vegetation cover within these gardens, both contributed significantly in providing widespread cooling benefits across the Western Adelaide region with localised reductions in land surface

Benefit type	Description
	temperatures of up to 5-6˚C compared to non-vegetated areas and land parcels (Ossola et al. 2020).
Improved air quality	According to The World Health Report 2013 (Dye 2013), air pollution is one of the main environmental risk factors affecting human health. Trees play an important role in filtering and cleaning the air of harmful gaseous and particulate pollutants, via uptake through leaves and interception and accumulation of particles on the plant surface (Nowak, et al. 2014, Davern et al. 2017), Kardan et al. 2015).
Physical health	Studies have reported a range of additional physical health benefits for adults and children in relation to trees, such as: decreased mortality (Donovan, et al. 2013), increased longevity for senior citizens (Takano, Nakamura and Watanabe 2002), decreased cardio metabolic conditions (Kardan et al. 2015, Astell-Burt & Feng 2019a), lower risk of asthma development in children (Lovasi, et al. 2008, Sarajevs 2011), enhanced motor skill development in children (Fjortoft 2001), increased physical exercise and sleep quality (Grigsby-Toussaint, et al. 2015, Astell-Burt & Feng 2019b) and decreased sun (UV) exposure (Parsons, et al. 1998, Sarajevs 2011, Ely & Pitman 2012).
Mental health	Australian-based research even suggests that neighbourhood 'greenness' is more important for influencing mental health than physical health (Sugiyama, et al. 2008). Residents living closer to and with greater exposure to green space are significantly less likely to suffer poor mental health (e.g. Beyer et al. 2014, Richardson et al. 2013). A systematic review found that children exposed to greenspace achieved greater mental well-being, reduced hyperactivity and inattention problems, and in adolescents and young adult less depressive symptoms outcomes (Vanaken and Danckaerts 2018).
Place making and increased economic value (amenity)	Several Australian studies have shown that living near to trees in public places, in particular street trees, can increase property prices. For example, Pandit et al. (2013) found being on a street with street trees increased the median property price in Perth by 1.9% and Plant et al. (2017) found that houses in Brisbane with street tree canopy cover of 50% increased the median house price by 5.05%.
Stormwater management	Vegetation plays a critical role in the natural water cycle, modifying rainfall inflows, soil infiltration and groundwater recharge, and patterns of surface runoff (Ely & Pitman 2014) and can ameliorate the impacts of urbanisation on stormwater management. A 1996 study of stormwater management costs, showed that the urban forest provided stormwater management benefits valued at US$15.4 million in Milwaukee, Wisconsin, and US$122 million in Austin, Texas, by reducing the need for constructing additional retention, detention and treatment capacity (MacDonald 1996). Brisbane City (2013) estimated that the Brisbane street tree population intercepted and infiltrated 635,733m3 of stormwater providing stormwater management services worth $1,444,533/yr.
Biodiversity	Trees can provide, for example, food, shelter, habitat, protection from predators, movement corridors to a range of plant, animal and fungal biodiversity. Healthy biodiversity plays a fundamental role in the functioning of ecosystems and their ability to deliver long-term ecosystem services, with biodiversity loss an issue of increasing global concern. Nature and biodiversity in cities contribute to our human sense of place, identity and psychological well-being. Green Infrastructure supports biodiversity by creating or conserving habitat patches linked by corridors, thereby reducing habitat fragmentation. While the 'urban nature' found in cities may be different from 'wild nature', it still contributes to healthy ecosystem function and has both intrinsic and human well-being values (Ely & Pitman 2014).

2.5.2. Costs of urban trees

There can be adverse tree impacts that need to be managed. For example, tree root growth can cause damage to kerbs, paving, foundations and other underground infrastructure; leaf litter can accumulate in gutters and drains; falling branches can cause risk to people, buildings and fences; and provision for trees may influence the footprint of buildings on small blocks. In many instances, adverse impacts reflect poor tree selection and/or poor site preparation and can be avoided e.g. selection of a tree that is too large for the site or irrigation is insufficient to prevent extensive surface root growth (Seed Consulting et al. 2019).

The 'tree effect' is also an important consideration for a structural engineer when they are designing the footings for a house. Factors they consider include the footing type, size of house, construction type, size of the tree at mature height, and distance away from the dwelling. The type of soil also has an important impact - sandy soils are better at accommodating trees from a footing perspective than highly reactive soils. These variables mean that there is no single design for house footings to factor in the tree effect, and therefore no single price for the impact of a tree on the cost of the footings. These issues are explored further in Section 2.6.

2.5.3. Study limitations

A cost benefit analysis has limitations. It can only include costs and benefits that are quantifiable in dollar terms, backed by the best available, relevant and defensible information. These limitations are greater when assessing the impact of policies that have costs and benefits that are not readily quantifiable from the available research.

Many of the benefits attributed to green cover are not readily expressed financially, and as a result, often go unquantified in dollar terms. There are a multitude of studies that have identified the link between urban trees and social benefits (see Table 2-6), but it is a challenge to find suitable studies from which to transfer values, without risk of misapplication. We have been careful and conservative in the values we have transferred from other studies to use in this study.

Some well-researched benefits that could not be defensibly quantified have therefore been excluded. These include structural values, biodiversity values, urban heat mitigation, and some physical and mental health benefits (more detail on physical and mental health benefits and structural values of trees is provided below). Nuisance costs have also been excluded due to a lack of defensibly quantifiable evidence, and because nuisance effects are generally associated with larger trees than those required under the proposed Code policy.

Physical health benefits

We have only quantified a limited sub-set of physical health benefits associated with a reduction in air pollution. There is a substantial literature which identifies and quantifies, in biophysical terms, the association between green infrastructure and mental and physical health outcomes. What is less readily available, is translating those biophysical outcomes to defensible dollar values. An example of a method that has achieved this is the i-Trees Eco tool. This tool puts a dollar value on human health outcomes from air pollution reduction provided by trees absorbing air pollutants nitrous oxide, sulphur dioxide and ozone. Valuing the human health outcomes is based on avoided health care expenses from non-exposure to these pollutants, avoided productivity losses associated with specific adverse health events and the avoided mortality based on the value of a statistical life (Nowak et al. 2014). The method, developed in the USA, has been adapted for Australian conditions and local examples are available (e.g. Seed Consulting 2018). The method requires tree canopy data, tree species, tree health assessment and local air quality data. Within the timeframe and resources available to this study it was only possible to undertake desktop analyses using existing studies (e.g. Seed Consulting 2018), where benefit values have been estimated and could be reasonably used in this study. Other physical health benefits have been excluded.

Mental health benefits

The prevalence of mental health issues generates significant economic cost on individuals, their employers and the community more broadly. In the workplace, for example, employees with mental illness are more likely to be absent from work and less productive when at work (KPMG and Mental Health Australia 2018). This has a flow-on effect at a macroeconomic level where mental health costs to the economy were an estimated $66 billion[17] in 2019. These significant costs are forecast to increase six-fold over the next 30 years (Doran and Kinchin 2019).

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17 Originally published in VISES (2016) as $56.7 billion for 2014, adjusted for inflation and population growth over the period 2014 to 2019.

Cox et al. (2017) notes that experiences with nature provide many mental health benefits, particularly for people living in urban areas. They demonstrate quantifiable associations of mental health with the characteristics of nearby vegetation. Ely and Pitman (2012) found that contact with nature can help children, and people in general, deal with stress. Natural outdoor settings have been shown to provide restoration from cognitive effort and stress (Kaplan and Kaplan 1989; Kaplan 1995), and one study in rural United States found that that the presence of vegetation near a home helped to moderate the impact of stressful life events on the psychological wellbeing of children (Wells and Evans 2003).

An important step for this analysis was to translate the improved mental health outcomes generated by the presence of vegetation near a home into economic outcomes. This entails applying a methodology to place an economic value on the direct, indirect and intangible health costs associated with the improved health outcomes.

Analysis by Cox et al. (2017) undertook an analysis to estimate the association between neighbourhood vegetation cover and levels of depression, anxiety and stress. The benefits from these associations "may be gained from intentionally interacting with nature (e.g. through visiting neighbourhood green spaces or spending time in a garden), from incidental interactions whereby people are exposed to nature as they engage in other activities (e.g. walking to the shops), or indirectly while not actually being present in nature (e.g. viewing it through a window)" (Cox et al. 2017, p.147). This analysis, combined with research from the Victorian Institute of Strategic Economic Studies (VISES 2016), was used to estimate and assign values for the impact of trees on avoided mental health costs associated with severe depression and anxiety (see Section 3.3.10). Other mental health benefits have been excluded.

Structural value

Given that trees are long-lived and provide a number of benefits, it is being increasingly recognised that trees should be considered as assets, the same way that livestock, buildings and employees are considered assets. Trees should be considered appreciating assets, as their replacement value and the services they provide increase over time.

In some industries, such as forestry, their capital valuation and treatment on corporate balance sheets is a well-established process. Local governments and other owners of trees in the public realm are increasingly putting a value on their tree assets to ensure proper accounting and management resourcing.

In cost benefit analysis, capital assets may still be capable of providing a future flow of benefits if they are not at the end of their useful life by the end of the analysis period. This is generally considered as the residual value of that capital, and is accounted for in the analysis. Typically, the residual value of capital is the replacement price of a 'like-for-like' item of capital, e.g. the residual value of a stormwater pipe with 20 years of useful life remaining at the end of the analysis period is the price that would be paid for an equivalent stormwater pipe with 20 years of useful life remaining.

The Seed Consulting (2018) study valued the structural value of trees, sometimes referred to as the 'replacement value', using a replacement cost based on the Council of Tree and Landscape Appraisers formulae in the i-Tree Eco tool.

This study used the structural value of trees using the method and appropriate values from the Seed Consulting (2018) study as part of the tree offset payments under Option 2 (see Section 3.3.3). It was, however, excluded as a benefit from the broader analysis as its application in this context was considered novel and untested.

2.6. House footings and the 'tree effect'

One of the concerns raised in consultation on the Code was the potential impact of tree planting on upfront housing affordability, as a result of higher footing costs. Addressing these concerns was a key focus of this report.

To inform this study, AGD commissioned independent advice from several structural engineering firms (including TMK Consulting Engineers) on the effect of a tree on house footings costs (costs are outlined in Section 3.3.1). The advice can be summarised as follows:

- Structural engineers will design house footings to factor in a 'single tree effect' if the distance between the dwelling and the tree is 1x the mature height of a single tree (in the case of one or two trees); or to factor in a 'group tree effect' if the distance between the dwelling and the trees is 1.5x the mature height of a group of trees (in the case of three trees close together) (AS2870-2011 Residential Slabs and Footings). See Figure 7 and Figure 8 for explanatory diagrams.
- However, if a tree is within the tree effect zone, the required footing depth can be influenced by a number of other factors e.g. soil type, construction method, the height of the tree at maturity, the number of other trees present, and the type and shape of footing. Therefore the cost impact of trees on footings is highly variable.
- There are five main soil types in Greater Adelaide, ranging from least reactive (sandy) to most reactive (clay). For less reactive soils, a tree (even planted quite close to a house) would have only a low impact on footing thickness (and therefore cost), while more reactive soils, the cost is much greater. See Section 2.6.1 for more information on soils.

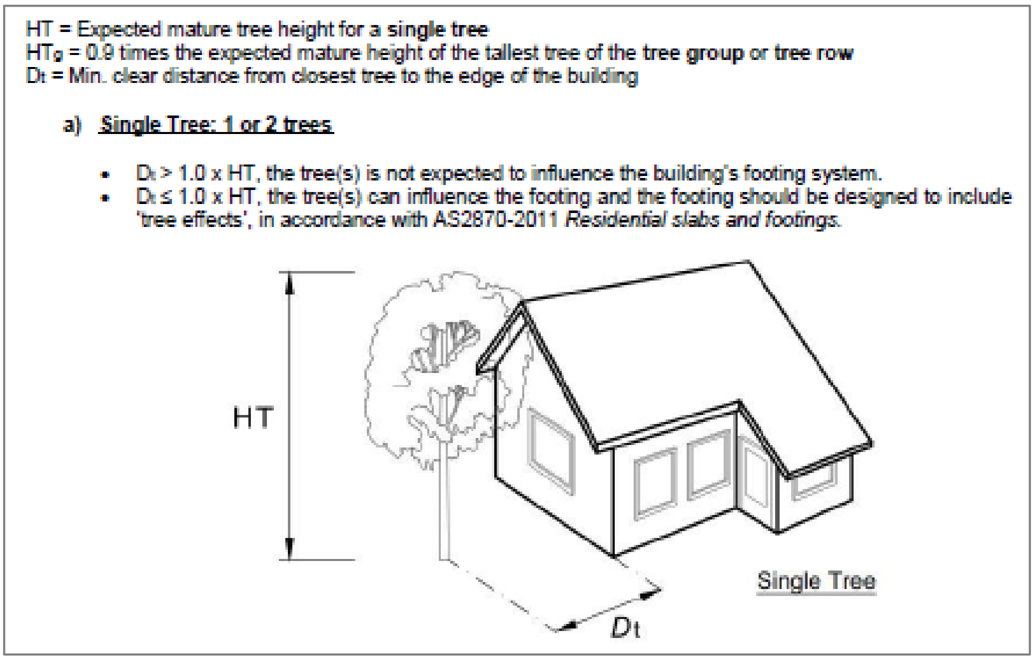
In an established urban area, it is estimated that house footings will already have to be designed to accommodate the impact of offsite trees in 75 per cent of cases, regardless of the tree policy (see Section 3.4.5).

Usually there is already a street tree and sometimes there is one or more neighbouring site trees within the tree effect zone of the new dwelling. Adding the proposed new tree (to the front garden for example) will often not add an additional footing design cost as the new dwelling would have to accommodate for a 'single tree effect' or 'group of tree effect' cost already. Further, many households already choose to retain existing trees or plant new trees when undertaking infill developments. Refer to the Glengowrie case study for further information. For example, our case study found that 58 per cent of households already choose to retain existing trees or plant new trees when undertaking infill developments (see Section 3.4.4).

Therefore, in the majority of cases, house footings will have to be designed to accommodate trees, regardless of the proposed 'One Tree Policy'.

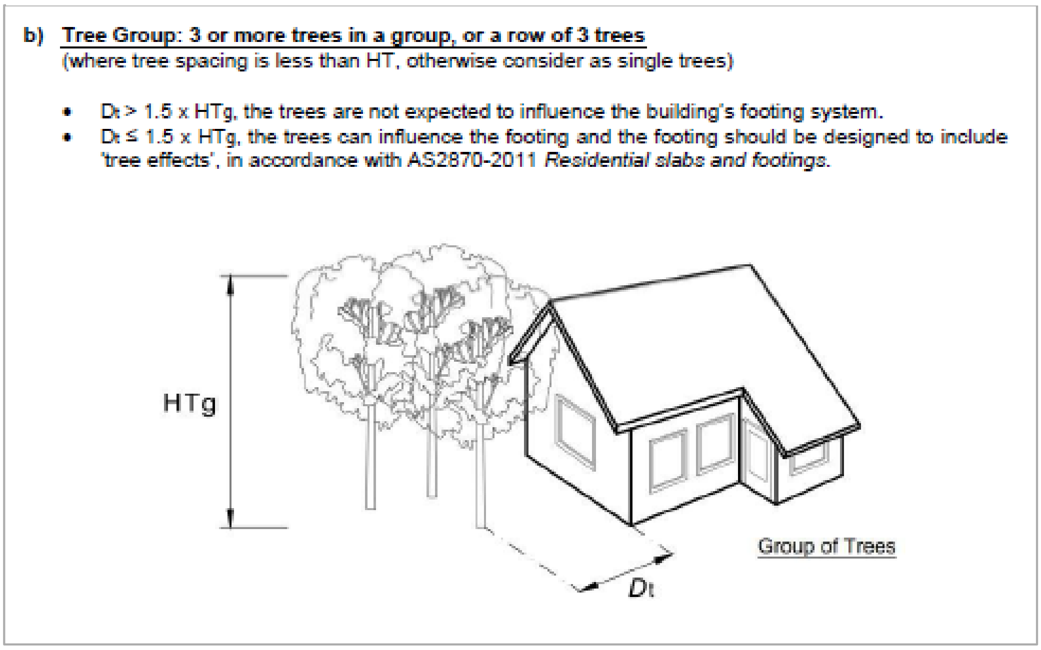
It is also prudent for home owners to consider that new trees in the future may be planted on neighbouring sites or in the public verge outside their house (within the zone of effect on their footings) therefore it is important to make sure that their house footings are not under designed.

Figure 7 The criteria for determining if a single tree will influence a building footing system



Source: TMK Consulting Engineers 2019

Figure 8 The criteria for determining if a group tree effect will influence a building footing system



Source: TMK Consulting Engineers 2019

2.6.1. Impact of soil type on the 'tree effect'

In cases where a new house footing cost may be incurred due to the tree effect, soil type is a significant factor in the magnitude of the cost impact (see Section 3.3.1 for estimated costs).

In Greater Adelaide there are five main soil types, ranging from least reactive (sandy) to most reactive (clay). They are classified as S, M-D, H2-D, H1-D and E-D, in order of least to most reactive. More reactive soils generally have a higher impact on footings, and less reactive soils a lower impact. However, the relationship is not necessarily linear (see Section 3.3.1 for independent costings). Distribution of soil types is highly variable across Greater Adelaide.

A comprehensive soil map for all areas of Greater Adelaide is not readily available. However, TMK Consulting Engineers, a prominent engineering firm in Adelaide, has produced an online map capturing the soil tests they have undertaken in the Adelaide area[18]. They kindly provided this data to the AGD Spatial Analyst Team for the purposes of this study, which has enabled production of Table 2-7 and Figure 9, showing how the soil types are distributed across Greater Adelaide.

While only 4,106 soil sample points are available, the data does provide a reasonably representative sample and some indication of the spatial distribution of the five soil types (S, M-D, H2-D, H1-D and E-D)[19].

The results show that many areas have a range of soil types, and there are two soil types that are most predominate in Greater Adelaide (H1-D and M-D). H1-D is more reactive, and M-D is less reactive.

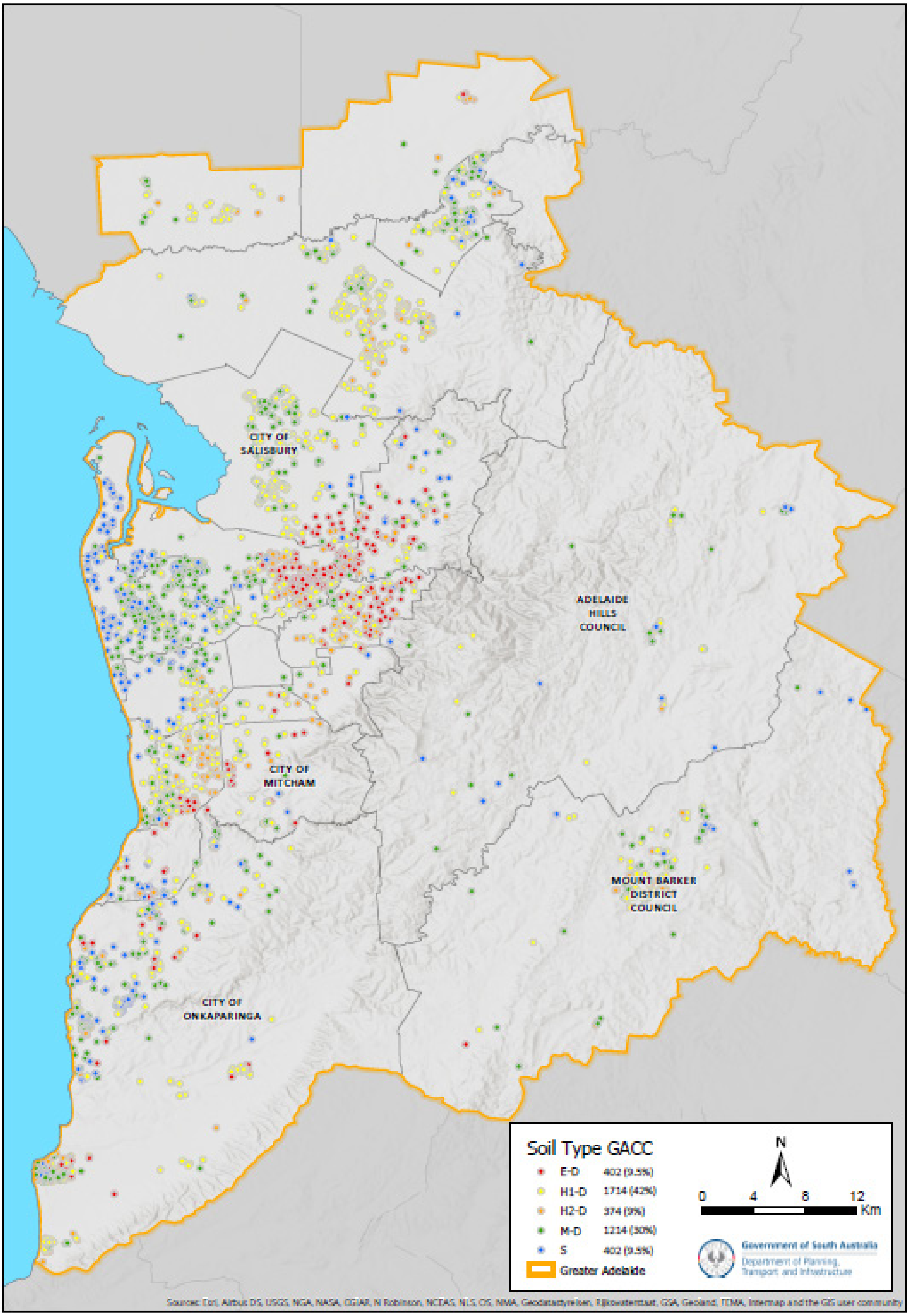
[18] Available online at http://www.tmkmaps.com.au/SoilMovement/

[19] Not all LGAs are well represented in the data, as it depends on where TMK has undertaken work as well as other factors like levels of infill development and natural features such as the Adelaide Hills.

Table 2-7 Distribution of soil types across local government areas, based on TMK soil samples (number of samples)

LGA	E-D	%	H2-D	%	H1-D	%	M-D	%	S	%	Total
Adelaide City							1	100%			1
Adelaide Hills			1	2%	18	35%	22	42%	11	21%	52
Adelaide Plains Council	1	2%	5	11%	29	64%	10	22%			45
Campbelltown	43	43%	18	18%	31	31%	7	7%	1	1%	100
Burnside	2	13%	7	44%	4	25%	2	13%	1	6%	16
Charles Sturt					54	19%	155	55%	74	26%	283
Holdfast Bay			1	3%	12	33%	18	50%	5	14%	36
Marion	24	9%	54	21%	116	45%	37	14%	28	11%	259
Mitcham	14	22%	6	9%	28	44%	12	19%	4	6%	64
Onkaparinga	62	7%	85	10%	314	38%	270	32%	105	13%	836
Playford	21	3%	76	10%	450	62%	162	22%	20	3%	729
Port Adelaide Enfield	164	36%	50	11%	52	11%	126	27%	68	15%	460
Prospect	2	12%	2	12%	4	24%	6	35%	3	18%	17
Salisbury	14	3%	7	2%	284	62%	151	33%	4	1%	460
Tea Tree Gully	40	27%	17	12%	36	24%	34	23%	20	14%	147
Unley	3	20%	2	13%	8	53%	2	13%			15
West Torrens			8	8%	41	40%	33	32%	20	20%	102
Light	5	6%	7	9%	22	27%	40	49%	8	10%	82
Mount Barker	4	2%	15	7%	127	56%	63	28%	17	8%	226
Norwood Payneham and St Peters	2	9%	7	32%	11	50%	2	9%			22
Walkerville			2	29%	5	71%					7
Gawler	1	1%	4	3%	68	46%	61	41%	13	9%	147
Total	**402**	**10%**	**374**	**9%**	**1,714**	**42%**	**1,214**	**30%**	**402**	**10%**	**4,106**

Figure 9 Distribution of soil types across Greater Adelaide, based on TMK soil samples



2.7. Offset schemes

A new feature of the *Planning, Development and Infrastructure Act* 2016 is the capacity to establish other schemes, beyond existing carpark funds, for 'off-setting contributions'. An offset scheme would allow councils to accept financial contributions from infill households, in-lieu of them complying with tree canopy provisions under the Code.

This would mean that where green cover outcomes cannot be met on an infill site, the infill household can instead choose to make a payment into a council-managed offset scheme, which would provide those tree outcomes offsite on public land. Preferably this would be in the local streetscape to ensure that the benefits are retained locally (Seed Consulting et al. 2019), however this may not be practical in every case. Establishing an offset scheme would also require identification of appropriate governance, ownership requirements and maintenance obligations (Seed Consulting et al. 2019).

Spatial issues

There would also need to be enough plantable public within the LGA, or across Greater Adelaide, to achieve desired landscape-scale outcomes like the 30-Year Plan target. The evidence is that there is not enough space on public land to keep up with the loss of trees and green cover due to infill development on private land (see Section 2.2).

Even if landscape-scale targets are able to be met, an offset scheme could result in localised loss of tree cover. If outcomes cannot be generated locally, infill households and the local community will miss out on the benefits of green cover (e.g. urban cooling, higher house values).

Case study: Native Vegetation

South Australia has experience with offsetting trees, through clearance management under the *Native Vegetation Act 1991*. Where significant clearance of native vegetation is proposed on a property (i.e. due to mining or major greenfield developments), there is often a requirement to offset this clearance. This may be done by protecting a separate area for conservation, or by paying into a fund.

The offset must provide a 'Significant Environmental Benefit', which means the gain needs to be over and above the loss caused by clearance. A similar approach could be adopted for urban green cover.

Pricing issues

An accurate valuation of trees would need to be ascertained if infill households are to contribute to the costs of:

- Re-instating tree cover that has been removed during the development process, or
- Providing tree cover outcomes on public land in lieu of providing them on private land.

There is currently a 3 x $94 fee for removing a significant tree and 2 x $94 fee for removing a Regulated tree on private land (under the *Development Regulations 1993)*. Fees are generally consolidated in a council-managed tree fund and used to maintain the health of existing trees (Seed Consulting et al. 2019). Feedback from council staff is that these fees fall well short of both the re-instatement cost of trees (especially mature trees), and their structural value as an appreciating asset (Seed Consulting et al. 2019).

A range of methods have been developed internationally and in Australia that can be used to determine the value of trees. In Australia these include:

- **Revised Burnley method** (Moore 2006): This is widely used around Australia, including by councils and arborists. Tree value is determined based on tree size, useful life expectancy, form and vigour, and location.
- **City of Melbourne method**: Where removal of a tree on public land is approved by Council's arborist in relation to a development, the tree value and removal cost is paid by the developer prior to its removal. The payment includes:
    - Removal Costs: Costs incurred by Council for physically removing the tree

    - Amenity Value: Calculated in accordance with Council's Amenity Formula
    - Ecological Services Value: Calculated in accordance with the i-Tree valuation tool
    - Reinstatement Costs: Costs incurred by Council in providing green infrastructure to replace loss to the landscape incurred by the removal.
- **City of Sydney method**: Tree value is determined based on the cost of planting a 200 litre (container size) tree in the City, age of the tree since planting, size of the tree, diameter of the tree trunk, condition of the tree, life expectancy of the tree, visibility of the tree from public areas, heritage status of the tree, and ownership of land where the tree is growing.

Application of these valuation methods for removal of trees on public land can generate values in the range of a few thousand dollars for small mature trees through to tens of thousands or more for large mature trees (see for example, Seed Consulting (2018)). As such, in current practice, there is at least an order of magnitude difference in the value placed on a tree on public land compared with private land.

3. STUDY APPROACH

As described in Section 1.1, this work sits within the context of the public consultation process for Phase 3 (Urban Areas) of the Planning and Design Code. A stakeholder reference group provided input and advice into the scope of this work. The consultation, review and evidence gathering process is described in Section 1.

Other key information sources include:

- Analysis of infill housing statistics for this study provided by AGD's Planning Research Analysis Unit
- The INFFEWS Value Tool, kindly made available for use by this study by the CRC for Water Sensitive Cities
- Seed Consulting Services 2019, *Perspectives on Performance-based Planning Provisions and Assessment Frameworks for Green Infrastructure and WSUD*, in association with DesignFlow, Ekistics and CRC for Water Sensitive Cities, prepared for Water Sensitive SA
- Seed Consulting Services 2018, *Valuing the Trees of Hazelwood Park, An i-Tree Eco Assessment*, prepared for the City of Burnside
- List of studies concerning the relationship between physical and mental health and green infrastructure compiled by Dr Tahna Pettman, Department of Health (see Appendix 1).

A full list of references is provided in this report.

3.1. Method of Analysis

This cost benefit analysis (CBA) was undertaken according to the principles and method outlined in South Australian and Australian Government guidelines for conducting evaluations of public sector initiatives (Department of Treasury and Finance (2008) and Department of Finance and Administration (2006)).

The key characteristics of the CBA method employed in this study include the following:

- The CBA includes a base case or counterfactual scenario, that is, the benchmark against which the Options were compared. The base case was defined as current requirements for trees in infill developments under the current Residential Code and Development Plans (Section 2.3.2)
- The CBA was conducted over a 25-year time period and results were expressed in terms of net benefits, that is, the incremental benefits and costs of the options relative to those generated by the base case scenario[20]
- Costs and benefits were specified in real terms (i.e. current 2020 dollars). Past and future values were converted to present values by applying a discount rate of 6 per cent
- In order to account for uncertainty, a sensitivity analysis was undertaken using a range of values for key variables
- The evaluation criteria employed in the analysis are net present value (NPV)[21] and benefit-cost ratio (BCR)[22]
- Costs and benefits for the option and base case scenarios have been listed in tabular form and include those that can be readily identified and valued in monetary terms as well as those which

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20 Where incremental benefits = (option benefits – base case benefits) and incremental costs = (option costs – base case costs).

21 NPV is defined as discounted net benefits, where net benefits = (incremental benefits – incremental costs).

22 BCR is defined as (discounted incremental benefits) / (discounted incremental costs).

cannot be easily valued in monetary terms because of the absence of market signals[23]. The tables also provide an indication of the likely distribution of the costs and benefits between stakeholder groups and the source of the information.

The cost benefit analysis was undertaken at two levels:

- **At the community level** – expected costs and benefits (both monetary and non-monetary) accruing to people (households, businesses and government) and the environment across Greater Adelaide[24], as a result of the proposed options.
- **At the individual household level** – expected cost and benefits (monetary only) accruing to the household undertaking the development, as a result of the proposed options.

3.2. Scope of the cost benefit analysis

3.2.1. Policy options analysed

The cost benefit analysis tested two policy options against the base case. The purpose of this approach is to test whether the Draft Code proposals stack up against the current South Australian policy requirements (see Section 2.3.2). Multiple scenarios were tested under each option to enable assessment of whether policies should be adjusted in specific scenarios.

The base case and policy options analysed were:

- **Base Case Scenario - Current ('business as usual') scenario**
  No tree planting provision. There are no provisions for landscaping in the current Residential Code. Landscaping provisions vary significantly in the current Development Plans but don't include a specific tree planting requirement for minor infill.
- **Option 1 – One onsite tree per allotment (Draft Code policy)**
  The proposed deemed-to-satisfy[25] provision for minor infill to provide one tree (or equivalent) on each allotment, which is small, medium or large depending on allotment size. Discounts apply for retaining existing trees and associated soil area.
- **Option 2 - Offset scheme**
  Applicants can choose to meet the one tree provision on their own allotment, or have the same outcome achieved offsite on public land, funded by an offset scheme.

3.2.2. Costs and benefits considered

Monetary costs and benefits considered include those that are direct (e.g. buying a tree) and those that are indirect (e.g. reduced demand for electricity). Non-monetary costs and benefits were also considered (e.g. amenity value of trees). The analysis only includes costs and benefits that are quantifiable in dollar terms, backed by the best available, relevant and defensible information. It likely captures a conservative estimate of the benefits, due to the rigorous and transparent approach taken to quantify benefits in financial terms. We have preferenced South Australian and then best practice Australian data sources.

The costs and benefits of options were measured using a 'with' and 'without' framework, that is, quantification of the incremental changes associated with the option compared to the base case scenario. A zero value indicates there is no change to accrued costs or benefits compared to the base case. A

[23] The analysis only includes costs and benefits that are quantifiable in dollar terms, backed by the best available, relevant and defensible information. It likely captures a conservative estimate of the benefits, due to the rigorous and transparent approach taken to quantify benefits in financial terms. We have preferenced South Australian, then best practice Australian data sources.

[24] Gawler, Port Adelaide Enfield, Tea Tree Gully, Charles Sturt, Prospect, Walkerville, Campbelltown, Adelaide, Norwood Payneham Dt Peters, West Torrens, Unley, Burnside, Holdfast Bay, Mitcham, Marion, Salisbury, Playford, Adelaide Hills, Mt Barker, Onkaparinga, Adelaide Plains (part of) and Light (part of).

[25] A deemed to satisfy policy is a measurable criteria which is one way of meeting a performance outcome in the Planning and Design Code. Applicants can instead choose alternative solutions that meet the relevant performance outcome.

negative cost indicates an avoided cost (i.e. a benefit) compared to the base case, and a negative benefit indicates a lost benefit (i.e. a cost) compared to the base case.

The major economic costs and benefits of the options are listed in Table 3-1 and Table 3-2, respectively. The method, data sources and assumptions used to quantify these values are described in Section 3.1. Consideration was given to those benefits and costs likely to occur over a 25-year period.

Table 3-1 Costs considered in the analysis

Option	Description of Costs	Bearer of Cost	Valued in $ Terms	Source of Information
Base Case	House footings	Infill household	Yes	AGD
	Onsite tree planting & maintenance	Infill household	Yes	Office for Design & Architecture SA
Options 1 & 2	House footings	Infill household	Yes	AGD
	Onsite tree planting & maintenance	Infill household	Yes	Office for Design & Architecture SA
	Offsite tree planting & maintenance costs	Local Government	Yes	Office for Design & Architecture SA
	Offset scheme management	Local Government	Yes	BDO EconSearch analysis
	Offset scheme payments	Infill household	Yes	BDO EconSearch analysis

Table 3-2 Benefits considered in the analysis

Option	Description of Benefits	Recipient of Benefit	Valued in $ Terms	Source of Information
Base Case	Improved air quality	Community	Yes	Seed Consulting 2018
	Carbon removed	Community	Yes	Seed Consulting 2018
	Avoided stormwater runoff	Community	Yes	Seed Consulting 2018
	Avoided loss of stored carbon	Community	Yes	Seed Consulting 2018
	Reduced household electricity use	Infill household	Yes	Cool Streets 2016
Options 1 & 2	Offset scheme receipts (Option 2)	Local Government	Yes	BDO EconSearch analysis
	Amenity value of trees	Households adjacent to offset plantings	Yes	Pandit et al. 2013
	Improved air quality	Community	Yes	Seed Consulting 2018
	Carbon removed	Community	Yes	Seed Consulting 2018
	Avoided loss of stored carbon	Community	Yes	Seed Consulting 2018
	Avoided stormwater runoff	Community	Yes	Seed Consulting 2018
	Reduced household electricity use	Infill household	Yes	Cool Streets 2016
	Improved mental wellbeing	Community	Yes	BDO EconSearch analysis

3.3. Quantifying the costs and benefits

3.3.1. Footing costs

To inform this study, AGD commissioned house footing costings from structural engineering firms for two case study dwelling types:

- A 200m^2 brick veneer detached single storey dwelling with a 6m tree (at mature height) planted 5m from the dwelling (refer to Figure 10)
- A smaller 90m^2 brick veneer two storey townhouse with a 6m tree (at mature height) planted 5m from the dwelling (refer to Figure 11).

The 6m tree was chosen as it is the maximum size of the deemed-to-satisfy provision for sites less than 450m^2 in the Draft Code[26]. The dwelling types were chosen because they are common in infill developments in Greater Adelaide. However, it is important to note that applicants can also choose a 4 metre (at mature height) tree option which could be accommodated outside the 'tree effect zone' in zones such as the General Neighbourhood and Suburban Neighbourhood Zones.

TMK Consulting Engineers and PT Design designed a footing for the 200m^2 detached dwelling. PT Design also prepared a design for the 90m^2 townhouse. Centina Homes costed both dwelling types. The costings consider the impact of all five soil types in Greater Adelaide on residential footing design. This analysis used the 'single tree effect' costings as these are the ones most likely to be relevant to the Code's single tree planting policy (refer to Section 2.6 for further information).

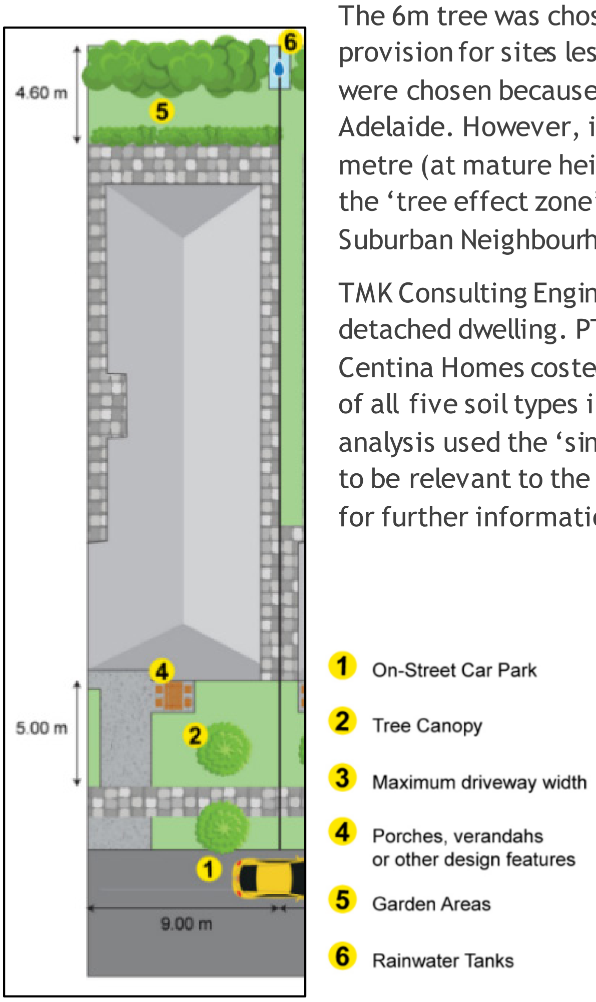


Figure 10
Hypothetical 200m2 brick veneer detached single storey dwelling

Figure 11
Hypothetical 90m2 brick veneer two-storey townhouse

[26] Our analysis indicated that most potential minor infill developments would occur on allotments that are between 200m^2 and 400m^2 in size.

The additional footing costs attributable to the newly planted trees are presented in

Table 3-3[27]. These costs provided by the structural engineering firms are used in this analysis. Appendix 1 details the costings and general advice provided by the structural engineering firms.

As outlined in Section 2.6, many variables impact footing costs, and it is not possible to identify an exact cost for every possible scenario. For the purposes of the individual household cost benefit analysis, the least cost and greatest cost options were tested as scenarios so that the bounds of policy impact could be assessed. These costs do not necessarily align with the least and most reactive soils, but can generally be classified as 'less reactive' and 'more reactive'.

Table 3-3 Additional costs to footings from single tree effects by soil type

Soil type	Prevalence	Case-study 1: 200m² single storey detached dwelling			Case-study 2: 90m² double storey townhouse
		Estimate 1	Estimate 2	Average	
S	10%	\$508	\$1,497	\$1,003	\$588
M-D	30%	\$496	\$699	\$597	\$601
H1-D	42%	\$3,484	\$1,710	\$2,597	\$186
H2-D	9%	\$3,803	\$3,469	\$3,636	\$2,377
E-D	10%	\$5,676	\$1,537	\$3,607	\$1,085

Source: Centina Homes costings of hypothetical footing designs by TMK Engineers and PT Design Engineers, 2019 with soil type prevalence drawn from TMK Engineers' soil sample points for metropolitan Adelaide

3.3.2. Tree planting and maintenance costs

Tree planting costs were based on estimates prepared by the Office for Design and Architecture SA. Using this data, it was assumed that the cost to an individual infill household to plant and establish a tree was \$220[28] per tree (applied to all options), and the cost for a tree to be planted and established offsite by a commercial contractor was \$782 per tree (applied to Option 2).

Ongoing tree maintenance costs were based on Knox City Council's published statistics (2016) for their maintenance program expenditures over a five-year period, and the estimated number of street trees in the council area. Annual costs per tree were derived and were updated to current dollars using all sectors CPI for Melbourne (ABS 2020). An annual tree maintenance cost of \$30 per tree was applied.

Total tree planting and maintenance costs over the study period are therefore \$603 on private land and \$1,165 on public land.

27 'Single Tree Effect': If one or two adjacent trees are less than their mature height from a dwelling than they should be designed to include 'tree effects', in accordance with AS2870-2011 Residential slabs and footings.
'Group Tree Effect': This occurs when there are three or more trees in a group, or a row of three trees (where tree spacing is less their mature height, otherwise consider as single trees). If a group of three trees are located less than 1.5m x mature height away from the dwelling they should be designed to include 'tree effects', in accordance with AS2870-2011 Residential slabs and footings.
28 Onsite tree planting and first year maintenance was based on ODASA 2020 Table 1 estimates, but with planting activities simplified and therefore the overall cost adjusted down from \$261.50 to \$220 per tree.

3.3.3. Offset scheme payments and management

Offset scheme development and management

A cost of $200,000[29] was assumed to apply to the first year of the analysis for offset scheme development. Ongoing, annual scheme administration costs of $220,000[30] was assumed. These costs apply to Option 2.

Offset scheme payments

It should be noted that this offset scheme has been developed for the purposes of this analysis and its formulation is intended to be illustrative only. It is consistent with the City of Melbourne method (see Section 2.7). Table 3.4 describes how the payment was estimated.

Offset scheme payments represent a cost to infill households and a benefit to offset scheme providers, and are, for the community level analysis, a transfer payment. These costs and benefits apply to Option 2.

The offset payment is made up of two components:

- A payment for the loss of an existing tree that could have been retained to meet draft Code requirements
- A payment for planting and maintaining a tree offsite to meet draft Code requirements.

The first component applies to the 40 per cent of infill households that have existing trees that they choose to remove. The second component applies to the 23 per cent of infill households that choose to pay into an offset scheme in lieu of meeting tree canopy requirements onsite. See Section 3.4.4 for how these proportions were derived.

The compensation for the loss of an existing tree is based on the cost to replace the physical asset (i.e. a tree of equivalent structural value), the loss of stored carbon and the loss of ongoing benefits (i.e. future tree services[31]). These values have been estimated from the results of an analysis of the value of tree assets in the City of Burnside's Hazelwood Park, and are based on the average values of non-regulated trees in that study (Seed Consulting 2018). This assessment was based on the i-Tree Eco tool, a well-established and accepted method of valuing trees in Australia.

The payment for planting and maintaining a tree offsite was based on the costs described in Section 3.3.2, discounted to a present value.

Table 3-4 Offset payments per tree

Component	Present value ($)
Removal of existing tree	
Structural value	3,318
Loss of stored carbon	39
Loss of future tree services	77
Total	**3,435**
Offsite planting and maintenance	
Planting cost	782
Maintenance cost	383
Total	**1,165**

[29] Equivalent to approximately 1.4 full-time equivalent at a Professional Officer Level 3 within the SA Government public service (including on costs and overheads).
[30] Equivalent to $10,000 per LGA for the 22 LGAs in Greater Adelaide.
[31] Future tree services were quantified and discounted to a net present value using our study's discount rate of 6 per cent.

3.3.4. Amenity benefits of trees on house prices

Amenity values are the characteristics that influence and enhance people's appreciation of a particular area. These values are derived from the pleasantness, aesthetic coherence and cultural and recreational attributes of an area. Urban trees can make a neighbourhood more scenic, provide privacy, block unwanted views and make areas more attractive to recreate in (Pandit et al. 2013, Pandit et al. 2014).

Pandit et al. (2013) undertook a hedonic pricing study of trees on private property and street trees for 23 suburbs in Perth. They found a significant, positive relationship between house price and street trees. They estimated that the presence of a street tree increased the median property value by 1.9 per cent. Other Australian studies found significant positive relationships between houses and street trees (e.g. Pandit et al. 2014 and Plant et al. 2017).

The Pandit et al. (2013) study results were applied to trees planted under the offset scheme (Option 2). That study's estimate of 1.9 per cent amenity value was applied to the median house price in metropolitan Adelaide ($485,000, DTF 2020). An estimate of the number of homes this would apply to was based on the number of trees planted in the offset scheme adjusted by the expected number of street trees per home (approximately 1.1 street trees/home[32]). This equated to an amenity value of $8,348 per tree planted in the offset scheme. This one-off value accrues to households adjacent to the offset plantings and was applied at the time of planting.

This analysis has assumed that the on-site trees (retained or planted) raise the capital value of the properties by 0.19 per cent (i.e. 10 per cent of 1.9 per cent increase in value estimated by Pandit et al. 2013). This equates to $922 per infill household that retains a tree or plants a tree on-site. This figure is based on the below analysis:

- Pandit et al 2013 did not find a statistically significant relationship between house price and on-site trees. They did not differentiate between the different levels of tree canopy cover onsite.
- Plant et al. (2017), however, found a significant, positive relationship between house price and trees on the same property provided the tree canopy cover was less than 20 per cent of the property. However, this study did not report the quantified effect.
- The Code 'One Tree Policy' is designed to apply when on-site tree canopy cover is less than 20 per cent.

It therefore seems reasonable to assume that there is a small, positive effect of having a tree on-site, when the tree canopy is less than 20 per cent. It is greater than 0 per cent and likely to be much smaller than 1.9 per cent. A value of 0.19 per cent is uncertain, but it is considered that this judgement is reasonable.

3.3.5. Improved air quality

As described in Section 2.5, air pollution is one of the main environmental risk factors affecting human health. Trees play an important role in filtering and cleaning the air of harmful gaseous and particulate pollutants, via uptake through leaves and interception and accumulation of particles on the plant surface. Seed Consulting (2018) undertook a study for the City of Burnside to value the trees of Hazelwood Park. Using the well-established i-Tree Eco tool, they estimated the value of the air pollution removed by trees to human physical health[33]. For non-regulated trees, the average annual value per tree for removed air pollution was $2.54 in current dollars. The 2018 dollar value was adjusted to current dollars using the all sectors CPI for Adelaide (ABS 2020). This value was applied to all planted and retained trees.

[32] Based on an average street tree planting distance of 12.8m (Inner West Council 2014) and an average home street frontage of 14.2m (Westbrooke Estate, 2020)

[33] See Nowak et al. 2014 for the method for estimating the value of avoided health costs through air pollution removal by trees, upon which the method within the i-Tree Eco tool has been based.

3.3.6. Carbon removed

As described in Section 2.5, another environmental benefit provided by trees is removal of carbon from the atmosphere, assisting with global goals to manage greenhouse gas emissions.

The Seed Consulting (2018) study also valued the annual removal of carbon from the atmosphere using the i-Tree Eco tool. For non-regulated trees within Hazelwood Park, the average annual value per tree for carbon removal was 0.01 tonnes of carbon dioxide equivalent (tCO_2e). It was assumed that the average age of the non-regulated trees in Hazelwood Park was 30 years, and a carbon sequestration by age profile was developed and applied.

A social cost of carbon was applied to the carbon removal volumes. The social cost of carbon is the marginal cost of the impacts caused by emitting one extra tonne of greenhouse gas (carbon dioxide equivalent) at any point in time, inclusive of 'non-market' impacts on the environment and human health (Yohe et al. 2007). The United States Government (2016) social cost of carbon price was used, which was the equivalent of A$63/$tCO_2e$ in 2021 rising to A$96/$tCO_2e$ in 2045. It was assumed that retained trees were the equivalent of 20 years old and planted trees were one year old. This value was applied to all planted and retained trees under the base case and both options.

3.3.7. Avoided loss of stored carbon

The carbon removed benefit described above is based on *future flows* of stored carbon. The avoided loss of stored carbon benefit puts a value on the carbon *already stored* by trees that are retained under Options 1 and 2 that would otherwise be removed under the base case.

The Seed Consulting (2018) study valued stored carbon using the i-Tree Eco tool. For non-regulated trees within Hazelwood Park, the average amount of stored carbon per tree was 0.62tCO_2e. As with the carbon removal benefit, this was assumed to apply to a 30 year old tree, and a stored carbon by age profile was developed and the social cost of carbon values applied. This value was applied to all planted and retained trees under the base case and both options.

3.3.8. Avoided stormwater runoff

As described in Section 2.5, another environmental benefit provided by trees is the interception of rainfall, allowing infiltration into the soil and thereby assisting with stormwater management.

The Seed Consulting (2018) study also valued the annual avoided stormwater runoff using the i-Tree Eco tool. For non-regulated trees within Hazelwood Park, the average annual value per tree for avoided stormwater runoff was $0.60 in current dollars. As with the carbon removal benefit, this was assumed to apply to a 30 year old tree and a benefit by age profile was developed and applied. This value was applied to all planted and retained trees under the base case and both options.

3.3.9. Reduced household electricity use

As described in Section 2.5, trees have been identified as a highly effective mechanism for cooling the local environment through shading and evapotranspiration. Coolstreets (LGNSW 2016) undertook a study with several neighbourhoods in Sydney and estimated that a neighbourhood of 40 houses on a street with trees reduced their electricity use (through less air-conditioning in summer) by 10,651kWh per year, compared to a similar street without street trees. It was estimated that the medium-sized street trees in the study were approximately 20 years old, and assuming a one year old tree would have a negligible effect on cooling, a tree age by energy saving profile was derived. Using a current price of retail electricity of $32/kWh it was possible to estimate the energy savings achieved by the planted and retained trees under the base case and both options.

3.3.10. Avoided mental health costs

Analysis by Cox et al. (2017) estimated the association between neighbourhood vegetation cover and levels of depression, anxiety and stress. Compared to a baseline of 10 per cent vegetation cover, the number of people showing symptoms of depression is reduced by up to 11 per cent in neighbourhoods with more than 20 per cent vegetation cover, and an additional reduction of around 10 per cent was demonstrated if vegetation cover was more than 30 per cent (Cox et al. 2017). A similar finding was reported in relation to anxiety and stress. Again using a baseline of 10 per cent vegetation cover, the number of cases of anxiety and stress could be reduced by 17 per cent if vegetation cover were more than 20 per cent, and a further 8 per cent if vegetation cover were more than 30 per cent (Cox et al. 2017).

These results suggest that, on average, each percentage point increase in vegetation cover above 20 per cent (the approximate average tree cover across the Greater Adelaide area), would result in:

- 1.0 per cent reduction in the number of people showing symptoms of depression
- 0.8 per cent reduction in the number of cases of anxiety and stress.

Therefore, the following assumptions have been made to estimate the mental health benefits of increasing tree cover across Greater Adelaide by 1 percentage point[34].

1. The effect on reducing the symptoms of depression and reducing the cases of anxiety and stress were assumed to be the same, using the lower coefficient of 0.8.
2. While it may be that a reduction in the number of people affected by mental health issues will see a corresponding reduction in the cost of service delivery, there are undoubtedly significant overhead (fixed) costs in delivery these services. This is conservatively estimated at 50 per cent[35].
3. Assumptions 1 and 2 above imply the following relationship: a 1 percentage point increase in vegetation cover above 20 per cent (e.g. from 20 per cent to 21 per cent) will result in a 0.4 per cent reduction in the cost of mental health related to depression, anxiety and stress.
4. The annual cost of mental health in Australia in 2019 is estimated to be $66.4 billion, derived from the VISES (2016) estimate ($56.7 billion), adjusted for inflation and population growth.
5. The proportion of people who suffer severe depression and anxiety (of the total suffering serious mental health issues) was estimated at 56.3 per cent (VISES 2016). Assuming the costs to the economy per person of those suffering from severe anxiety and severe depression are, on average, similar to the costs associated with those suffering other types of severe mental illness (e.g. schizophrenia and bipolar disorder), the national cost of severe anxiety and severe depression in Australia in 2019 was estimated to be $37.4 billion (56.3 per cent x $66.4 billion).
6. The prevalence of mental illness in Greater Adelaide was assumed to be the same as in Australia as whole. In June 2019, the population of Greater Adelaide was 5.4 per cent of the national population. Accordingly, the annual cost of those suffering severe anxiety & severe depression in the study area was estimated to be $2.0 billion (5.4 per cent x $37.4 billion).
7. Applying assumption #3 to assumption #6 implies that, in the study area, a 1 percentage point increase in vegetation cover above 20 per cent will result in an $8.0 million avoided mental health cost related to severe anxiety and depression (0.4 per cent x $2.0 billion).

[34] Our analysis estimated that, relative to the base case, Option 1 would increase urban tree canopy cover by 0.01% in the first year and by 0.73% by year 25. Similarly, Option 2 would increase urban tree canopy cover by 0.02% and 1.04% respectively.

[35] Noting that many of the costs of mental health are additional to the direct costs of providing mental health services which will not have a fixed cost component, i.e. they will vary directly with the number of people with mental illnesses. This implies an adjustment value of 50% is likely to be high and therefore very conservative.

3.4. Defining key variables

Defining a number of key variables was an important step in undertaking the cost benefit analysis. These key variables allowed us to define a realistic base case and options for the community-level analysis, and a realistic suite of the most common scenarios likely to apply to an infill household for the dwelling-level analysis.

The variables are:

- Number of dwellings to be built per year
- Proportion of dwelling types to be built
- Proportion of allotments on each soil type
- Proportion of allotments with trees retained, planted and lost
- Proportion of allotments with nearby trees.

3.4.1. Number of dwellings to be built per year

To undertake this cost benefit analysis, we needed to know the number of infill dwellings likely to be built per year in Greater Adelaide during the study period of 2020 to 2045 (i.e. the number of dwellings that would be subject to the proposed policy)[36]. Projections for minor infill in the study area, between 2016 and 2035, were provided by AGD (see Table 3.5). For the period of 2036 to 2045, the annual increase was based on the average of the previous four periods.

Table 3-5 Minor infill development projections and estimates

	2016-2020	2021-2025	2026-2030	2031-2035	2036-2045
No. dwellings built/year	4,579	4,507	4,639	4,477	4,551

Source: AGD, 2020 pers. comm.

3.4.2. Proportion of dwelling types to be built

For this purpose of this analysis, AGD defined two common dwelling types to use as case studies:

- A 200m^2 brick veneer detached single storey dwelling
- A smaller 90m^2 brick veneer two storey townhouse.

The dwelling types were chosen because they are common in infill developments in Greater Adelaide. While this is not an exhaustive list, it enabled AGD to seek independent costings of house footing costs, to then enable an indicative assessment of the impact of trees. Because of the many variables impacting house footing costs, it is not possible to identify the exact cost applicable to every individual household in every possible scenario.

The approximate proportions of single storey detached and double storey townhouse infill dwellings relative to each other are 88 per cent and 12 per cent respectively (AGD 2020). These proportions were applied to the distribution of case study dwellings.

3.4.3. Proportion of allotments on each soil type

As outlined in Section 2.6, soil type has a significant impact on house footing cost where there is a tree effect. For the purpose of the community-scale analysis, the prevalence of soil types across Greater Adelaide (TMK Consulting Engineers, 2020) was used. For the purpose of the infill household-scale analysis,

[36] Section 2.1 refers to an approximate net gain of 2,500 infill dwellings per year (e.g. one dwelling demolished to build two new dwellings = net gain of one dwelling). Section 3.3.1 refers to the average annual number of new infill dwellings built per year (e.g. one dwelling demolished to build two new dwellings = two new dwellings, which the policy will apply to).

scenarios testing the most expensive and least expensive footings (as a result of soil type) were used. See Section 3.3.1 for more details.

3.4.4. Proportion of allotments with trees retained, planted and lost

Even though there is no current requirement to plant a tree (see Section 2.3.2), and Draft Code policy stipulates one tree per allotment (see Section 2.4.2), it cannot be assumed that every allotment will start from a base case of zero trees and end up with a single tree. This is important because we need to be able to test the economic outcomes of realistic future scenarios against realistic base case scenarios. Importantly, impacts on house footing costs can only be assessed if we know how likely it is that footings will be impacted by no trees, a single tree or a group of trees[37].

The general assumption is that at the time of occupation, a relatively small proportion of minor infill developments have planted a tree or retained a tree. AGD undertook a case study investigation to test this assumption – see Glengowrie case study (overleaf).

This case study is the best available information on what currently happens with trees in minor infill developments in Greater Adelaide. The findings were therefore assumed to represent the base case.

It was assumed that introducing regulatory and financial incentives to retain trees would encourage more households to retain mature trees. For the purpose of this analysis, it was assumed the One Tree Policy (Option 1) would increase the tree retention rate by 50 per cent compared to the base case, and introduction of an offset scheme (where payments could be avoided if tree outcomes were already met onsite) would double the tree retention rate compared to the base case. For Option 2, it was also assumed that half of households that did not retain a tree would choose to plant one onsite, and half would choose to pay into the offset scheme instead.

These assumptions result in the following proportions of trees post-development under each option[38]:

- **Base case** (no tree requirement): 27 per cent retain a tree, 30 per cent plant a tree onsite, 43 per cent have no tree (37 per cent remove an existing tree and 6 per cent had no trees pre-development)
- **Option 1** (One Tree Policy): 41 per cent retain a tree, 59 per cent plant a tree onsite
- **Option 2** (One Tree Policy with offset scheme option): 54 per cent retain a tree, 23 per cent plant a tree onsite, and 23 per cent pay into the offset scheme (no tree onsite).

[37] 'Single Tree Effect': If one or two adjacent trees are less than their mature height from a dwelling than they should be designed to include 'tree effects', in accordance with AS2870-2011 Residential slabs and footings.
'Group Tree Effect': This occurs when there are three or more trees in a group, or a row of three trees (where tree spacing is less their mature height, otherwise consider as single trees). If a group of three trees are located less than 1.5m x mature height away from the dwelling they should be designed to include 'tree effects', in accordance with AS2870-2011 Residential slabs and footings.

[38] Note that percentage calculations have been rounded.

Glengowrie Case Study

AGD reviewed a case study infill site to determine whether infill households typically retain existing trees, remove them, and/or plant a new tree.

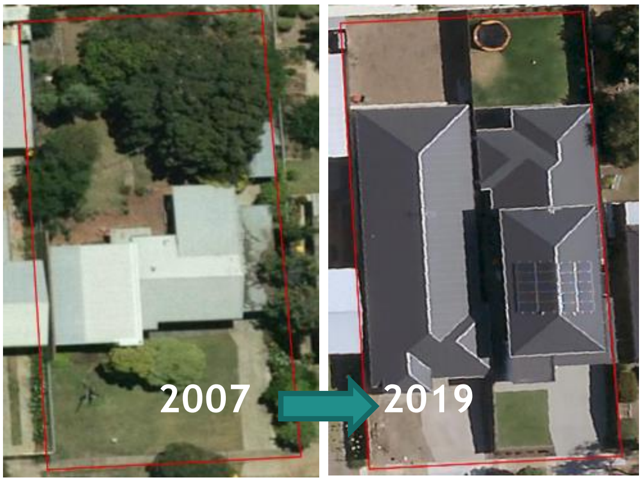
The case study site chosen was the Frederick Street catchment in Glengowrie, in the City of Marion. This area was chosen as it has had significant infill development, and is the same case study site used in the Stormwater Report. See Appendix 1 for a copy of the maps produced for this case study.

Methodology

This investigation used a 2007 to 2019 Lidar data set[39] to manually identify all the mature trees[40] (assumed to be over 2 metres) within the infill study area.

The analysis involved:

- Combining tree data with infill data to investigate gain/loss of vegetation per parcel (for 2007 to 2019)
- Reviewing the 2019 trees against the 2007 imagery to identify what was an existing tree and what was a new planting
- Calculating statistics of trees as outlined in key findings (overleaf).



Refer overleaf for the key findings from this case study.

[39] Lidar data (captured in March 2018) was used for automatically identifying trees over 2m. The analyst then manually added or removed any trees that did not match the 2019 imagery. 2007 tree data was entirely manual.

[40] Tree counts are for extent of original parcel pre demolition not new dwelling lots.

Key findings - Glengowrie Case Study

- 76 out of 81 (94%) parcels in 2007 had at least 1 mature tree pre-infill development.
- 22 of the 76 parcels (29%) chose to **retain** at least one tree **(excludes new plantings)**
- 30 of the 76 parcels (39%) did **not retain OR plant** any trees **(left with no trees in 2019)**
- 24 of the 76 parcels (32%) that **did not retain** any trees **DID** plant 1 or more new trees
- Overall 38 of the 76 parcels (50%) planted at least 1 tree.

Further AGD investigations have identified that these 81 parcels were sub-divided into 166 allotments. Out of these new allotments, 20% retained an existing mature tree on site, while 38% planted one or more new trees. Overall 51% of these new allotments did not have a mature tree on site in 2020. Note: sometimes a site retained both a mature tree(s) and planted a new tree(s) – however these were the minority.

Local context

A AGD review has found that the 81 original parcels have been subdivided into 166 new allotments. These new allotments have the following number of nearby trees (either street trees and/or trees in neighbouring property front gardens) in 2020:

- none: 25%
- 1 nearby tree: 41%
- 2 nearby trees: 19%
- 3 nearby trees: 15%.

These 81 allotments were sub-divided into 166 new allotments with the following characteristics.

- 1 parcel into 1 replacement dwelling: 12%
- 1 into 2 new dwellings: 55%
- 1 into 3 or more dwellings: 37%.

3.4.5. Proportion of allotments with nearby trees

Another important factor is whether there are trees on neighbouring allotments or on the street that are close enough to have a tree effect on the new dwelling. As described in Section 2.6, house footings must be designed to factor in the tree effect when there is a single tree or a group of trees (existing or planted) within the zone of influence[41]. In an urban infill environment, it is likely that an allotment will already have nearby trees close enough to affect the footings, either on the street or on neighbouring allotments.

Intrax Consulting Engineers, who participated in the State Planning Commission's series of Infill Improvements Forums in 2019, undertook a review of some of their past work for Rivergum Homes. These four randomly selected residential building projects were from Mount Barker, Aldinga, Plympton Park and Elizabeth North. Intrax found that all sites had existing tree effects when they were built. For 75 per cent of the new dwellings, the existing tree effect came from trees located outside of the property (refer to Appendix 1).

It was therefore assumed for this analysis that 75 per cent of new dwellings are subject to tree effects from trees outside their property (either existing single or group tree effect).

Further analysis of the Glengowrie case study (81 parcels sub-divided into 166 new dwellings) also found similar results. This analysis by AGD found that 25 per cent had no nearby tree (street or neighbouring site tree) and 75 per cent had some form of existing tree effect. Refer to Glengowrie case study for further details.

[41] 'Single Tree Effect': If one or two adjacent trees are less than their mature height from a dwelling than they should be designed to include 'tree effects', in accordance with AS2870-2011 Residential slabs and footings.
'Group Tree Effect': This occurs when there are three or more trees in a group, or a row of three trees (where tree spacing is less their mature height, otherwise consider as single trees). If a group of three trees are located less than 1.5m x mature height away from the dwelling they should be designed to include 'tree effects', in accordance with AS2870-2011 Residential slabs and footings.

4. COST BENEFIT ANALYSIS RESULTS

The cost benefit analysis was undertaken at two levels:

- **At the community level** – expected costs and benefits (both monetary and non-monetary) accruing to people (households, businesses and government) and the environment across Greater Adelaide, as a result of the proposed options. For results, see Section 4.1.1.
- **At the individual household level** – expected cost and benefits (monetary only) accruing to the household undertaking the development, as a result of the proposed options. For results, see Section 4.2.2.

4.1. Community

4.1.1. Cost benefit analysis results

The results of the community level, social CBA are provided in Table 4-1. These results are based on the expected values for key variables, as outlined in Section 3.4.

Table 4-1 Results of the community cost benefit analysis, Greater Adelaide

Description	Option 1	Option 2
Incremental Benefits ($m[a])		
Amenity	24.5	128.5
Improved air quality	0.4	0.6
Carbon removed	0.1	0.2
Avoided loss of stored carbon	0.1	0.1
Avoided stormwater runoff	0.4	0.8
Reduced household electricity use	15.1	16.6
Avoided mental health costs	23.8	36.8
Offset scheme receipts (Government)	NA	99.8
Total Incremental Benefits ($m[a])	**64.3**	**283.4**
Incremental Costs ($m[a])		
House footing costs	29.0	2.6
Onsite tree planting & maintenance costs	9.0	-2.1
Offsite tree planting & maintenance costs	NA	14.8
Offset scheme development & management	NA	3.2
Offset scheme payments (infill homeowners)	NA	99.8
Total Incremental Costs ($m[a])	**38.0**	**118.3**
Net Present Value ($m[a])	**26.4**	**165.1**
Benefit Cost Ratio	**1.7**	**2.4**

[a] Current dollars, present value (PV)

BDO EconSearch analysis.

Option 1

Compared to the base case, introducing the 'One Tree Policy'[42] is expected to deliver economic, amenity and liveability gains to the Greater Adelaide community valued at **$26.4 million** (**BCR 1.7**), and is therefore a worthwhile initiative for government to consider.

The additional house footing costs and onsite tree planting and maintenance costs (borne by infill households) is offset by the non-market environmental and social benefits that increased tree canopy provides to the community of Greater Adelaide, and the cost-saving benefit of reduced electricity use to infill households. This option would **return $1.70 to the community for every $1 invested.**

Option 2

This option[43] is estimated to **return $2.40 to the community for every $1 invested**. Providing the option for infill households to have the same 'one tree' outcome achieved offsite on public land, funded via an offset scheme, is therefore a worthwhile initiative for government to consider.

It should be noted that this offset scheme has been developed for the purposes of this analysis and its formulation is intended to be illustrative only. However, as formulated in this study, providing an offset option is expected to deliver gains to the Greater Adelaide community valued at an **estimated $165.1 million.**

Option 2 had a significantly higher return than Option 1 for three reasons:

- **Amenity value of offsite trees is significantly greater than onsite trees** – valued at $104.0 million in additional community benefits.
- **Most house footing costs would be avoided**, with some households choosing to pay an offset instead – valued at $26.3 million in avoided household costs compared to Option 1.
- **More mature trees would be retained** (incentivised via avoided offset payments) – valued at $15.2 million in retained community benefits compared to Option 1.

4.1.2. Sensitivity analysis

The results of the analysis were sensitivity tested to reflect any uncertainties present in key variables. Sensitivity analyses were undertaken for the following variables:

- Discount rate
- Period of analysis
- Amenity.

The range of values used for each uncertain variable and results of the sensitivity analysis are set out below with some interpretation of the results. Note that each sensitivity analysis for each variable was undertaken by holding all other variables constant at their 'expected' values.

Discount rate

Costs and benefits are specified in real terms (i.e. current 2020 dollars) and future values are converted to present values by applying a discount rate of 6 per cent. A sensitivity analysis was conducted using discount rates of 4 and 8 per cent (Table 4-2).

[42] The proposed deemed-to-satisfy provision for minor infill to provide one tree (or equivalent) on each allotment, which is small, medium or large depending on allotment size. Discounts apply for retaining existing trees and associated soil area. Detailed requirements are described in Section 2.4.2. This policy is intended to be included in Gen 1 of the Planning and Design Code.

[43] Applicants can choose to meet the one tree DTS provision on their own allotment, or have the same outcome achieved offsite on public land, funded by an offset scheme. More information on offset schemes is provided in Section 2.7. This policy may be considered in later generations of the Code.

Table 4-2 Results of the sensitivity analysis - discount rate

Discount rate	Option 1		Option 2	
	NPV ($m[a])	BCR	NPV ($m[a])	BCR
4%	36.6	1.8	204.6	2.4
6%[b]	26.4	1.7	165.1	2.4
8%	19.2	1.6	136.1	2.4

a In current dollars

b Expected value

Source: BDO EconSearch analysis

As expected, the NPV and BCR improve with the lower (4 per cent) discount rate and decrease under the higher discount rate (8 per cent). This occurs because, although the bulk of the project costs are upfront and are not significantly affected by the discount rate, the benefits accrue over many years and are greater, in present value terms, when the discount rate is lower.

The results are shown to be sensitive to changes in discount rate. This means that a 4 or 8 per cent discount rate will have a significant effect on the magnitude of the NPV and BCR results, however the results remain positive across the range in this variable.

Period of analysis

Many of the tree benefits increase over time as the trees become older or more mature, and can take decades to become significant, however major planning policies are likely to have a life of two to three decades. A sensitivity analysis was undertaken with a period of analysis of 15 years and 40 years (Table 4-3).

Table 4-3 Results of the sensitivity analysis - period of analysis

Period of analysis	Option 1		Option 2	
	NPV ($m[a])	BCR	NPV ($m[a])	BCR
15 years	8.5	1.3	110.4	2.2
25 years[b]	26.4	1.7	165.1	2.4
40 years	56.4	2.2	223.4	2.6

a In current dollars

b Expected value

Source: BDO EconSearch analysis

For both Option 1 and Option 2, the results are shown to be moderately sensitive to changes in period of analysis, however the results remain positive across the range in this variable.

Amenity

The amenity value to households of gaining or retaining a tree on site or nearby was derived from a study in Perth. It is possible that the community in Adelaide values street trees differently from people in Perth. A sensitivity analysis was conducted using a 25 per cent decrease and increase in the expected value of 1.9 per cent of the median house price (Table 4-4).

Table 4-4 Results of the sensitivity analysis - amenity

Amenity	Option 1		Option 2	
	NPV ($m[a])	BCR	NPV ($m[a])	BCR
25% less	20.2	1.5	132.9	2.1
Expected value[b]	26.4	1.7	165.1	2.4
25% more	32.5	1.9	197.2	2.7

[a] In current dollars
Source: BDO EconSearch analysis

The results are moderately sensitive to change. If a zero value is assumed for amenity benefits, then the NPV for Option 1 drops to $1.9 million and for Option 2 drops to $36.6 million, however the results are still positive.

4.2. Individual infill households

4.2.1. Scenarios tested

For the household level analysis, we sought to test the two policy options against a realistic suite of the scenarios that may apply to an individual household. This analysis provides an indication of the likelihood and significance of costs and benefits, but due to the many variables at play, it is not possible to identify the exact net cost or benefit applicable to every individual household in every possible scenario, or to provide a weighted average cost or benefit per household. The scenarios below are based on the expected values for key variables, as outlined in Section 3.4.

For individual households, our case study indicates that **57 per cent of infill developments** would have retained or planted a tree anyway[44] (see Section 3.4.4). This means they will be no better or worse off, so they have not been tested in the household scenario analysis.

Households that in the base case would have removed a tree (or had no tree) and would not have planted one, will be required to plant a tree onsite (under Option 1), or will be able to choose whether to plant a tree onsite or pay into an offset scheme (under Option 2). The possible scenarios fit into four categories:

- A tree can be planted onsite without creating an additional tree effect on footing costs (**Scenario 1**). This is the most likely scenario.
- Proposed dwelling has no nearby trees, and planting an onsite tree will create an additional tree effect on footing costs (**Scenarios 2-5**). These scenarios are considered less likely.
- Household chooses to pay an offset rather than plant a tree onsite (Option 2 - **Scenarios 6-7**). These scenarios are estimated to represent 23 per cent of developments (see Section 3.4.4).

Scenarios 2-5 tested variations based on the two different dwelling types, and the soil types with the least expensive footings and most expensive footings. Scenarios 6-7 tested variations based on whether the household had no existing tree, or chose to remove an existing tree.

[44] In a Glengowrie case study site, including developments occurring between 2007 and 2019, trees were retained in 27% of developments, and new trees were planted in 30% of developments. This case study is the best available information on household behaviour in relation to trees in minor infill settings in Greater Adelaide.

Explanatory notes

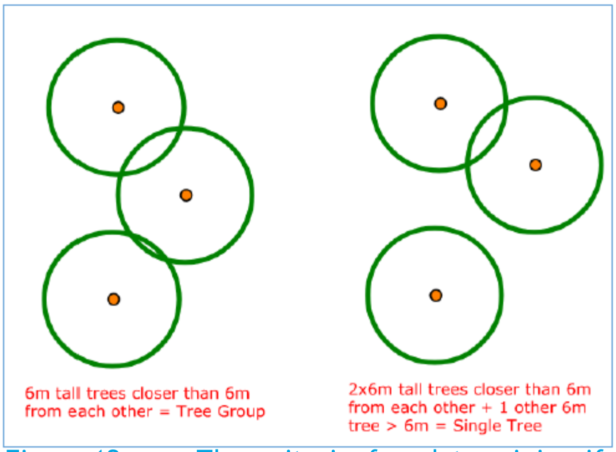


Figure 12 The criteria for determining if trees create a 'group of tree' effect

- An additional tree effect on house footings is caused by moving from no tree effect to a single tree effect (from 0 to 1 trees), or by moving from a single tree effect to a group of trees effect (from 2 to 3 trees). There is no additional tree effect caused by moving from 1 to 2 trees, because the single tree effect applies when there are one or two trees (AS2870-2011 Residential Slabs and Footings). Refer to Figure 12 for a diagram showing when a single tree effect moves to a group of trees effect.
- Scenario 1 covers cases where the new tree is planted outside the tree effect zone OR where there is already one nearby tree (causing an existing single tree effect on footings) OR where there is already a group of nearby trees (causing an existing group of trees effect on footings). Note all development in the General Neighbourhood and Suburban Neighbourhood Zones has the opportunity to plant a 4 metre tree at least 4 metres away from the footings.
- Scenarios 2-5 are considered less likely to occur as dwellings in the General Neighbourhood and Suburban Neighbourhood Zones have minimum setbacks that mean a small tree can be planted outside the zone of tree effect if an applicant chooses. However this case study situation could occur in denser zones with smaller setbacks (or if the household chooses to plant a larger tree or plant within the tree effect zone) and there is no nearby tree causing an effect[45].

4.2.2. Cost benefit analysis results

For individual households, our case study indicates that 57 per cent of infill developments will be no better or worse off than under the base case, because they would have retained or planted a tree anyway[46].

This study tested a number of likely common infill development scenarios.

In the most likely scenario, a tree is planted onsite without creating a new or additional tree effect (Scenario 1). In this case, infill households will realise a significantly positive net benefit of $888 (BCR 2.5).

This study also tested the impact of infill developments planting a 6m tree 4m from the dwelling's footings, which will impose a new tree effect on house footing costs. The study found that where the soil has lower reactivity[47], the household will realise a net benefit, and where the soils have higher reactivity[48], the household will incur a net cost (BCRs range from 1.9 to 0.4 respectively).

This indicates that house footprint size and configuration, and tree height and placement (compared to existing nearby trees and the house), will be an important cost consideration for households in areas with more reactive soils. Therefore there may be merit in identifying additional options for households to meet tree cover outcomes while minimising upfront costs, in the scenario they will incur a net cost.

[45] In an established urban area, it is estimated that house footings will already have to be designed to accommodate the impact of nearby offsite trees in 75 per cent of all infill developments.

[46] In a Glengowrie case study site, including developments occurring between 2007 and 2019, trees were retained in 27% of developments, and new trees were planted in 30% of developments. This case study is the best available information on household behaviour in relation to trees in minor infill settings in Greater Adelaide.

[47] See Scenario 2 and 4 in the Cost Benefit Analysis.

[48] See Scenario 3 and 5 in the Cost Benefit Analysis.

It is also important to acknowledge that the study has only included a limited sub-set of benefits that were able to be defensibly quantified in dollar terms. Other benefits likely to accrue to households with onsite trees include improved house value (monetary) and improved physical and mental health (non-monetary).

The cost benefit analysis results are provided in Table 4-5, and Table 4-6, and detailed in Appendix 2.

Table 4-5 Results of the individual household cost benefit analysis - Scenarios 1-5, Options 1 and 2

Description	Scenario 1[b]	Scenario 2[c]	Scenario 3[d]	Scenario 4[e]	Scenario 5[f]
Benefits ($[a])					
Household electricity bill saving	570	570	570	570	570
Amenity	922	922	922	922	922
Total Benefits ($[a])	**1,491**	**1,491**	**1,491**	**1,491**	**1,491**
Costs ($[a])					
House footing costs	0	186	2,377	597	3,636
Onsite tree planting & maintenance costs	603	603	603	603	603
Total Costs ($[a])	**603**	**790**	**2,980**	**1,201**	**4,239**
Net Present Value ($[a])	**888**	**702**	**-1,489**	**291**	**-2,748**
Benefit Cost Ratio	**2.5**	**1.9**	**0.5**	**1.2**	**0.4**

[a] In current dollars

[b] Scenario 1: Tree is planted onsite without creating a new or additional tree effect.

[c] Scenario 2: Tree is planted where it creates a tree effect, least expensive footing (less reactive soil), double storey dwelling.

[d] Scenario 3: Tree is planted where it creates a tree effect, most expensive footing (more reactive soil), double storey dwelling.

[e] Scenario 4: Tree is planted where it creates a tree effect, least expensive footing (less reactive soil), single storey dwelling.

[f] Scenario 5: Tree is planted where it creates a tree effect, most expensive footing (more reactive soil), single storey dwelling.

Source: BDO EconSearch analysis.

Table 4-6 presents the results for individual infill households choosing to pay into an offset scheme in the following scenarios:

- Scenario 6: No existing tree, household pays offset for tree to be planted offsite
- Scenario 7: Existing tree removed, household pays offset for loss of existing tree and for new tree to be planted offsite.

These scenarios are relevant to Option 2 only.

Table 4-6 Results of the individual household cost benefit analysis - Scenarios 6-7, Option 2

Description	Scenario 6[b]	Scenario 7[c]
Benefits ($m[a])		
Household electricity bill saving	-	-
Structural value of tree	-	-
Total Benefits ($m[a])	**0**	**0**
Costs ($m[a])		
House footing costs	-	-
Onsite tree planting & maintenance costs	-	-
Offset scheme payment	**1,165**	**4,630**
Total Costs ($m[a])	**1,165**	**4,630**
Net Present Value ($m[a])	**-1,165**	**-4,630**
Benefit Cost Ratio	**-**	**-**

[a] In current dollars

[b] Scenario 6: No existing tree, offset paid for tree to be planted offsite.

[c] Scenario 7: Existing tree removed, offset paid for loss of existing tree and for new tree to be planted offsite.

Source: BDO EconSearch analysis

4.2.3. Sensitivity analysis

The results of the analysis were sensitivity tested to reflect any uncertainties present in key variables. Sensitivity analyses were undertaken for the following variables:

- Discount rate
- Period of analysis
- Amenity.

The range of values used for each uncertain variable and detailed results of the sensitivity analysis are set out below with some interpretation of the results. Note that each sensitivity analysis for each variable was undertaken by holding all other variables constant at their 'expected' values.

Discount rate

Costs and benefits are specified in real terms (i.e. current dollars) and future values are converted to present values by applying a discount rate of 6 per cent. A sensitivity analysis was conducted using discount rates of 4 and 8 per cent (Table 4-7).

Table 4-7 Results of the sensitivity analysis - discount rate

Discount rate	Scenario NPV ($[a])						
	1	2	3	4	5	6	7
4%	980	794	-1,396	383	-2,655	-1,165	-4,600
6%[b]	888	702	-1,489	291	-2,748	-1,165	-4,600
8%	825	638	-1,552	227	-2,811	-1,165	-4,600

[a] In current dollars

[b] Expected value

Source: BDO EconSearch analysis

As expected, the NPVs improve with the lower (4 per cent) discount rate and decrease under the higher discount rate (8 per cent). This occurs because, although the bulk of the project costs are upfront and are not significantly affected by the discount rate, the benefits accrue over many years and are greater, in present value terms, when the discount rate is lower.

The exceptions are Scenarios 6 and 7, which incur all costs upfront and no benefits (see Table 4-7) and so are indifferent to discount rate.

Period of analysis

Many of the tree benefits increase over time as the trees become older or more mature, and can take decades to become significant, however major planning policies are likely to have a life of two to three decades. A sensitivity analysis was undertaken with a period of analysis of 15 years and 40 years (Table 4-8).

Table 4-8 Results of the sensitivity analysis – period of analysis

Period of analysis	Scenario NPV ($[a])						
	1	2	3	4	5	6	7
15 years	718	532	-1,659	121	-2,918	-1,165	-4,600
25 years[b]	888	702	-1,489	291	-2,748	-1,165	-4,600
40 years	1,099	912	-1,278	501	-2,537	-1,165	-4,600

a In current dollars

b Expected value

Source: BDO EconSearch analysis

As expected, the NPVs improve with the longer (40 years) period of analysis and decrease under the shorter period of analysis (15 years). This occurs because, although the bulk of the project costs are upfront and are not significantly affected by the discount rate, the benefits accrue over many years and are greater, in present value terms, when the period of analysis is longer. The exceptions to this are Scenarios 6 and 7, which incur all costs upfront and no benefits (see Table 4-8) and so are indifferent to the period of analysis.

Amenity

The amenity value to households of gaining or retaining a tree on site was derived from a study in Perth. It is possible that the community in Adelaide values street trees differently from people in Perth. A sensitivity analysis was conducted using a 25 per cent decrease and increase in the expected value of 1.9 per cent of the median house price (**Error! Reference source not found.**). The results are shown to be moderately sensitive to changes in period of analysis, however the results remain positive across the range in this variable.

Table 4-9 Results of the sensitivity analysis – amenity

Amenity	Scenario NPV ($[a])				
	1	2	3	4	5
25% less	658	471	-1,719	60	-2,978
Expected value	888	702	-1,489	291	-2,748
25% more	1,118	932	-1,258	521	-2,517

[a] In current dollars

[b] Expected value

Source: BDO EconSearch analysis

5. KEY POLICY CONSIDERATIONS

1. Nuanced policy implementation for more reactive soils in denser zones

- A nuanced application of the policy could be considered for households expected to incur a net cost. This may occur in denser zones (with smaller lots and setbacks) with more reactive soils.
- Distribution of more reactive soils is highly variable across Greater Adelaide.

> ### New infill development zones
>
> The new **General Neighbourhood** and **Suburban Neighbourhood** Zones have a minimum 5m setback. Infill developments in these zones can usually meet the 'One Tree Policy' provisions without incurring any new costs to house footings.
>
> The denser **Housing Diversity** and **Urban Renewal** Zones have a minimum 3m setback. In these zones, households could choose to avoid additional house footing costs by setting their house back further than the minimum, or they can choose to accommodate the 'tree effect' in their house footing design. Due to the small block size and minimum setback, it is likely that many of these developments will already have to consider some form of 'tree effect' from nearby street trees or other neighbouring trees, regardless of the 'One Tree Policy'.

2. Putting a price on tree loss

- Retained trees, being more mature, provide relatively more economic, social and environmental benefits than newly planted trees.
- There is currently a 3 x $150 fee for removing a Significant tree and 2 x $150 fee for removing a Regulated tree on private land. It is clear this nominal fee falls short of covering the costs of planting and maintaining a replacement tree ($603 on private land, $1,165 on public land) – not to mention the lost benefits to the community (estimated at $3,435 for an average unregulated tree).
- Mechanisms could be considered for appropriately pricing removal of trees to reflect the true cost imposed on the community (e.g. lost carbon storage, lost urban heat mitigation, reduced house values, reduced health outcomes, etc.).

3. Providing an offset scheme for trees to be planted offsite

- Option 2, as formulated in this study, does put a price on lost benefits and replacement costs when removing existing trees. This is expected to incentivise higher retention of existing trees.
- An appropriately priced offset scheme may provide households with greater choice in how they fulfil their contribution to the desired policy outcome of improved tree canopy cover. For example, an offset payment may be attractive to households on sites with more reactive soils.
- Individual households may have other costs external to the analysis, such as site configuration or particular house designs, which they are prepared to trade-off against the cost of payment into the offset scheme.
- If an offset scheme is pursued, its design should consider the practicalities of replacing and maintaining a tree in the public realm (including space constraints), the loss of tree benefits where they are needed most, and the required administrative arrangements of an offset scheme.
- Consideration would also need to be given to appropriately distributing offset payment receipts to equalise lost tree benefits, both by location (so tree benefits can be provided where they are needed most) and by sector (so the lost benefits can be provided by alternative means).

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Disclaimer

The assignment is a consulting engagement as outlined in the 'Framework for Assurance Engagements', issued by the Auditing and Assurances Standards Board, Section 17. Consulting engagements employ an assurance practitioner's technical skills, education, observations, experiences and knowledge of the consulting process. The consulting process is an analytical process that typically involves some combination of activities relating to: objective-setting, fact-finding, definition of problems or opportunities, evaluation of alternatives, development of recommendations including actions, communication of results, and sometimes implementation and follow-up.

The nature and scope of work has been determined by agreement between BDO and the Client. This consulting engagement does not meet the definition of an assurance engagement as defined in the 'Framework for Assurance Engagements', issued by the Auditing and Assurances Standards Board, Section 10.

Except as otherwise noted in this report, we have not performed any testing on the information provided to confirm its completeness and accuracy. Accordingly, we do not express such an audit opinion and readers of the report should draw their own conclusions from the results of the review, based on the scope, agreed-upon procedures carried out and findings.

APPENDIX 1 Background evidence gathering

As a first stage to this work, AGD sought to identify and review some of the likely costs and benefits associated with proposed Code policies. These efforts were informed by a number of stakeholder workshops and forums, which included members of the Stakeholder Reference Group as well as representatives from key government agencies, local councils and developers with experience in infill development. This Appendix contains the relevant outputs of that earlier work.

Summary of engagement activities

Engagement activity	Participants	Purpose	Summary of key outcomes and further info
Industry Infill Advisory Forum 13 August 2019	Local developers, builders and four inner metropolitan councils (West Torrens, Salisbury, Campbelltown and Charles Sturt)	The purpose of this workshop was to seek input and evidence sources on the costs and benefits of WSUD and urban greening.	There was strong interest in identifying what role rainwater tanks might have in local stormwater management. John Eckert (from River Gum Homes) also volunteered to organise for three of the structural engineers that commonly do work for small scale infill development for Rivergum Homes to participate in the below workshop.
Footings and the Effects of Trees Workshop 29 August 2019	Local developer (Rivergum Homes), structural engineers and landscape architects	The purpose of the workshop was to identify: • opportunities and challenges with the proposed tree planting policy, including any factors specific to Adelaide • ways to improve the policy • any further information or support that industry would need to implement the policy.	There was a diversity of viewpoints raised. Trees were seen by most at the workshop as common existing 'infrastructure' in neighbourhoods that needed to be designed for and were therefore not a 'new cost'. It was recommended that further supporting guidance was provided about this policy such as trees not to plant.
Infill Advisory Forum 24 September 2019	Representatives from the SPC, Ministerial Liaison Group, 3 x Planning Reform Advisory Groups (Development and Industry, Local Government and Community and Sustainability), local councils, government agencies and research groups	Workshop - Understanding and balancing the different costs and benefits of WSUD / greening: • What are the benefits and challenges? • What are the opportunities to address the challenges? • What further information/support is needed to assist implementation	There was a diversity of viewpoints raised. Some groups thought that the Code policies proposed weren't strong enough, while other industry groups preferred that they were removed. There was discussion about potential implementation issues e.g. compliance with rainwater tank installation. There was also discussion about whether guidance material was needed about what type of tree and where to plant.
Stakeholder Reference Group meetings	As listed in the Options Analysis	Three meetings to discuss the scope and findings of the Options Analysis	

Literature review on the key benefits of improving urban tree canopy cover

Green infrastructure and water sensitive urban design have multiple benefits – especially in the context of increasing urban infill. These benefits include improving amenity, reducing the urban heat island effect, improving physical and mental health, reducing stormwater run-off and improving the overall liveability of urban communities. AGD undertook a literature review to identify some of the likely costs and benefits associated with proposed Code policies. The key findings and references are listed below.

The role of trees in promoting positive health and wellbeing of communities

There are a range of well documented positive health and wellbeing outcomes provided by trees and green public spaces. Those impacts which may be associated with trees in private spaces, such as urban gardens, are outlined in the below table and are drawn from a literature review undertaken by SA Health, and including references identified by the Heart Foundation.

Positive Impacts to Public Health and Wellbeing for the Whole of Community	
Impact	**Public Health and Wellbeing Outcomes**
Improved air quality	Urban trees have been associated with a lower prevalence of asthma. Increased densities of trees have been found to lower childhood asthma prevalence by 29%.
	Trees, and other vegetated areas, are known to filter pollutants including nitrogen oxides, ozone, carbon monoxides and sulphur oxides, and of other large particulate matter.
	The filtering capacity of trees has been found to reduce particulate matter concentrations downwind of the trees by more than 10%.
	In the United States alone, it is estimated that trees provide $18.3 billion in annual value due to air pollution, reduced building energy use, carbon sequestration and avoided pollutant emissions.
Decreased cardio metabolic conditions[49]	After controlling for demographics including age, income and education, research suggests that residents living in areas of with a high number of and/or large trees on streets and have significantly fewer cardio-metabolic conditions.
	Canadian research suggests that the inclusion of 10 trees per urban block can have health impacts which are equivalent to being seven years younger in age.
	There is early evidence that evergreen canopy coverage is linked to a reduction in the proportion of communities with cardio metabolic conditions.
Improved wellbeing and mental health	Evidence suggests that high tree species diversity can improve mental health and wellbeing.
	In Toronto, living in a street having 10 or more trees was found to equate to health benefits equivalent to being seven years younger or receiving a $10,000 salary rise. People who live in areas that have more (and/or larger) trees on the streets report significantly fewer cardio-metabolic conditions. People reported decrease of 0.04 units of cardio-metabolic conditions (0.5% of the 0–8 scale for cardio-metabolic conditions) for every increase of 408 cm2/m2 in tree density. This is approximately equivalent to 11 more average-sized trees on the streets per city block. This effect for cardio-metabolic conditions is equivalent to a $20,200 increase in both area median income and annual household income adjusted for other variables. This decrease in cardio-metabolic conditions is also, on average, equivalent to being 1.4 years younger.
	Exposure to 30% or more tree canopy compared with 0% to 9% tree canopy was associated with 31% lower odds of incident psychological distress, whereas exposure to 30% or more grass was associated with 71% higher odds

[49] Cardio metabolic conditions are a collection of disorders that occur together and increase the risk of developing type 2 diabetes or cardiovascular disease.

		of prevalent psychological distress after adjusting for age, sex, income, economic status, couple status, and educational level.
		Lower odds of short sleep were more consistently observed among people living near more tree canopy in both the cross-sectional and longitudinal tests. Neither open grass nor other low-lying vegetation were associated with prevalent or incident short sleeps. This suggests urban greening strategies that prioritise increasing the availability of and reducing inequalities in tree canopy coverage may help to support population-wide improvements in sleep.
Reduced risk of small for gestational age births		Higher canopy cover within 50 metres of the home can reduce stress for pregnant women, lowering the risk of small for gestational age births.
		Tree canopy cover is a predictor of greater physical activity, which can reduce the risk of small for gestational age births.
Reductions in UV Radiation		Individual trees can reduce exposure to UV radiation by an equivalent SPF of 6-10.
		The denser and more continuous the shading from tree canopies the higher the UV radiation reductions.
		This can reduce impacts to the public health system through a reduction in cataracts, skin cancers and heat related illnesses.
		One Californian study showed “the benefit: cost ratio was $3.81 for every $1.00 spent on tree planting and management”
Improved nutrition		The planting of productive trees can improve nutrition and reduce the cost of purchasing foods, providing food security.
Reduced impacts from climate extremes		Strategic location of trees around buildings can support lower energy spending on heating and cooling.
	Cold events	Trees can reduce the risk of hypothermia-related health problems when planted as windbreaks.
		Tree canopies have been found to reduce wind speeds by up to 10%, which reduces the need for heating in nearby buildings during cooler weather.
	Heat events	Tree cover on the streets of Parramatta can mean a difference of 10C on a hot day
		Higher canopies are a predictor of urban cooling.
		Vegetation has been found to be more effective at increasing the albedo effect than other mitigation strategies, including pale roofs and light coloured paths and roads.
		Air temperature differentials under tree canopies have been recorded at between 10-30C lower than the surrounding areas.
		Cooling effects of urban trees can be extended beyond the shaded areas through dispersal by air currents.

Vulnerable Sub-Populations and the Impact of Trees		
Sub-Population	**Vulnerabilities**	**Impact of Trees**

Elderly[50]	Physiological changes: • Less active/delayed sweat response leading to dehydration as not as likely to increase fluid intake as thirst response is delayed. • Decreased ability to increase blood flow to the skin to dissipate heat. • Concerns over bladder control and reduced renal system functions, which may discourage drinking for fear of embarrassing situations. • Likely to have multi-variant pre-existing chronic health illnesses which are frequently associated with increased risk from heat-related illness. • Medications which may increase heat production, increase speed of dehydration and impair natural thermoregulation. • May have cognitive impairments and not perceive heat Managing thermal environments: • House may be older buildings which can be thermally inefficient – draughty, poor solar orientation, poorly insulated • Less likely to run air conditioners due to the costs of electricity costs when on a fixed income	It has been estimated that, in heat events, shading provided by large trees can reduce energy use and associated bills by 10%. Strategic placement of trees around buildings has been found to reduce air conditioning requirements by up to 30% and heating requirements by up to 20-50%. Vegetation has been found to be more effective at increasing the albedo effect than other mitigation strategies, including pale roofs and light coloured paths and roads.

Mental and Behavioural Disorders	Physiological susceptibilities:
	• Evidence of a number of disorders becoming exacerbated when ambient temperatures reach, and exceed, 26.7C.
	• A range of disorders, and treatment medications, can interfere with thermoregulation by:
	  o Reducing the ability to sweat,
	  o Increasing core body temperature.
	• Impaired cognitive awareness of environmental conditions and subsequent appropriate reactions to these conditions can exacerbate risk to heat related illness.
		It has been estimated that, in heat events, shading provided by large trees can reduce energy use and associated bills by 10%.
		
		Strategic placement of trees around buildings has been found to reduce air conditioning requirements by up to 30% and heating requirements by up to 20-50%
		
		Vegetation has been found to be more effective at increasing the albedo effect than other mitigation strategies, including pale roofs and light coloured paths and roads.

Managing the cumulative impacts of longer lasting, more intense extreme temperature events is a future challenge for the public health system. Given the constraints of councils to plant trees in public spaces, the impact of planting on private property to assist with climate mitigation and improved public health and wellbeing outcomes should not be underestimated. Strategic selection of species and planting location

[50] Elderly people are those ages 65+ years.

in private properties may be a low-cost and effective strategy to assist in mitigating the impacts of extreme temperature events, not only for those vulnerable sub-populations, but for residents of neighbouring properties too.

Other key trends, benefits and challenges

Benefits of taking action + 'costs doing nothing'	Examples / evidence
Mitigating the impacts of climate change	Climate projections indicate there will be: • Warming temperatures in all seasons across South Australia. By 2100 it is projected that average temperatures will increase by up to 3°C. • Increasing frequency and intensity of heatwaves and hot days. By 2100 it is projected that Adelaide will experience more than 15 days over 40°C per year and Marree will experience more than 50 days over 50°C per year. • Reduced annual rainfall and more time spent in drought. By 2100 it is projected that winter and spring rainfall will decrease by between 10% and 45%. Recent Regional Climate Partnerships work has found that green infrastructure (trees and shrubs) significantly reduce local surface temperatures: • For example, 2.8 C + an additional 1.7C if irrigated.
Reducing the loss of tree canopy in existing metropolitan Adelaide neighbourhoods	Overall 1.92% tree canopy loss (2013-216) Adelaide has the second lowest tree canopy levels in Australian capital cities
Higher household running costs	US studies have found that tree shade can also reduce air conditioning costs of buildings by 20-50% providing suitable tree placement Increasing tree cover by 10% – or strategically planting about three shade trees per building lot – saves annual heating and cooling costs by an estimated $50 to $90 per dwelling.
Social license / community support / affordability	The existing Residential Code is silent on stormwater management, WSUD and landscaping requirements. This is one of the reasons that there is rising concern amongst some community members about small scale infill development. Including some policy to mitigate this concern may help keep the 'social licence' for continuing infill development to support affordable housing provision in locations well serviced by public transport as well as avoid need to avoid further encroachment into valuable primary production and environmental assets at the fringes of metropolitan Adelaide. Adelaide has the lowest residential construction cost in Australia Housing supply in established neighbourhoods is critical to maintaining affordability
Increased property values and economic value of protecting infrastructure	AECOM research focuses on three Sydney suburbs, where we conservatively estimate that a 10 percent increase in the leaf canopy of street trees could increase the value of properties by an average of $50,000 It is estimated that properties in tree-lined streets are valued around 30% higher than those in streets without trees. Urban forests that provide significant canopy coverage improve the lifespan of certain assets such as asphalt by shading them from harmful UV rays – potentially by 30%.

	In Perth, "broad leaved street trees were shown to have a significant effect on the sale price of properties, increasing the median value by $16,889.
Economic value of trees	In Adelaide a four year old tree was estimated to generate a gross annual benefit of $171/ tree, consisting of energy savings, air quality improvements, stormwater management, aesthetics and other benefits. It has been suggested that this value is closer to $424/tree. Urban forests that provide significant canopy coverage improve the lifespan of certain assets such as asphalt by shading them from harmful UV rays - potentially by 30%. One Californian study showed .....“the benefit: cost ratio was $3.81 for every $1.00 spent on tree planting and management” (Maco and Macpherson in Ely, 2010).

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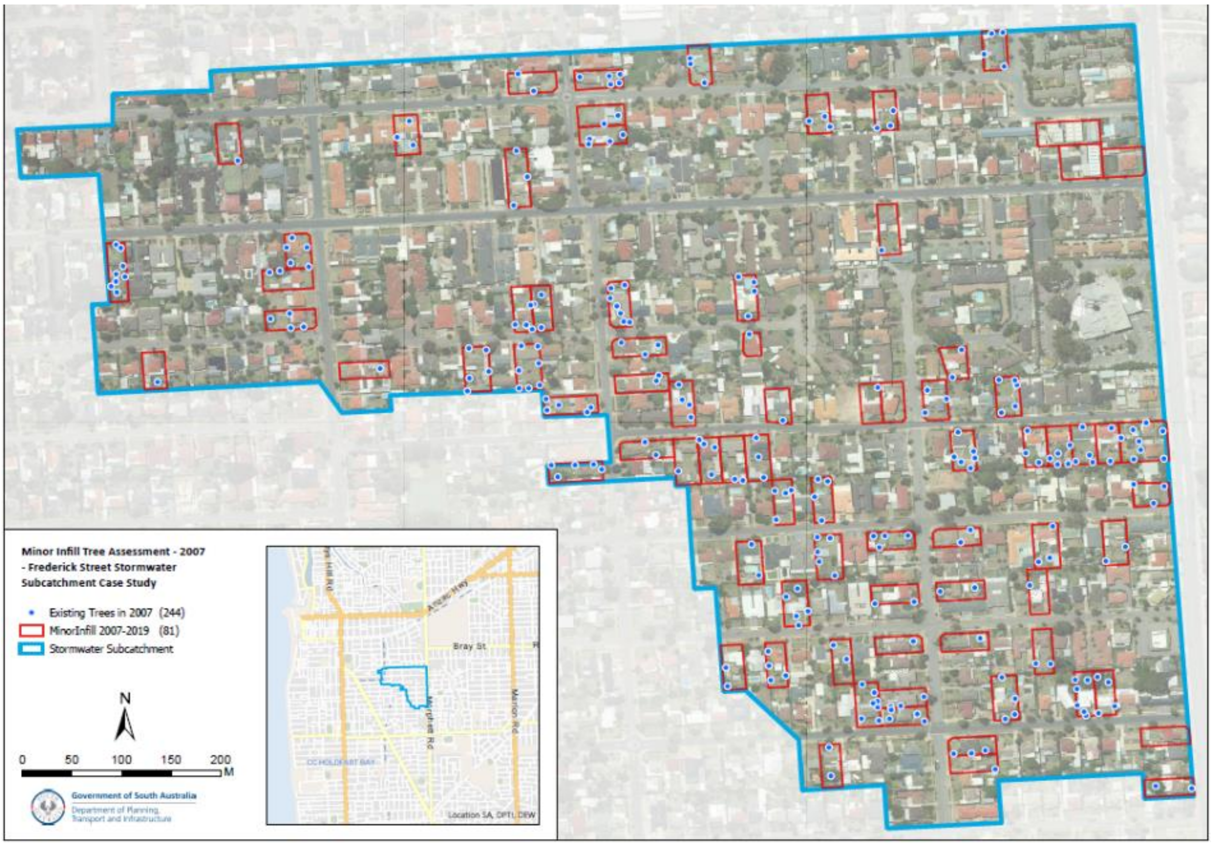
Case Study: Tree canopy retained, lost and planted in Glengowrie, City of Marion

Case study undertaken by AGD to determine whether new infill developments typically keep their existing tree(s) and/or plant a new tree.

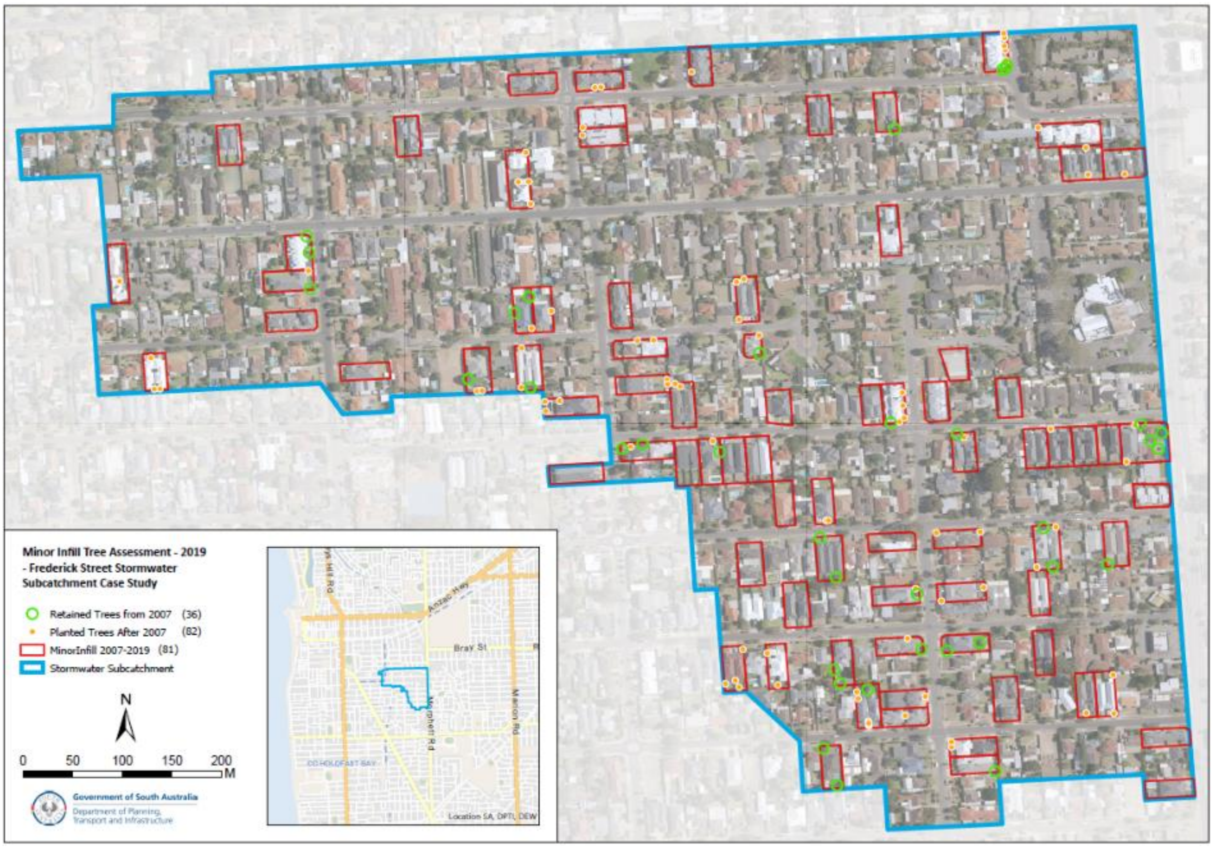
The case study site chosen was the Frederick Street Stormwater Catchment area in Glengowrie, City of Marion. This area was chosen as it has had significant infill development, and is the same case study site used in the Stormwater Report.

Refer below and overleaf for a copy of the maps produced.

Glengowrie Case Study Site - Minor Infill and Tree Canopy Assessment – 2007



Glengowrie Case Study Site - Minor Infill and Tree Canopy Assessment – 2019



Costings – tree effect on footings

The following approach was undertaken by AGD to investigate the impact of trees on footings on new dwellings:

- Commission of independent advice from TMK Consulting engineering (with costings undertaken by Centina)
- Commission of independent advice from PT Design consulting engineering (with costings undertaken by Centina)
- Rivergum Homes organised for four of their completed dwellings to be reviewed by Intrax Consulting Engineers.

14th October 2019

A 69 King William St, Kent Town
P 08 8266 6370
F 08 8312 6009
E admin@centina.com.au
W centina.com.au

Department of Planning, Transport and Infrastructure
77 Grenfell Street
Adelaide SA 5000

Attention: Alison Collins

Dear Alison,

RE: Request for cost assessment of footing layouts of different classifications with and without the effects of trees.

Thank you for contacting us in regards to your case study,

It was interesting and beneficial for us to run the cost analysis and we are pleased to present the results to you.

Please refer to the table below for the cost per footing as per the drawings/tables provided.

Note: Footings cost includes, excavation, spoil removal, reinforcement supply, reinforcement fixing, concrete supply, concrete labour, termite protection treatment, slab edge protection, builders margin and GST.

*The costing provided is for an exercise purpose only.

Should you have any queries or require anything further, please don't hesitate to contact me as undersigned.

Yours Sincerely,

CENTINA GROUP PTY LTD

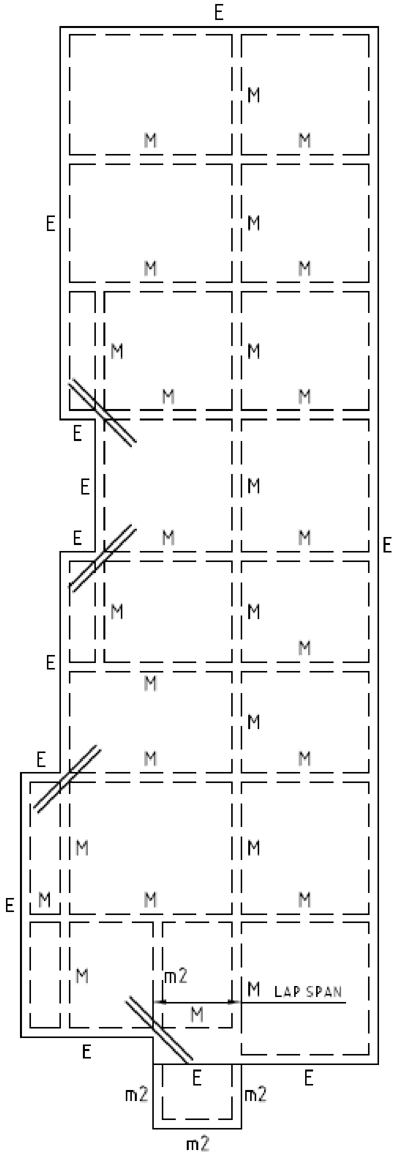
Max Clarke
Estimator

M 0429 197 625
E max@centina.com.au

CENTINA

ANALYSIS OF THE EFFECTS OF TREES ON FOOTING COST

CENTINA
COST ASSESSMENT SUBMISSION



SITE CLASS	ys (mm)	TREES	yt (mm)	FOOTINGS		
S-D	19mm	-	-	E	200 x 500	1-N16T & 1-N20B, W8 @ 800 c/c
				M	200 x 500	1-N16T & 1-N20B, W8 @ 800 c/c
				m2	200 x 400	1-N16T & 1-N16B, W8 @ 800 c/c
		SINGLE	13	E	200 x 500	1-N20T & 1-N20B, W8 @ 800 c/c
				M	200 x 500	1-N20T & 1-N20B, W8 @ 800 c/c
				m2	200 x 400	1-N16T & 1-N16B, W8 @ 800 c/c
		GROUP	22	E	200 x 500	1-N20T & 1-N20B, W8 @ 800 c/c
				M	200 x 500	1-N20T & 1-N20B, W8 @ 800 c/c
				m2	200 x 400	1-N16T & 1-N16B, W8 @ 800 c/c
M-D	40mm	-	-	E	200 x 500	1-N16T & 1-N20B, W8 @ 800 c/c
				M	200 x 500	1-N16T & 1-N20B, W8 @ 800 c/c
				m2	200 x 400	1-N16T & 1-N16B, W8 @ 800 c/c
		SINGLE	11	E	200 x 500	1-N20T & 1-N20B, W8 @ 800 c/c
				M	200 x 500	1-N20T & 1-N20B, W8 @ 800 c/c
				m2	200 x 400	1-N16T & 1-N16B, W8 @ 800 c/c
		GROUP	22	E	200 x 600	1-N20T & 1-N20B, W8 @ 800 c/c
				M	200 x 600	1-N20T & 1-N20B, W8 @ 800 c/c
				m2	200 x 500	1-N16T & 1-N20B, W8 @ 800 c/c
H1-D	59mm	-	-	E	200 x 600	1-N20T & 1-N20B, W8 @ 800 c/c
				M	200 x 600	1-N20T & 1-N20B, W8 @ 800 c/c
				m2	200 x 500	1-N16T & 1-N20B, W8 @ 800 c/c
		SINGLE	15	E	200 x 750	1-N24T & 1-N24B, W8 @ 800 c/c
				M	200 x 750	1-N24T & 1-N24B, W8 @ 800 c/c
				m2	200 x 650	1-N20T & 1-N20B, W8 @ 800 c/c
		GROUP	29	E	250 x 850	1-N28T & 1-N28B, W10 @ 800 c/c
				M	250 x 850	1-N28T & 1-N28B, W10 @ 800 c/c
				m2	250 x 750	1-N24T & 1-N24B, W10 @ 800 c/c
H2-D	74mm	-	-	E	200 x 750	1-N24T & 1-N24B, W8 @ 800 c/c
				M	200 x 750	1-N24T & 1-N24B, W8 @ 800 c/c
				m2	200 x 650	1-N20T & 1-N20B, W8 @ 800 c/c

NOTES

- FOR COMPARISON PRICING ONLY.
- FOOTING SIZES SHOWN ARE FOR THE CONFIGURATION OF THE FOOTING LAYOUT SHOWN.
- TREE EFFECTS ARE CALCULATED BASED ON Df/H = 0.66
- FOOTING SIZES DEPICTED ONLY REPRESENT AN APPROXIMATION AND MAY CHANGE DUE TO SPECIFIC SITE CONDITIONS.
- SLAB ON GROUND TO BE 100mm THICK AND REINFORCED WITH ONE LAYER OF SL72T PLACED 25mm FROM THE TOP FACE (UNO).

1. SLAB THICKNESS AND FOOTING DEPTH TO BE MAINTAINED AT ALL SETDOWNS. (PROVIDE STEPS AS PER STANDARD DETAILS.)
2. LAPS IN MESH TO BE ONE FULL SQUARE PLUS 25mm.
3. CONCRETE GRADE 'N20' U.N.O.
4. WHERE BRITTLE FLOOR COVERING USED, PROVIDE 2 LAYERS OF SL72 FABRIC OR 1 LAYER OF SL92 FABRIC
5. DENOTES 2-N16 X 2000 LONG CRACK CONTROL BARS TOP.

0 1 2 3 4 5 10m

P.A.	PRELIMINARY	JLI	GM	24.09.19
No.	REVISION	DRAWN	CHECK'D	DATE

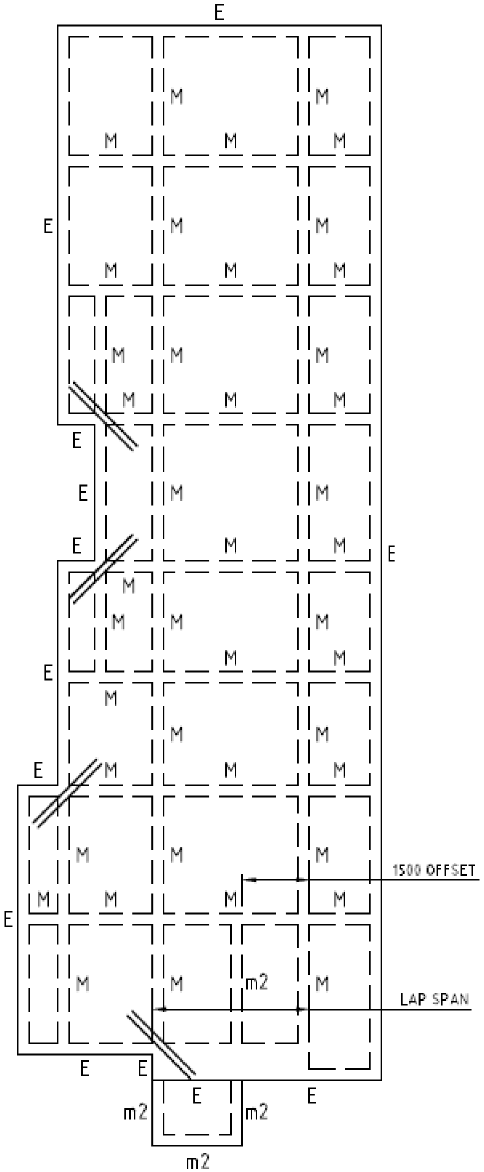
PRELIMINARY

TITLE FOOTING PLAN

Civil – Structural
Environmental – Geotechnical
Mechanical – Electrical
Fire – Hydraulics
Lifts – Green ESD

Level 6, 100 Pirie Street
Adelaide SA 5000
Telephone 08 8238 4100
Facsimile 08 8410 1405
Barri Office: 25 Vaughan Terrace,
Barri SA 5343

SCALE	1:100 @ A3	JOB No.	1908171
DRAWN	JLI		
DATE	Sep-19	DWG. No.	CR3A/PA
ENGINEER	GM		



SITE CLASS	ys (mm)	TREES	yt (mm)	FOOTINGS		
H2-D	74mm	SINGLE	28	E	200 x 800	1-N28T & 1-N28B, W10 @ 800 c/c
				M	200 x 800	1-N28T & 1-N28B, W10 @ 800 c/c
				m2	200 x 650	1-N20T & 1-N20B, W10 @ 800 c/c
		GROUP	60	E	250 x 1100	1-N32T & 1-N32B, W10 @ 800 c/c
				M	250 x 1100	1-N32T & 1-N32B, W10 @ 800 c/c
				m2	250 x 900	1-N28T & 1-N28B, W10 @ 800 c/c
E-D	104mm	-	-	E	250 x 900	1-N28T & 1-N28B, W10 @ 800 c/c
				M	250 x 900	1-N28T & 1-N28B, W10 @ 800 c/c
				m2	250 x 750	1-N24T & 1-N24B, W10 @ 800 c/c
		SINGLE	31	E	250 x 1100	1-N32T & 1-N32B, W10 @ 800 c/c
				M	250 x 1100	1-N32T & 1-N32B, W10 @ 800 c/c
				m2	250 x 1000	1-N32T & 1-N32B, W10 @ 800 c/c
		GROUP	62	E	250 x 1250	1-N32T & 1-N32B, W10 @ 800 c/c
				M	250 x 1250	1-N32T & 1-N32B, W10 @ 800 c/c
				m2	250 x 1100	1-N32T & 1-N32B, W10 @ 800 c/c

NOTES

- FOR COMPARISON PRICING ONLY.
- FOOTING SIZES SHOWN ARE FOR THE CONFIGURATION OF THE FOOTING LAYOUT SHOWN.
- TREE EFFECTS ARE CALCULATED BASED ON Dt/H = 0.66
- FOOTING SIZES DEPICTED ONLY REPRESENT AN APPROXIMATION AND MAY CHANGE DUE TO SPECIFIC SITE CONDITIONS.
- SLAB ON GROUND TO BE 100mm THICK AND REINFORCED WITH ONE LAYER OF SL72T PLACED 25mm FROM THE TOP FACE (UNO).

1. SLAB THICKNESS AND FOOTING DEPTH TO BE MAINTAINED AT ALL SETDOWNS. (PROVIDE STEPS AS PER STANDARD DETAILS.)
2. LAPS IN MESH TO BE ONE FULL SQUARE PLUS 25mm.
3. CONCRETE GRADE 'N20' U.N.O.
4. WHERE BRITTLE FLOOR COVERING USED, PROVIDE 2 LAYERS OF SL72 FABRIC OR 1 LAYER OF SL92 FABRIC.
5. ⁄⁄ DENOTES 2-N16 X 2000 LONG CRACK CONTROL BARS TOP.

0 1 2 3 4 5 10m

PA.	PRELIMINARY	JLI	GM	24.09.19
No.	REVISION	DRAWN	CHECK'D	DATE

PRELIMINARY

TITLE FOOTING PLAN

Civil – Structural
Environmental – Geotechnical
Mechanical – Electrical
Fire – Hydraulics
Lifts – Green ESD

Level 6, 100 Pirie Street
Adelaide SA 5000
Telephone 08 8238 4100
Facsimile 08 8410 1405
Berri Office: 25 Vaughan Terrace,
Berri SA 5343

TMK CONSULTING ENGINEERS

SCALE	1:100 @ A3	JOB No.	1908171
DRAWN	JLI		
DATE	Sep-19	DWG. No.	CR3B/PA
ENGINEER	GM		

AGD - FOOTING ASSESSMENT (2) 14.10.2019										
SITE CLASS	ys (mm)	DESIGN LAYOUT	TREES	yt (mm)	FOOTING BEAM	FOOTING SIZE	REINFORCEMENT	TOTAL COST (inc. GST)	E/O for TREE EFFECTS	% INCREASE
S-D	19mm	CR3A_PA	-	-	E	200x500	1-N16T & 1-N20B. W8 @ 800 c/c	$19,602.76	-	
					M	200x500	1-N16T & 1-N20B. W8 @ 800 c/c			
					m2	200x400	1-N16T & 1-N16B. W8 @ 800 c/c			
		CR3A_PA	SINGLE	13	E	200x500	1-N20T & 1-N20B. W8 @ 800 c/c	$20,110.96	$508.20	3%
					M	200x500	1-N20T & 1-N20B. W8 @ 800 c/c			
					m2	200x400	1-N16T & 1-N16B. W8 @ 800 c/c			
M-D	40mm	CR3A_PA	-	-	E	200x500	1-N16T & 1-N20B. W8 @ 800 c/c	$19,602.76	-	
					M	200x500	1-N16T & 1-N20B. W8 @ 800 c/c			
					m2	200x400	1-N16T & 1-N16B. W8 @ 800 c/c			
		CR3A_PA	SINGLE	11	E	200x500	1-N20T & 1-N20B. W8 @ 800 c/c	$20,098.86	$496.10	3%
					M	200x500	1-N20T & 1-N20B. W8 @ 800 c/c			
					m2	200x400	1-N16T & 1-N16B. W8 @ 800 c/c			
H1-D	59mm	CR3A_PA	-	-	E	200x600	1-N20T & 1-N20B. W8 @ 800 c/c	$21,421.03	-	
					M	200x600	1-N20T & 1-N20B. W8 @ 800 c/c			
					m2	200x500	1-N16T & 1-N20B. W8 @ 800 c/c			
		CR3A_PA	SINGLE	15	E	200x750	1-N24T & 1-N24B. W8 @ 800 c/c	$24,904.68	$3,483.66	16%
					M	200x750	1-N24T & 1-N24B. W8 @ 800 c/c			
					m2	200x650	1-N20T & 1-N20B. W8 @ 800 c/c			
H2-D	74mm	CR3A_PA	-	-	E	200x750	1-N24T & 1-N24B. W8 @ 800 c/c	$24,904.68	-	
					M	200x750	1-N24T & 1-N24B. W8 @ 800 c/c			
					m2	200x650	1-N20T & 1-N20B. W8 @ 800 c/c			
		CR3B_PA	SINGLE	28	E	200x800	1-N28T & 1-N28B. W10 @ 800 c/c	$28,707.38	$3,802.69	15%
					M	200x800	1-N28T & 1-N28B. W10 @ 800 c/c			
					m2	200x650	1-N20T & 1-N20B. W10 @ 800 c/c			
E-D	104mm	CR3B_PA	-	-	E	250x900	1-N28T & 1-N28B. W10 @ 800 c/c	$33,935.95	-	
					M	250x900	1-N28T & 1-N28B. W10 @ 800 c/c			
					m2	250x750	1-N24T & 1-N24B. W10 @ 800 c/c			
		CR3B_PA	SINGLE	31	E	250x1100	1-N32T & 1-N32B. W10 @ 800 c/c	$39,612.30	$5,676.35	17%

Case-study 2: 200m2 single storey detached dwelling (PT Consulting Engineering footing design and costed by Centina Homes)

15th November 2019

A 69 King William St, Kent Town
P 08 8266 6370
F 08 8312 6009
E admin@centina.com.au
W centina.com.au

Department of Planning, Transport and Infrastructure
77 Grenfell Street
Adelaide SA 5000

Attention: Alison Collins

Dear Alison,

RE: Request for cost assessment of footing layouts of different classifications with and without the effects of trees.

Thank you for contacting us in regards to your case study,

It was interesting and beneficial for us to run the cost analysis and we are pleased to present the results to you.

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*The costing provided is for an exercise purpose only.

Should you have any queries or require anything further, please don't hesitate to contact me as undersigned.

Yours Sincerely,

CENTINA GROUP PTY LTD

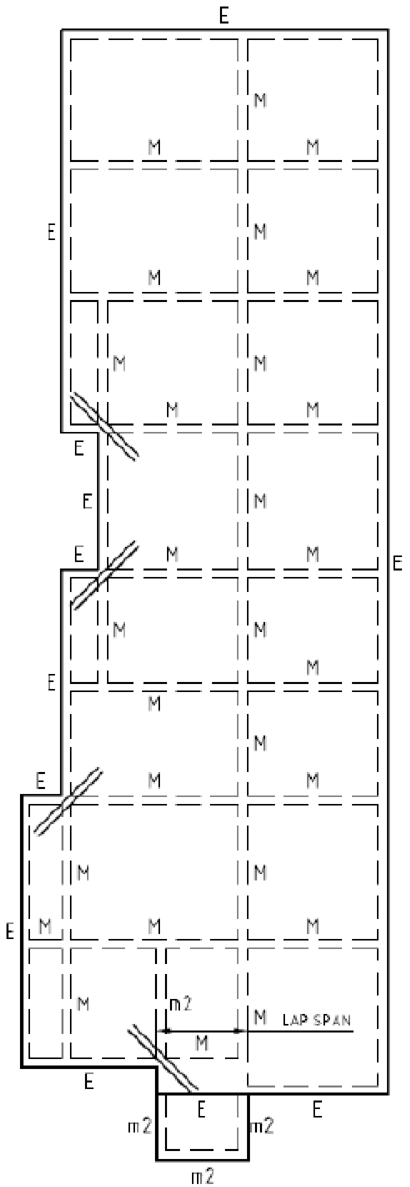
Max Clarke
Estimator

M 0429 197 625
E max@centina.com.au

CENTINA

ANALYSIS OF THE EFFECTS OF TREES ON FOOTING COST

CENTINA
COST ASSESSMENT SUBMISSION



SITE CLASS	ys (mm)	DESIGN LAYOUT	TREES	yt (mm)	FOOTING BEAM	FOOTING SIZE	REINFORCEMENT
S-D	19mm	CR3A_PA	-	-	E	200x350	1-N12T & 1-N12B. W8 @ 800 c/c
					M	200x350	1-N16T & 1-N16B. W8 @ 800 c/c
					m2	200x350	1-N16T & 1-N16B. W8 @ 800 c/c
		CR3A_PA	SINGLE	13	E	200x400	1-N16T & 1-N16B. W8 @ 800 c/c
					M	200x400	1-N16T & 1-N16B. W8 @ 800 c/c
					m2	200x400	1-N16T & 1-N16B. W8 @ 800 c/c
		CR3A_PA	GROUP	22	E	200x450	1-N16T & 1-N16B. W8 @ 800 c/c
					M	200x450	1-N16T & 1-N16B. W8 @ 800 c/c
					m2	200x450	1-N16T & 1-N16B. W8 @ 800 c/c
M-D	40mm	CR3A_PA	-	-	E	200x400	1-N16T & 1-N16B. W8 @ 800 c/c
					M	200x400	1-N16T & 1-N16B. W8 @ 800 c/c
					m2	200x400	1-N16T & 1-N16B. W8 @ 800 c/c
		CR3A_PA	SINGLE	11	E	200x450	1-N16T & 1-N16B. W8 @ 800 c/c
					M	200x450	1-N16T & 1-N16B. W8 @ 800 c/c
					m2	200x450	1-N16T & 1-N16B. W8 @ 800 c/c
		CR3A_PA	GROUP	22	E	200x500	1-N20T & 1-N20B. W8 @ 800 c/c
					M	200x500	1-N20T & 1-N20B. W8 @ 800 c/c
					m2	200x500	1-N20T & 1-N20B. W8 @ 800 c/c
H1-D	59mm	CR3A_PA	-	-	E	200x500	1-N16T & 1-N16B. W8 @ 800 c/c
					M	200x500	1-N16T & 1-N16B. W8 @ 800 c/c
					m2	200x500	1-N16T & 1-N16B. W8 @ 800 c/c
		CR3A_PA	SINGLE	15	E	200x550	1-N20T & 1-N20B. W8 @ 800 c/c
					M	200x550	1-N20T & 1-N20B. W8 @ 800 c/c
					m2	200x550	1-N20T & 1-N20B. W8 @ 800 c/c
		CR3A_PA	GROUP	29	E	200x550	1-N20T & 1-N20B. W8 @ 800 c/c
					M	200x550	1-N20T & 1-N20B. W8 @ 800 c/c
					m2	200x550	1-N20T & 1-N20B. W8 @ 800 c/c

NOTES

- FOR COMPARISON PRICING ONLY.
- FOOTING SIZES SHOWN ARE FOR THE CONFIGURATION OF THE FOOTING LAYOUT AND SITE CLASSIFICATIONS SHOWN.
- TREE EFFECTS ARE CALCULATED BASED ON DF/H = 0.5.
- FOOTING SIZES DEPICTED ONLY REPRESENT AN APPROXIMATION AND MAY CHANGE DUE TO SPECIFIC SITE CONDITIONS.
- SLAB ON GROUND TO BE 100mm THICK AND REINFORCED WITH ONE LAYER OF SL72T PLACED 25mm FROM THE TOP FACE (UNO).

1. SLAB THICKNESS AND FOOTING DEPTH TO BE MAINTAINED AT ALL SETDOWNS. (PROVIDE STEPS AS PER STANDARD DETAILS)
2. LAPS IN MESH TO BE ONE FULL SQUARE PLUS 25mm.
3. CONCRETE GRADE 'N20' U.N.O.
4. WHERE BRITTLE FLOOR COVERING USED, PROVIDE 2 LAYERS OF SL72 FABRIC OR 1 LAYER OF SL92 FABRIC.
5. DENOTES 2-N16 X 2000 LONG CRACK CONTROL BARS TOP.

0 1 2 3 4 5 10m

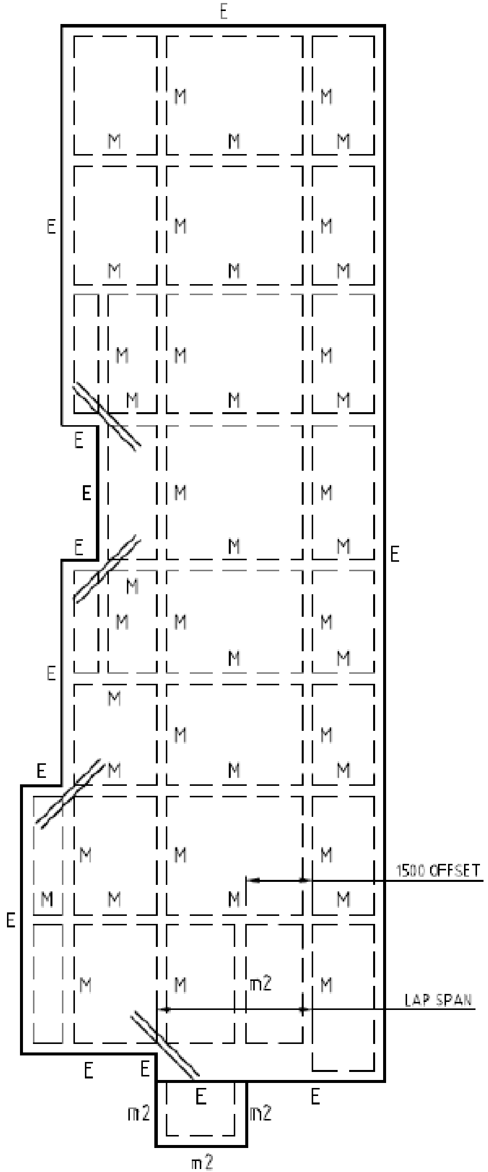
P.A.	PRELIMINARY	JLI	GM	24.09.19
No.	REVISION	DRAWN	CHECK'D	DATE

PRELIMINARY

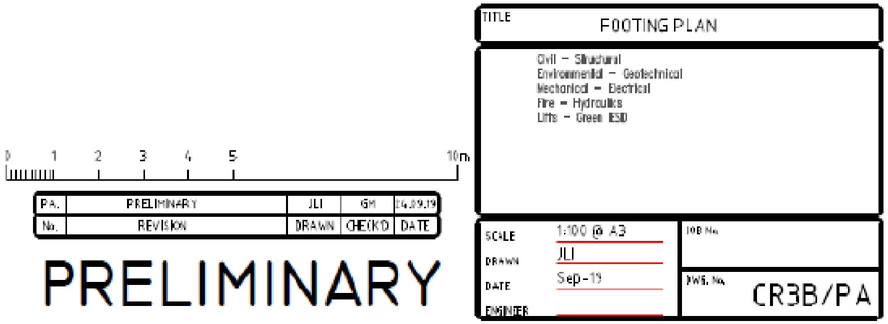
TITLE FOOTING PLAN

Civil – Structural
Environmental – Geotechnical
Mechanical – Electrical
Fire – Hydraulics
Lifts – Green ESD

SCALE	1:100 @ A3	JOB No.	1908171
DRAWN	JLI		
DATE	Sep-19	DWG. No.	CR3A/PA
ENGINEER	GM		



SITE CLASS	ys (mm)	DESIGN LAYOUT	TREES	yt (mm)	FOOTING BEAM	FOOTING SIZE	REINFORCEMENT
H2-D	74mm	CR3A_PA	-	-	E	200x550	1-N16T & 1-N16B. W8 @ 800 c/c
					M	200x550	1-N16T & 1-N16B. W8 @ 800 c/c
					m2	200x550	1-N16T & 1-N16B. W8 @ 800 c/c
		CR3B_PA	SINGLE	28	E	200x600	1-N20T & 1-N20B. W8 @ 800 c/c
					M	200x600	1-N20T & 1-N20B. W8 @ 800 c/c
					m2	200x600	1-N20T & 1-N20B. W8 @ 800 c/c
		CR3B_PA	GROUP	60	E	200x750	1-N24T & 1-N24B. W8 @ 800 c/c
					M	200x750	1-N24T & 1-N24B. W8 @ 800 c/c
					m2	200x750	1-N24T & 1-N24B. W8 @ 800 c/c
E-D	104mm	CR3A_PA	-	-	E	200x800	1-N24T & 1-N24B. W8 @ 800 c/c
					M	200x800	1-N24T & 1-N24B. W8 @ 800 c/c
					m2	200x800	1-N24T & 1-N24B. W8 @ 800 c/c
		CR3B_PA	SINGLE		E	200x750	1-N24T & 1-N24B. W8 @ 800 c/c
					M	200x750	1-N24T & 1-N24B. W8 @ 800 c/c
					m2	200x750	1-N24T & 1-N24B. W8 @ 800 c/c
		CR3B_PA	GROUP	62	E	250x1000	1-N28T & 1-N28B. W8 @ 800 c/c
					M	250x1000	1-N28T & 1-N28B. W8 @ 800 c/c
					m2	250x1000	1-N28T & 1-N28B. W8 @ 800 c/c

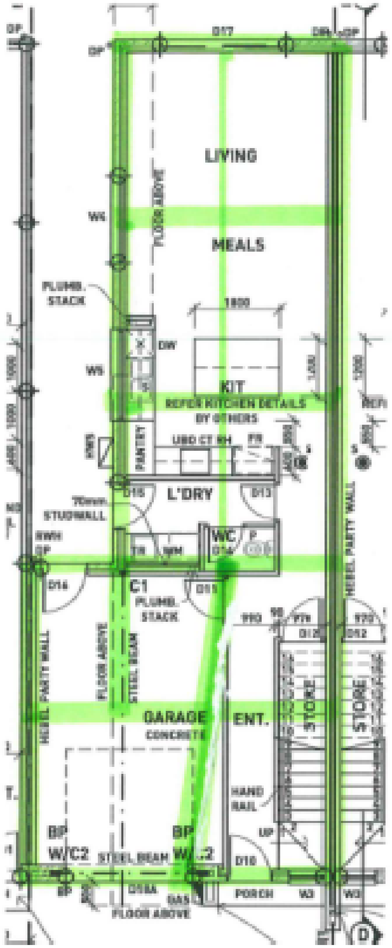


AGD - FOOTING ASSESSMENT (2) 15.11.2019										
SITE CLASS	ys (mm)	DESIGN LAYOUT	TREES	yt (mm)	FOOTING BEAM	FOOTING SIZE	REINFORCEMENT	TOTAL COST (inc. GST)	E/O for TREE EFFECTS	% INCREASE
S-D	19mm	CR3A_PA	-	-	E	200x350	1-N12T & 1-N12B. W8 @ 800 c/c	$17,549.24	-	
					M	200x350	1-N16T & 1-N16B. W8 @ 800 c/c			
					m2	200x350	1-N16T & 1-N16B. W8 @ 800 c/c			
		CR3A_PA	SINGLE	13	E	200x400	1-N16T & 1-N16B. W8 @ 800 c/c	$19,046.44	$1,497.20	9%
					M	200x400	1-N16T & 1-N16B. W8 @ 800 c/c			
					m2	200x400	1-N16T & 1-N16B. W8 @ 800 c/c			
M-D	40mm	CR3A_PA	-	-	E	200x400	1-N16T & 1-N16B. W8 @ 800 c/c	$19,046.44	-	
					M	200x400	1-N16T & 1-N16B. W8 @ 800 c/c			
					m2	200x400	1-N16T & 1-N16B. W8 @ 800 c/c			
		CR3A_PA	SINGLE	11	E	200x500	1-N16T & 1-N16B. W8 @ 800 c/c	$19,745.03	$698.60	4%
					M	200x500	1-N16T & 1-N16B. W8 @ 800 c/c			
					m2	200x500	1-N16T & 1-N16B. W8 @ 800 c/c			
H1-D	59mm	CR3A_PA	-	-	E	200x500	1-N16T & 1-N16B. W8 @ 800 c/c	$20,443.63	-	
					M	200x500	1-N16T & 1-N16B. W8 @ 800 c/c			
					m2	200x500	1-N16T & 1-N16B. W8 @ 800 c/c			
		CR3A_PA	SINGLE	15	E	200x550	1-N20T & 1-N20B. W8 @ 800 c/c	$22,153.78	$1,710.16	8%
					M	200x550	1-N20T & 1-N20B. W8 @ 800 c/c			
					m2	200x550	1-N20T & 1-N20B. W8 @ 800 c/c			
H2-D	74mm	CR3A_PA	-	-	E	200x550	1-N16T & 1-N16B. W8 @ 800 c/c	$21,142.22	-	
					M	200x550	1-N16T & 1-N16B. W8 @ 800 c/c			
					m2	200x550	1-N16T & 1-N16B. W8 @ 800 c/c			
		CR3B_PA	SINGLE	28	E	200x600	1-N20T & 1-N20B. W8 @ 800 c/c	$24,611.42	$3,469.20	16%
					M	200x600	1-N20T & 1-N20B. W8 @ 800 c/c			
					m2	200x600	1-N20T & 1-N20B. W8 @ 800 c/c			
E-D	104mm	CR3A_PA	-	-	E	200x800	1-N24T & 1-N24B. W8 @ 800 c/c	$26,871.28	-	
					M	200x800	1-N24T & 1-N24B. W8 @ 800 c/c			
					m2	200x800	1-N24T & 1-N24B. W8 @ 800 c/c			
		CR3B_PA	SINGLE	31	E	200x750	1-N24T & 1-N24B. W8 @ 800 c/c	$28,408.09	$1,536.81	6%
					M	200x750	1-N24T & 1-N24B. W8 @ 800 c/c			
					m2	200x750	1-N24T & 1-N24B. W8 @ 800 c/c			

Case-study 3: 90m2 two storey townhouse (PT Consulting Engineering footing design and costed by Centina Homes)

ANALYSIS OF THE EFFECTS OF TREES ON FOOTING COST

CENTINA
COST ASSESSMENT SUBMISSION



SITE CLASS	ys (mm)	DESIGN LAYOUT	TREES	yt (mm)	FOOTING SIZE	REINFORCEMENT
S-D	20mm	21428	-	-	350x300	3-N12T & 3-N12B. W8 @ 800 c/c
		21428	SINGLE	7.2	400x300	3-N12T & 3-N12B. W8 @ 800 c/c
		21428	GROUP	9.3	450x300	3-N12T & 3-N12B. W8 @ 800 c/c
M-D	40mm	21428	-	-	450x300	3-N12T & 3-N12B. W8 @ 800 c/c
		21428	SINGLE	14.3	500x300	3-N12T & 3-N12B. W8 @ 800 c/c
		21428	GROUP	18.5	500x300	3-N12T & 3-N12B. W8 @ 800 c/c
H1-D	60mm	21428	-	-	500x300	3-N12T & 3-N12B. W8 @ 800 c/c
		21428	SINGLE	21.5	500x300	3-N12T & 4-N12B. W8 @ 800 c/c
		21428	GROUP	27.8	600x300	3-N16T & 3-N16B. W8 @ 800 c/c
H2-D	75mm	21428	-	-	500x300	3-N16T & 3-N16B. W8 @ 800 c/c
		21428	SINGLE	26.9	700x300	3-N16T & 3-N16B. W8 @ 800 c/c
		21428	GROUP	34.7	750x300	3-N16T & 3-N16B. W8 @ 800 c/c
E-D	105mm	21428	-	-	1100x300	3-N16T & 3-N16B. W8 @ 800 c/c
		21428	SINGLE	37.6	1000x350	3-N16T & 3-N16B. W8 @ 800 c/c
		21428	GROUP	48.6	1150x300	3-N20T & 3-N20B. W8 @ 800 c/c

NOTES

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- FOOTING SIZES DEPICTED ONLY REPRESENT AN APPROXIMATION AND MAY CHANGE DUE TO SPECIFIC SITE CONDITIONS.
- SLAB ON GROUND TO BE 100mm THICK AND REINFORCED WITH ONE LAYER OF SL72T PLACED 25mm FROM THE TOP FACE (U.N.O).

1. SLAB THICKNESS AND FOOTING DEPTH TO BE MAINTAINED AT ALL SETDOWNS. (PROVIDE STEPS AS PER STANDARD DETAILS.)
2. LAPS IN MESH TO BE ONE FULL SQUARE PLUS 25mm.
3. CONCRETE GRADE 'N20' U.N.O.
4. WHERE BRITTLE FLOOR COVERING USED, PROVIDE 2 LAYERS OF SL72 FABRIC OR 1 LAYER OF SL92 FABRIC.
5. ⁄ DENOTES 2-N16 X 2000 LONG CRACK CONTROL BARS TOP.

P.A.	PRELIMINARY	JU	GH	24.09.19
No.	REVISION	DRAWN	CHECK'D	DATE

PRELIMINARY

TITLE FOOTING PLAN

Civil – Structural
Environmental – Geotechnical
Mechanical – Electrical
Fire – Hydraulics
Lifts – Green ESD

SCALE
DRAWN
DATE
DESIGNED

JOB No. 21428
DWG. No.

AGD - FOOTING ASSESSMENT 3 - 19.11.2019									
SITE CLASS	ys (mm)	DESIGN LAYOUT	TREES	yt (mm)	FOOTING SIZE	REINFORCEMENT	TOTAL COST (inc. GST)	E/O for TREE EFFECTS	% INCREASE
S-D	20mm	21428	-	-	350x300	3-N12T & 3-N12B. W8 @ 800 c/c	$12,349.64	-	
		21428	SINGLE	7.2	400x300	3-N12T & 3-N12B. W8 @ 800 c/c	$12,937.19	$587.55	5%
M-D	40mm	21428	-	-	450x300	3-N12T & 3-N12B. W8 @ 800 c/c	$13,524.75	-	
		21428	SINGLE	14.3	500x300	3-N12T & 3-N12B. W8 @ 800 c/c	$14,125.61	$600.86	4%
H1-D	60mm	21428	-	-	500x300	3-N12T & 3-N12B. W8 @ 800 c/c	$14,125.61	-	
		21428	SINGLE	21.5	500x300	3-N12T & 4-N12B. W8 @ 800 c/c	$14,311.95	$186.34	1%
H2-D	75mm	21428	-	-	500x300	3-N16T & 3-N16B. W8 @ 800 c/c	$15,256.96	-	
		21428	SINGLE	26.9	700x300	3-N16T & 3-N16B. W8 @ 800 c/c	$17,633.80	$2,376.84	16%
E-D	105mm	21428	-	-	1100x300	3-N16T & 3-N16B. W8 @ 800 c/c	$22,374.16	-	
		21428	SINGLE	37.6	1000x350	3-N16T & 3-N16B. W8 @ 800 c/c	$23,459.26	$1,085.10	5%

Costing of completed dwellings (Rivergum Homes)

Rivergum Homes supplied four randomly selected real life examples to Intrax Consulting Engineers to test the effects of trees on footings and the subsequent costs of this. The Intrax engineer also identified whether the original footing design considered the effect of trees and therefore whether trees were actually a new cost or not.

For all projects, every tree identified on the survey (and shown on the civil plan) was considered during the original design. This includes street trees and neighbouring trees if they are visible at the time of the survey/design.

Dwellings[51] in the following geographical locations (soil types) were selected:

- Mount Barker
- Aldinga Beach
- Plympton Park
- Elizabeth North.

Rivergum Homes subsequently organised for one of their cost estimators to provide costings.

Key findings

All sites had existing tree effects when they were built.

For 3 out of the 4 dwellings, the critical existing tree was actually located outside of the property. Therefore even if a site is free from trees at the time of being built, often they will have to take into account neighbouring or street trees.

In all cases, it was considered that if the engineer was astute, and had control over tree placement, the effects of planting the new tree could have been negligible.

Even in this small analysis it has highlighted that having an engineer with a very good understanding of nuances in the tree requirements in the code and this policy could have a large impact on their ability to achieve more favourable results (assuming they have discretion over where the tree is planted) than would have been the case in the past. Two of the developments assessed (Elizabeth and Mount Barker) could have had different outcomes depending on engineer's choices.

Costings

The cost estimator undertook a comparison between costings for current, proposed and no tree effect footing design depth.

The cost estimator also advised that as a guide, the additional cost to footings is approximately $2,000 retail for every 100mm added to the depth of the footing.

5151 These had a range of different allotment sizes and dwelling characteristics.

APPENDIX 2 Detailed CBA Models

Appendix Table 2-1 Detailed community level CBA, Option 1[a,b]

Base Case	PV	2021	2025	2026	2030	2031	2035	2036	2044	2045
Benefits ($m)										
Improved air quality	0.66	0.00	0.02	0.02	0.04	0.05	0.07	0.08	0.14	0.15
Carbon removed	0.24	0.00	0.01	0.01	0.01	0.02	0.03	0.03	0.06	0.06
Avoided stormwater runoff	0.16	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.03	0.04
Avoided loss of stored carbon	0.79	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.07	0.07
Reduced household electricity use	24.08	0.11	0.65	0.82	1.56	1.76	2.67	2.92	5.21	5.52
Total Benefits ($m)	**25.93**	**0.17**	**0.74**	**0.91**	**1.68**	**1.90**	**2.85**	**3.11**	**5.52**	**5.84**
Costs ($m)										
House footing costs	86.86	6.36	6.36	6.54	6.54	6.32	6.32	6.42	6.42	6.42
On-site tree planting & maintenance costs	9.06	0.29	0.46	0.51	0.67	0.71	0.87	0.91	1.24	1.28
Total Costs ($m)	**95.92**	**6.65**	**6.81**	**7.05**	**7.22**	**7.02**	**7.18**	**7.33**	**7.66**	**7.70**
Option 1										
Benefits ($m)										
Amenity	24.47	1.79	1.79	1.84	1.84	1.78	1.78	1.81	1.81	1.81
Improved air quality	1.06	0.01	0.03	0.04	0.07	0.08	0.12	0.13	0.23	0.24
Carbon removed	0.38	0.00	0.01	0.01	0.02	0.03	0.04	0.05	0.09	0.10
Avoided stormwater runoff	0.25	0.00	0.01	0.01	0.02	0.02	0.03	0.03	0.05	0.06
Avoided loss of stored carbon	1.19	0.07	0.08	0.08	0.09	0.09	0.09	0.10	0.11	0.11
Reduced household electricity use	39.13	0.17	1.02	1.28	2.49	2.83	4.34	4.77	8.66	9.19
Avoided mental health costs	23.80	0.10	0.60	0.75	1.48	1.68	2.63	2.89	5.46	5.84
Total Benefits ($m)	**90.28**	**2.14**	**3.54**	**4.02**	**6.01**	**6.50**	**9.03**	**9.77**	**16.41**	**17.34**
Costs ($m)										
House footing costs	115.81	8.48	8.48	8.72	8.72	8.42	8.42	8.56	8.56	8.56
On-site tree planting & maintenance costs	18.10	0.59	0.91	1.01	1.35	1.41	1.73	1.82	2.48	2.56
Total Costs ($m)	**133.91**	**9.06**	**9.39**	**9.74**	**10.07**	**9.83**	**10.15**	**10.38**	**11.04**	**11.12**
Incremental Benefits ($m)	**64.35**	**1.98**	**2.80**	**3.11**	**4.32**	**4.60**	**6.18**	**6.66**	**10.89**	**11.50**
Incremental Costs ($m)	**37.98**	**2.41**	**2.57**	**2.69**	**2.85**	**2.81**	**2.97**	**3.05**	**3.38**	**3.42**
Net Benefits (NPV) ($m)	**26.36**	**-0.44**	**0.23**	**0.42**	**1.47**	**1.80**	**3.21**	**3.61**	**7.51**	**8.08**
Standard BCR	**1.7**									

[a] Years 2-4, 7-9, 12-14 and 17-23 hidden for presentational purposes.

[b] In current dollars.

BDO EconSearch analysis.

Appendix Table 2-2 Detailed community level CBA, Option 2[a,b]

Base Case	PV	2021	2025	2026	2030	2031	2035	2036	2044	2045
Benefits ($m)										
Improved air quality	0.66	0.00	0.02	0.02	0.04	0.05	0.07	0.08	0.14	0.15
Carbon removed	0.24	0.00	0.01	0.01	0.01	0.02	0.03	0.03	0.06	0.06
Avoided stormwater runoff	0.16	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.03	0.04
Avoided loss of stored carbon	0.79	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.07	0.07
Reduced household electricity use	24.08	0.11	0.65	0.82	1.56	1.76	2.67	2.92	5.21	5.52
Total Benefits ($m)	**25.93**	**0.17**	**0.74**	**0.91**	**1.68**	**1.90**	**2.85**	**3.11**	**5.52**	**5.84**
Costs ($m)										
House footing costs	86.86	6.36	6.36	6.54	6.54	6.32	6.32	6.42	6.42	6.42
On-site tree planting & maintenance costs	9.06	0.29	0.46	0.51	0.67	0.71	0.87	0.91	1.24	1.28
Total Costs ($m)	**95.92**	**6.65**	**6.81**	**7.05**	**7.22**	**7.02**	**7.18**	**7.33**	**7.66**	**7.70**
Option 2										
Benefits ($m)										
Amenity	128.46	9.40	9.40	9.68	9.68	9.34	9.34	9.49	9.49	9.49
Improved air quality	1.27	0.01	0.04	0.05	0.08	0.09	0.14	0.15	0.27	0.28
Carbon removed	0.45	0.00	0.01	0.01	0.03	0.03	0.05	0.05	0.11	0.12
Avoided stormwater runoff	0.30	0.00	0.01	0.01	0.02	0.02	0.03	0.04	0.06	0.07
Avoided loss of stored carbon	1.58	0.10	0.11	0.11	0.12	0.12	0.13	0.13	0.15	0.15
Reduced household electricity use	40.68	0.22	1.21	1.49	2.73	3.06	4.50	4.89	8.35	8.81
Avoided mental health costs	36.75	0.19	1.05	1.30	2.41	2.72	4.05	4.42	7.81	8.30
Offset scheme receipts (Government)	99.82	7.31	7.31	7.52	7.52	7.26	7.26	7.38	7.38	7.38
Total Benefits ($m)	**309.32**	**17.22**	**19.13**	**20.17**	**22.59**	**22.64**	**25.50**	**26.56**	**33.62**	**34.59**
Costs ($m)										
House footing costs	89.48	6.55	6.55	6.74	6.74	6.51	6.51	6.61	6.61	6.61
On-site tree planting & maintenance costs	6.96	0.23	0.35	0.39	0.52	0.54	0.67	0.70	0.95	0.98
Off-site tree planting & maintenance costs	14.82	0.80	0.93	0.98	1.11	1.11	1.24	1.28	1.53	1.57
Offset scheme development & management	3.18	0.42	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Offset scheme payments (households)	99.82	7.31	7.31	7.52	7.52	7.26	7.26	7.38	7.38	7.38
Total Costs ($m)	**214.26**	**15.30**	**15.35**	**15.85**	**16.11**	**15.64**	**15.89**	**16.19**	**16.70**	**16.76**
Incremental Benefits ($m)	**283.39**	**17.05**	**18.39**	**19.26**	**20.91**	**20.74**	**22.65**	**23.44**	**28.10**	**28.74**
Incremental Costs ($m)	**118.33**	**8.65**	**8.54**	**8.80**	**8.89**	**8.62**	**8.70**	**8.86**	**9.04**	**9.06**
Net Benefits (NPV) ($m)	**165.06**	**8.40**	**9.85**	**10.46**	**12.02**	**12.13**	**13.95**	**14.58**	**19.06**	**19.69**
Standard BCR	**2.4**									

[a] Years 2-4, 7-9, 12-14 and 17-23 hidden for presentational purposes.
[b] In current dollars.
BDO EconSearch analysis.

Appendix Table 2-3 Detailed individual homeowner level CBA, Scenario 1[a,b,c]

Base Case	PV	2021	2025	2026	2030	2031	2035	2036	2044	2045
Benefits ($)										
Total Benefits ($)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Costs ($)										
House footing costs	1,411	1,411	0	0	0	0	0	0	0	0
Total Costs ($)	**1,411**	**1,411**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Option 1 or 2										
Benefits ($)										
Household electricity bill saving	570	4	21	25	42	46	63	67	96	99
Property value increase (amenity)	922	922	0	0	0	0	0	0	0	0
Total Benefits ($)	**1,491**	**926**	**21**	**25**	**42**	**46**	**63**	**67**	**96**	**99**
Costs ($)										
House footing costs	1,411	1,411	0	0	0	0	0	0	0	0
On-site tree planting & maintenance costs	603	220	30	30	30	30	30	30	30	30
Total Costs ($)	**2,014**	**1,631**	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**
Incremental Benefits ($)	**1,491**	**926**	**21**	**25**	**42**	**46**	**63**	**67**	**96**	**99**
Incremental Costs ($)	**603**	**220**	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**
Net Benefits (NPV) ($)	**888**	**705**	**-9**	**-5**	**12**	**16**	**33**	**37**	**65**	**68**
Standard BCR	**2.5**									

[a] Years 2-4, 7-9, 12-14 and 17-23 hidden for presentational purposes.

[b] In current dollars.

[c] Scenario 1: tree is planted where there is an existing tree effect onsite from other, offsite trees or the new tree has a mature height that is outside the distance of tree effect.

BDO EconSearch analysis.

Appendix Table 2-4 Detailed individual homeowner level CBA, Scenario 2[a,b,c]

Base Case	PV	2021	2025	2026	2030	2031	2035	2036	2044	2045
Benefits ($)										
Total Benefits ($)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Costs ($)										
House footing costs	0	0	0	0	0	0	0	0	0	0
Total Costs ($)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Option 1 or 2										
Benefits ($)										
Household electricity bill saving	570	4	21	25	42	46	63	67	96	99
Property value increase (amenity)	922	922	0	0	0	0	0	0	0	0
Total Benefits ($)	**1,491**	**926**	**21**	**25**	**42**	**46**	**63**	**67**	**96**	**99**
Costs ($)										
House footing costs	186	186	0	0	0	0	0	0	0	0
On-site tree planting & maintenance costs	603	220	30	30	30	30	30	30	30	30
Total Costs ($)	**790**	**407**	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**
Incremental Benefits ($)	**1,491**	**926**	**21**	**25**	**42**	**46**	**63**	**67**	**96**	**99**
Incremental Costs ($)	**790**	**407**	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**
Net Benefits (NPV) ($)	**702**	**519**	**-9**	**-5**	**12**	**16**	**33**	**37**	**65**	**68**
Standard BCR	**1.9**									

a Years 2-4, 7-9, 12-14 and 17-23 hidden for presentational purposes.

b In current dollars.

c Scenario 2: tree is planted where it creates a tree effect requiring additional cost to footings, double storey, least cost (less reactive soil).

BDO EconSearch analysis.

Appendix Table 2-5 Detailed individual homeowner level CBA, Scenario 3[a,b,c]

Base Case	PV	2021	2025	2026	2030	2031	2035	2036	2044	2045
Benefits ($)										
Total Benefits ($)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Costs ($)										
House footing costs	0	0	0	0	0	0	0	0	0	0
Total Costs ($)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Option 1 or 2										
Benefits ($)										
Household electricity bill saving	570	4	21	25	42	46	63	67	96	99
Property value increase (amenity)	922	922	0	0	0	0	0	0	0	0
Total Benefits ($)	**1,491**	**926**	**21**	**25**	**42**	**46**	**63**	**67**	**96**	**99**
Costs ($)										
House footing costs	2,377	2,377	0	0	0	0	0	0	0	0
On-site tree planting & maintenance costs	603	220	30	30	30	30	30	30	30	30
Total Costs ($)	**2,980**	**2,597**	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**
Incremental Benefits ($)	**1,491**	**926**	**21**	**25**	**42**	**46**	**63**	**67**	**96**	**99**
Incremental Costs ($)	**2,980**	**2,597**	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**
Net Benefits (NPV) ($)	**-1,489**	**-1,672**	**-9**	**-5**	**12**	**16**	**33**	**37**	**65**	**68**
Standard BCR	**0.5**									

[a] Years 2-4, 7-9, 12-14 and 17-23 hidden for presentational purposes.

[b] In current dollars.

[c] Scenario 3: tree is planted where it creates a tree effect requiring additional cost to footings, double storey, greatest cost (more reactive soil).

BDO EconSearch analysis.

Appendix Table 2-6 Detailed individual homeowner level CBA, Scenario 4[a,b,c]

Base Case	PV	2021	2025	2026	2030	2031	2035	2036	2044	2045
Benefits ($)										
Total Benefits ($)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Costs ($)										
House footing costs	0	0	0	0	0	0	0	0	0	0
Total Costs ($)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Option 1 or 2										
Benefits ($)										
Household electricity bill saving	570	4	21	25	42	46	63	67	96	99
Property value increase (amenity)	922	922	0	0	0	0	0	0	0	0
Total Benefits ($)	**1,491**	**926**	**21**	**25**	**42**	**46**	**63**	**67**	**96**	**99**
Costs ($)										
House footing costs	597	597	0	0	0	0	0	0	0	0
On-site tree planting & maintenance costs	603	220	30	30	30	30	30	30	30	30
Total Costs ($)	**1,201**	**818**	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**
Incremental Benefits ($)	**1,491**	**926**	**21**	**25**	**42**	**46**	**63**	**67**	**96**	**99**
Incremental Costs ($)	**1,201**	**818**	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**
Net Benefits (NPV) ($)	**291**	**108**	**-9**	**-5**	**12**	**16**	**33**	**37**	**65**	**68**
Standard BCR	**1.2**									

[a] Years 2-4, 7-9, 12-14 and 17-23 hidden for presentational purposes.

[b] In current dollars.

[c] Scenario 4: tree is planted where it creates a tree effect requiring additional cost to footings, single storey, least cost (less reactive soil).

BDO EconSearch analysis.

Appendix Table 2-7 Detailed individual homeowner level CBA, Scenario 5[a,b,c]

Base Case	PV	2021	2025	2026	2030	2031	2035	2036	2044	2045
Benefits ($)										
Total Benefits ($)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Costs ($)										
House footing costs	0	0	0	0	0	0	0	0	0	0
Total Costs ($)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Option 1 or 2										
Benefits ($)										
Household electricity bill saving	570	4	21	25	42	46	63	67	96	99
Property value increase (amenity)	922	922	0	0	0	0	0	0	0	0
Total Benefits ($)	**1,491**	**926**	**21**	**25**	**42**	**46**	**63**	**67**	**96**	**99**
Costs ($)										
House footing costs	3,636	3,636	0	0	0	0	0	0	0	0
On-site tree planting & maintenance costs	603	220	30	30	30	30	30	30	30	30
Total Costs ($)	**4,239**	**3,856**	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**
Incremental Benefits ($)	**1,491**	**926**	**21**	**25**	**42**	**46**	**63**	**67**	**96**	**99**
Incremental Costs ($)	**4,239**	**3,856**	**30**	**30**	**30**	**30**	**30**	**30**	**30**	**30**
Net Benefits (NPV) ($)	**-2,748**	**-2,931**	**-9**	**-5**	**12**	**16**	**33**	**37**	**65**	**68**
Standard BCR	**0.4**									

[a] Years 2-4, 7-9, 12-14 and 17-23 hidden for presentational purposes.

[b] In current dollars.

[c] Scenario 5: tree is planted where it creates a tree effect requiring additional cost to footings, single storey, greatest cost (more reactive soil).

BDO EconSearch analysis.

Appendix Table 2-8 Detailed individual homeowner level CBA, Scenario 6[a,b,c]

Base Case	PV	2021	2025	2026	2030	2031	2035	2036	2044	2045
Benefits ($)										
Total Benefits ($)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Costs ($)										
House footing costs	0	0	0	0	0	0	0	0	0	0
Total Costs ($)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Option 2										
Benefits ($)										
Total Benefits ($)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Costs ($)										
House footing costs	0	0	0	0	0	0	0	0	0	0
Offset payment	1,165	1,165	0	0	0	0	0	0	0	0
Total Costs ($)	**1,165**	**1,165**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Incremental Benefits ($)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Incremental Costs ($)	**1,165**	**1,165**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Net Benefits (NPV) ($)	**-1,165**	**-1,165**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

a Years 2-4, 7-9, 12-14 and 17-23 hidden for presentational purposes.

b In current dollars.

c Scenario 6: No existing tree, payment for planting and maintaining tree offsite.

BDO EconSearch analysis.

Appendix Table 2-9 Detailed individual homeowner level CBA, Scenario 7[a,b,c]

Base Case	PV	2021	2025	2026	2030	2031	2035	2036	2044	2045
Benefits ($)										
Total Benefits ($)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Costs ($)										
House footing costs	0	0	0	0	0	0	0	0	0	0
Total Costs ($)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Option 1										
Benefits ($)										
Total Benefits ($)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Costs ($)										
House footing costs	0	0	0	0	0	0	0	0	0	0
Offset payment	4,600	4,600	0	0	0	0	0	0	0	0
Total Costs ($)	**4,600**	**4,600**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Incremental Benefits ($)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Incremental Costs ($)	**4,600**	**4,600**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Net Benefits (NPV) ($)	**-4,600**	**-4,600**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

a Years 2-4, 7-9, 12-14 and 17-23 hidden for presentational purposes.

b In current dollars.

c Scenario 7: Existing tree removed, payment for loss of existing tree and for planting and maintaining tree offsite.

BDO EconSearch analysis.