Perspectives on performance-based planning provisions and assessment frameworks for green infrastructure and WSUD

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ekistics

CRC for Water Sensitive Cities

Perspectives on performance-based planning provisions and assessment frameworks for green infrastructure and WSUD

prepared for Water Sensitive South Australia

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Contents

Tables

Figures

Acronyms

AEP – Annual exceedance probability

ARI – Average recurrence interval

BDP – Better Development Plan

CRC WSC – Cooperative Research Centre for Water Sensitive Cities

DCI – Directly connected imperviousness

DEW – Department for Environment and Water

DHW – Department for Health and Wellbeing

DPTI – Department of Planning, Transport and Infrastructure

DBH – Diameter at breast height

EI – Effective imperviousness

GAR – Green Area Ratio

GI – Green infrastructure

IWCM – Integrated water-cycle management

LGAs – Local Government Area

MUSIC - Model for Urban Stormwater Improvement Conceptualization

PDC - Principle of Development Control

PDI Act – *Planning, Development and Infrastructure Act 2016*

SAPPL – South Australian Planning Policy Library

TN – Total nitrogen

TP – Total phosphorous

TSS – Total suspended solids

WSUD – Water Sensitive Urban Design

Executive summary

There is growing recognition of the multiple benefits to the community, economy and environment that come from investment in green infrastructure and water sensitive urban design (WSUD). This includes cooler, greener and more liveable suburbs; reduced flooding; better waterways; and clean coastal and marine environments.

This background paper provides detailed evidence of the need for policy reform in relation to green infrastructure and WSUD, a stocktake of existing policy and tools being applied locally, interstate and internationally to achieve the proposed urban greening and water management objectives and recommendations to support the urban green cover targets and the WSUD strategies within The 30 Year Plan for Greater Adelaide.

Challenges and opportunities

Urban densification and/or regeneration, climate change, increasing health costs, decreasing water quality and declining biodiversity are driving an increased interest in green infrastructure and WSUD due to the multiple benefits that they can provide. These benefits include improving amenity; reducing the urban heat island effect; improving physical, mental and emotional health; improving stormwater runoff quality and better managing stormwater runoff volumes and rates; increasing biodiversity; and enhancing the overall liveability, sustainability and resilience of urban communities (CRC for Water Sensitive Cities 2017).

The stormwater drainage networks of areas subject to high levels of urban growth, particularly urban infill, are increasingly failing to contain the storm events they were designed to manage. Historically drainage networks have been designed for catchments that are 35% impervious (the proportion of area consisting of roads, roofs and other paved surfaces), however, in the future some precincts are predicted to increase to 89% impervious (Jensen Planning + Design 2011).

The cost to duplicate these networks to cater for the significant increases in stormwater runoff in established suburbs is outside of the realm of Council budgets. The disruption to communities for drainage system upgrade works required as a result of a business as usual approach to the way we develop our city will be significant.

At source, control of stormwater complemented by increased quality green spaces will become increasingly important under projected infill scenarios. Higher density urban areas can be compatible with increased green cover, but not under current planning policies and developments.

Context

With the introduction of the *Planning, Development and Infrastructure (PDI) Act 2016*, South Australia is currently undergoing the most significant planning reform since the 1990s. The PDI Act, which will come gradually into operation over the next five years, will include replacing all Council Development Plans with one state-wide planning and design code (the Code).

This reform presents an opportunity to better implement green infrastructure and WSUD in new development through the planning system. The State Planning Commission has therefore included green infrastructure and water sensitive urban design as a priority policy conversation area for further engagement and potential improvement for either Generation 1 of the Code or in future generations. There are also other planning and non-planning tools that have a role to play.

Objectives of the paper are to inform and support the development of:

- high level objectives and principles for green infrastructure and WSUD under the PDI Act;
- performance-based planning provisions for green infrastructure and WSUD for the Code, Standards and Guidelines;
- a framework to enable an assessment of green infrastructure and WSUD elements of a development against the performance criteria;
- identify other potential tools or levers needed to support green infrastructure and WSUD.

Key opportunities

Green infrastructure performance measures related to tree canopy cover for an allotment could be met by providing an area of deep, uncompacted soil in addition to enhanced measures to retain existing vegetation. These can apply to a range of scales and are easily measurable and assessable at the planning stage. Tree canopy provisions should be complemented with the development of a green cover performance measure, which could be assessed through calculation of a green cover score based on a range of landscaping features such as trees, shrubs, irrigated turf, vertical gardens and green roofs.

WSUD performance measures relate to flooding control, water conservation and stormwater quality improvements. An on-line stormwater assessment tool for South Australia is currently available in beta test format that enables simple assessment as part of development assessment for small-scale applications, i.e. less than 2,500 m^2. The Insite Water tool has been created to support better WSUD outcomes while providing significant efficiencies in the development (planning) application and approvals process. The tool offers a mechanism for self-assessment and third-party certification of stormwater management solutions. It is anticipated the tool will vastly reduce the cost of compliance with stormwater management requirements by providing quicker and easier approval pathways for small-scale development applicants.

For most typical residential applications, meeting WSUD requirements has minimum costs and may include solutions such as upgrading rainwater tank size and/or using permeable paving rather than hard paved surfaces for driveways.

The planning reform process and proposed e-planning system provide an excellent opportunity to streamline approval processes, saving time and money through the application of tools that support third-party certification, with a range of deemed-to-satisfy solutions for achievement of urban green cover, tree canopy and WSUD objectives.

Tables of recommendations for green infrastructure and WSUD are provided in Section 7 of this paper.

Consultation

Water Sensitive SA, through the project team, has worked with multiple government agencies, local government and industry partners, to identify potential opportunities to make green infrastructure and WSUD solutions easier and more cost effective to implement for the best outcomes.

Preparation of this paper has been overseen by a steering committee of local and state government representatives with a commitment to delivering future development in line with the canopy cover and WSUD objectives of The 30-Year Plan for Greater Adelaide. Consultation has included:

- a stakeholder workshop in December 2017 attended by 50 practitioners from local and state governments and the consulting industry;
- an expert panel workshop in March 2018;
- face-to-face meetings with key agencies and industry associations; and
- Water Sensitive SA special meeting November 2018.

This paper builds on those parts of the State Planning Commission's Policy Discussion Papers that address green infrastructure and WSUD. Water Sensitive SA will provide targeted additional engagement in 2019 to work with key stakeholders to further inform them of how this paper was prepared and how it can be applied. Any interest in participating in this additional engagement should be directed to admin@watersensitivesa.com.

Note: The State Planning Commission has released a series of Policy Discussion Papers which identify opportunities to transition existing development plan policies to the Code, as well as opportunities for reform in the future. Refer to the Natural Resources and Environment Discussion Paper at www.saplanningportal.sa.gov.au) for further information about green infrastructure and WSUD policies.

1 Introduction

1.1 Overview

The state's land use planning system is a key lever to facilitate multifunctional green infrastructure and water sensitive urban design (WSUD). Under the planning reforms and the *Planning, Development and Infrastructure Act 2016* (the PDI Act) there will be an increased emphasis on long-term integrated planning, high quality design (including of the public realm), sustainability and liveability. This emphasis is:

- identified in the objects of the PDI Act (Liveability & Prosperity, Ecological Sustainability & Design Quality etc); and
- highlighted in the Principles of Good Planning established by the PDI Act and in the State Planning Policies;
- reflected in *The 30-Year Plan for Greater Adelaide, 2017-Update*; and
- supported by the State Planning Commission's selection of 'Green Infrastructure and Water Sensitive Urban Design' as a priority policy conversation area.

This emphasis will also be reflected in the other planning tools as they are rolled out over the next few years.

Of these tools, the proposed Planning and Design Code (the Code), Design Standards for the public realm and infrastructure (Standards), and Practice Guidelines (Guidelines) will focus on performance outcomes and acceptable solutions including design techniques. Hence, these tools represent a significant opportunity to facilitate multifunctional green infrastructure and WSUD to enhance liveability via development processes.

1.2 Context

Urban densification and/or regeneration, climate change, increasing health costs, decreasing water quality and declining biodiversity are driving an increased interest in green infrastructure and WSUD due to the multiple socio-cultural, economic and environmental benefits that they can provide.

These benefits include improving amenity, reducing the urban heat island effect, improving physical, mental and emotional health, improving stormwater runoff quality and better managing stormwater runoff volumes and rates, increasing biodiversity, and enhancing the overall liveability, sustainability and resilience of urban communities (CRC for Water Sensitive Cities 2017).

DEW, the Adelaide and Mount Lofty Ranges NRM Board, and Water Sensitive SA strategic and business plans all identify the importance of the state's land use planning system as a key lever to facilitate the integration of green infrastructure and WSUD into planning and development processes. The Healthy Parks Healthy People Framework jointly developed by DEW and DHW

identifies access to quality green infrastructure as a key driver of population health and wellbeing.

For example, Action 2 of the state's Water Sensitive Urban Design Policy (*Water sensitive urban design – creating more liveable and water sensitive cities in South Australia*) is "ensure WSUD is strongly supported through the State's land-use planning system", and a key policy and planning objective of the Green Infrastructure Project Plan is to "embed green infrastructure into urban planning and design frameworks". Further, Activity 5.3 of the Water Sensitive SA Business Plan is to "coordinate practitioner input into project scoping and implementation for the development of a deemed-to-comply guideline (for WSUD) to inform the proposed urban design code (under the planning reform)".

1.3 Objective

This paper has been developed to provide

- Evidence of the need for policy reform in relation to green infrastructure and WSUD;
- A stocktake of existing policy and tools being applied locally, interstate and internationally to achieve proposed urban greening and water management objectives; and
- Recommendations to support the urban green cover targets and the WSUD strategies within The 30 Year Plan for Greater Adelaide.

This paper relates to those parts of the State Planning Commission's Policy Discussion Papers that address green infrastructure and WSUD and aims to encourage discussion and debate amongst local and state governments, industry and the community on policy issues that will shape our future cities and towns for the better.

In particular, the paper aims to inform input on:

- Department of Planning, Transport and Infrastructure (DPTI) *Natural Resources and Environment Discussion Paper* (available for consultation until 3 December 2018); and
- drafting of the Planning & Design Code policies over the next 12 months.

1.4 Method

The project was undertaken by combining a technical review with key stakeholder consultation. The technical review consisted of a stocktake of existing best practice planning provisions and tools being applied locally, interstate and internationally that can be used to achieve green infrastructure and water management outcomes as well as support the urban green cover targets and the WSUD strategies in the 30 Year Plan for Greater Adelaide.

Key stakeholder engagement involved working with multiple government agencies, local government and industry partners. Preparation of this paper was overseen by a steering committee of local and state government representatives with a commitment to delivering future development in line with the canopy cover and WSUD objectives of The 30-Year Plan for Greater Adelaide. Consultation included:

- a stakeholder workshop in December 2017 attended by 50 practitioners from local and state governments and the consulting industry;
- an expert panel workshop in March 2018; and
- face-to-face meetings with key agencies and industry associations.

1.5 Definitions

1.5.1 What is green infrastructure?

Green infrastructure is described by the Botanic Gardens of South Australia in its "Green Infrastructure Evidence Base" (Botanic Gardens of South Australia 2015) as the network of green spaces and water systems that deliver multiple environmental, economic and social values and benefits to urban settlements. The CRC for Water sensitive Cities Adoption Guidelines for Green Treatment Technologies expands this definition by recognising that green infrastructure or technologies also include a set of engineered elements that provide multiple ecosystem services at building and urban scales. The value of green infrastructure in urban landscapes is becoming increasingly recognised by health professionals, water managers, planners, policy makers and designers around the world.

Green infrastructure includes parks and reserves, backyards and gardens, waterways and wetlands, streets and transport corridors, pathways and greenways, squares and plazas, rain gardens, roof gardens and living walls, sports fields and cemeteries. It is often measured via metrics such as tree canopy, shrub cover and/or general green cover as well as catchment imperviousness (e.g. Fowdar, et al. 2018).

As described on the Natural Resources Adelaide and Mount Lofty Range's Green Infrastructure website, green infrastructure is:

- **Integrated** with development and other infrastructure, and is considered in urban strategies and plans, individual developments, and ongoing asset management plans;

- **Connected** through links to existing and new green assets, it benefits people by enhancing recreation opportunities and benefits the environment by countering habitat fragmentation and improving ecosystem health; and

- **Multifunctional** through the delivery of multiple social, economic and environmental functions compared to conventional single-purpose infrastructure.

The terminology of "nature-based solutions" is also gaining traction internationally, and applies similar principles. Here, nature-based solutions are those that mimic natural processes to contribute to the improved management of water (United Nations World Water Assessment Programme and UN-Water 2018).

1.5.2 What is WSUD?

Water-sensitive urban design (WSUD) is a way of integrating the water cycle with the built environment through good planning and design. WSUD brings components of the water cycle together: supply and demand, mains water, wastewater, rainfall, runoff and groundwater, as well as its contribution to local character, environment and community. Using this approach can improve quality of life, while also addressing flooding, pollution and water scarcity issues, changing water from a potential nuisance to a valuable resource. WSUD can be applied at every scale from individual allotments to large subdivisions and commercial and industrial developments,.

WSUD uses techniques to avoid or minimize environmental impacts of urbanisation from excess stormwater flow and pollution. It also emphasises the benefits of stormwater as a resource to be used on site to reduce water demands or to promote infiltration for healthier vegetation and the benefits that increasing Green Infrastructure brings (e.g. cooling, amenity etc.). The design of WSUD measures that introduce water into soils must give due consideration of geotechnical conditions, to avoid any damage to nearby structures and pavements and to groundwater levels and quality.

Managing urban run-off in a water sensitive manner not only addresses the problems associated with stormwater, it also can improve social and environmental amenity of the urban landscapes by keeping allotments and streets greener, cooler, and a healthier and more enjoyable place to live.

WSUD applies the following principles:

- Preserve natural systems;
- Protect downstream ecosystems;
- Drinking water conservation (e.g. reuse);
- Reduce wastewater (e.g. water efficient appliances);
- Reduce stormwater runoff downstream impacts;
    - flooding (e.g. on-site retention);
    - improve runoff quality (e.g. use natural filters, raingardens);and
    - Maintain acceptable groundwater level and quality; and
- Integrate water within an urban landscape to support green infrastructure, delivering urban cooling.

Australian Rainfall and Runoff (Engineers Australia 2016) promotes the following approach (termed ‘Volume management objectives’) to help achieve the above WSUD principles:

- Controlling peak discharge and volumes (reducing flow rates from a site);
- Harvesting or infiltrating stormwater (retaining or using more water on-site); and
- Improving water quality (reducing stormwater pollutant export).

These objectives should be applied in an integrated manner with each objective being complementary to the others (as Figure 1 illustrates).

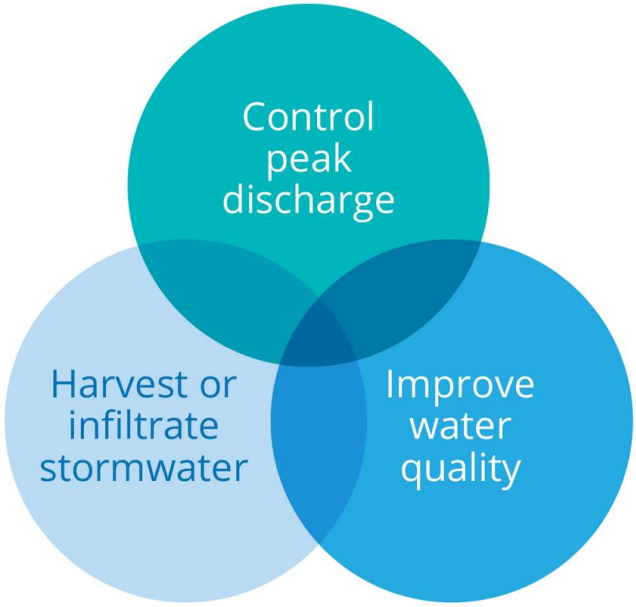

Figure 1. Potential overlapping volume management design objectives (from Phillips et al. 2016).

Examples of typical WSUD measures that can be applied at different scales and their likely outcomes are shown in Table 1.

Table 1. Example WSUD measures applicable at small scales and their outcomes.

EXAMPLE WSUD MEASURES APPLICABLE AT SMALL SCALES AND THEIR OUTCOMES		
WSUD measure	**Description**	**WSUD objectives/ outcomes**
Rainwater tanks	Dedicated tank to capture roof runoff from a building Can be used for outdoor, toilets and laundries. Can be configured to have flood detention function.	pollutant capture reduce flooding water conservation urban greening, including cooling
Raingardens	Sunken garden beds with sandy soil. Runoff is directed into raingardens where flows percolate through the soil and vegetation filters the water.	slow flow rates pollutant capture improve soil moisture urban greening, including cooling
Porous or permeable paving	Hard surfaces configured to allow rainfall to percolate through into underlying soils	pollutant capture improve soil moisture reduce flow volumes
Buffers / swales	Vegetated areas that flow is directed to/ along that filters stormwater before leaving a site (flow is directed perpendicular to buffers and along swales)	pollutant capture improve soil moisture urban greening, including cooling
Infiltration systems	Vegetated areas designed to percolate water into local groundwater	slow flow rates improve soil moisture urban greening, including cooling
Wetlands & ponds	Vegetated permanent waterbodies that temporarily hold storm flows and slowly release them with vegetation filtering pollutants.	slow flow rates pollutant capture improve soil moisture urban greening, including cooling
Gross pollutant trap	Litter trap used to intercept and filter debris from stormwater. Typically used on non-residential properties.	pollutant capture contaminant spill control
Green roof	Vegetated roof with supporting soil profile	pollutant capture slow flow rates urban greening, including cooling

2 Challenges and opportunities

2.1 Planning reforms

With the introduction of the PDI Act, South Australia is currently undergoing the most significant planning reform since the 1990's. Under the planning reforms and the PDI Act there will be an increased emphasis on long-term integrated planning, high quality design (including of the public realm), sustainability and liveability. This emphasis is reflected in the 30 Year Plan and will be reflected in the other planning tools as they are rolled out over the next few years.

The PDI Act, which will come gradually into operation over the next 5 years, will replace the Development Act and Regulations and all Council Development Plans with one State wide 'Planning and Design Code' (Code). This drafting process is being undertaken by DPTI and will focus on Performance Outcomes and Design Standards. 'Deemed to Satisfy' provisions are intended to offer measurable, more definitive targets for applicants to achieve which, in doing so, will offer applicants a more streamlined planning assessment process and offer a cost-effective compliance option.

The new system will broadly consist of the following tools:

- State Planning Policies;
- Regional Plans (e.g. The 30-Year Plan for Greater Adelaide);
- Framework (against which development is assessed):
  - Planning and Design Code;
  - Building Code;
  - Design Standards (public realm and infrastructure);
  - Practice Directions, specifying procedural requirements or steps in connection with any matter under the PDI Act (rules specify procedural requirements or steps in connection with any matter arising under this Act);
- Assessment pathways (for assessing development):
  - Exempt;
  - Accepted;
  - Code assessed:
    - deemed-to-satisfy;
    - performance assessed;
  - Impact assessed;
- Guidance:
  - Practice Guideline, specifying guidance on interpretation, use or application of Planning Rules or Building Rules; and
- Monitoring and Reporting.

Of these tools, the proposed Planning & Design Code, Design Standards and Practice Guidelines will focus on performance outcomes and acceptable solutions including design techniques, and hence lend themselves to facilitating multifunctional green infrastructure and WSUD.

Introduction of the Code provides the opportunity to gain the consistency in policy content and structure that was not able to be achieved through the Better Development Plan (BDP). Progress in delivering on ground WSUD and green infrastructure outcomes has been particularly hampered by the inconsistent approach between Councils and individual planners. A single Code will significantly resolve this issue, supported by a series of Practice Guidelines that will assist planners to interpret the Code policy in a consistent manner.

The code could also address the current siloed approach to planning, to enable more integrated and synergistic land use/urban and water planning that would in turn improve the efficiency of planning processes, and lead to more sustainable outcomes.

The State Planning Commission has released a series of Policy Discussion Papers which identify opportunities to transition existing development plan policies to the Code, as well as opportunities for reform in the future. The *Natural Resources and Environment (NRE) Policy Discussion Paper* (released in August 2018) was developed concurrently to the drafting of this background paper.

The evidence base detailed in this paper (and the associated recommendations) has informed the proposed green infrastructure and WSUD policy responses in the NRE Policy Discussion Paper - Theme 1 Sustainable and Liveable Urban Environments (Table 2~~Table 2~~). This paper and the Natural Resources and Environment Discussion Paper recommend a new, easier approach that will reduce assessment time and create greater consistency, while still enabling solutions to be tailored to individual sites.

Refer to the Natural Resources and Environment Paper (available on consultation until 3 December 2018 at www.saplanningportal.sa.gov.au) for further information about proposed green infrastructure and WSUD policies.

Table 2. Description of how this paper contributes to the State Planning Commission Natural Resources and Environment Discussion Paper.

Drawn from DPTI Natural Resources and Environment Discussion Paper				**Contribution of this paper to proposed DPTI response**
Ref No	**Key opportunities and challenges**	**Proposed response**	**Proposed timing**	
1.1 Green Infrastructure and Water Sensitive Urban Design				
1A	Councils that have converted to the SAPPL have introduced provisions that support the inclusion of WSUD principles in urban areas, including stormwater management. It is important to review and transition these to the Code.	Review, refine and transition existing SAPPL WSUD policy where appropriate	Transition ready	Existing best practice SAPPL, SA Local Government and interstate policy has been documented.
1B	There is increasing recognition of the value of green infrastructure in creating cooler, more liveable and economically viable neighbourhoods. To this end, green infrastructure policies were introduced in 2017 to some higher density mixed use zones in Development Plans in metropolitan Adelaide. There is an opportunity to transition these over to the Code, where appropriate.	Review and transition existing SAPPL green infrastructure policy where appropriate	Transition ready	Green infrastructure policies proposed to be applied to all infill development not only mixed use zones.
1C	There is inconsistent policy across some Development Plans to manage stormwater volume and, in some cases, WSUD policy is applied inconsistently. Currently some WSUD policy is applicable only to master planned/ large scale developments and not to small scale in-fill, which is an increasing	Develop new 'Deemed to Satisfy' and 'performance outcomes' policy for WSUD and green infrastructure.	Reform (Generation 1)	WSUD performance targets are recommended applicable to all development types and scales.

Drawn from DPTI Natural Resources and Environment Discussion Paper				**Contribution of this paper to proposed DPTI response**
Ref No	**Key opportunities and challenges**	**Proposed response**	**Proposed timing**	
	percentage of new development. Policy is therefore needed that is scalable to cater for all development types.			
1D	In infill areas, where there is limited private land, there may be an opportunity to consider off-site green infrastructure and WSUD solutions where appropriate. This may provide an efficient and affordable model for delivering urban green cover and tree canopy targets in line with The 30-Year Plan for Greater Adelaide and State WSUD objectives.	Explore policy that connects the ability of road reserves to accommodate tree planting or other suitable green infrastructure in lieu of provision on private allotments.	Reform (Generation 2 and beyond)	Several examples of offset schemes for green infrastructure and WSUD interstate are documented

2.2 Changing urban form

The 30 Year Plan for Greater Adelaide set a target to manage growth within the existing urban footprint. This has seen a significant increase in the ratio of infill development compared to fringe or so called greenfield development in Greater Adelaide.

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 development opportunities within established suburbs. Currently, approximately 76 per cent of Greater Adelaide's new housing growth is in these established suburbs.

The 30 Year Plan (2017 update) recognises the need to manage the changing urban form while at the same time addressing WSUD and green infrastructure objectives. For example, it identifies policies such as the following:

> *"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); and*
>
> *"Incorporate water-sensitive urban design in new developments to manage water quality, water quantity and water use efficiency and to support public stormwater systems" (Policy 109).*

Despite the intent of the 30 Year Plan, there are observations of greenfield and small scale infill developments that are not occurring in a way that addresses WSUD and green infrastructure objectives. For example, infill developments on large residential lots (sometimes referred to as 1 into 2 or 1 into 3 developments) can result in the removal of trees and green cover on a block and replacement with nearly 100% hard, impermeable surfaces, presented as a mixture of roof space surrounded by concrete and paved driveways and footpaths. This trend is counter to the 30 Year Plan for Greater Adelaide which has set the following target:

> *"Urban green cover is increased by 20% in metropolitan Adelaide by 2045"*

Despite the target for an increase in green cover, the evidence is that most Metropolitan Adelaide Councils have experienced a decline in canopy cover. Across 19 LGAs, a recent report (Amati et al. 2017) found loss of tree and shrub canopy and increase in hard surfaces from 2013 to 2017 (Table 3~~Table 3~~). The analysis, which used i-Tree Canopy[1], suggests 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.

[1] i-Tree Canopy is a web based software tool that estimates tree cover and tree benefits for a given area with a random sampling process that enables users to easily classify ground cover types. Further information on the statistical approach to this analysis is provided at https://canopy.itreetools.org/resources/iTree_Canopy_Methodology.pdf

Table 3. Changes in land surface cover from 2013 to 2017 (Source: Amati, et al. 2017).

Key statistics	2013 (%)	2016 (%)	Change as % land area
Tree Canopy Cover	21.37	19.45	1.92% Loss
Shrub Cover	5.92	5.23	0.69% Loss
Grass Cover	32.08	32.10	0.02% Gain
Hard Surface	40.63	43.20	2.57% Increase

In addition to the urban green cover targets, the 30-year Plan for Greater Adelaide has set the following tree canopy targets:

- *"for council areas with less than 30% tree canopy cover currently, cover should be increased by 20% by 2045; and*

- *for council areas with more than 30% tree canopy cover currently, this should be maintained to ensure no net loss by 2045."*

A number of Metropolitan Adelaide councils have undertaken more detailed analysis of changing canopy cover. For example, an assessment of land cover using i-Tree Canopy within the City of Charles Sturt was conducted for 39 suburbs comprising the Council area (Seed Consulting Services 2016). In each suburb, land cover was assessed in three time periods (1998, 2008, 2014), and across land tenure (private versus public). Key findings include that:

- between 2008 and 2014, impervious cover has increased significantly across the City (from 55.25% up to 60.16%), plantable space has decreased (from 23.63% down to 19.38%), and tree cover has decreased (from 14.81% down to 14.28%);
- changes in land cover across the City have been driven primarily by changes on private land, for example:
    - impervious cover increased by ~5% across the city, but more so on private (~6.5% increase) than public land (~1% increase).

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 3~~Table 3~~.

2.3 Climate change

Climate change is causing Adelaide to experience warmer and drier conditions. By 2030, temperature is expected to increase by *around 0.5 to 1.1 °C above the climate of 1986-2005 (Hope,P.et al. 2015)*. By the end of the century, average annual maximum temperatures could increase by 1.8-3.4°C (e.g. Goyder Institute for Water Research 2016, City of Port Adelaide

Enfield 2016). Rainfall impacts are not equal across seasons, with the spring rainfall decline projected to be greater than for autumn and winter (Goyder Institute for Water Research 2016)[2].

Amongst various other impacts, an increase in the intensity of rainfall is projected, which could lead to greater likelihood of localised flooding and increased periodic runoff, the latter of which will impact the performance of stormwater management systems.

In response to projected climate change impacts, Local and State Government, business, regional organisations, communities and individuals worked together to prepare regional climate change adaptation plans. Four were developed to cover Metropolitan Adelaide.

- Adapting Northern Adelaide - Climate Change Adaptation Plan for the Northern Adelaide Region (http://www.playford.sa.gov.au/AdaptingNorthernAdelaide);
- AdaptWest - Western Adelaide Region Climate Change Adaptation Plan (https://www.charlessturt.sa.gov.au/Climate_Change);
- Resilient East Region Climate Change Adaptation Plan (https://www.npsp.sa.gov.au/our_environment/resilient_east); and
- Resilient South Regional Climate Change Adaptation Plan (https://www.marion.sa.gov.au/services-we-offer/environment/climate-change/resilient-south-project).

Each of these plans provides a more detailed summary of key climate change projections for Adelaide.

In order to address projected changes to temperature and rainfall, a number of common responses were identified across regional climate change adaptation plans for Metropolitan Adelaide that are relevant to WSUD and green infrastructure, including to:

- increase green cover and tree canopy to provide cooling benefits and to offset the impacts of heatwaves and the urban heat island effect;

- manage urban runoff to mitigate flood risk and improve water quality and reuse, such as through greater investment in water sensitive urban design; and

- prepare ‘climate-ready’ guidelines for plant selection, landscaping, water management and any irrigation needs for open space planning and management.

Combined the four plans recognise that the ability for Adelaide to adapt to a future climate that is warmer and drier, and experiences more intense rainfall, will be highly influenced by investment in green infrastructure and WSUD in the coming decade.

[2] Further information on the Goyder Institute for Water Research climate change projections are provided at: http://www.goyderinstitute.org/research/climate-action

2.4 Urban heat islands

The urban heat island is a well-researched phenomenon in Australia cities, as is the ability to mitigate these effects using water sensitive urban design and green infrastructure (e.g. Broadbent, et al. 2018, Thom, et al. 2016, Loughnan, et al. 2013). Research demonstrates the human health impacts of urban heat islands, which exacerbate the impact of heat waves for people who live and work within them (Broadbent, et al. 2018). The impact of heat waves on human health is well established. For example, Adelaide experienced an extreme and prolonged 13 day duration heatwave in the summer of 2009/10 (Zhang et al. 2013). The health impacts of this heatwave included an almost 14-fold increase in direct heat-related hospital admissions.

Heat mapping provides a way to better understand how heat accumulates across the landscape as a result of different land surface types. At a landscape scale it is often undertaken using thermal cameras attached to fixed wing aircraft or satellites. The resulting data can be used to identify hot spots at a scale of a few metres, or “heat islands”.

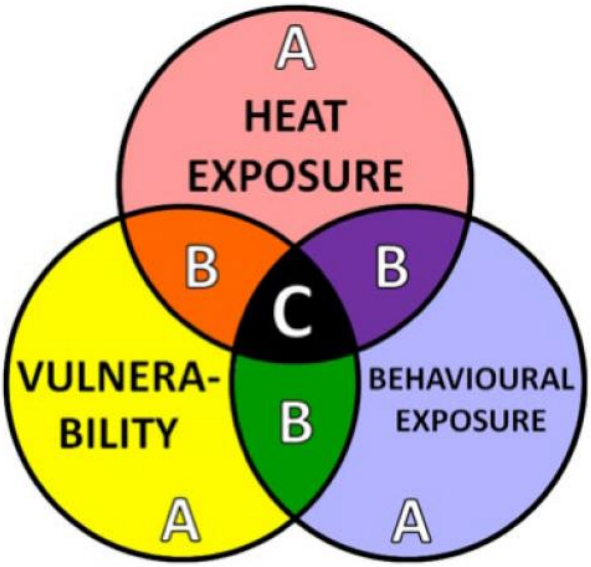

Figure 2. Heat mapping can be used to inform risk to people, with priority areas identified in the overlap between heat exposure, population vulnerability (e.g. age) and behavioural exposure (e.g. public transport corridors) (Norton, et al. 2015).

Heat mapping has been conducted in a number of projects across Metropolitan Adelaide, including Western Adelaide thermal mapping (Seed Consulting Services et al. 2017) and Resilient South heat mapping (Arbor Carbon 2016). They identify hot spots and heat islands across parts of Adelaide and provide insight into the magnitude of the impact of land surface type and surface materials on surface temperature and heat accumulation.

Drawing on the results of the recent Western Adelaide heat mapping analysis[3] (Figure 3), key observations that can be deduced from heat mapping that are relevant to further developing policy and practice for green infrastructure and WSUD are that:

- land use and building and pavement material selection in Western Adelaide can cause at least a 7°C difference in surface temperature;
- temperatures were, on average, 2.8°C lower over green infrastructure, with irrigation creating an additional cooling effect of 1.7°C compared with non-irrigated open space which was mostly non-irrigated grass;
- roadside WSUD features can provide localised cooling benefits;
- artificial turf is significantly warmer than average surface temperatures (5.5°C) and can be up to 14°C warmer than irrigated natural turf surfaces; and
- tree lined streets are significantly cooler than streets without trees.

Research by the CRC Water Sensitive Cities also finds that green infrastructure, when used with WSUD (i.e. irrigated green infrastructure) provides a practical tool to cool cities. Water is required to maintain vegetation health in green infrastructure, as well as to support the important process of evapotranspiration. The CRC research also finds that these benefits can be provided via a range of different green infrastructure, including trees, raingardens, green roofs and walls, and even grassed surfaces (to a lesser extent).

The impact of different levels of density in residential zones is also described in Box 1.

Recommendations arising from the Western Adelaide report to address the heat island effect include:

1. Despite the pressure from infill, the amount of green space and tree cover should at least be maintained;
2. Guidelines should be developed for the amount of green space and landscaping required and building materials to be used in medium and high-density developments;
3. Trees, grass and raingardens should be used alongside or to shade bitumen covered surfaces;
4. Where feasible, green infrastructure should be irrigated (including passive irrigation) to maximise its cooling effect;
5. Where feasible the carriage way for main roads should be narrowed, stormwater treatment devices installed, and road pavement changed to lighter coloured materials;
6. Light coloured roofs should be encouraged rather than dark roofs; and
7. Material selection should be carefully considered for recreation areas. Substrates such as artificial turf and rubber softfall covering used only after consideration is given to how heat absorption can be offset.

Guidelines have been developed to assist in the placement of green infrastructure to maximise cooling benefits, such as the Trees for a Cool City guide (Coutts and Tapper 2017). Key

[3] Data were collected on 9 February 2017, which at 39.2°C was the fourth hottest day and second warmest night (25.2°C) of the 2016/2017 summer.

principles when placing green infrastructure for cooling benefit include the effectiveness of the cooling process, and the vulnerability of the population being protected.

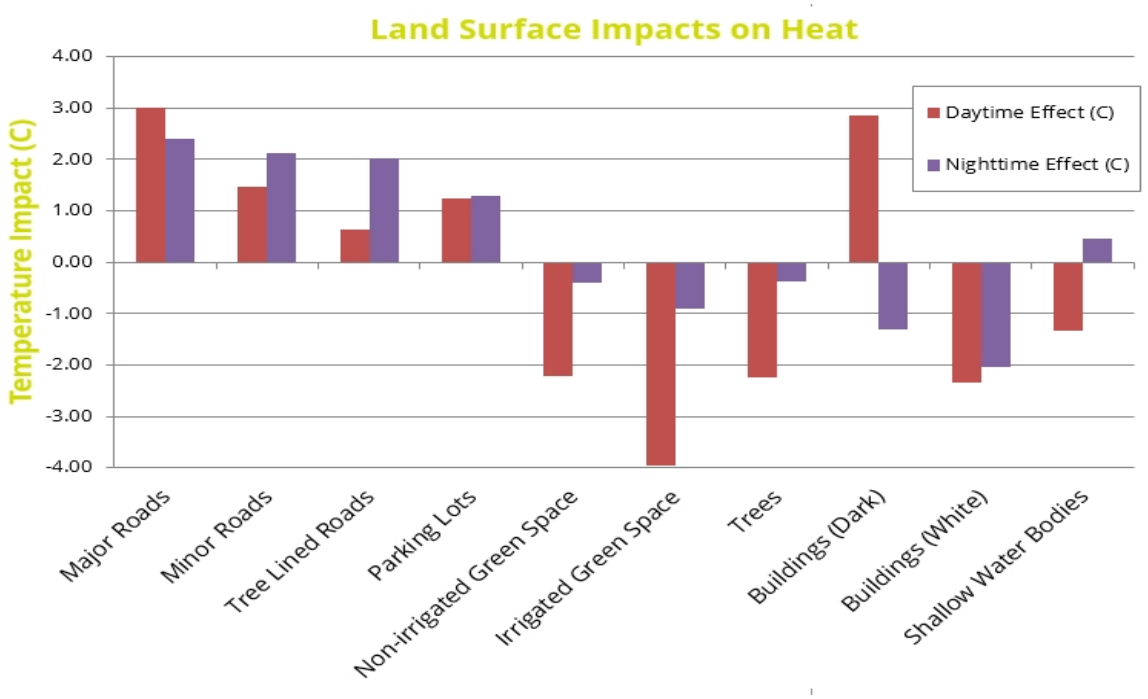

Figure 3. Daytime and night-time surface temperature deviations from the average for a range of land surface types in Western Adelaide based on collection of thermal data on 9 February 2017. Average temperatures for each land surface type were determined using sub-sampling of a total of 670 points (2 m x 2 m) (Seed Consulting Services et al. 2017).

Box 1. Case study of development density impact on surface temperature. Source (Seed Consulting Services et al. 2017)

A 2017 study undertaken in Western Adelaide assessed the location of urban heat islands and the impact of different building, construction and pavement materials and land form on surface temperatures. Data were collected on 9 February 2017, which at 39.2°C was the fourth hottest day and second warmest night (25.2°C) of the 2016/2017 summer.

Part of this analysis considered the different surface temperature for areas of low, medium and high-density residential zones (Figure 4). Areas with a low density of dwellings, such as Fulham, have more room for green space which can offset the warming impact of impervious driveways, roads, and dark roofs. Medium density residential areas, such as West Croydon, have less room and fewer options for mitigation but still preserve some landscape for open space providing some relief from heat. High density residential zones, such as areas within Northgate, have limited public and private green (open) space and few options for heat mitigation.

Comparing surface temperatures across different density development zones, high density areas of Northgate were found to be 2.9°C warmer than the low density zones of Fulham. The high density and predominately dark roofs create a heat island for the residents in this area of Northgate raising their surface temperatures more than 2°C above the regional average surface temperature.

At a suburban scale, these findings suggest that the density of development can have at least as great an effect on temperature as climate change. In order to reduce this impact, careful consideration needs to be given to material selection in higher density developments and how to encourage green space.

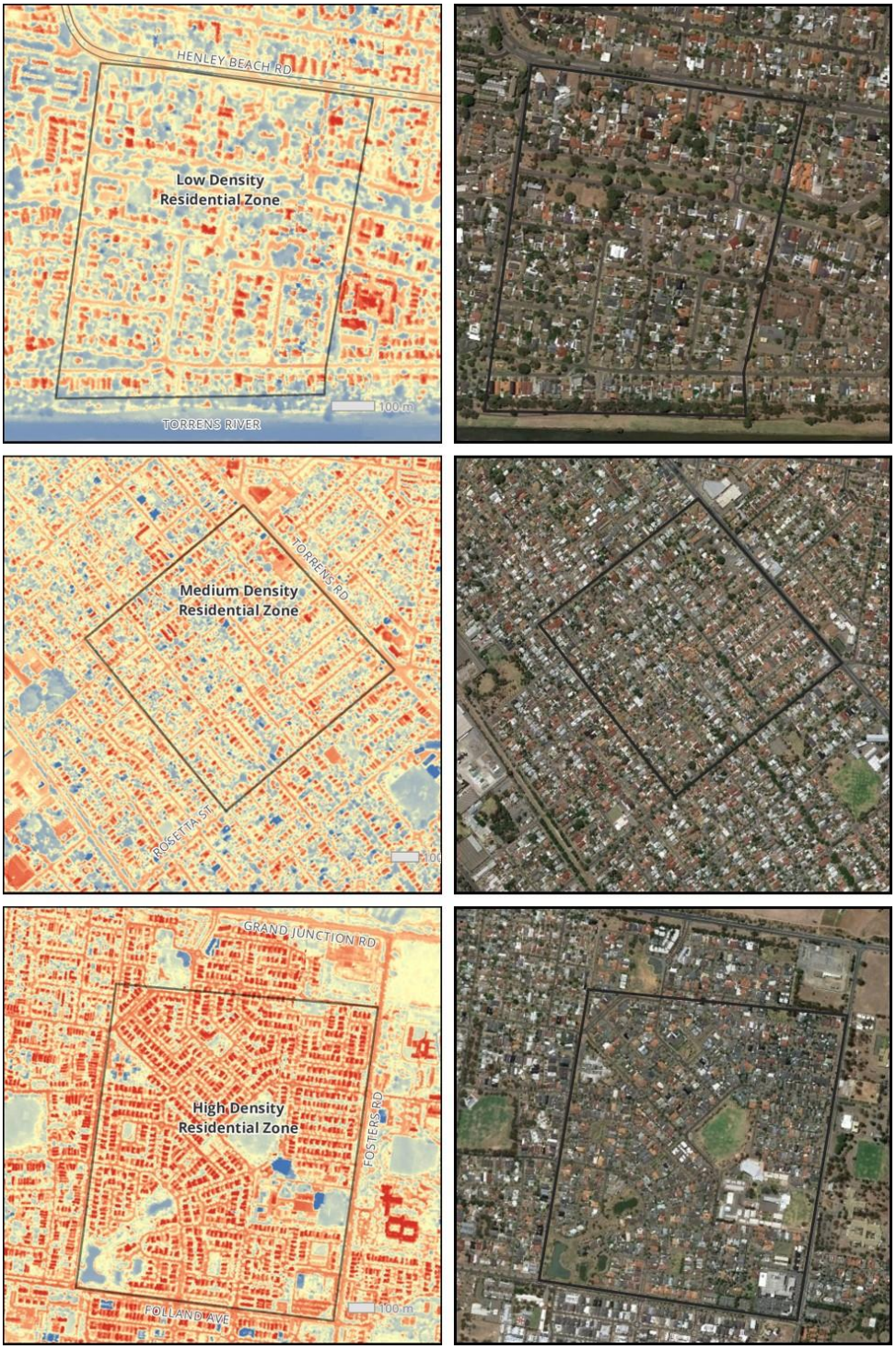

Figure 4. Surface temperatures in low (Fullham), medium (West Croydon) and high (Northgate) density residential zones produced from the Western Adelaide heat mapping project. Daytime surface temperatures were collected on 9 February 2017. Red areas indicate warmer surface temperatures than average, whereas blue indicates cooler temperatures than average (Seed Consulting Services et al. 2017).

3 Policy stocktake

Planning policy dealing with WSUD is still relatively new in South Australia. For most Councils, the inclusion of WSUD planning policy within their Development Plan's occurred when Councils elected to undertake the '*Better Development Plan*' (BDP) Development Plan Amendment (DPA) to update their respective Development Plans. Many South Australian Councils undertook the BDP conversion between 2007 and 2015, the aim of which was to provide standardised 'leading practice' Development Plan policies that dealt with common issues experienced by most SA councils.

A summary of WSUD policy within Greater Adelaide Development Plans is provided in Attachment A and a similar summary is provided for Green Infrastructure in Attachment B.

The intent of the BDP conversion was to have all Councils adopt a standard format, based on a single South Australian Planning Policy Library (SAPPL) template and aimed to have Development Plans with consistent policy content, structure and presentation, while using clear, plain English wording and eliminating repetition. Another key goal of the BDP was to ensure Development Plans aligned with the State Planning Strategy and the 30-year Plan for Greater Adelaide.

The SAPPL introduced, amongst a wide range of planning policy, provisions that supported the inclusion of WSUD principles in urban areas, including stormwater management in accordance with the 30-Year Plan for Greater Adelaide's strategies and targets to achieve more sustainable development outcomes. These policies were typically included in the general ('Council Wide') section of the Development Plan in the 'Natural Resources' module and were therefore applicable to all areas within Council and all forms of development.

Examples of early WSUD provisions included those in the Onkaparinga Development Plan (consolidated 29 March 2007). Examples of 'Council Wide 'Catchment Water Management' 'Objectives' and a 'Principle of Development Control' (PDC) are extracted below:

Objective 9: Integrated stormwater management at the catchment level, drainage system level and site level including incorporation of water sensitive design[10] in all development.

Objective 10: Storage and/or use of water including treated wastewater and/or imported water[11] which avoids adverse impact on public health, water, soil and their dependent ecosystems.

Objective 11: Design of buildings and places to manage, protect and conserve the urban water cycle through features to retain, detain and re-use stormwater on-site.

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[8] 'Floodplain' of a watercourse refers to: (a) the floodplain (if any) of the watercourse identified in a catchment water management plan or a local water management plan, adopted under Part 7 of the Water Resources Act 1997, or (b) where paragraph (a) does not apply – the floodplain (if any) of the watercourse identified in a Development Plan under the Development Act 1993, or (c) where neither paragraph (a) nor paragraph (b) applies – the land adjoining the watercourse that is periodically subject to flooding from the watercourse.

[9] 'Catchment' refers to an area of land determined by the topographic features within which rainfall will contribute to run-off at a particular point.

[10] Water Sensitive Design refers to the planning and design that seeks to sustain the protection and conservation of the urban water cycle and water-dependent ecosystems through integrated land and water management, from the catchment to the sea.

[11] 'Imported Water' refers to water that has been brought into a catchment area from outside of the receiving catchment area (eg by the means of a pipe or channel)

Consolidated - 29 March 2007

23 Development design and construction should:

(a) incorporate water sensitive design measures to manage, protect and conserve water through features to retain, re-use and detain water on-site, and

(b) maximise the potential for stormwater harvesting, and

(c) incorporate detention measures to minimise any concentrated stormwater discharge from the site.

Some Zones included policy aimed at encouraging the harvesting, treatment, storage and reuse of stormwater. Note that this is encouraging, not strictly requiring these measures hence the wording used in the example below. In 2007, Onkaparinga's Residential Zone included the following PDC (Onkaparinga Development Plan, consolidated 29 March 2007).

7 Development of broad acre residential areas or residential enclaves should incorporate a stormwater management scheme that:

(a) encourages on-site water harvesting to maintain garden and lawn areas;

(b) provides sufficient land in drainage reserves and floodways for the construction of appropriate structural controls, such as flow retardation basins, wet retention basins, wetlands and trash rack facilities;

(c) maintains the volume and rate of run-off from newly-developed areas at levels as near as possible to those which existed prior to the development;

(d) takes into consideration the impacts the development will have on existing watercourses and downstream stormwater control facilities;

(e) includes an engineering design which aims to preserve rather than eliminate natural drainage systems; and

(f) avoids direct discharge into the marine environment.

17 Buildings should be designed so that as much stormwater as possible is retained on the development site through the application of an appropriate range of the following techniques:

(a) the direction of roof run-off onto garden areas;

(b) the design of paved areas so that stormwater is directed onto garden areas;

(c) in-ground soakage pit(s) or sump(s) in locations and with capacity to absorb likely peak roof water flows;

(d) landscaped areas with hard paving surfaces constituting not more than 50 per cent of such areas; and

(e) rainwater tank(s) of at least 450 litre capacity connected to roof downpipes.

NB. In relation to the above, it should be noted that 17(e) is now out of date and there is likely to be a push toward retention tanks in the range 2,000 to 3,000 L or more for highly impervious allotments.

The Mooney Valley City Council (Victoria) planning scheme (section 22.03-2) seeks to provide for the adoption of water sensitive urban design elements within a development as a climate adaptation measure, with the objective:

> *To reintegrate urban water into the landscape to facilitate a range of benefits including: microclimate cooling, local habitat and provision of attractive spaces for community use and well-being.*

Adoption of the BDP format by Councils was, however, voluntary and as a result not all Councils converted to this format. This meant that for many years, certain Councils had little WSUD policy content other than basic policies to manage stormwater and prevent flooding.

The opportunity to make localised amendments to the standard BDP policy was also common place, leading to a level of inconsistency in the BDP converted Development Plans that undermined the original intent.

In 2016-17 WSUD performance based policy was consolidated into the Development Plans of nine SA Murray-Darling Basin Councils in the General Section, Natural Resources policy module, as part of the *Integrated Water Management Regional DPA* lead by the Rural City of Murray Bridge, set a new benchmark for SA planning policy.

In particular policy was introduced to manage:

(a) stormwater runoff flow rates of discharge

13 Development should include stormwater management systems designed to achieve the following stormwater runoff outcomes:

(a) for up to but not including the-5 year average return interval flood event area:

(i) pre-development peak flows should not be exceeded

(ii) the time to peak should match that of the pre-development case, as far as practical, provided this does not exacerbate downstream flooding

(iii) runoff should be contained within designed flow paths that avoid unplanned nuisance flooding.

(b) for the 5 year to up to and including the 100 year average return flood event:

(i) flooding of residential, commercial, institutional, recreation and industrial buildings should be avoided

(ii) the time to peak and the peak flow should match that of the pre-development case, as far as practical (provided this does not exacerbate downstream flooding), unless catchment wide benefits can be demonstrated.

(b) stormwater runoff quality

15 Land division that results in the creation of more than 5 allotments should include stormwater management systems designed to achieve the following stormwater runoff quality outcomes:

(a) 80 per cent reduction in average annual total suspended solids

(b) 60 percent reduction in average annual total phosphorus

(c) 45 percent reduction in average annual total nitrogen.

16 Development likely to result in significant risk of export of litter, oil or grease should include stormwater management systems designed to achieve the following gross pollutant outcomes:

(a) 90 per cent reduction of litter / gross pollutants compared to untreated stormwater runoff

(b) no visible oils/grease for flows up to the 1-in-3 month average return interval flood peak flow.

Stormwater runoff from carparks can be readily managed on site to provide amenity and urban cooling by sustaining green infrastructure. Without on-site management of carpark runoff,

downstream green spaces will inevitably need to store this stormwater, reducing the use and functionality of these spaces. Instead, grey infrastructure needs to work harder, so that green spaces can have people and their enjoyment of the space at the centre of design rather than stormwater. With this in mind, other leading WSUD policy includes the District Council of Mount Barker's, Residential Neighbourhood Zone policy area:
:

Energy Efficiency and Water Sensitive Urban Design

32 Design and construction of a building should incorporate water harvesting techniques.

33 Design and construction of landscaping and car parking areas should incorporate water harvesting techniques, so that landscape areas function as drainage swales to collect runoff with the excess stormwater flowing to drainage points connected to a stormwater outlet.

23 Detention basins should be designed and constructed to allow sediments to settle, prior to discharge.

24 Where large roof catchments are proposed, stormwater management systems should direct roof stormwater overflow into one of the following, a:

(a) soakage trench

(b) retention/overflow well

(c) sump.

25 Development should incorporate Water Sensitive Urban Design solutions and discharge water in accordance with one of the following:

(a) into grass swales, vegetation or garden strips

(b) into stone filled trenches either open to a surface or underground absorption field.

Concurrent to the BDP implementation, *The Water Sensitive Urban Design Technical Manual for the Greater Adelaide Region* (Government of South Australia 2010) was released by the State Government in December 2010, aimed as a tool for use by Councils, planners and people working in the development industry to apply WSUD principles to developments within Adelaide. The manual outlines the legislative requirements, design processes and tools, construction, maintenance and operating requirements, indicative costs and case studies.

While useful as a reference tool, particularly as it applies to different types and scales of development as well as in public areas and open space, the extent to which the manual is used within the planning and development industry appears limited. Importantly, the manual did not form a reference document within Council Development Plans so there is no easy mechanism for applicants to be informed of the existence of the manual nor onus on applicants to adopt the recommended measures.

Examples of current policy within the SAPPL related to WSUD includes:

7 Development should be sited and designed to:
(a) capture and re-use stormwater, where practical
(b) minimise surface water runoff
(c) prevent soil erosion and water pollution

(d) protect and enhance natural water flows
(e) protect water quality by providing adequate separation distances from watercourses and other water bodies
(f) not contribute to an increase in salinity levels
(g) avoid the water logging of soil or the release of toxic elements
(h) maintain natural hydrological systems and not adversely affect:
(i) the quantity and quality of groundwater
(ii) the depth and directional flow of groundwater
(iii) the quality and function of natural springs.

14 Stormwater management systems should:
(a) maximise the potential for stormwater harvesting and re-use, either on-site or as close as practicable to the source
(b) utilise, but not be limited to, one or more of the following harvesting methods:
(i) the collection of roof water in tanks
(ii) the discharge to open space, landscaping or garden areas, including strips adjacent to car parks
(iii) the incorporation of detention and retention facilities
(iv) aquifer recharge.

While this WSUD SAPPL content delivered significantly improved policy against which Council planners could assess applications, it remained (and still remains) difficult to measure compliance against many of these polices as they are not easily quantifiable.

The ability to incorporate WSUD into new greenfield or 'broadacre' developments is now reasonably well established. However, planning policy requiring the delivery of WSUD features into individual dwelling sites, urban infill proposal (i.e. 1 into 2) and medium density developments is still deficient and often ineffectual given it is paid little heed by applicants. This may have been exacerbated by the current 'Residential Code' (the checklist for complying dwellings and additional to existing dwelling) which is silent on stormwater management. Instead, there is greater reliance on the Building Code which requires new dwellings and some extensions or alterations to have an additional water supply to supplement mains water (i.e. rainwater tank) plumbed to the toilet or laundry. This was initially established as a water conservation measure in response to water restrictions during the Millennium Drought.

While the mandatory Building Code of Australia requirements are useful, their benefits are focussed on addressing water conservation objectives. The deficiency of stormwater management requirements within the Residential Code has resulted in best practice WSUD opportunities being overlooked in new dwellings constructed in areas subject to the Residential Code, to provide multiple benefits in flow management, water quality improvement, water course protection from erosion and green space requirements.

In relation to green infrastructure, this term is also quite new within the planning and development industry. Interest in the concept of 'green' verses 'grey' infrastructure has grown quickly within State Government and Councils in recent years, however, mechanisms to embody these principles into Development Plans, which predominantly inform development on private land rather than public land, have proven challenging.

In May 2017, the following policy provision was included into numerous South Australian Council Development Plans via the 'Inner and Middle Metropolitan Corridor (Design) DPA. Within the planning industry, this is considered one of the first 'green infrastructure' planning policies which calls for applicants to demonstrate quantifiable site design outcomes to ensure on site mature tree plantings (extract from Unley (City) Development Plan, consolidated 30 May 2017).

288 Deep soil zones should be provided to retain existing vegetation or provide areas that can accommodate new deep root vegetation, including tall trees with large canopies.

One way of achieving this is in accordance with the following table:

Site area	Minimum deep soil area	Minimum dimension	Tree/ deep soil zones
<300m²	10m²	1.5 metres	1 small tree / 10m² deep soil
300-1500m²	7% site area	3 metres	1 medium tree / 30m² deep soil
>1500m²	7% site area	6 metres	1 large or medium tree / 60m² deep soil
Tree size and site area definitions			
Small tree:	< 6 metres mature height and < less than 4 metres canopy spread		
Medium tree:	6-12 metres mature height and 4-8 metres canopy spread		
Large tree:	12 metres mature height and > 8 metres canopy spread		
Site area:	The total area for development site, not average area per dwelling		

Similarly, the Adelaide (City) Development Plan recently introduced the policy, which requires applicants of proposals that seek to exceed maximum building heights to provide a range of value add features in their designs, such as rooftop gardens covering a majority of the available roof area supported by services that ensure ongoing maintenance, and green walls / façades supported by services that ensure ongoing maintenance (PDC 21, Capital City Zone, Adelaide (City) Development Plan, consolidated date 02 June 2017).

This is an example of an incentivised policy method, which offers applicants potential development gains subject to the inclusion of 'green' design features.

4 Green infrastructure

4.1 Benefits

Urban green infrastructure, beyond its amenity and biodiversity value, provides critical services in helping to make cities healthier and more pleasurable places to live (Pittman et al. 2015). Tree canopy cover in particular is receiving increasing attention from urban land planners and managers nationally and internationally. This is due in large part 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; and
- broader economic benefits from enhanced commerce and property values, health care and energy savings, and ecosystem services.

Further information on several of these benefits is presented in Table 4. 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) and in Pittman et al. (2015).

Despite the benefits of green infrastructure being well documented, 43% of metropolitan Adelaide's local government areas (LGAs) have had a significant loss in tree canopy cover since 2013 as a result of urban development (Amati et al. 2017). This can occur in a range of ways, such as when the development of greenfield sites or residential infill replaces green space and trees with buildings and hard, impervious surfaces.

Despite the benefits of green infrastructure, there can also be adverse impacts. For example, tree root growth can cause damage to roads, kerbs, pavements and foundations; 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 site preparation e.g. selection of a tree that is too large for the site or irrigation is insufficient to prevent extensive surface root growth. While noting the potential adverse impacts of green infrastructure in some settings, the focus of this paper is on how to achieve increased green infrastructure targets. Options for how

to mitigate adverse impacts should be dealt with on a site by site basis or through the preparation of urban forest strategies, tree policies and procedures manuals that guide and direct species selection and planting protocols, use of guidance documents, literature (e.g. (Cameron and Beal 2018) and standards such as AS2870-2011 on the requirements for residential slabs and footings.

Table 4. Examples of the 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 0.5-1ºC cooling of land surface temperatures; and other studies have shown that tree shading can cool air temperatures up to 4ºC (compared to unshaded areas), and cool soil surface temperatures by between 3-12ºC (Coutts, Broadbent, et al. 2014, Lin and Lin 2010, Armson, Rahman and Ennos 2013). A modelling study (Alexandri and Jones 2008) on an urban canyon of 5 m height and 10 m width showed that a decrease in air temperature between 2.5°C and 4°C can be achieved by incorporating green walls. An average temperature reduction of 7°C was achieved for buildings with both green wall and green roofs. The reduction in canyon air temperature was found to be more significant in hotter climates.
Air pollution	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).
Physical health	Studies have reported a range of additional physical health benefits for adults and children, such as: Decreased mortality (Donovan, et al. 2013); Increased longevity for senior citizens (Takano, Nakamura and Watanabe 2002); Lower risk of asthma development in children (Lovasi, et al. 2008); Enhanced motor skill development in children (Fjortoft 2001) Increased physical exercise and sleep quality (Grigsby-Toussaint, et al. 2015) Decreased sun (UV) exposure (Parsons, et al. 1998).
Mental health	Several studies have reported that living in urban areas has significant negative impacts on our mental health and well-being, with this impact being most significant in people born and raised in urban areas. Australian-based research even suggests that neighbourhood 'greenness' is more important for influencing mental health than physical health (Sugiyama, et al. 2008).
Place making and property values	A range of studies have shown that views of green cover can increase property prices, including 1.9% higher property prices for a view of a neighbourhood park in China to an increase in property prices of around $50,000 for a 10 % increase in tree canopy (Gunawardena, et al. 2017).

4.2 Objectives

There are currently no standard guidelines for integrating green infrastructure into urban development, other than a global push to increase green infrastructure in general in urban areas. Standards are lacking due to the huge variation in development types, green infrastructure types, willingness, urban contexts and pressures, opportunities (e.g. space, climates, landuses).

In the absence of standard guidelines, green infrastructure policy and plans tend to initially focus on high level objectives and principles. These typically draw on a broad range of benefits of green infrastructure and design and management considerations. A summary of examples of principles and high-level objectives from selected literature is provided in Table 5~~Table 5~~. Objectives are taken here to describe themes and the broad direction for policy, and principles provide an indication of how to achieve objectives. It should be noted that there is no standard way in which these concepts are applied, in some cases objectives are used to provide higher level direction than principles.

Drawing on this literature, the following themes are common amongst green infrastructure principles and objectives:

1. **Integration**: Combine green infrastructure with urban development and grey infrastructure. This is especially relevant to the combined benefits of WSUD and green infrastructure.
2. **Multifunctionality**: Create and maintain green infrastructure that delivers multiple benefits and ecosystem services simultaneously and that is adaptable
3. **Community** - Involve stakeholders to identify community needs, promote health and wellbeing, encourage social interaction and be meaningful to place and community
4. **Connectivity** - Understand and create an interconnected network of green infrastructure
5. **Diversity** - Provide structural and species diversity as a target
6. **Environmental** - Protect and restore natural areas and consider biodiversity outcomes
7. **Management** - Plan for maintenance and irrigation and embody environmental sustainability (e.g. water wise) to maximise benefits.

Table 5. Summary of objectives and principles from selected green infrastructure policies and plans.

Source and relevant scale	Description of objectives and principles
Coutts, A and Tapper. N. (2017). Trees for a Cool City: Guidelines for optimised tree placement. Melbourne Australia: Cooperative Research Centre for Water Sensitive Cities.	This provides broad principles for how to manage and increase tree cover across the urban landscape. These principles are provided with the specific objective of reducing urban air temperatures and improving human thermal comfort. **Existing trees** *Aim to maximise the cooling potential of existing trees and vegetation cover first. Trees that are healthy, with a full canopy and actively transpiring will provide the greatest benefit. Existing vegetation must be supported with sufficient water (preferably from water sensitive urban design or alternative water sources)* **Lack of vegetation** *Focus on dense urban environments with little or no vegetation. Well-watered vegetation is most effective at cooling under warm/hot and dry conditions and this coincides with areas of highest heat exposure that can place vulnerable populations at risk.* **Use trees** *Harness the cooling and HTC benefits of trees that achieve cooling via both evapo-transpiration and shading. Trees also deliver more cooling and improvement in HTC for the amount of water applied, compared to other urban green approaches.* **Distribute trees** *Trees and vegetation need to be distributed at regular intervals throughout the urban environment. Distributing trees throughout the landscape should provide a larger areal extent of cooling than large, but isolated green areas.* **Smart planning** *Work with the built environment to accentuate cooling influences through strategic design. Urban spaces should be sensitive to local and regional climatic influences (such as sea breezes and prevailing winds) and maintain natural cooling mechanisms such as ventilation and trees.*

Source and relevant scale	Description of objectives and principles
South Australia's Planning Framework for Water Sensitive Urban Design (Department of Environment, Water and Natural Resources 2013) (City-scale)	Implement WSUD in a way that promotes establishment of 'green infrastructure' and achievement of multiple outcomes, for example: public amenity, habitat protection and improvement, reduced energy use and greenhouse emissions, and other outcomes that contribute to the wellbeing of South Australians
Quality Green Space Supporting Health, Wellbeing and Biodiversity: A Literature Review (Davern, et al. 2017) (Broader-scale objectives, with local scale principles)	Urban design and development incorporates green infrastructure in such a way as to maximise benefits to human health and the environment, including the physical, mental and social health of individuals and communities, and the maintenance of ecosystem services and biodiversity • Principle 1: Promote and protect community and environmental health • Principle 2: Identify community needs • Principle 3: Understand the network of green spaces • Principle 4: Heterogeneity as a target (i.e. diversity of species) • Principle 5: Consider biodiversity outcomes • Principle 6: Maximising the quality of public open space (POS) • Principle 7: Plan for maintenance and irrigation • Principle 8: Type and scale of green spaces

Source and relevant scale	Description of objectives and principles
Framework for the Integration of Flooding and Stormwater Management into Open Space. (Water by Design 2011) (Regional scale)	Open space corridors serve multiple functions. Therefore, they must be carefully planned and designed to generate the best net benefit to the community and to the natural environment. Contemporary design principles for public open space include: • being meaningful to place and community • being multi-functional and adaptable being connected to desirable routes and other nodes • providing diversity • encouraging social interaction • promoting health and wellbeing • providing equity and accessibility • embodying environmental sustainability (e.g. water wise) • providing connectivity within strategic open space network.
Green Infrastructure for Southwestern Neighbourhoods (McAdam 2010) (Neighbourhood scale)	• Protect and restore natural areas • Serve multiple functions with green infrastructure • Include the community
Greener Places: Establishing an urban Green Infrastructure policy for New South Wales (Draft) (Government Architect NSW 2017) (State scale, with intent for application at multiple scales from private yard to neighbourhood and suburb planning, and metro-wide considerations)	• Integration: combine Green Infrastructure with urban development and grey infrastructure • Connectivity: create an interconnected network of open space • Multifunctionality: deliver multiple ecosystem services simultaneously • Participation: involve stakeholders in development and implementation

4.3 How to implement and assess green infrastructure as part of a development

Achieving objectives for green infrastructure policies and plans requires qualitative and quantitative targets to guide on ground action. Targets contained in existing policies and plans vary depending on scale and site context, however, they typically address aspects of the following:

- tree canopy or aspects of green space such as green roofs, walls or vegetated areas;
- suitable conditions for plant establishment, growth and maintenance;
- pervious surfaces, providing sufficient ability for rainwater to absorb into the soil to support green infrastructure;
- landscaping requirements or plans;
- plant species selection to support diversity of species and canopy structure;
- tree protection, especially for significant or remnant vegetation; and
- access to green space by the community.

Sections 4.3.1 to 4.3.4 discuss some of the specific considerations in setting targets for green infrastructure under the planning reforms.

Sections 4.3.5 and 4.3.6 describe assessment options for green infrastructure, which will vary depending on the target being considered. For the purpose of this paper, the key considerations for assessment are:

- how to value a tree, which is relevant to options for retaining existing vegetation;
- how to determine whether a development has sufficient amounts of green cover, and in the right locations to maximise benefits; and
- how to disconnect impervious areas of a development from stormwater systems using green infrastructure as a buffer between the two.

4.3.1 Canopy cover

Many cities now have implementation targets for urban tree canopy and various analysis and reports recommend that cities develop their own specific targets based on their specific constraints. Targets are often proposed at a landscape, city, or local government area scale. They typically relate to achieving a percentage of the total land area as tree canopy or green cover or set a target for increasing canopy or green cover by a set time. For example, the London Environment Strategy (Draft) states that “More than half of London’s area will be green, and tree canopy cover will increase by ten per cent by 2050.”[4]

In Australia, a national target of increasing green space by 20% by 2020 has been promoted by Vision 202020[5]. This has been supported by a large number of councils in Australia.

At a local government level, urban forest strategies are being developed around the nation that set more specific, locally relevant canopy cover targets. For example, the:

[4] https://www.london.gov.uk/sites/default/files/draft_environment_strategy_-_executive_summary.pdf
[5] http://202020vision.com.au

- City of Sydney's aim is to increase the canopy coverage of the LGA by 50% by 2030[6];

- City of Melbourne has a strategy to increase canopy cover in the public realm from 22% at present to 40% by 2040;

- City of Greater Geelong is aiming to improve its tree canopy cover from 14% to 25% over a thirty-year period.[7]

As described in Section 2.2, the 30-year Plan for Greater Adelaide has set the following tree canopy targets:

- for council areas with less than 30% tree canopy cover currently, cover should be increased by 20% by 2045; and

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

Complementing the canopy targets are targets to increase green cover by 20% in metropolitan Adelaide by 2045. Compared with urban tree canopy, green cover also includes landscape features such as living turf, shrubs, green roofs and green walls.

Given the trend of declining tree and shrub canopy cover due to development in Adelaide (See Section 2.4), setting canopy targets for public and private land becomes important, especially in the context of ensuring that 85% of Adelaide's development occurs through in-fill as sought within the 30 Year Plan targets.

Using canopy targets to inform development assessments will be especially difficult though if development trends of clearing almost all vegetation on a site to provide a "clean slate" for construction works continues. Dedicated consideration could instead be given in the development planning stage to how construction may work around existing trees on site, particularly mature trees. Moving away from the "business as usual" approach to development through efforts to retain existing vegetation on development blocks will greatly help to achieve green infrastructure targets.

A key consideration influencing the clearance of trees on development sites is the management of significant and regulated trees, which are defined as follows[8]:

- A regulated tree is any tree in metropolitan Adelaide, Adelaide Hills Council townships and parts of the Mount Barker Council with a trunk circumference of 2.0 metres or more (measured at a point 1.0 metre above natural ground level); and
- A significant tree is a regulated tree in metropolitan Adelaide, Adelaide Hills Council townships and parts of the Mount Barker Council with a trunk circumference of 3 metres or more (measured at a point 1 metre above natural ground level).

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[6] http://www.cityofsydney.nsw.gov.au/__data/assets/pdf_file/0004/154156/George-Street-Concept-Design-Part-3.pdf

[7] https://www.geelongaustralia.com.au/common/public/documents/8d30153dfee2a6c-Urban%20Forest%20Strategy.pdf

[8] Full definition is available at https://www.sa.gov.au/topics/planning-and-property/land-and-property-development/building-and-property-development-applications/regulated-and-significant-trees

Protection is therefore limited to vegetation that meets these criteria. While trees of this size require development approval for removal on private property, mature trees of smaller size (e.g. 1 metre circumference measured at a point 1 metre above natural ground level), do not. Yet, mature trees of smaller size still provide significant canopy and may be the only sized tree capable of growing and achieving canopy targets in small and medium sized allotments. For example, common street and park trees in Adelaide that contribute valuable canopy with a 1 m circumference include the Golden rain tree, Jacaranda, Common plum, Weeping bottle brush and Callery pear (Table 6~~Table 6~~). As such, greater protection for mature trees that do not meet the definition of significant and regulated trees is required, or an offsets scheme should be implemented to account for the loss of mature, non-regulated trees (see Section 4.3.6 for discussion of offset scheme options).

Where it is determined that vegetation absolutely must be cleared – including of significant, regulated and mature trees - targets developed to inform development must focus on the ability for sufficient canopy and green cover to develop to its growth potential, rather than its existence at the time of development.

Table 6. Example of canopy cover for common street and park trees found in Adelaide with a circumference of 1m at 1m above natural ground level. Estimates generated using i-Tree Eco[9]. DBH – Diameter at breast height.

Scientific name	**Common name**	**Leaf type**	**DBH (cm)**	**Canopy (m2)**
Koelreutaria paniculata	Golden rain tree	Deciduous	32	59
Quercus robur	English oak	Deciduous	32	54
Jacaranda mimosifolia	Jacaranda	Deciduous	32	53
Platanus acerifolia 'Bloodwood'	London plane tree	Deciduous	32	64
Prunus cerasifera	Common plum	Deciduous	32	47
Callistemon viminalis	Weeping bottle brush	Evergreen	32	29
Lophostemon confertus	Brush box	Evergreen	32	29
Fraxinus angustifolia ssp. angustifolia	Desert ash	Deciduous	32	57
Brachychiton populneus	Kurrajong	Semi-deciduous	32	43
Ulmus procera	English elm	Deciduous	32	57
Corymbia ficifolia	Red flowering gum	Evergreen	32	29
Gleditsia triacanthos	Honey locust	Deciduous	32	65
Celtis australis	Southern hackberry	Deciduous	32	57
Melia azedarach	White cedar	Deciduous	32	59
Pyrus calleryana	Callery pear	Semi-deciduous	32	48

[9] i-Tree Eco is a flexible software application designed to use data collected in the field from single trees, complete inventories, or randomly located plots throughout a study area along with local hourly air pollution and meteorological data to quantify forest structure, environmental effects, and value to communities. Further reading: https://www.itreetools.org/eco/

4.3.2 Soil characteristics

Given the difficulty in assessing future canopy or green cover, an option is to ensure sufficient soil is available to support the growth of vegetation. The soil quantity and quality needs to be sufficient to provide the water and nutrients required for a tree to reach maturity and full health, which is essential if the benefits it provides are to be fully realised.

One option to achieve this is to ensure that a deep soil zone is available for roots (City of Sydney 2016). Deep soil zones are areas within a development of natural ground with no obstructions above or below the surface and relatively natural soil profiles. As such they exclude areas on structures, pools and non-permeable paved areas. They are a dedicated area of a site that can help promote healthy growth of large trees, protect existing mature trees and allow infiltration of rain water into the water table to reduce stormwater runoff. Areas of deep soil are to remain in place once building and site development has been completed.

Reference to deep soil zones is made in the SA Planning Policy Library (version 6) and a number of Development Plans in South Australia. For example, SAPPL says that:

> Gen.Sec. Res. Dev. PDC 13. Private open space at ground level should be designed to provide a consolidated area of deep soil (an area of natural ground which excludes areas where there is a structure underneath, pools and non- permeable paved areas) to:
>
> (a) assist with ease of drainage;
>
> (b) allow for effective deep planting; and
>
> (c) reduce urban heat loading and improve micro-climatic conditions around sites and buildings.

Furthermore, the City of Unley Development Plan states that in relation to the Street Interface:

> PDC [10] 8. Development facing the street should be designed to provide attractive, high quality and pedestrian friendly street frontage(s) by:
>
> (b) providing a well landscaped area that contains a deep soil zone space for a medium to large tree in front of the building (except in a High Street Policy Area or other similar location where a continuous ground floor façade aligned with the front property boundary is desired).

In relation to the Environment

> PDC 23. Deep soil zones should be provided to retain existing vegetation or provide areas that can accommodate new deep root vegetation, including tall trees with large canopies.

[10] Development plans contain objectives, principles and policies that control and affect the design and location of proposed land use activities.

Box 2. Methods and considerations for deep soil zones. (City of Sydney 2016)

The City of Sydney provides the following methods and considerations for the provision of deep soil zones within a development include:

- designing car parking so it does not cover the whole site, providing zones for deep soil and where possible containing underground carparking beneath the building footprint;
- providing consolidated and contiguous areas of free draining soil;
- locating deep soil in areas connected to existing deep soil systems such as on site boundaries or within setbacks;
- utilising permeable paving materials where paving is required in deep soil zones; and
- utilising deep soil areas to retain existing trees and planting new large trees to support the urban tree canopy, biodiversity and urban wildlife linkages.

For PDC 23, the minimum area of deep soil zone is proposed for developments of different sizes (see also Section 3 of this paper for an example of specific details of the minimum area per development size).

As building and development styles evolve in Adelaide, greater consideration will also be required as to how deep soil zones can be incorporated into new built form typologies. Such typologies may make it easier to incorporate elements of deep soils into new developments.

An additional consideration to deep soil zones, but related to soil quality, is the amount of soil compaction. As reported in a literature review by Johnson (2017), tree root penetration and growth is best supported by porous, well-aerated, low strength soil through which oxygen can diffuse and water can infiltrate. Therefore, provided that soil compaction is not too great, tree growth should still be optimal. It follows from this that permeable pavers when placed on top of soil that has been compacted only lightly, can provide a hard surface for various uses (e.g. pathways, driveways) but still allow sufficient movement of water and oxygen. This has the potential to enable trees to access areas of soil beneath hard surfaces, enabling developers to still incorporate areas of hard surfaces for use by residents. Inclusion of a soil compaction measure would require agreement on what is an appropriate level of compaction, when and how it is measured, and what is appropriate for different textured soils. A more detailed discussing on growth limiting bulk density and how it differs between soil texture types is provided in Johnson (2017).

The City of Vincent (WA) Planning and Building Policy Manual, Policy N0. 7.1.1 Built Form provides deemed-to-comply solutions (C4.10.1 to C4.10.4) for landscaped areas that offer incentives for retaining mature trees in association with deep soil zone requirements in residential developments within Transit Corridor policy areas, as per the extract below:

- Deep soils zones are to be provided as follows:

Site Area	*Minimum Area*	*Deep Soil Zone (% of site)*
<650m2	*1m2*	*15%*
650m2 – 1,500m2	*3m2*	*15%*
>1,500m2	*6m2*	*15%*

Note: the minimum dimension for the area of deep soil zone is to be 1m

- *50% of the front setback to b provided as soft landscaping*
- *The required deep soil zone can be reduced to 12% where mature trees, which contribute to 30% or more of the required canopy coverage, are retained.*

Carparks within Transit Corridors, within the City of Vincent are also required to contribute to canopy cover targets in accordance with the policy (C4.10.7 to C4.10.9) below:

- *Open air car parks are to have a minimum of 80% canopy coverage at maturity*
- *All open-air parking areas are to be landscaped at a rate of one tree per four car bays*
- *The perimeter of all open-air parking areas are to be landscaped by a planting strip of at least 1.5 m width*

4.3.3 Open space provisions

Open space presents a major opportunity for increasing tree canopy and green cover. Clause 50 (1)(c) of the Development Regulations requires *"up to 12.5 per cent in area of the relevant area be vested in the council or the Crown (as the case requires) to be held as open space".* This equates to around 4 ha per 1,000 people in a lower density development area of 35 hectares (based on 15 dwellings per hectare and 1.9 persons per household). It is understood that this target is relevant to provision of open space on public land for sport and recreation and was originally developed for low density housing developments. The target was recently challenged in the Best Practice Open Space in Higher Density Developments Project (City of Charles Sturt 2012), which suggests that:

- the adequacy of 'up to 12.5% of land for open space' in higher density developments has been questioned in a number of previous studies and there is a sense that additional land is justified. Some studies suggest that an increase in open space is required to compensate the increase in density with people having less private open space;

- successful higher density developments have around 25-50% of open space, including public, private and communal open space; and

- there is recognition that the quality, robustness and functionality of open space in higher density areas are of greater importance than quantity, although this is balanced by the need for adequate open space for activity and aesthetics.

Given the need for large areas of public open space to be used for sport and recreation, these areas alone will be insufficient to meet canopy cover targets across metropolitan Adelaide and therefore private open space is also critical.

The planning system controls (or can control) the amount of private open space and communal open space, including the amount of private landscaped open space. For example, the South Australian Planning Policy Library (version 6) presents Principles of Development Control for Residential Development that describe a minimum area of private open space and state that (Gen.Sec. Res. Dev. PDC 13):

> *Private open space at ground level should be designed to provide a consolidated area of deep soil (an area of natural ground which excludes areas where there is a*

structure underneath, pools and non- permeable paved areas) to:

(a) assist with ease of drainage

(b) allow for effective deep planting

(c) reduce urban heat loading and improve micro-climatic conditions around sites and buildings.

Requirements for minimum areas of private open space and landscaping and/or deep soil zones are also provided in Development Plans. For example:

- City of Adelaide Development Plan, City Living Zone, East Terrace Policy Area 29 requires" "A minimum of 30 percent landscaped open space should be provided on the site of any development."

- City of Unley, City of Prospect, and City of Norwood, Payneham and St Peters include minimum areas of deep soil for different sized developments (see Section 3 of this paper for an example of specific details of the minimum area per development size).

The provision for minimum areas of deep soil for different sized developments is also addressed in the "Design Guidelines Draft for Consultation - Design Quality and Housing Choice", which in relation to the "Landscape" section which includes a design suggestion to:

- "Provide deep soil zones in locations to enable maximum benefit from new or existing tree planting. Consider engineered solutions where space is limited, such as structural soils or structural soil cells, to enable healthy root growth".

The move toward mandating minimum areas of private open space for landscaping is occurring elsewhere in Australia as well. For example, the State of Victoria proposes to amend Plan Melbourne to address "development that consumes the whole block" by requiring a percentage of garden space on the block, as follows:

- blocks 400-500sqm will require 25 per cent minimum garden area;
- blocks 501-600sqm will need 30 per cent garden space; and
- blocks larger than 650sqm must have 35 per cent garden space.

Setting future targets for open space needs to ensure that provisions are made for (a) medium and high-density developments, noting that these are an increasingly common form of infill, and (b) areas to be landscaped to contribute to green cover objectives and allow for inclusion of deep soil zones, capable of supporting mature trees.

4.3.4 Landscape plans

While assessing potential future canopy is not possible at the time of a development application, for medium density developments developers should continue to be required to provide landscaping plans. The purpose of a landscape plan should be to focus on how to meet canopy or green cover targets for a certain area.

Landscaping plans are used by some local government authorities to require the planting of vegetation of a certain minimum size in association with medium density residential development. Development approvals for this type of development where landscaping plans are required are accompanied with conditions of approval relating to the requirement to plant (prior to occupation) and maintain the vegetation for the duration of the development.

Landscape plans are used in an adhoc way in South Australia, often in relation to landscape planting requirements. In contrast, landscape plans are already a requirement for development applications in many councils in Victoria and New South Wales. The plans are required so as to maintain the character of residential areas, help manage stormwater runoff and achieve WSUD objectives. An example of the requirements for a landscape plan in Kingston City Council is outlined in Box 3.

To address improved landscaping, Schedule 5 of the Development Regulations 2008 should be carried over to the new PDI Regulations and outline information regarding the minimum requirements for general landscaping plans. Currently this Schedule only requires the location of regulated trees to be identified with other landscaping at the discretion of individual councils. Consistent and quality landscape plans that outline initial design and ongoing maintenance approaches will play an important function in the delivery of tree canopy cover and urban green cover targets.

Box 3. Landscape Plan Case Study - Kingston City Council

The requirements of landscape plans varies between councils. For example, Kingston City Council in Victoria requires that a Landscape Plan is drawn to a scale of 1:100 and clearly shows (City of Kingston 2018):

- Land orientation to north;
- Property address;
- Proposed and retained building(s) with windows, doors and number of storeys indicated
- Site boundaries and road frontages;
- Landscape consultant's name and contact number; and
- Legend illustrating all plant types and materials (for example: paving, retaining walls, clothes lines and garden edging).

The Council requires that all landscape plans are prepared by a suitably qualified person such as a Landscape Architect or Landscape Designer. For large development proposals, Landscape Plans must form part of the planning application, whereas for small to medium sized development proposals a Landscape Plan is required after the planning permit has been issued.

4.3.5 Tree valuation

Valuing a tree is required if developers are to contribute to the cost of re-instating a tree, or equivalent green infrastructure, that has been removed during the development process. Currently the removal of significant and regulated trees on private land attracts a small fee that varies from council to council, but is in the range of a few hundreds of dollars. These

funds can be consolidated in a council managed tree fund and used to maintain the health of existing trees.

General feedback from council staff is that such removal fees fall well short of either the re-instatement cost of trees, especially mature trees, or their structural value. 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:

- The Revised Burnley method (Moore 2006) – This is widely used around Australia and may be used by councils and/arborists where an alternate or council specific method has not been agreed. Value is determined based on tree size, useful life expectancy, form and vigour and location;

- City of Melbourne method - Where a public tree removal is approved by Council's arborist in relation to a development, the associated cost of the tree and its removal is paid by the property owner or representative prior to the removal. The costs associated with removal of a public tree include:

A – Removal Costs	Amounting to the fees incurred by Council for physically removing the tree
B – Amenity Value	Calculated in accordance with Council's Amenity Formula.
C – Ecological Services Value	Calculated in accordance with the i-Tree valuation tool
D – Reinstatement Costs	Calculated in accordance with the greening required to replace the loss to the landscape incurred by the removal.

- City of Sydney method – This approach calculates tree value based on planting cost of a 200 litre (container size) grown tree in the City, size of plant, age of the tree since planting, 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. As such, there is at least an order of magnitude difference in the value placed on a tree on public compared with private land.

The cost for removal of existing mature trees therefore needs to take greater consideration of the true ecological, amenity and re-instatement costs of trees on private land. If a new valuation method was applied in a consistent manner across councils it could be used to generate funds for reinstating trees or green cover on public or private land. The supply of such public land for substitutional planting is finite and needs to be accounted for in costing removal on private land.

4.3.6 Green cover assessment

The 30 Year Plan for Greater Adelaide sets a target to increase green cover by 20% in metropolitan Adelaide by 2045. Green cover targets relate to more than just tree canopy and

can include shrub cover, irrigated turf, green walls, green roofs and other landscaping features. Where tree canopy targets prove difficult to achieve, green cover will become increasingly important to provide benefits such as local cooling and health and amenity outcomes.

In the United States, novel approaches have been developed to assess the overall green cover of proposed landscaping for developments. The advantage of these scoring systems is that they:

- help create consistency in how landscape plans are developed without mandating how a landscape should be developed;
- provide flexibility in the way that green cover compliance can be achieved; and
- provide an opportunity to integrate some aspects of offsets on public land, for example, by including bonus credits for landscaping that improves the verge on public land.

Two examples of green cover scores are provided below, which may be applicable for encouraging increased green cover in Adelaide.

- Seattle Green Factor
  The Seattle Green Factor (SGF) is a score-based code requirement that increases the amount of and improves the quality of landscaping in new developments. If a project is to meet the SGF, it must reach a minimum score based on the zoning of a property. Proponents can choose from a "menu" of landscape credits for various features, including green roofs, rain gardens, vegetated walls, and trees, and shrubs. Bonus credits can be provided for plantings along the footpath, use native plants, or creating a food garden.

  Assessing whether your project meets the SGF is done using a simple excel spreadsheet. The SGF is underpinned by a standards for landscaping document, sample landscape management plan, tree and plant list. Further details on the SGF can be found at: http://www.seattle.gov/dpd/codesrules/codes/greenfactor/default.htm

- Washington Green Area Ratio
  The Green Area Ratio (GAR) is an environmental sustainability zoning regulation managed by the Department of Energy and Environment in Washington D.C. that sets standards for landscape and site design to help reduce stormwater runoff, improve air quality, and keep the city cooler. All new buildings that require a certificate of occupancy must comply with the GAR. Additions and interior renovations to existing buildings must comply with the GAR when the cost to construct exceeds 100% of the assessed building value within any twelve-month period.

  The GAR Scoresheet is used to calculate the total area of landscape elements necessary to reach the GAR score, which differs between zoning districts. To meet minimum GAR coverage requirements, developers must consider integration of environmental performance landscape features at the beginning of project development. A wide variety of landscape elements can be used to achieve compliance. The GAR Guidebook provides detailed guidance for design development and appropriate standards. Further details on the Washington GAR can be found at: https://doee.dc.gov/service/green-area-ratio-overview

Developing a green cover scoring system for Adelaide would provide the opportunity for flexibility in how green cover is provided, enabling innovation in how various elements such as turf, landscaped beds, trees, green walls, vertical gardens, and WSUD features can be incorporated into new developments. This flexibility will be beneficial as new built form typologies emerge in Greater Adelaide. The simple spreadsheet based scoring system developed for the Washington Green Area Ratio could be adapted or revised for South Australian conditions. This could be done in such a manner that developers for low density developments could apply the tool with limited assistance, while medium and high density developments with requirements for green cover on smaller blocks could use the tool to demonstrate how they are achieving green cover objectives.

4.3.7 Trading schemes for offsite green cover solutions

Where green cover targets remain difficult to achieve, even with the flexibility afforded by a green cover scoring system as described above, another option is to establish a trading scheme for offsite green cover solutions. This would mean that where green cover targets can not be met on a given site, funds are provided by a developer to establish green cover at an alternate site. Preferably this would be in the local streetscape to ensure that the benefits are retained locally.

South Australia already has experience with offsetting through the approach to managing native vegetation clearance under The *Native Vegetation Act 1991*. Where clearance of native vegetation is required on a property there is often a requirement to 'offset' the removal of native vegetation, usually by protecting a separate area of land for conservation. The offset needs to provide a "Significant Environmental Benefit", meaning it needs to provide an environmental gain over and above the damage being done to the native vegetation in the clearing activity. A similar approach could be adopted in relation to green cover to ensure that where development reduces green cover, this is more than compensated for at another site.

While such an approach may help achieve landscape scale green cover targets, it could mean that residents and the local community miss out on the benefits of green cover, such as cooler neighbourhoods, if offsets are not generated locally. It would also be important to ensure that sufficient plantable space exists across Greater Adelaide to achieve desired landscape scale outcomes. In addition to addressing these issues, an offsets scheme would require appropriate governance, ownership requirements and maintenance obligations to be identified.

If a green cover scoring system, green cover offsets scheme and WSUD targets are pursued at the same time it would be important that they work consistently together to achieve common outcomes. This could be addressed by developing an index that integrates green infrastructure, tree canopy and WSUD, and prioritises solutions that achieve all three.

4.3.8 Effective imperviousness

Green infrastructure can be effective in also achieving WSUD objectives when it acts as a buffer between impervious areas and natural waterways. In this regard, it mimics the role of a riparian zone to filter pollutants and slow down stormwater flow. In Australia, the metrics of

effective imperviousness (EI) and directly connected imperviousness (DCI) have been used to describe this effect. EI describes the proportion of a catchment made up of impervious areas that are directly connected to receiving waters via a constructed drainage system and includes roofs as well as impervious surfaces on or above ground level and swimming pools with or without covers. Green infrastructure can be designed to reduce a direct connection of impervious areas to waterways through integration with WSUD techniques that enable stormwater to be detained and infiltrated. Importantly, this can be achieved through a range of green infrastructure approaches at different scales including green roofs and green walls, in addition to trees and open space areas.

This approach can be taken further by considering the benefits of a network of green infrastructure. Connecting distributed green spaces with green (vegetated) and blue (waterway) corridors provides opportunities for flow attenuation in urban environments (Wong, et al. 2013). To support new developments that adopt this approach, guidance material could be developed to encourage the use and placement of green infrastructure to disconnect impervious areas from waterways and regional drainage systems.

4.3.9 Biodiversity

Maintaining biodiversity and ecosystem health is essential if ecosystems are to continue to deliver beneficial services to cities and urban areas. As stated by the Botanic Gardens of South Australia (2015), urban biodiversity is maximized using an urban ecology approach in which nature is recognised as an integral part of a healthy functioning city, with people being one part of the greater urban ecosystem. Green infrastructure, including the urban forest and green cover in general, can play a significant role in enhancing urban ecosystems, not only for people, but also for native species biodiversity. For example, informed plantings and revegetation programs can help reduce impacts of habitat loss and fragmentation through revegetating areas that link otherwise isolated ecological assets like parks, gardens, reserves, coastal dune systems, and waterways. This not only provides additional habitat areas and resources for species (potentially serving as important refugia) but can also promote species conservation by facilitating species movements and dispersals needed to maintain genetic diversity and to remain in suitable habitat conditions in response to climate change induced habitat shifts (Garden et al. 2015).

Under an urban ecology approach, planting programs in urban areas would specifically consider the needs and sensitivities of native species. Whilst there will be species and context specific nuances, a good rule of thumb is to maximise the diversity of plants used in planting programs. In this sense, diversity of plant selection includes a diversity of plant taxon (i.e. Family, Genus and species), age classes, and structural types (e.g. trees, shrubs, grasses) (Garden et al. 2007, Garden et al. 2010). Increasing this planting diversity will be essential for building resilience into urban ecosystem, as well as meeting certain habitat requirements for different animal species, such as, foraging, shelter, and reproduction. If planting programs do not strive to be diverse, urban environments will be at higher risk of severe loss and degradation, resulting in greatly compromised resilience and healthy functioning of ecosystems, and subsequent significant impacts to people and wildlife.

The Santamour Diversity Index (SDI) is often used as a guide for achieving urban planting diversity, particularly in street trees (Santamour Jnr 1990). The SDI states that no tree

species should comprise more than 10% of a city's street tree population, no tree Genus should comprise more than 20%, and no tree Family should comprise more than 30%. This rule of thumb is often adapted to suit local requirements. For example, diversity targets applied for the City of Sydney and City of Melbourne range between no more than 20-40% of the one Family, 10-30% of the same Genus, and 5-10% of the same species.

In addition to meeting minimum standards for urban tree and green cover diversity, the spatial application of new urban forest and green cover plantings should also aim to create improved functional landscape connections for biodiversity and people. For example, in Greater Sydney the Government Architect of NSW has proposed a network of high-quality green space that connects town centres, public transport hubs, and major residential areas (Government Architect NSW 2018). Known as the Sydney Green Grid, it is intended to deliver an interconnecting network of open space that will keep the city cool, encourage healthy living, enhance biodiversity and ensure ecological resilience.

By explicitly considering plant diversity and spatial configuration, future investments can create more balanced outcomes that improve the liveability, health and resilience of cities for people, biodiversity and the environment.

5 Water Sensitive Urban Design

5.1 Benefits

Changes to our city, particularly infill development, can dramatically increase the amount of hard surfaces. When it rains, most of the rainfall that lands on hard (impervious) surfaces turns into runoff, significantly increasing the amount of water flowing from an area and reducing infiltration. The power of stormwater runoff erodes urban streams and conveys pollutants that have settled on the hard surfaces.

Urban densification contributes to greater volumes of stormwater reaching receiving waterways more often, more quickly and carrying an array of pollutants. Stormwater can carry a wide range of pollutants, including litter, leaves and debris, sediments, nutrients, micro-organisms, toxic substances, heavy metals and hydrocarbons – almost anything that deposits on hard surfaces.

Urban densification can increase flooding, dramatically reduce amenity and degrade the ecology of natural waterways. The traditional approach to managing stormwater (i.e. getting rid of it as fast as possible) also does not take advantage of stormwater as a precious alternative water source and does little to replenish local groundwater to support vegetation and associated urban green cover and canopy cover targets.

To protect our urban waterways and receiving waters, such as Gulf St Vincent, management of stormwater flow volumes and rates and treating stormwater to reduce pollutants and run-off impacts can no longer be ignored. It should be considered an essential part of planning and building new communities.

A component of WSUD is an approach to stormwater management that slows flows down, promotes use of alternative water and stormwater infiltration and captures pollutants transported by stormwater. Managing urban stormwater in a water sensitive manner not only provides many opportunities to integrate water features into urban design but improves the social and environmental amenity of urban development.

Other benefits include:

- increased water conservation by using stormwater for irrigation, household reuse and infiltration to improve soil moisture;
- improved stormwater quality leaving a site, therefore improved water quality in urban waterways and the Gulf;
- improved habitat and biodiversity through the establishment of ‘blue infrastructure’ (wetlands, raingardens etc.) and supporting green infrastructure;
- providing an adoption measure to help address climate change impacts such as flooding and urban heat island effect;
- improved amenity with increased vegetation and water elements;
- flood mitigation by slowing down water movement through urban areas with local infiltration, reuse and detention; and
- providing a sustainable source of water to support green infrastructure and associated benefits.

Error! Reference source not found. One of the most influential local analyses that reinforces the importance of WSUD, is the Adelaide Coastal Waters Study (Fox et al. 2007). It established that nutrients primarily from wastewater, and suspended sediment primarily from stormwater, are mainly responsible for the decline in ecological health of coastal waters off Adelaide. To improve water quality to a level that would sustain healthy seagrass, a 75% reduction in total nitrogen (TN) and 50% reduction in total suspended solids (TSS) loads from 2003 levels was recommended for land-based discharges overall. Implementation of WSUD can play a vital role in achieving these targets.

WSUD can be applied at a wide range of scales, from an individual allotment to a suburban wide approach. Therefore, implementing WSUD whenever an opportunity is triggered (e.g. a development application) is possible.

While WSUD can deliver many benefits, as listed above, careful considerations during design are required to ensure that the WSUD system selected is suitable for the site and does not compromise any structures, pavements or other assets in the vicinity. There are many design manuals and guidelines available to assist designers. In addition, the space required for WSUD measures needs to be considered to ensure that it does not compromise other uses within an urban area.

5.2 Objectives

To guide the design for stormwater systems and sites, WSUD has a range of objectives that can be measured and assessed. Design objectives generally fall into categories of water conservation, pollutant export reduction, flood management and landscape integration objectives. These are highlighted in the “Water sensitive urban design - Creating more liveable and water sensitive cities in South Australia” the State’s WSUD Policy Document (Department of Environment, Water and Natural Resources 2013) and cover water conservation, pollutant reduction, flow management and integration into landscapes. These are also consistent with WSUD objectives used in states along the eastern seaboard.

More specifically these objectives are:

Flow

- Maintain pre-development peak minor flows (e.g. 1 in 5 year average recurrence interval (ARI) or Q5, 20% annual exceedance probability (AEP))
- Safely manage major flows (e.g. Q100, 1% AEP)
- Or more site specific objectives (depending on the council)

Landscape integration

- Integrate WSUD within landscapes to provide enhanced site vegetation, create cooling effects, and amenity

Drinking water conservation

- Encourage water reuse and efficient appliances
- Promote water reuse for irrigation to support enhanced vegetation without increasing potable water demands

Pollutant load reduction (compared to the developed catchment/site with no treatment)

- Reduce annual loads of stormwater pollutants by the following amounts:
    - 80% Total Suspended solids (TSS)
    - 60% Total Phosphorous (TP)
    - 45% Total Nitrogen (TN)
    - 90% gross pollutants (litter)

Key references underpinning the science behind these objectives include Duncan (1999), Melbourne Water et al. (1999), Meyers et al. (2011) and Fletcher et al. (2014). These targets may be refined over time as further catchment-based data and information becomes available.

5.2.1 Managing stormwater volume for multiple objectives

Hydrology is one of the primary drivers of ecological condition of waterways. The ecological health of waterways is impacted by the hydrologic and water quality changes which occur due to urbanisation which creates major changes to stream morphology and hydrology with the latter often cited as a primary stressor of urban stream ecosystems (Anim, et al. 2018). Walsh et al. (2012) suggest that catchments with as little as 5–10% total imperviousness and conventional stormwater drainage are associated with poor in-stream ecological condition, reduced contributions to baseflows and increases in the frequency and magnitude of storm flows. However, catchments with a similar level of impervious surfaces that apply an informal drainage system that flows to forested hillslopes and use no direct piped discharge to a stream, show little hydrologic change and streams retain good ecological condition.

This research has been applied in the Healthy Waterways Strategy (Melbourne Water 2018) in which flow objectives target intact, high value waterways (i.e. in greenfield development). In this scenario, very large volumes of stormwater must be harvested and reused. The Little Stringybark Creek project (Walsh et al. 2012) provides an indication of the harvesting required. This project estimates that for 1 Ha of impervious surface, the volume of excess stormwater is:

- 2.6–3.0 ML/y in catchments with mean annual rainfall of 400 mm rising to; and
- 5.1–7.8 ML/y in catchments with 1200 mm/year of rainfall.

Thus, protecting stream ecological values in an urbanised catchment may require in the order of 50-90% reduction in flow volumes, with stormwater harvesting, infiltration and reuse key contributors to reaching such a target.

Less research has been undertaken on restoration of flows in already urbanised catchments (i.e. those with impervious areas substantially greater than 5% of the total catchment area). Given the practical challenges of harvesting 50-90% of flows and the limited scientific basis for such an approach for protecting stream ecology in developed catchments, the focus has instead historically been upon managing for water quality. This can still be achieved by infiltration and harvesting, for instance via green infrastructure and rainwater tanks. Other localised benefits of infiltration systems include urban cooling, associated with increases in soil moisture that support green infrastructure objectives for trees and canopy cover.

Urban infill often results in increased pressure on existing drainage infrastructure. This lowers the standard of flood protection provided by existing drainage infrastructure, in

particular the ‘minor’ system which represents a significant proportion of drainage infrastructure expenditure. (*Myers et al., 2017).*

Retaining stormwater on site (using both reuse and infiltration where conditions are suitable) has many benefits including retaining moisture in the soil profile, reducing pollutant export, water conservation and a reduction in discharge peak flow rates. Encourage the implementation of measures to prevent an increase in the volume of stormwater leaving a site and, where possible, couple with peak flow reduction to maintain the flood protection offered by the minor drainage system downstream.

Therefore, while flow management is an important part of WSUD, responses that are simultaneously practical, cost effective and scientifically justified tend towards:

- prioritising specific volume objectives to intact, high value waterways (typically those with catchments that have less than 5% impervious cover);
- managing flow by harvesting or disconnecting impervious areas from waterways (the effective impervious approach);
- taking a long term approach to addressing catchment imperviousness in redevelopment scenarios – essentially to ensure that effective imperviousness does not increase as infill development occurs; and
- using simple deemed to comply solutions such as a rainwater tank capturing (say) 50% of roof area.

The soil type and characteristics, in particular the propensity of the soil to expand or swell due to the presence of reactive clays, will be a key consideration in how and where infiltration systems to manage stormwater runoff volumes can be applied.

The Minister’s Specification SA 78AA, September 2003 On-Site Retention of Stormwater sets the criteria for the application of cost-effective technical solutions to the requirements for peak flow and volume management of stormwater. This guide offers deemed to satisfy solutions via system sizing charts for soakage trenches and wells. Caution should be taken when considering the application of infiltration systems on sites where reactive clay soils are the predominant soil type. Suitable offsets from buildings and property boundaries for these soil types fall outside the guidelines of the Minister’s Specification and further expert advice will be required for application of infiltration systems under these circumstances. If site constraints restrict adequate offsets being achieved, alternative stormwater management solutions may be more cost effective under these conditions.

5.3 How to implement and assess WSUD as part of a development

WSUD is consistently required interstate for new development with the development industry becoming familiar with design requirements over the last 15 years or so. This is particularly the case in Victoria, Queensland and New South Wales. WSUD is a widely known and accepted design consideration by the development industry and this translates into WSUD on-ground works as part of development.

There are a variety of ways that WSUD is required as part of new developments around the country. Generally, the implementation mechanism varies depending on the scale of development. WSUD can be required at every scale of development from large scale

greenfield sites to an extension of an existing dwelling. The point of subdivision, whether it is 1 into 2 or hundreds of allotments, is considered the best trigger to require WSUD as part of planning provisions and should be considered under the current planning reforms.

Typically, a subdivision of land requires planning approval and usually this triggers a need for WSUD to be implemented at the development scale. This can be directed at a local government scale (e.g. Onkaparinga) or through State wide policies (e.g. reciprocal EPA and State Planning polices, Victoria).

Requirements are typically expressed as measurable targets (that typically include stormwater flow rates and quality) as well as promoting stormwater reuse and integration of water into the landscape. Measurable targets are assessed using approved software – e.g. the Model for Urban Stormwater Improvement Conceptualization (MUSIC) is commonly used to assess the performance objectives for WSUD listed in Section 4.2 (See Box 4). Specific designs are then developed for individual developments to demonstrate how the objectives are achieved.

At smaller scales, some municipalities around Australia require WSUD compliance for any development application (for as small as a 50 m^2 house extension – City of Port Phillip, Victoria). WSUD can readily be applied at this scale.

The mechanism to assess WSUD also differs depending on scale. Larger developments typically will employ specialist designers to develop bespoke designs that maximise WSUD opportunities for site constraints and the landscape design for a development.

At smaller scales, developers are unlikely to engage specialist designers so authorities develop either simplified assessment tools or deemed to satisfy designs. This simplified approach to WSUD allows solutions to be included efficiently at smaller development scales, including single dwellings (and assessed as part of an application). Over time the integrated benefits of applying WSUD on small developments will accumulate. This is especially relevant to the development profile anticipated in many suburbs of Adelaide where “minor” infill development will account for a large proportion of new development.

Box 4. MUSIC - Model for Urban Stormwater Improvement Conceptualisation

The Model for Urban Stormwater Improvement Conceptualisation (MUSIC) was first released in 2001by the CRC for Catchment Hydrology, to provide urban water professionals with a decision support system to evaluate stormwater treatment measures and strategies.

MUSIC is software that helps developers and planners devise water sensitive urban designs (WSUD) and integrated water-cycle management capability (IWCM) to manage urban stormwater. Thousands of professionals working on stormwater management across Australia use MUSIC. In some states MUSIC is mandatory for designing new urban developments.

With MUSIC you can:

- simulate stormwater flows and detention from lot-scale to suburb-scale

- estimate the potential for stormwater harvesting and reuse, and the effects on downstream flows and water quality;
- model pollutants including suspended solids, total phosphorus and total nitrogen, and estimate the impacts of various treatment options
- model water balances
- compare the water-quantity, quality and cost vs benefit objectives achieved by alternative treatment-train scenarios
- plan entire stormwater systems.

Further details on MUSIC are provided at https://ewater.org.au/products/music/music-overview/

A flexible approach to stormwater management solutions, in association with the proposed introduction of performance-based policy for WSUD in the Planning and Design Code (the Code), would provide for solutions that are best suited to the site context. A planning system that supports sustainable stormwater management targets while offering mechanisms for off-site solutions where appropriate, may provide the most efficient and affordable model for delivering on WSUD objectives.

Stormwater off-set or so called “contribution in lieu” schemes are used around the country where developers can choose to purchase off-sets (either fully or partially) to meet WSUD requirements (e.g. Onkaparinga; Mackay Regional Council, Qld.; City of Kingston, Vic.). Successful off-set schemes are voluntary and have defined and costed WSUD opportunities that the off-set funds can be used to implement. Each Council has developed a WSUD strategy that sets out preferred precinct or catchment scale solutions, as the basis for offsets.

A thorough review of applying WSUD through planning mechanisms is provided in “Pathways for implementation of WSUD in SA” by the Goyder Institute (Cook et al., 2015). Select examples of different WSUD requirements for a range of scales around Australia are shown in
Table 7
~~Table 7~~ to provide context. The CRC for Water Sensitive Cities report Policy frameworks for water sensitive urban design in 5 Australian cities provides a comparative analysis of the policy regimes across five cities, including Adelaide. Based on these analyses, the report makes a range of planning reform recommendations for each State and for consideration nationally.

Table 7. Select examples of WSUD policies around Australia.

SELECT EXAMPLES OF WSUD POLICIES AROUND AUSTRALIA				
AREA	**POLICY**	**WHEN IT IS APPLIED**	**TARGET**	**ASSESSMENT***
City of Port Phillip (Vic.)	Planning Scheme (Clause 22.12)	individual lots (including >50m2 extensions)	stormwater quality flow reduction reuse	STORM tool
Victoria	State Planning Provisions (Clause 56.07)	residential subdivision > 5 ha	stormwater quality flow reduction	MUSIC
SA Murray Darling Basin councils	Integrated Water Management DPA	subdivision 5 - 20 lots	stormwater quality flow reduction	MUSIC
City of Moonee Valley (Vic.)	Planning Scheme (Clause 22.03)	allotments and small subdivisions	stormwater quality flow reduction/ reuse water integrated into landscape	STORM tool
City of Onkaparinga (SA)	Minimum Engineering Service Levels	subdivisions > 20 lots	stormwater quality	MUSIC
City of Marion (SA)	Development Plan (Water Sensitive Design)	all development > 40m2	flow rates	hydraulic calculations
City of Kingston (Vic.)	Planning Scheme (22.08 Environmentally sustainable development)	individual lots & subdivision, residential and non-residential	stormwater quality	STORM tool or MUSIC depending on scale

* STORM is a simplified web based assessment tool, MUSIC is a detailed hydrologic model needing specialist input

Water Sensitive SA has developed the Insite Water tool to assist state and local government and the development industry to assess the adequacy of the size of proposed WSUD elements on allotments. In particular, the tool allows the user to optimise stormwater management solutions, to maximise conservation of water resources; manage peak stormwater runoff flows and volume to ensure the carrying capacities of downstream systems are not overloaded; and manage stormwater runoff quality.

6 Discussion and recommendations

Based on the discussion of benefits, objectives and targets for green infrastructure (Section 4) and WSUD (Section 5), a series of recommendations have been prepared to guide the development of 'desired outcomes', 'performance outcomes policies' and 'deemed to satisfy criteria' within the Code.

The abbreviations for recommendations presented below relate to the abbreviations used in Section 7.2 and 7.3. For example, Green infrastructure recommendation 1 = G1, and WSUD recommendation 1 = W1).

Recommendation

- The Planning and Development Code includes desired outcomes, performance outcomes and deemed to satisfy criteria based on the recommendations outlined in this section. (See Section 7 for Summary of recommendations).

The recommendations have been developed assuming that:

- the new Code will include revised or new definitions for some key terms;
- a list of 'minimum requirement' application documentation will be presented in the regulations to inform the quality of development applications; and
- some requirements of the Code may require a revision to the relevant legislation.

While the focus of this report is the identification of opportunities to improve performance-based planning policy, the following are important to underpin implementation of the new Code:

- Community engagement and education – Community engagement and improved knowledge through educational opportunities will continue to play an important role in encouraging on-ground action to achieve green infrastructure and WSUD outcomes; and

- Monitoring and compliance – Compliance monitoring should be undertaken to determine whether imposed Planning Conditions are being adhered to in new developments for both green infrastructure and WSUD.

Recommendations

- Support should continue to be provided for existing and new initiatives that raise awareness of the benefits of green infrastructure and WSUD and engage the community in establishing and maintaining green infrastructure and WSUD projects from the dwelling to landscape scale.
- Noting current resource limitations, monitoring and compliance should be further explored either through site-based assessments by compliance officers or through the use of remote sensing technology to determine, for example, the extent to which green cover and tree canopy targets are being met. (G13 and W5)

6.1 Green infrastructure

The challenge for green infrastructure is to condense multiple objectives into simple, measurable, transparent performance measures that will result in good outcomes. By having measurable performance outcomes and deemed to satisfy criteria that result in good outcomes most of the time, significant progress will be made in promoting and sharing the significant benefits of green infrastructure.

The main focus of this document is to address the challenge presented by infill development at the allotment scale and therefore the performance measures need to take this into account. Another important consideration is the ease of assessment and compliance and the need for the performance-based provisions to be independent of scale (i.e. so they apply universally). If performance measures are too complex, it is highly likely the policies will be poorly implemented.

Deep soil and tree protection zones

Given that future canopy cover cannot be assessed at the time of a development application, dedicated areas of land capable of sustaining trees and associated greening should be used as a surrogate. Associated soil characteristics could include that:

- the soil is uncompacted and freely draining;
- the soil is good quality for plants and complies with Australian Standard Soils for landscaping and garden use AS4419 - 2003[11];
- provision for a deep soil zone; and
- a proportion of the deep soil area can be used as substrate for permeable paving.

Ensuring that soil remains uncompacted during the construction phase could be assisted by establishing a tree protection zone around existing vegetation or areas for new plantings. This should be in accordance with AS 4970-2009 which relates to the "Protection of trees on development sites". This would ensure that heavy machinery does not impact the area. Designated soil areas for new plantings could then be deep ripped to 70 cm at 50 cm intervals to ensure that soil is suitable for tree planting.

Achieving future canopy also requires determining how much area to assign as deep, uncompacted soil, given the high value of allotments and what is a 'reasonable' requirement that will also deliver meaningful green infrastructure outcomes. It is important that this area provides sufficient space for trees and other vegetation to be planted thus providing for canopy cover. Areas for minimum deep soil should be developed to ensure they also align with provisions for private and communal open space.

To determine a required area of deep soil to support future canopy, a ratio of how much canopy cover results from an area of deep, uncompacted soil needs to be assumed. It should be noted that for optimal health of a tree, a ratio of 1:1 is recommended i.e. 1m^2 of deep soil per 1 m^2 of tree canopy.

Drawing on feedback received during the development of this paper, if sufficiently large trees are desired a ratio of 2:1 – 4:1 is required (i.e. 1 m^2 of deep soil can equate to 2-4 m^2 of

[11] This Standard sets out requirements for general purpose soils, top dressing, topsoil and landscaping mixes, for domestic and commercial use, supplied in either bulk or bagged lots.

canopy). Clearly this is not accurate for all tree species, with the actual ratio dependent on each species. While not proposed here, an alternate would be to develop a ratio "look up table" for different species, although it is anticipated that this would be too complex to use as the basis of the proposed performance provisions.

Using a ratio of 3:1 (i.e. midway between 2:1 to 4:1), 7-12% of planted deep, uncompacted soil at a site could result in around 21% to 36% (depending on the trees species), which is broadly consistent with the 30% city-wide canopy cover targets contained in the 30 Year Plan for Greater Adelaide.

Recommendation

- Establish minimum required areas of uncovered deep soil zones to be provided for different sized developments to provide sufficient space for tree canopy targets in the 30 Year Plan for Greater Adelaide to be met. (G1)
- Definitions for deep soil zones and tree protection zones be included in relevant planning documents (G2).

Landscaping plans

Landscaping plans are used by some local government authorities to require the planting of vegetation of a certain minimum size in association with medium density residential development. However, landscape plans are used in an adhoc way in South Australia, often in relation to landscape planting requirements. In contrast, landscape plans are already a requirement for development applications in many councils in Victoria and New South Wales. In addition to consistent requirements for landscape plans, Schedule 5 of the Development Regulations 2008 should be carried over to the new PDI Regulations and outline information regarding the minimum requirements for general landscaping plans. Currently this Schedule only requires the location of regulated trees to be identified with other landscaping at the discretion of individual councils. Consistent and quality landscape plans will play an important function in the delivery of tree canopy cover and urban green cover targets.

Recommendation

- Ensure consistent requirements to provide adequate landscape plans (G3).

Green cover assessment

Given that tree canopy targets alone will not deliver green cover targets, there is a need for provisions that assess whole of site green cover. Rather than mandating minimum areas of green cover, an alternate is to adopt a scheme similar to the Seattle Green Factor or Washington Green Area Ratio. Such a scheme, which could be called the "Adelaide Green Factor" (or similar), would provide flexibility in how green cover targets are met and could allow for tree plantings, green walls, green roofs, and structural soil systems to all contribute to achieving green cover targets. This would need to be supported by creation of an easy to complete online assessment tool, which could draw on information from a landscape plan. The Adelaide Green Factor could be applied at the point of sub-division.

Where green cover targets remain difficult to achieve, even with the flexibility afforded by a green cover scoring system as described above, another option is to establish a trading scheme for offsite green cover solutions. This would mean that where green cover targets

cannot be met on a given site, funds are provided by a developer to establish green cover at an alternate site.

If a green cover scoring system, green cover offsets scheme and WSUD targets are pursued at the same time it would be important that they work consistently together to achieve common outcomes. This could be addressed by developing an index that integrates green infrastructure, tree canopy and WSUD, and prioritises solutions that achieve all three.

Recommendation

- Provide flexibility in how green cover targets are met by implementing a green cover scoring system. (G4)
- Establish a trading scheme for offsite green cover solutions for situations where streetscape solutions are deemed by the local Council to provide the greatest community benefit. (G5) or
- Develop an index that integrates green infrastructure, tree canopy and WSUD, and prioritises solutions that achieve all three. (G6)

Disconnecting impervious areas from waterways

Impervious areas of a development can be disconnected from stormwater systems using green infrastructure as a buffer between the two. This is an effective technique to reduce peak stormwater flows and volumes and reduce pollutant loads to urban streams and coastal water environments.

Recommendation

- Develop guidance material to encourage the use and placement of green infrastructure to disconnect impervious areas from waterways and regional drainage systems (i.e. guidance material to encourage multi-functional green infrastructure). (G7)

Open space provision

Open space presents a major opportunity for increasing tree canopy and green cover. Clause 50 (1)(c) of the Development Regulations requires *"up to 12.5 per cent in area of the relevant area be vested in the council or the Crown (as the case requires) to be held as open space".* This equates to around 4 ha per 1,000 people in a lower density development area of 35 hectare). The adequacy of 'up to 12.5% of land for open space' in higher density developments has been questioned in a number of previous studies and there is a sense that additional land is justified. Given the need for large areas of public open space to be used for sport and recreation, these areas alone will be insufficient to meet canopy cover targets across metropolitan Adelaide and therefore private open space is also critical.

Recommendation

- Investigate new criteria for rate of open space provision for medium and high-density developments based upon population density. (G8)

Protecting existing trees

The first requirement is the retention of existing trees to maintain canopy. This is essential given that overall canopy is in decline in Adelaide and is at odds with The 30-Year Plan for Greater Adelaide's Urban Green Cover Target. The performance outcome needs to extend

beyond the existing definition and protection provisions of significant and regulated trees, which only represent a small percentage of all trees that contribute to canopy cover. This could be done by broadening the definition for what constitutes significant or regulated trees (such as by reducing the circumference at 1.0 m from ground level), developing a new definition for existing mature trees and/or offering development outcome incentives for the retention of mature vegetation.

Recommendations

- Provide greater protection for existing trees such as by developing a new definition for existing trees with a trunk circumference less than that of significant or regulated trees. (G9)
- Investigate options for incentive-based planning policy which facilitates desirable development outcomes for proponents (i.e. additional building levels, higher density outcomes, a trade off of private open space for larger areas of communal open space for example) where mature trees, which may not be otherwise protected, are retained and integrated into a development proposal. (G10)

Valuing trees

Where existing trees (over a certain size) are not able to be retained and/or are approved for removal, developers should contribute to a tree fund. This would build on existing provisions for an "Urban trees fund" in Section 50B of the *Development Act 1993,* which is currently applied inconsistently across councils. Funds would be used for increasing tree canopy on public and/or private land. Current costs for removing significant or regulated trees on private land are very low, and generally considered to be ineffective as a disincentive to removal. To address this, a new method for determining the cost of removing existing mature trees / the actual value of these trees should be developed (see discussion in Section 4.3.5), or a common method should be agreed to (e.g. that used by the City of Melbourne), which considers the structural, amenity, ecological services value of trees drawing on a range of existing valuation methods. This method should then be used as the basis for determining the cost of removing trees and provide sufficient funds to plant new trees and/or acquire additional land on which green cover can be planted.

Recommendation

- Develop an agreed approach for (a) valuing trees, and (b) administering tree funds, for the purpose of development approvals. (G11)

Biodiversity

Maintaining biodiversity and ecosystem health is essential if ecosystems are to continue to deliver beneficial services to cities and urban areas. Under an urban ecology approach, planting programs in urban areas should specifically consider the needs and sensitivities of native species. In addition to meeting minimum standards for urban tree and green cover diversity, the spatial application of new urban forest and green cover plantings should also aim to create improved functional landscape connections for biodiversity and people. By explicitly considering plant diversity and spatial configuration, future investments can create more balanced outcomes that improve the liveability, health and resilience of cities for people, biodiversity and the environment.

Recommendation

- Establish minimum diversity guidelines for future urban tree planting, considering the local and broader landscape context, and encourage alignment between green infrastructure investment, ecosystem health, biodiversity conservation, and landscape connectivity. (G12)

6.2 WSUD

WSUD policies have been included in development plans for a number of years. There is the opportunity to improve a number of these. Given a large proportion of development in Adelaide is predicted to be infill, a focus of this background paper is how to implement WSUD at the allotment scale in a fair, transparent and meaningful way. This is not intended to take focus from larger developments implementing WSUD, rather it is to ensure that all developments, large or small, have requirements for WSUD that are implemented through the planning scheme.

This approach will help to offset the accumulated impacts of infill development and greenfield developments on (mainly) stormwater and downstream waterways (and in most cases also having the added benefit of improving local green amenity).

6.2.1 Large developments (>2,500m^2 for residential and >5,000m^2 for non-residential)

For larger developments (i.e. greater than 2,500m^2) the following performance measures are recommended for the Planning and Design Code. These are transparent, measurable and will lead to widespread implementation of WSUD.

Water conservation

- WELS 3-star minimum for fittings and appliances
- Encourage water reuse
- SA residential building requirements for Class 1 Buildings

Pollutant load reduction (compared to no treatment)

- Reduce annual loads of stormwater pollutants by the following amounts:
    - 80% Total Suspended solids (TSS)
    - 60% Total Phosphorous (TP)
    - 45% Total Nitrogen (TN)
    - 90% gross pollutants (litter)

Flow

- Maintain pre-development peak minor flows (e.g. 1 in 5 year average recurrence interval (ARI) or Q5, 18.1% annual exceedance probability (AEP))
- Safely manage major flows (e.g. Q100, 1% AEP)
- Any more site-specific flow rate objectives (depending on the council)
- Promote flow volume reduction techniques such as stormwater reuse and infiltration.

Landscape integration

- Integrate WSUD within landscapes to provide enhanced site vegetation and amenity, improve stormwater quality, reduce stormwater discharges and support cooling effects.

Assessment of these performance measures is to be demonstrated with a MUSIC model (following SA MUSIC guidelines), a flood management report and an integrated landscape plan for the site. It is not recommended that sites larger than 2,500 m^2 should use a Deemed to Satisfy solution.

6.2.2 Small developments (<2,500m^2 for residential and <5,000m^2 for non-residential)

At small scales (e.g. individual lots, or turning one lot into two, townhouses and commercial developments etc.) a simplified approach to assessing WSUD is recommended. This will help to improve transparency of WSUD requirements, make assessment easier and therefore increase the likelihood of widespread adoption.

It is also important not to be prescriptive of any solutions, but rather set performance objectives that can be met in a variety of ways.

To assess these 'simplified' objectives an on-line tool is proposed that enables quick and easy inputs and assessment.

A similar approach has been used in a range of Melbourne councils (and Melbourne Water) - the STORM tool (*www.storm.melbournewater.com.au*). This requires simple inputs to a web-based program (e.g. location, site details and proposed WSUD measures) and then calculates a 'score' to check against compliance. It does not require a WSUD expert to develop a WSUD site strategy.

The Insite Water online stormwater assessment tool for small-scale development is similar to the STORM tool as it allows for the assessment of the stormwater quality improvement of various lot scale WSUD solutions. However Insite Water differs in that it provides for an assessment that considers objectives for the management of stormwater runoff peak flows, volumes and water conservation, in addition to runoff quality. Insite Water is currently in the final stages of testing.

Recommendations

- Provide a deemed to satisfy approach for small development (<2,500m^2 for residential and <5,000m^2 for non-residential). (W3)
- Develop a pilot trial of the Insite Water on-line tool with metropolitan Councils that enables quick and easy inputs and assessment for small scale development. (W4)

Water Sensitive SA is currently developing an on-line tool to serve this purpose that is tailored to Adelaide conditions and includes measures to be employed at small scales. This tool will assess a development's resultant stormwater quality, volume management and flow management criteria using simplified inputs. Development proponents will need to demonstrate their development complies with the tool by providing an outcomes certificate.

The tool is currently in beta testing and can be viewed at:

www.watersensitivesa.insitewater.com. It will be accompanied by a guideline for stormwater management for small-scale developments.

The tool is based on the following performance measures that are adopted to enable a simplified modelling approach to be used within the on-line tool. Meeting these objectives will for most cases result in WSUD measures that will meet the same objectives as the larger scale developments (i.e. those listed above).

Stormwater quality
Meet 45% reduction in total nitrogen load.

Water conservation
Water conservation and efficiency achieved through:

- WELS 3-star minimum for the majority of fittings and appliances
- Encourage water reuse

Flooding

- Maintain the 1 in 5 year ARI (20% Annual Exceedance Probability (AEP)) storm event peak flow rate – residential;
- Maintain the 1 in 10 year ARI (10% AEP) – commercial; and
- More specific requirements may exist for each municipality

Harvest and use or infiltrate stormwater

- Reduce post development runoff volumes

7 Summary of recommendations

7.1 Overarching recommendations

Opportunities exist to better support the objectives and targets for tree canopy cover, urban green cover and water sensitive urban design within The 30-Year Plan for Greater Adelaide. The new Planning & Design Code, associated regulations, assessment tool for third party self-certification, incentives and guidelines will all play an important role in the planning system.

The recommendations below provide a summary of the key initiatives that will lay the foundation for a policy and regulatory framework that will shape our cities and communities, delivering resilience and wellbeing. The proposed timeframes for the key recommendations are within the next 6 months to two years to ensure a cohesive package of works that compliment implementation of Generation 1 (and future generations) of the Planning and Design Code.

Support should continue to be provided for existing and new initiatives that raise awareness of the benefits of green infrastructure and WSUD and engage the community in establishing and maintaining green infrastructure and WSUD projects from the individual dwelling to landscape scale.

The Planning and Code recommendations presented below are considered to be the most important in meeting The 30-Year Plan for Greater Adelaide green infrastructure targets.

7.2 Green infrastructure recommendations

Recommendation	Challenge/ opportunity	P&D Code	Regulation	Incentives	Guidelines	Potential partners	When
G1. Establish minimum required areas of uncovered deep soil zones to be provided for different sized developments to provide sufficient space for tree canopy targets in The 30 Year Plan for Greater Adelaide to be met.	New developments need to provide minimum space for the potential establishment of tree canopy cover.	✓				DPTI, LGA	Generation 1 of the Code
G2. Definitions for deep soil zones and tree protection zones be included in relevant planning documents.	Provide clarity for development applicants on green infrastructure terminology	✓	✓				Generation 1 of the Code
G3. Ensure consistent requirement to provide adequate landscape plans.	Consistent and quality landscape plans will play an important function in the delivery of tree canopy cover and urban green cover targets	✓	✓		✓	DPTI, LGA	Generation 1 of the Code
G4. Establish a green cover score system and assessment tool.	The cumulative loss of private green space is a significant contributor to Adelaide's urban heat island.		✓		✓	DPTI, DEW, Water Sensitive SA, AILA, LGA	Generation 2 of the Code
G5. Establish a trading scheme for offsite green cover solutions for situations where streetscape solutions are deemed by the local Council to provide the greatest community benefit.	Provide flexibility in how green cover targets are met as appropriate to the site and context		✓	✓	✓	DPTI, DEW, Water Sensitive SA, AILA, LGA	Generation 2 of the Code

Recommendation	Challenge/ opportunity	P&D Code	Regulation	Incentives	Guidelines	Potential partners	When
G6. In lieu of recommendation 4, develop an index that integrates green infrastructure, tree canopy and WSUD, and prioritises solutions that achieve all three.	WSUD that integrates water back into the urban landscape can support green infrastructure			✓	✓	DPTI, DEW, Water Sensitive SA, AILA, LGA	Generation 2 of the Code
G7. Develop guidance material to encourage the use and placement of green infrastructure to disconnect impervious areas from waterways and regional drainage systems (i.e. guidance material to encourage multi-functional green infrastructure).	Communities can no longer afford single purpose green spaces. Integrated design will be critical to deliver of multiple benefits from a single asset				✓	Water Sensitive SA, CRCWSC	June 2020
G8. Investigate new criteria for rate of open space provision for medium and high-density developments based upon population density.	12.5% open space targets were created for low density developments. Higher density precincts will require a different metric for determining open space needs of the community	✓	✓			DPTI, AILA, Water Sensitive SA	Generation 2 of the Code
G9. Investigate options for incentive-based planning policy which facilitates desirable development outcomes for proponents (i.e. additional building levels, higher density outcomes, a trade-off of private open space for larger areas of communal open space for example) where mature trees, which may not be otherwise protected, are retained and integrated into a development proposal.	Provide incentives to deliver greater density while maximising canopy cover and urban green cover as appropriate to the site and context	✓		✓		DPTI, AILA	Generation 1 of the Code
G10. Provide greater protection for existing trees with a trunk circumference less than that of significant or regulated trees.	Canopy cover and urban green cover targets will not be met if unregulated mature		✓			DPTI, DEW, Treenet	Generation 2 of the Code

Recommendation	Challenge/ opportunity	P&D Code	Regulation	Incentives	Guidelines	Potential partners	When
	trees are not protected or replaced if removed.						
G11. Develop an agreed approach for (a) valuing trees, and (b) administering Urban Tree Funds, for the purpose of development approvals.	Methods calculating the value of trees identified for removal in Adelaide do not consistently take account of their age, vigor, useful life expectancy, amenity value, and ecological services value.		✓			DPTI, Treenet, LGA	Generation 2 of the Code
G12. Establish minimum diversity guidelines for future urban tree planting, considering the local and broader landscape context, and encourage alignment between green infrastructure investment, ecosystem health, biodiversity conservation, and landscape connectivity.	Effectively integrating biodiversity programs with urban forest strategy implementation in the public and private realm.				✓		Generation 2 of the Code
G13. Monitoring and compliance either through site-based assessments by compliance officers or through the use of remote sensing technology.	Benchmark progress towards canopy cover and urban green cover targets.					DPTI, DEW	Ongoing

7.3 WSUD Recommendations

Recommendation	Challenge/ opportunity	P&D Code	Regulation	Incentives	Guidelines	Potential partners	When
W1. Provide easily assessable WSUD criteria (in the form of new 'deemed to satisfy' criteria) for all developments that focus on water conservation, stormwater quality improvements and peak flow management	Practical solutions exists to meet WSUD targets at a range of scales from the allotment scale through to large scale land divisions	✓			✓	Water Sensitive SA / DPTI	Generation 1 of the Code
W2. Promote landscape integration of WSUD, stormwater volume reduction from developments and combining WSUD and green infrastructure measures for multiple benefits	Practical solutions exists to meet WSUD targets at a range of scales from the allotment scale through to large scale land divisions	✓			✓	Water Sensitive SA / DPTI	Generation 1 of the Code
W3. Provide a 'Deemed to Satisfy' solution for small developments (<2,500m2 for residential and <5,000m2 for non-residential) that addresses the identified performance measures for stormwater quality, water conservation, and flooding.	Simple deemed to satisfy solutions will support efficient development approvals while delivering better outcomes for urban water management	✓			✓	Water Sensitive SA / DPTI	Generation 1 of the Code
W4. Develop a pilot trial of the Insite Water on-line WSUD/stormwater tool with metropolitan Councils that enables quick and easy inputs and assessment for small-scale development.	Provide flexibility in how WSUD performance targets are met as appropriate to the site and context Note: Insite Water tool currently in beta testing			✓		Water Sensitive SA / DPTI	Generation 1 of the Code
W5. Monitoring and compliance through site-based assessments by compliance officers	Ensure WSUD solutions are implemented in accordance with approved plans to deliver upon performance targets						Ongoing

8 References

Alexandri, E, and P Jones. 2008. “Temperature decreases in an urban canyon due to green walls and green roofs in diverse climates.” *Building and Environment* 43 (4): 480-493.

Amati, M, M Boruff, B Caccetta, P Devereux, and D Kas. 2017. *Where should all the trees go? Investigating the impact of tree canopy cover on socio-economic status and wellbeing in LGA’s.* Prepared for Horticulture Innovation Australia Limited by the Centre for Urban Research, RMIT University.

Anim, D, T Fletcher, G Pasternack, and M Burns. 2018. “Effect of urbanization on stream hydraulics.” *River Research and Applications* 1-14. doi:DOI: 10.1002/rra.3293.

Arbor Carbon. 2016. *Airborne Thermal Imagery and Analysis 2016 - Resilient South .* Report No. 16-04 prepared for Resilient South.

Armson, D, M A Rahman, and A R Ennos. 2013. “A comparison of the shading effectiveness of five different street tree species in Manchester, UK.” *Arboriculture and Urban Forestry* 39: 157-164.

Botanic Gardens of South Australia. 2015. “Green Infrastructure Evidence Base.” The Green Infrastructure Project is a partnership between DEWNR; DPTI; Botanic Gardens of South Australia; Natural Resources, Adelaide and Mount Lofty Ranges; and Renewal SA. Accessed March 2, 2018. http://gievidencebase.botanicgardens.sa.gov.au/.

Broadbent, A, A Coutts, N Tapper, and M Demuzere. 2018. “The cooling effect of irrigation on urban microclimate during heatwave conditions.” *Urban Climate* 309-329.

Cameron, D A, and N S Beal. 2018. “Estimation of foundation movement and design of footing systems on reactive soils for the effects of trees.” *Australian Geomechanics Journal* 46(3): 97-113.

Choi, L, and B McIlrath. 2016. “South Australia's Planning Framework for Water Sensitive Urban Design.” In *Statutory Planning for Water Sensitive Urban Design (Project B5.1)*. Cooperative Research Centre for Water Sensitive Cities Ltd. B5. 1-3.

City of Charles Sturt. 2012. *Best Practice Open Space in Higher Density Developments.* Adelaide: City of Charles Sturt.

City of Kingston. 2018. *Preparing a landscape plan: Planning guide and checklist.* Accessed November 26, 2018. file:///C:/Users/User/Downloads/Kingston-Landscape-Guide_FINALWEB.pdf.

City of Port Adelaide Enfield. 2016. *AdaptWest Climate Change Adaptation Plan.* Prepared for the City of Port Adelaide Enfield by URPS in collaboration with Seed Consulting Services and AECOM.

City of Sydney. 2016. *Sydney Landscape Code. Volume 2: All Development Except for Single Dwellings.* Sydney: City of Sydney.

Coutts, A, A Broadbent, J Thom, M Loughnan, and N Tapper. 2014. *The Impacts of WSUD Solutions on Human Thermal Comfort: Green Cities and Microclimate.* Cooperative Research Centre for Water Sensitive Cities, Victoria.

Coutts, A, and N Tapper. 2017. *Trees for a Cool City: Guidelines for optimised tree placement.* Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.

CRC for Water Sensitive Cities. 2017. "The climatic benefits of green infrastructure." https://watersensitivecities.org.au/wp-content/uploads/2017/11/IndustryNote_Climatic-benefit-of-green-infrastructure.pdf.

Davern, M, A Farrar, D Kendal, and B Giles-Corti. 2017. *Quality Green Space Supporting Health, Wellbeing and Biodiversity: A Literature Review.* Report prepared for the Heart Foundation, SA Health, Department of Environment, Water and Natural Resources, Office of Recreation and Sport, and Local Government Association (SA). University of Melbourne, Victoria.

Department of Environment, Water and Natural Resources. 2013. *Water sensitive urban design: Creating more liveable and water sensitive cities in South Australia.* Government of South Australia.

Donovan, Geoffrey H, David T Butry, Yvonne L Micahel, Jeffrey P Prestemon, Andrew M Liebhold, Demetrios Gatziolis, and Megan Y Mao. 2013. "The relationship between trees and human health: Evidence from the spread of the emerald ash borer." *American Journal of Preventative Medicine* 44 (2): 139-145.

Duncan, H. 1999. *Urban stormwater quality : a statistical overview.* Clayton, Victoria: CRC for Catchment Hydrology.

Dye, C. 2013. *The World Health Report 2013: Research for Universal Health Coverage.* World Health Organisation, Geneva.

Fjortoft, I. 2001. "The natural environment as a playground for children: the impact of outdoor play activities in pre-primary school children." *Early Childhood Education Journal* 29 (2): 111-117.

Fletcher, T D, G Vietz, and C J Walsh. 2014. "Protection of stream ecosystems from urban stormwater runoff: The multiple benefits of an ecohydrological approach." *Progress in Physical Geography: Earrth and Environment* 38 (5): 543-555. doi:https://doi.org/10.1177/0309133314537671.

Fowdar, H, A Deletic, B E Hatt, and N Barron. 2018. *Adoption Guidelines for Green Treatment Technologies.* Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.

Garden, J G, C A McAlpine, and H P Possingham. 2010. “Multi-scaled habitat considerations for conserving urban biodiversity: native reptiles and small mammals in Brisbane, Australia.” *Landscape Ecology* 25 (7): 1013–1028.

Garden, J G, C A McAlpine, H P Possingham, and D N Jones. 2007. “Habitat structure is more important than vegetation composition for local-level management of native terrestrial reptile and small mammal species living in urban remnants: a case study from Brisbane, Australia.” *Austral Ecology* 32 (6): 669-685.

Garden, J G, T O'Donnell, and C P Catterall. 2015. “Changing habitat areas and static reserves: challenges to species protection under climate change.” *Landscape Ecology* 30: 1959–1973. doi:https://doi.org/10.1007/s10980-015-0223-3.

Government Architect NSW. 2017. *Greener Places: Establishing an urban Green Infrastructure policy for New South Wales (Draft).* NSW Government.

Government Architect NSW. 2018. *Sydney Green Grid.* Sydney. Accessed November 28, 2018. https://www.governmentarchitect.nsw.gov.au/projects/sydney-green-grid.

Government of South Australia. 2010. *Technical manual for water-sensitive urban design in Greater Adelaide.* Technical Manual – December 2010. https://www.sa.gov.au/topics/planning-and-property/land-and-property-development/planning-professionals/water-sensitive-urban-design.

Goyder Institute for Water Research. 2016. *SA Climate Ready - Climate Projections for South Australia - Adelaide and Mt Lofty.* http://www.goyderinstitute.org/_r210/media/system/attrib/file/201/SA%20Climate%20Ready%20Regional%20Summary%20-%20AMLR.pdf.

Grigsby-Toussaint, DS, KN Turi, M Krupa, NJ Williams, SR Pandi-Perumal, and G Jean-Louis. 2015. “Sleep insufficiency and the natural environment: results from the US Behavioural Risk Factor Surveilland System survey.” *Preventative Medicine* 78: 78-84.

Gunawardena, A, F Zhang, J Fogarty, and M S Iftekhar. 2017. *Review of non-market values of water sensitive systems and practices: An update.* Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.

Hope, P. et al. 2015, Southern and South-Western Flatlands Cluster Report, Climate Change in Australia Projections for Australia’s Natural Resource Management Regions: Cluster Reports, eds. Ekström, M. et al., CSIRO and Bureau of Meteorology, Australia.

Jensen Planning + Design. 2011. *Stormwater Management Plan: Cities of Holdfast Bay and Marion. Discussion Paper: Development Potential within the Catchment.* Prepared for the Cities of Holdfast Bay and Marion.

Johnson, T. 2017. *Trees, stormwater, soil and civil infrastructure: synergies towards sustainable urban design. PhD Thesis. .* Adelaide: University of South Australia.

Lin, B.-S., and Y.-J. Lin. 2010. “Cooling effect of shade trees with different characteristics in a subtropical urban park.” *Hortscience* 45: 83-86.

Loughnan, M, N Tapper, N Phan, T Lynch, and K McInnes. 2013. *A spatial vulnerability analysis of urban populations during extreme heat events in Australian capital cities.* Gold Coast: National Climate Change Adaptation Research Facility.

Lovasi, GS, JW Quinn, KM Neckerman, MS Perzanowski, and A Rundle. 2008. “Children living in areas with more street trees have lower prevalence of asthma.” *Journal of Epidemiology and Community Health* 62: 647-349.

McAdam, J. 2010. “Green Infrastructure for Southwestern Neighbourhoods.” In *Report prepared for Watershed Management Group*, by T Syracuse, J DeRoussel and K Roach. Watershed Management Group.

Melbourne Water et al. 1999. *Best Practice Environmental Management Guidelines for Urban Stormwater.* Collingwood, Victoria: CSIRO Publishing, Prepared for the Stormwater Committee with assistance from the Environment Protection Authority, Melbourne Water Corporation, Department of Natural Resources and Environment and Municipal Association Victoria.

Meyers, B, S Cook, D Maheepala, D Pezzaniti, S Beecham, G Tjandraatmadja, A Sharma, G Hewa, and L Neumann. 2011. *Interim Water Sensitive Urban Design Targets for Greater Adelaide. Goyder Institute for Water Research Technical Report Series No. 11/7.* Adelaide, South Australia: CSIRO.

(Myers, B, Pezzaniti, D & Kemp, D 2017, The impact of infill development and WSUD solutions on minor drainage system performance - Australian Flow Management Group, University of South Australia, Adelaide, SA, Australia.

Moore, G M. 2006. “Urban Tree Valuation - A current perspective and progress report.” *The 7th National Street Tree Symposium 2006.* https://treenet.org/wp-content/uploads/2017/06/06TS-URBAN-TREE-VALUATION_Dr-GM-Moore.pdf.

Natural Resources Adelaide and Mount Lofty Ranges. 2018. Accessed May 2, 2018. http://www.naturalresources.sa.gov.au/adelaidemtloftyranges/plants-and-animals/green-infrastructure.

Norton, B A, A M Coutts, S J Livesley, R J Harris, A M Hunter, and N S Williams. 2015. “Planning for cooler cities: A framework to prioritise green infrastructure to mitigate high temperatures in urban landscapes.” *Landscape and Urban Planning* 134: 127-138.

Nowak, D, S Hirabayashi, A Bodine, and E Greenfield. 2014. “Tree and forest effects on air quality and human health in the United States.” *Environmental Pollution* 193: 119-129.

Parsons, PG, R Neale, P Wolski, and A Green. 1998. “Shady side of solar protection.” *Medical Journal of Australia* 168 (7): 327-330.

Phillips, B, M van der Sterren, and J Argue. 2016. “Chapter 4. Stormwater Volume Management.” In *ARR: A guide to flood estimation*, by Geoscience Australia. Commonwealth of Australia.

Pitman, S D, C B Daniels, and M E Ely. 2015. “Green infrastructure as life support: urban nature and climate change.” *Transactions of the Royal Society of South Australia* 139 (1): 97–112. doi:http://dx.doi.org/10.1080/03721426.2015.1035219.

Santamour Jnr, F S. 1990. “Trees for urban planting: Diversity, uniformity, and common sense.” *Proceedings of the 7th Conference of the Metropolitan Tree Improvement Alliance.* 57-65.

Seed Consulting Services. 2016. *Tree Canopy Cover in the City of Charles Sturt – Benchmark Assessment.* A report prepared for the City of Charles Sturt, South Australia.

Seed Consulting Services, Airborne Research Australia and EnDev Geographic. 2017. *Western Adelaide Urban Heat Mapping Project Report .* Adelaide: Prepared for the Cities of West Torrens, Charles Sturt and Port Adelaide Enfield, and the Adelaide Mount Lofty Ranges Natural Resources Management Board.

Shashua-Bar, D, D Pearlmutter, and E Erell. 2011. “The influence of trees and grass on outdoor thermal comfort in a hot-arid environment.” *International Journal of Climatology* 31:1498-1506.

Sugiyama, T, E Leslie, B Giles-Corti, and N Owne. 2008. “Associations of neighbourhood greenness with physical and mental health: do walking, social coherence and local social interaction explain the relationships?” *Journal of Epidemiology and Community Health* 69: e9.

Takano, T, K Nakamura, and M Watanabe. 2002. “Urban residential environments and senior citizens' longevity in megacity areas: the importance of walkable green spaces.” *Journal of Epidemiology and Community Health* 56 (12): 913-918.

Thom, J, A Coutts, A Broadbent, and N Tapper. 2016. “The influence of increasing tree cover on mean radiant temperature across a mixed development suburb in Adelaide, Australia.” *Urban Forestry and Urban Greening* 20: 233-242.

United Nations World Water Assessment Programme and UN-Water. 2018. *The United Nations World Water Development Report 2018: Nature-Based Solutions for Water.* Paris: UNESCO.

Walsh, C, T Fletcher, and M Burns. 2012. “Urban Stormwater Runoff: A New Class of Environmental Flow Problem.” *PLoS ONE 7(9): e45814* https://doi.org/10.1371/journal.pone.0045814.

Water by Design. 2011. *Framework for the Integration of Flooding and Stormwater Management into Open Space. Version 1.1. .* Healthy Waterways Limited.

Wong, T, R Allen, R Brown, A deletic, L Gangadharan, W Gernjak, C Jakob, et al. 2013. *bluprint2013 - Stormwater Management in a Water Sensitive City.* Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.

Zhang, Y, M Nitschke, and B Peng. 2013. “Risk factors for direct heat-related hospitalization during the 2009 Adelaide heatwave: A case crossover study.” *Science of the Total Environment* 442: 1-5. doi:https://doi.org/10.1016/j.scitotenv.2012.10.042.

Attachment A

WSUD policy in Greater Adelaide Development Plans as at September 2019

Council Development Plan	Includes current SAPPL NR module WSD provisions?	Other references to 'WSD' or 'WSUD' in DP
Adelaide (City)	No.	• Indicates development in the Riverbank Zone will have an emphasis on WSUD, and also indicates that in the Riverbank Zone development should incorporate a range of WSUD measures that minimise water quality impacts on the River Torrens
Adelaide Hills Council	No.	• Obj 127 (under Catchment Water Management) indicates *Integrated stormwater management at the catchment level, drainage system level and site level including incorporation of water sensitive design in all development* • Obj 327 (under Stormwater Management) indicates development design and construction should incorporate WSD measures to manage, protect and conserve water • Stirling Core Policy Area indicates (Character and Built Form), the layout and design of development should incorporate WSUD principles relating to stormwater management • Stirling Fringe Policy Area indicates (Design and Character) that development near the Aldgate Creek should manage runoff from the policy area and upstream sources by implementing WSUD principles in a Stormwater Management Plan which… minimises water quality issues • Residential Zone (form and character) indicates that residential allotments and sites should have the appropriate area and dimensions to accommodate… WSD that enables the storage, and reuse, or stormwater, where practical • Medium Density Policy Area 43 indicates (desired character) WSUD principles will be incorporated into the layout and design of the policy area
Alexandrina Council	Yes, under Natural Resources.	• Natural Resources Module. Land division that results in the creation of more than 5 allotments should include stormwater management systems designed to achieve the following stormwater runoff quality outcomes: (a) 80 per cent reduction in average annual total suspended solids (b) 60 percent reduction in average annual total phosphorus (c) 45 percent reduction in average annual total nitrogen. • Natural Resources Module. Development likely to result in significant risk of export of litter, oil or grease should include stormwater management systems designed to achieve the following gross pollutant outcomes: (a) 90 per cent reduction of litter / gross pollutants compared to untreated stormwater runoff

Council Development Plan	Includes current SAPPL NR module WSD provisions?	Other references to 'WSD' or 'WSUD' in DP
		(b) no visible oils/grease for flows up to the 1-in-3 month average return interval flood peak flow. • Development should include stormwater management systems designed to achieve the following stormwater runoff outcomes: (a) for up to but not including the-5 year average return interval flood event area: (i) pre-development peak flows should not be exceeded (ii) the time to peak should match that of the pre-development case, as far as practical, provided this does not exacerbate downstream flooding (iii) runoff should be contained within designed flow paths that avoid unplanned nuisance flooding. (b) for the 5 year to up to and including the 100 year average return flood event: (i) flooding of residential, commercial, institutional, recreation and industrial buildings should be avoided (ii) the time to peak and the peak flow should match that of the pre-development case, as far as practical (provided this does not exacerbate downstream flooding), unless catchment wide benefits can be demonstrated. • Port Elliot West Community Policy Area 32 indicates practical stormwater mitigation measures (incorporating WSUD principles) will form an integral part of any development; and indicates stormwater should be disposed on-site or directed through an integrated drainage scheme (incorporating WSUD principles) to the adjacent Urimbirra Creek and wetland
The Barossa Council	Yes, under Natural Resources	• Menge Road Policy Area 11 indicates development will incorporate WSUD principles
Burnside (City)	Yes, under Environmental Protection	• Urban Corridor Zone indicates that WSUD for the harvest, treatment, storage and reuse of stormwater will be • integrated at the neighbourhood, street, site and building level
Campbelltown Council	Yes, under Natural Resources	• Residential Development indicates residential allotments and sites should have the area and dimensions to accommodate WSD systems that enable the storage, treatment and reuse of stormwater
Charles Sturt Council	Yes, under Natural Resources	• Residential Development indicates residential allotments and sites should have the area and dimensions to accommodate WSD systems that enable the storage, treatment and reuse of stormwater • Integrated Medium Density Policy Area 20 indicates stormwater management and WSUD initiatives would need to consider

Council Development Plan	Includes current SAPPL NR module WSD provisions?	Other references to 'WSD' or 'WSUD' in DP
		potential contamination at the site to avoid mobilisation of contaminants and to protect receiving waters from water quality impacts associated with urban stormwater runoff. • Cheltenham Park Policy Area 22 indicates the area of open space will incorporate WSUD features and sustainable landscapes to enhance biodiversity • Urban Core Zone indicates WSUD systems, including the harvest and reuse of storm water, will be integrated throughout the area at the neighbourhood, street, site and building level
Gawler (CT)	Yes, under Natural Resources	• Under Form of Development indicates urban development should… be based on principles of ecologically sustainable development that includes WSUD. • Under Deferred Urban Zone indicates the future character of this land should be defined by development that incorporates WSUD principles
Holdfast Bay Council	Yes, under Natural Resources	• Residential Development indicates residential allotments and sites should have the area and dimensions to accommodate WSD systems that enable the storage, treatment and reuse of stormwater • Commercial Zone (desired character) indicates Landscaping will also provide opportunities for WSD (including storm-water capture and dispersal) • Light industry zone (desired character) indicates Landscaping will also provide opportunities for WSUD (including storm-water capture and dispersal
Land not within a council area (Metropolitan)	N/A	• This Development Plan only relates to areas outside of the Development Plans for geographic areas assigned to the responsibility of a Council and is the area seaward of the low water mark, to the extent of the State's waters, but within the coastal boundary of Metropolitan Adelaide as defined under the Development Act 1993
Light Regional Council	Yes, under Natural Resources	Nil. However, does include some other statements relating to protection of water quality including receiving waters
Mallala Council	Yes, under Natural Resources	• Bulk Handling Zone (desired character) indicates all development will incorporate eco-friendly and appropriate WSD techniques • Recreation Policy Area 1 (desired character) indicates all development will incorporate appropriate water WSD techniques • Industry Zone (desired character) indicates all development will incorporate environmentally sustainable building design - eco-friendly and appropriate WSD techniques • Light Industry Zone (desired character) indicates all development will incorporate environmentally sustainable building design - eco-friendly and appropriate WSD techniques

Council Development Plan	Includes current SAPPL NR module WSD provisions?	Other references to 'WSD' or 'WSUD' in DP
		• Residential Zone (desired character) indicates all development will incorporate environmentally sustainable building design - eco-friendly and appropriate WSD techniques • Rural Living Zone (desired character) indicates all development will incorporate environmentally sustainable building design, eco-friendly and appropriate WSD techniques • Settlement Zone (desired character) indicates **a**ll development will incorporate environmentally sustainable building design, eco-friendly and appropriate WSD techniques • Suburban Neighbourhood Zone (desired character) indicates WSUD systems, including the harvest, treatment, storage and reuse of storm water, will be integrated throughout the area at the neighbourhood, street, site and building level. • Town Centre Zone (desired character) indicates all development will incorporate environmentally sustainable building design, eco-friendly and appropriate WSD techniques • Township Zone (desired character) indicates all development will incorporate environmentally sustainable building design, eco-friendly and appropriate WSD techniques
Marion Council	Yes, under Natural Resources	• On land north of Seacombe Road, all new buildings and building extensions of 20 square metres or more in floor area, shall incorporate on-site stormwater retention systems which ensure that the first 15 millimetres of rainfall within any 24 hour period is retained on site. Where such retention systems rely on the use of infiltration, and testing shows that site soils will not permit infiltration of retained stormwater within a 24 hour period, provision of additional storage shall be provided either within an infiltration trench or tank which has sufficient capacity to contain runoff from 15 millimetres of rainfall and discharges over a period of at least 2 hours and no greater than 24 hours. • Residential Development indicates residential allotments and sites should have the area and dimensions to accommodate WSD systems that enable the storage, treatment and reuse of stormwater • Suburban Activity Node Zone (desired character) indicates WSUD systems, including the harvest, treatment, storage and reuse of stormwater, will be integrated throughout this zone and the adjoining Urban Employment Zone at the neighbourhood, street, site and building level. • Urban Employment Zone (desired character) indicates WSUD systems, including the harvest, treatment, storage and reuse of stormwater, will be integrated throughout the area at the neighbourhood, street, site and building level; and… WSUD systems, including the harvest, treatment, storage and reuse of stormwater, will be integrated throughout this zone and the adjoining Suburban Activity Node Zone at the neighbourhood, street, site and building level
Mitcham (City)	No	• Nil. However, it does include statements such as: development of stormwater management systems should be designed and located to improve the quality of stormwater, minimise pollutant

Council Development Plan	Includes current SAPPL NR module WSD provisions?	Other references to 'WSD' or 'WSUD' in DP
		transfer to receiving waters, and protect downstream receiving waters from high levels of flow
Mount Barker Council	Yes under Natural Resources.	• Natural Resources Module. Land division should include stormwater management systems designed to achieve the following stormwater runoff quality outcomes (compared to untreated stormwater runoff): (a) 80 per cent reduction in average annual total suspended solids (b) 60 percent reduction in average annual total phosphorus (c) 45 percent reduction in average annual total nitrogen. • Natural Resources Module. Development likely to result in significant risk of export of litter, oil or grease should include stormwater management systems designed to achieve the following gross pollutant outcomes: (a) 90 per cent reduction of litter / gross pollutants compared to untreated stormwater runoff (b) no visible oils/grease for flows up to the 1-in-3 month average return interval flood peak flow. • Development should include stormwater management systems designed to achieve the following stormwater runoff outcomes: (a) for up to but not including the-5 year average return interval flood event area: (i) pre-development peak flows should not be exceeded (ii) the time to peak should match that of the pre-development case, as far as practical, provided this does not exacerbate downstream flooding (iii) runoff should be contained within designed flow paths that avoid unplanned nuisance flooding. (b) for the 5 year to up to and including the 100 year average return flood event: (i) flooding of residential, commercial, institutional, recreation and industrial buildings should be avoided (ii) the time to peak and the peak flow should match that of the pre-development case, as far as practical (provided this does not exacerbate downstream flooding), unless catchment wide benefits can be demonstrated. • Also includes additional (green text) indicating that Development should incorporate WSUD solutions and discharge water in accordance with one of the following: (a) into grass swales, vegetation or garden strips (b) into stone filled trenches either open to a surface or underground absorption field. • *Residential Neighbourhood Zone (desired character) indicates* WSUD principles will be incorporated into the layout and design of the zone; and… (Energy Efficiency and WSUD desired character) design and construction of a building should incorporate water harvesting techniques… design and construction of landscaping and car parking areas should incorporate water harvesting techniques

Council Development Plan	Includes current SAPPL NR module WSD provisions?	Other references to 'WSD' or 'WSUD' in DP
Murray Bridge		• Natural Resources Module. Land division that results in the creation of more than 10 allotments should include stormwater management systems designed to achieve the following stormwater runoff quality outcomes: (a) 80 per cent reduction in average annual total suspended solids (b) 60 percent reduction in average annual total phosphorus (c) 45 percent reduction in average annual total nitrogen. • Natural Resources Module. Development likely to result in significant risk of export of litter, oil or grease should include stormwater management systems designed to achieve the following gross pollutant outcomes: (a) 90 per cent reduction of litter / gross pollutants compared to untreated stormwater runoff (b) no visible oils/grease for flows up to the 1-in-3 month average return interval flood peak flow. • Development should include stormwater management systems designed to achieve the following stormwater runoff outcomes: (a) for up to but not including the-5 year average return interval flood event area: (i) pre-development peak flows should not be exceeded (ii) the time to peak should match that of the pre-development case, as far as practical, provided this does not exacerbate downstream flooding (iii) runoff should be contained within designed flow paths that avoid unplanned nuisance flooding. (b) for the 5 year to up to and including the 100 year average return flood event: (i) flooding of residential, commercial, institutional, recreation and industrial buildings should be avoided (ii) the time to peak and the peak flow should match that of the pre-development case, as far as practical (provided this does not exacerbate downstream flooding), unless catchment wide benefits can be demonstrated.
Norwood Payneham and St Peters (City)	No.	• Residential Zone desired character statement indicates WSUD principles will be applied to new development, in order to reduce the quantity (and improve the quality) of stormwater entering our drainage systems • Residential Character Zone indicates WSUD principles will also be applied to new development, in order to reduce the quantity (and improve the quality) of stormwater entering our drainage systems • Residential Character (Norwood) Zone indicates WSUD principles will also be applied to new development, in order to reduce the quantity (and improve the quality) of stormwater entering our drainage systems

Council Development Plan	Includes current SAPPL NR module WSD provisions?	Other references to 'WSD' or 'WSUD' in DP
Onkaparinga Council	Yes under Natural Resources.	• Residential Development indicates **r**esidential allotments and sites should have the area and dimensions to accommodate: WSD systems that enable the storage, treatment and reuse of stormwater • Bulky Goods Zone (desired character statement) indicates **l**andscaping should be designed to incorporate WSUD. • Hepenstal Road Policy Area 68 (desired character) indicates WSUD will include the harvesting, treatment, storage and reuse of stormwater and will be integrated into the village square to improve its aesthetic and functional value • Regional Centre Zone (desired character) indicates the centre will exhibit techniques and strategies to conserve resources and improve resilience to future energy and climatic conditions. These techniques may include … use of WSUD at the neighbourhood, street, site and building level.
Playford Council	Yes, under Natural Resources.	• Residential Development indicates residential allotments and sites should have the area and dimensions to accommodate: WSD systems that enable the storage, treatment and reuse of stormwater • Buckland Park Policy Area 9 (green text) (Water Sensitive Urban Design) indicates that design and construction of building(s) should incorporate water harvesting techniques; and… design and construction of landscaping and car parking areas should incorporate water harvesting techniques.
Port Adelaide Enfield Council	Yes, under Natural Resources.	• Suburban Neighbourhood Zone (desired character – open space) indicates larger open spaces will support WSUD principles; and… WSUD systems will be integrated throughout the area at the neighbourhood, street, site and building level. • Industrial development. The layout of subdivisions should ensure adequate provision for stormwater management including: (a) the use of overland flow paths, which take into account existing flow paths (b) the provision of detention or retention basins. • Industrial development. Stormwater generated within an industrial, warehouse, storage, commercial or transport distribution development should be managed by a minor system (underground pipe network) for the 1-in-10 year average return interval flood event , and a major system (overland flow via the road network) for the gap flows between the minor system and the 1-in-100 year average return interval storm event. • Land division. The arrangement of roads, allotments, reserves and open space should enable the provision of a stormwater management drainage system that: (a) contains and retains all watercourses, drainage lines and native vegetation …. (c) integrates with the open space system and surrounding area. • The width of reserves abutting watercourses within the Metropolitan Open Space System should be sufficient to allow

Council Development Plan	Includes current SAPPL NR module WSD provisions?	Other references to 'WSD' or 'WSUD' in DP
		for: (a) flood control; (b) stormwater management and (c) retention of the riverine ecosystem … • Open space and recreation. No greater than 20 per cent of the land provided as public open space, as part of the 12.5 per cent developer contribution, should be inundated by a stormwater event more frequent than a 1-in-10 year average return interval flood event.
Prospect (City)	Yes, spread across several parts of the DP	• 'council wide - Water Sensitive Design' indicates (Obj 36) development consistent with the principles of WSD. • Includes (pg 67 principles of development control etc) WSD
Salisbury Council	Yes, under Natural Resources.	• Commercial Zone (desired character) indicates landscaping will incorporate WSUD measures and be linked to on-site stormwater detention and reuse or regional schemes • Industry Zone (desired development) indicates as an objective, WSUD and landscaping incorporated as integral elements of development within the zone • Mixed Use (Bulky Goods, Entertainment and Leisure) Zone indicates landscaping and development should be designed to incorporate WSUD and provide for on-site stormwater retention and detention • Neighbourhood Centre Zone (Precinct Specific Provisions - Precinct 18 Saints Road Neighbourhood Centre) indicates development within the precinct should incorporate 'WSUD' techniques, including, but not limited to: harvesting, storage, treatment and beneficial use of runoff (at building, car park and street level, including stormwater; treatment and reuse of wastewater generated on the site; use of vegetation for treatment purposes, water efficient landscaping and enhancing biodiversity and amenity; the provision of an appropriate landscaped buffer (where practical) adjacent to Cobbler Creek. • Urban Employment Zone (desired character) indicates WSUD systems, including the harvest, treatment, storage and reuse of stormwater, will be integrated throughout the area at the neighbourhood, street, site and building level, taking advantage of large allotment sizes and impervious areas.
Tea Tree Gully Council	Yes, under Natural Resources.	• Residential Development indicates residential allotments and sites should have the area and dimensions to accommodate: WSD systems that enable the storage, treatment and reuse of stormwater
Unley (City)	Yes, under Natural Resources.	• Urban Corridor Zone indicates WSUD for the harvest, treatment, storage and reuse of stormwater… is envisaged with development
Victor Harbor (City)	No	• None, however the DP includes statements such as Water Quality Management: The design of the land division should facilitate the storm drainage system: maximising the interception, retention and removal of water-borne pollutants (including sediment, litter, nutrients, microbial contaminants and other potential toxic materials) prior to their discharge to receiving

Council Development Plan	Includes current SAPPL NR module WSD provisions?	Other references to 'WSD' or 'WSUD' in DP
		water, whether surface or underground; and… Water Conservation: The design of the site (including landscaping, paving and car parking) and building should facilitate conservation of main water and in turn reliance on the River Murray
Walkerville Council	No	• None, but includes statements such as: Development should be sited and designed to: minimise surface water runoff; prevent soil erosion and water pollution; protect stormwater from pollution sources; The quality of water leaving the site of a development should be of a physical, chemical and biological condition equivalent to or better than pre-development conditions, and the rate of water discharged from the site should not exceed the rate of discharge from the site in pre-development conditions; Development should include stormwater management systems to protect it from damage during a minimum of a 1-in-100 year average return interval flood; Development should, where practical, capture and re-use stormwater; Development should have adequate provision to control any stormwater over-flow runoff from the site and should be sited and designed to improve the quality of stormwater and minimise pollutant transfer to receiving waters; Development should include stormwater management systems to mitigate peak flows and manage the rate and duration of stormwater discharges from the site to ensure downstream systems are not overloaded; Development should include stormwater management systems to minimise the discharge of sediment, suspended solids, organic matter, nutrients, bacteria, litter and other contaminants to the stormwater system)
West Torrens Council	Yes, under Natural Resources.	• Residential Development (principles of development control) indicates residential allotments and sites should … have the area and dimensions to accommodate: WSD systems that enable the storage, treatment and reuse of stormwater
Yankalilla (DC)	No.	• None but includes statements such as: development should not be undertaken if the construction, operation and/or management of such development is likely to result in: the pollution of surface or groundwater; increased risk of flooding or impairment of stream water quality through the disposal of • stormwater; or sealing of large areas of ground likely to result in increased stormwater run-off; Development should take place in a manner which will not interfere with the utilisation, • conservation or quality of water resources, and protects the natural systems that contribute to • natural improvements in water quality; (Primary industries) development should not compromise the utilisation, conservation or quality of water resources, or the capacity for natural systems to restore or maintain water quality

Attachment B

GI policy in Greater Adelaide Development Plans as of August 2018

Council Development Plan	References to 'Green Infrastructure' or related policy in DP
Adelaide (City)	• Incentive approach used - Development in the Capital City Zone which seeks to exceed max building height is required to offer 'value add' features incl. GI such as rooftop gardens, green roofs, greenwalls/façades w/ services providing ongoing maintenance • Rooftop gardens & terraces encouraged for all med-high scale residential development and in office towers
Burnside (City)	• Ground level private open space should provide consolidated deep soil (excl. areas w/ structure underneath, pools & non-permeable paved areas) to assist drainage, ensure effective deep planting, decrease Urban and heat loading & improve micro-climatic site/building conditions. • Incentive approach used - Transit Living (Glenside) Policy Area (recently added policy) seeks for development seeking to exceed the max building height on strategic dev sites (1 or more lots w/ primary road corridor frontage & over 1500m2) to incorporate at least 1 GI feature e.g. rooftop garden covering majority of avail. roof or greenroof or greenwalls/facades (similar approach to Adelaide)
Campbelltown Council	• Ground level private open space should provide consolidated deep soil (as per Burnside) • Green roofs encouraged for new residential, commercial or mixed-use buildings (Med-High Rise Dev section) • Incentive approach used in Urban Corridor Zone: additional building storey permitted if building has rooftop garden occupying min 50% of building footprint • One particular Policy Area (High Street) specifically encourages GI public realm feature incl. the use of creepers, greenwalls & planter boxes on footpath
Charles Sturt Council	• Ground level private open space should provide consolidated deep soil (as per Burnside) • Green roofs encouraged for new residential, commercial or mixed-use buildings (Med-High Rise Dev section) • Residential Zone: Roof decks & green roofs may exceed max building height (subject to design features) and if max wall height (4.5m) exceeded, design techniques e.g. green landscaped walls/gardens are to be utilised • Incentive approach used - Urban Core Zone: additional storey permitted in Bowden Urban Village if building has rooftop garden occupying min 25% of building footprint • One particular Policy Area (Main Street) specifically encourages GI public realm feature incl. the use of creepers, greenwalls & planter boxes on footpath
Marion Council	• Ground level private open space should provide consolidated deep soil (as per Burnside)

<table>
<tr><th>Council Development Plan</th><th>References to ‘Green Infrastructure’ or related policy in DP</th></tr>
<tr><td></td><td>

Green roofs encouraged for new residential, commercial or mixed-use buildings (Med-High Rise Dev section)
Regional Activity Zone: integration of vegetation & water into dev design is encouraged to decrease urban heat island effect: i.e. landscaping, living architecture (green roofs & walls), & water bodies or features.
Dev exceeding max building height should meet criteria, including incorporation of sustainability initiatives, e.g. green roofs & green walls & 6-star greenstar rating.

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<tr><td>Mitcham (City)</td><td>

Med-High development - aims to enhance pub realm for residents, workers & visitors through landscaping, green walls & roofs.
Deep soil zones for tree planting in front of commercial buildings encouraged (suggested: 4m x 4m)
Green roofs encouraged for new residential, commercial or mixed use buildings
Deep soil zones should be provided to accommodate new or existing deep root vegetation as per following table:

<table>
<tr><th>Site area</th><th>Minimum deep soil area</th><th>Minimum dimension</th><th>Tree/ deep soil zones</th></tr>
<tr><td><300m^2</td><td>10m^2</td><td>1.5 metres</td><td>1 small tree/10m^2 deep soil</td></tr>
<tr><td>300-1500m^2</td><td>7% site area</td><td>3 metres</td><td>1 medium tree/30m^2 deep soil</td></tr>
<tr><td>>1500m^2</td><td>7% site area</td><td>6 metres</td><td>1 large or medium tree/60m^2 deep soil</td></tr>
<tr><td colspan="4">Tree size and site area definitions</td></tr>
<tr><td>Small tree</td><td colspan="3">< 6 metres mature height and < less than 4 metres canopy spread</td></tr>
<tr><td>Medium tree</td><td colspan="3">6-12 metres mature height and 4-8 metres canopy spread</td></tr>
<tr><td>Large tree</td><td colspan="3">12 metres mature height and > 8 metres canopy spread</td></tr>
<tr><td>Site area</td><td colspan="3">The total area for development site, not average area per dwelling</td></tr>
</table>

Medium / high rise dev abutting a zone accommodating low-rise residential should incorporate deep soil zones along common boundary for screening. Suggestion: 6m min setback from zone boundary to accommodate deep soil zone.

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<tr><td>Mount Barker Council</td><td>

Green roofs encouraged for new residential, commercial or mixed-use buildings (Med-High Rise Dev section)
Rooftop gardens are encouraged for residential flat buildings (i.e. apartment buildings)
Regional Town Centre Zone: New residential & mixed-use buildings should include rooftop gardens & green roof technologies

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<tr><td>Norwood Payneham & St Peters (City)</td><td>

Similar policy to Mitcham (City) in relation to Medium and High-rise residential development

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<tr><td>Onkaparinga Council</td><td>

Regional Centre Zone: Will exemplify techniques conserving resources & improving climate change resilience e.g. green roofs & walls to create distinct ‘model’ streetscape [pub realm]
One particular Policy Area (Seaford) specifically encourages GI public realm feature incl. the use of creepers, greenwalls & planter boxes on footpath
Seaford Heights Policy Area advocates areas of useable space incl. rooftop gardens & terraces for med density residential dev

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</table>

Council Development Plan	References to 'Green Infrastructure' or related policy in DP
	• Similar policy to Mitcham (City) in relation to Medium and High-rise residential development
Playford Council	• Green roofs encouraged for new residential, commercial or mixed-use buildings (Med-High Rise Dev section) • Incentive approach used - Curtis Rd Town Centre - additional building storey permitted if building has rooftop garden occupying min 25% of building footprint
Port Adelaide Enfield Council	• Med-High development - aims to enhance pub realm for residents, workers & visitors through landscaping, green walls & roofs. • Urban Renewal Zone: Methods utilising high quality design, materials & vegetation (including green walls) preferential to improve appearance when redeveloping sites. In public realm, GI (e.g. trees, verge landscaping, swales, rain gardens, parks, parklets) that compliment & enhance built form is encouraged
Prospect (City)	• Med-High development - aims to enhance pub realm for residents, workers & visitors through landscaping, green walls & roofs. • Urban Corridor Zone: green landscaped walls/vertical gardens encouraged for solid walls • Various Policy Areas advocate extensive use of green infra on buildings/structures (rooftops, walls & verandas), in rear yards & on zone boundaries to enhance built form, pedestrian amenity & transition between public and private realms • Boulevard Policy area seeks deep root zones in the public realm
Salisbury Council	• Green roofs encouraged for new residential, commercial or mixed-use buildings (Med-High Rise Dev section) • Urban Core Zone/s: Solar rooftops, green walls & other design initiatives considered to max solar access & utilisation • One particular Policy Area (Main Shopping) specifically encourages GI public realm feature incl. the use of creepers, greenwalls & planter boxes on footpath
Tea Tree Gully Council	• Green roofs encouraged for new residential, commercial or mixed-use buildings (Med-High Rise Dev section) • Rooftop gardens are encouraged for residential flat buildings (i.e. apartment buildings) • Ground level private open space should provide consolidated deep soil (excl. areas w/ structure underneath, pools & non-permeable paved areas) to assist drainage, ensure effective deep planting, decrease Urban and heat loading & improve micro-climatic site/building conditions. • Initiative approach used - Urban Core Zone: Additional building storey permitted if building has rooftop garden occupying min 25% of building footprint
Unley (City)	• Green roofs as per Mitcham (City) DP • Rooftop gardens & green 'living' walls encouraged to reduce the 'Urban heat island effect', (Energy Efficiency, Residential Development policies)

Council Development Plan	References to 'Green Infrastructure' or related policy in DP
	• District Centre Zone: Well-designed landscaping integrated w/ building design (including rooftop gardens & green walls) will assist in softening & screening building façades & provide amenity, biodiversity & micro-climate benefits. • Rising residential densities necessitates greater green open space – encourages plazas, forecourts, green walls & pub or communal rooftop gardens. • District Centre Zone others - GI elements will be established; i.e. streetscape vegetation, green roofs, green walls, green facades & rain gardens. Positive externalities of water re-use, decreasing the urban heat island effect, inc food opportunities, water harvesting, biodiversity, liveability & amenity
Walkerville Council	• Green roofs encouraged for new med-high residential, commercial or MU buildings. Can be substituted for private or communal open space • Rooftop gardens are encouraged for residential flat buildings (i.e. apartment buildings)"
West Torrens Council	• Green roofs as per Mitcham (City) DP • Ground level private open space should provide consolidated deep soil (excl. areas w/ structure underneath, pools & non-permeable paved areas) to assist drainage, ensure effective deep planting, decrease urban and heat loading & improve micro-climatic site/building conditions • Med-high residential development encourages communal open space on elevated gardens or rooftops where design is integrated & useful for amenity needs • Urban Renewal Zone: Methods utilising high qual design, materials & vegetation (incl green walls) preferential to improve appearance when redeveloping sites. In pub realm, GI (e.g. trees, verge landscaping, swales, rain gardens, parks, parklets) that complement & enhance built form is encouraged