WSUD 01

WATER SENSITIVE SA

A guide for water sensitive urban design

Stormwater management for small-scale development

GUIDELINE

January 2020

Contents

Figures

Tables

For enquiries contact Water Sensitive SA
www.watersensitivesa.com

Disclaimer

Organica Engineering, Water Sensitive SA and its partners take no responsibility for the selective application or interpretation by third parties of the information that constitutes the document. This document and its associated materials have been produced in good faith with all information contained deemed to be correct at time of production. Organica Engineering Pty Ltd, the authors, reviewers and contributors take no responsibility, legally or financially, for any loss/damage to property/persons/projects resulting directly/indirectly from the document in whole or part, its associated materials, or the interpretation thereof. Organica Engineering makes no claim as to the accuracy or authenticity of the content of this document and does not accept liability for loss or damages incurred as a result of reliance placed upon it.

This guide is of a general nature only. Advice from a suitably qualified professional should be sought for your particular circumstances. Depending on each unique situation, there may be occasions where compliance is not achieved.

This guide and the Tool does not provide a detailed design and layout for the piping and general drainage system in your development, which should be prepared by a qualified civil engineer or hydrologist. In addition, InSite Water does not guarantee compliance for footing protection (*as per* Minister's Specification SA 78AA September 2003 – *On-Site Retention of Stormwater*[1]), which needs to come from a qualified geotechnical or structural engineer.

The following is outside the scope of this guide, however it is critical that all designers consider the following:

- Manage expectations and risks around occasional surface water and ponding.
- Ensure that uncontrolled stormwater does not flow over property boundaries or otherwise cause a nuisance.
- Plan for major flood pathways – locate away from, adapt (raise floors above predicted flood levels) and defend buildings against potential major flooding.
- Plan to reduce annual average damages and safety risks.
- Take into account local conditions such as slope, topography and soils (type, reactivity, permeability, water table level, salinity, dispersiveness, acid sulphate soils, etc.).
- Ensure that soil moisture and building clearance is considered in areas of reactive clays or where varying soil moisture levels could damage buildings.
- For steeper sites, ensure the design includes geotechnical considerations such as slope stability with varying soil saturation levels.
- Compliance with other Australian Standards, regulations and Council requirements.

[1] Minister's Specification SA 78AA September 2003 – *On-site retention of stormwater*, https://www.sa.gov.au/__data/assets/pdf_file/0017/7046/SA_78AA_Onsite_retention_of_stormwater.pdf

Urban stormwater design elements

The aim of this document is to provide a user-friendly guide to assist with the design of stormwater systems on small-scale developments (up to 5000 m^2) and to introduce the Water Sensitive SA online stormwater assessment tool, InSite Water, which is available at https://www.watersensitivesa.insitewater.com/

This guide assists stormwater professionals and other building designers to understand stormwater targets and how they can be met on private land.

This guideline is part of a suite of resources that have been created to support development applications, serving as an ancillary technical document with respect to water conservation and efficiency, and stormwater runoff flow, volume and quality management.

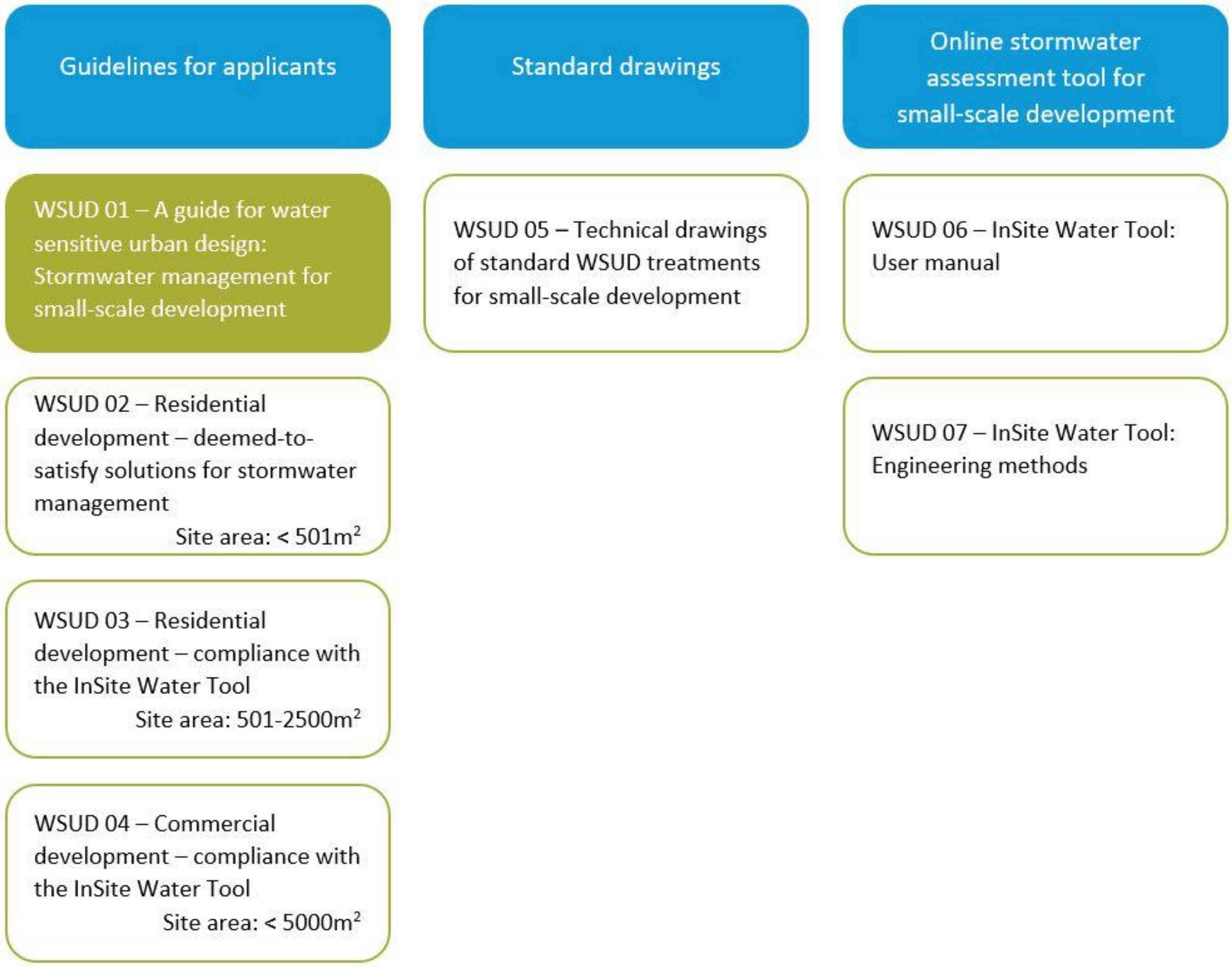

Figure 1: Water sensitive urban design resources for development applicants

As the area of impermeable surfaces connected to a drainage system increases, additional burden is placed on existing infrastructure. Existing pipe systems are designed for a specific purpose, such as for drainage for low-density housing. As an area develops into higher-density development, and more impervious surfaces are connected, piping systems no longer function well and are more frequently flooded. Additional stormwater runoff volumes and increased flooding frequency scour downstream watercourses and pollute coastal environments. Strategies to reduce this impact should be included as part of the development design process.

Stormwater design needs to consider the specific needs of a site, the conditions of the surrounding catchment, and the capacity of receiving waterways or drainage system. Water sensitive urban design (WSUD) promotes the sustainable management of water in new developments, and considers water from all sources including rainwater, stormwater, groundwater, mains water and wastewater. WSUD measures can be applied to residential, commercial and industrial developments, including retention and detention storages, infiltration systems, at source water quality treatments, and other systems as described on the *South Australian Government Information and services for South Australians* website[2] SA.GOV.AU.

Efficient stormwater management in new developments has multiple social, economic and environmental benefits including:

- reduced supply costs for potable water where retention storages are incorporated for supplying toilets, hot water services, laundry washing and cold-water outlets, and irrigation systems
- improved effectiveness and extended life of existing stormwater infrastructure
- reduced flood risk and resultant damage
- improved stormwater quality to protect coastal environments from pollution
- protecting the integrity of urban water courses from erosion
- reduced impervious surfaces resulting in reduced heat and stormwater runoff
- creating greener urban environments with high visual amenity.

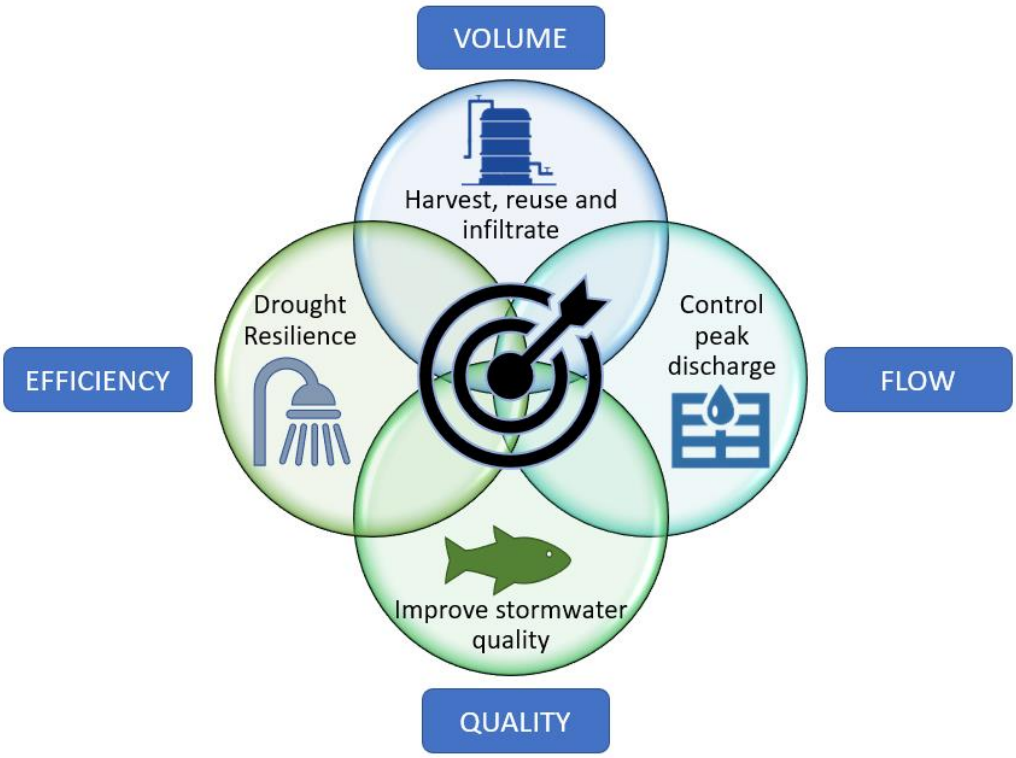

Figure 2: Developments must target multiple criteria

Figure 2 is Adapted from *Australian Rainfall and Runoff Guide – ARR 2016*, Engineers Australia 2016, refer to Chapter 9 (Urban Drainage) Figure 9.4.1. Potential overlapping volume management design objectives – Volume Management

[2] *South Australian Government Information and services for South Australians* https://www.sa.gov.au/topics/planning-and-property/land-and-property-development/planning-professionals/water-sensitive-urban-design

1 Design and performance criteria

Urban stormwater design has traditionally focused on peak flow management only, however, design standards have evolved and now require stormwater design to consider the changes in catchment conditions that are created by urbanisation. Engineers Australia[3] now recommends the design and installation of volume reduction facilities and water quality improvement systems as part of stormwater drainage design (ARR 2016). In addition, water efficiency and drought proofing are important criteria in South Australia.

These performance criteria should be read in conjunction with the *Australian Rainfall and Runoff Guide – ARR 2016*[4], and other relevant state and local guidelines. In particular, Book 9 Chapter 4 outlines the concepts of volume management and the updated approaches to urban stormwater, which may not be familiar to civil engineering practitioners.

For an explanation of stormwater terms, refer to the Glossary at the end of this document.

Developments must incorporate measures to address each of the following objectives:

Table 1: Typical stormwater management solutions that can meet the performance objectives

	VOLUME	FLOW	QUALITY	EFFICIENCY
Objective	Harvest or infiltrate stormwater	Control peak discharge flows	Improve stormwater runoff water quality	Increase drought resilience
Target	No increase in annual average runoff volume (post-development compared with pre-development) (a 10% increase is allowed as a margin of error in the tool)	Increase in peak discharge flows (post-development compared with pre-development) less than or equal to zero.	Achieve a pollution reduction score of 100[1] or more [1]A score of 100 is equivalent to achieving a 45% reduction in nitrogen runoff	Greater than 25% potable water use reduction
Typical solutions				
Rainwater (retention) tanks	✓	✓	✓	✓
On-site detention (OSD)		✓		
Permeable paving	✓	✓	✓	
Infiltration systems	✓	✓	✓	
Unlined swales	✓		✓	
Biofiltration, e.g. raingardens			✓	
Water efficient fixtures with high WELS ratings				✓
Recycled water plumbed to toilets and outdoor uses				✓
Water efficient irrigation systems				✓

[3] Adapted from *Australian Rainfall and Runoff Guide – ARR 2016*, Engineers Australia 2016, see Chapter 9 (Urban Drainage)

[4] Adapted from *Australian Rainfall and Runoff Guide – ARR 2016*, Engineers Australia 2016, see Chapter 9 (Urban Drainage)

1.1 Volume – harvest and re-use or infiltrate stormwater

Performance Objective 1:

No increase in annual average runoff volume (post-development compared with pre-development) (a 10% increase is allowed as a margin of error in the Tool)

This volume management objective is adapted from *Australian Rainfall and Runoff Guide* (ARR 2016)[5], and removes excess stormwater runoff volume from a catchment for re-use or to recharge groundwater to provide the following benefits:

- Protect existing downstream stormwater system assets
- increase soil moisture to support trees and canopy cover and benefit urban cooling
- maintain waterway stability and reduce scour
- maintain hydrologic behaviour in catchments including natural runoff regimes
- increase volume of water stored in an aquifer
- increase availability of water for harvesting and use.

Average annual volume reduction can often be achieved through the implementation of permeable pavement systems, retention and/or infiltration systems. See *Water Sensitive SA Fact Sheet WSUD 02* for further information. Please note that this VOLUME objective is not directly related to peak stormwater discharge events (flooding), which is addressed by the next objective – FLOW. Average annual volume is a separate measure from peak discharge flows.

Note that the Tool allows for a 10% increase from pre-development levels to allow for uncertainties in the calculations.

1.2 Flow – control peak stormwater discharge flows or volume

Performance objective 2:

2.1 Stormwater flow management performance measure – residential:

- **Post development peak rate of runoff from the development site for the critical design storm shall not exceed that from the pre-development site from a 5-year ARI (18.13% AEP or 0.2 EY) storm event.**

2.2 Stormwater flow management performance measure – commercial, industrial and institutional development:

- **Post development peak rate of runoff from the development site for the critical design storm shall not exceed that from the pre-development site from a 20-year ARI (5% AEP) storm event.**

This objective is to limit peak flood flows from minor flooding events to provide the following benefits:

- reduce property flood damage
- reduce personal safety risks due to flood
- reduce infrastructure damage
- reduce upgrade requirements for council and stormwater authority infrastructure.

---

[5] Adapted from *Australian Rainfall and Runoff Guide – ARR 2016*, Engineers Australia 2016, see Chapter 9 (Urban Drainage)

The capacity of the existing drainage system should not be exceeded. Ultimately the design storm event used for the design of the on-site drainage system should reflect the importance of a facility and the consequences of failure[6].

Note: In-ground drainage systems are usually only useful for minor flooding events in line with the above performance objectives. A comprehensive drainage plan must also address major flooding from rare rainfall events, and ensure overland flow paths are considered, and that buildings and assets are placed above major flood levels. Major flooding events are outside the scope of this guide, and professional design advice should be sought for your particular circumstances.

1.3 Quality – improve stormwater runoff water quality

Performance objective 3:

Development sited and designed to improve the quality of stormwater and minimise pollutant transfer to receiving waters by incorporating measures that reduce annual pollutant loads by:

- **a) 80% for total suspended solids**
- **b) 60% for total phosphorous**
- **c) 45% for total nitrogen**
- **d) 90% for gross pollutants.**

compared with untreated stormwater runoff.

These targets have been set within state policy within *Water sensitive urban design Creating more liveable and water sensitive cities in South Australia (also known as "the SA WSUD Policy").* The policy is underpinned by the B. Myers, et al (2011), *Interim Water Sensitive Urban Design Targets for Greater Adelaide* [7]. This report represents the most recent assessment of performance-based stormwater runoff quality measures for Greater Adelaide.

Subsequent work by Rouse K, et al (2016*) New modelling capability to target stormwater interventions that support seagrass health along Adelaide's coast* [8], places increasing importance on the role of sediment in the degradation of coastal sea grass habitats, particularly sediment <63um particles especially during falling hydrograph flows during winter.

Objective 3 seeks to reduce urban runoff contamination to:

- maintain aquatic health and biodiversity
- maintain amenity of waterways
- protect coastal environments.

Stormwater quality and sediment control devices should typically be sized to treat the peak discharge that is generated during a design storm event. A design storm event for quality and sediment control devices should be between a 4 EY (3-month ARI) and a 1 EY (1-year ARI) storm event (see ARR 2016, Book 9, Chapter 3). The device should be designed with sediment control and for larger flows to bypass the device to reduce damage.

---

[6] Adapted from *Australian Rainfall and Runoff Guide* – ARR 2016, Engineers Australia 2016, See Chapter 9 (Urban Drainage)

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

[8] Rouse K, Gonzalez D, Fernandes M, van Gils J, Maheepala S, He Y, Mirza F, Daly R and Cuddy SM (2016*) New modelling capability to target stormwater interventions that support seagrass health along Adelaide's coast*, Goyder Institute for Water Research Technical Report Series No. 16/9, Adelaide, South Australia

In addition, it is critical that stormwater quality devices and all downstream drainage infrastructure are protected from sediment in runoff during construction phase.

1.4 Water conservation and water-use efficiency

Objective 4:

Development designed to achieve 25% potable (mains) water reduction compared to a building that has no water saving features[9].

This objective reduces potable water demand to:

- reduce the risk of communities running low on water and improve drought resilience
- adapt to population growth and climate change
- reduce the need for new reservoirs and desalination plants
- allow for more environmental flows for aquatic ecosystems.

The water saving target has been set using extensive national experience in Victoria with the BESS tool and in NSW with the BASIX tool, based on what a household can reasonably achieve using cost effective water sensitive design principles. Usually about 10% of savings are provided by efficient fittings and an additional 15% of savings are provided by the rainwater tank. This will vary based on the specific building design. Higher targets are technically feasible, but they tend to require more complex and expensive equipment such as greywater or blackwater recycling. Extensive calibrations of the InSite water tool have demonstrated that the efficiency target can be achieved with either stringent efficiency or only a rainwater tank, though this is harder. A balanced approach of a rainwater tank (or a third pipe alternative water supply), plus efficient fittings is recommended. A building that is not connected to a reticulated potable water source is deemed to comply with water saving targets.

Interstate comparisons:

- Victoria – 25% potable water reduction target calculated with Built Environment Sustainability Scorecard (BESS)
- NSW – 40% reduction target calculated with BASIX (Note: The water usage baseline or benchmark for this target is very high)

---

[9] Water Sensitive Urban Design (December 2010) *Greater Adelaide Region Technical Manual*, Chapter 4 (Demand reduction)
Myers B, Cook S, Maheepala S, Pezzaniti D, Beecham S, Tjandraatmadja G, Sharma A, Hewa G and Neumann L (2011) *Interim Water Sensitive Urban Design Targets for Greater Adelaide*, Goyder Institute for Water Research Technical Report Series No. 11/7
Rouse K, Gonzalez D, Fernandes M, van Gils J, Maheepala S, He Y, Mirza F, Daly R, Cuddy SM (2016*) New modelling capability to target stormwater interventions that support seagrass health along Adelaide's coast*, Goyder Institute for Water Research Technical Report Series No. 16/9, Adelaide, South Australia

2 Rainwater tanks

The purpose of rainwater tanks is to: Capture and use rainwater to conserve potable mains supplies; reduce stormwater runoff volumes; and reduce pollutants reaching downstream waterways. Rainwater tanks are suitable on all developments, however they are most effective on developments that incorporate large roof areas (to maximise capture), and have high water demand such as residential dwellings or apartments, offices and public buildings, or developments with large gardens areas that require irrigation.

Figure 3: Common rainwater (retention) tank installations (Source: Andrew King)

Design and application

To maximise rainwater re-use and reduce potable water supply, it is recommended that rainwater tanks be plumbed to all toilets, washing machines, laundry cold water outlets, and irrigation systems for any landscaped areas of the site. General design tips for rainwater tanks that will be used for internal uses are:

- install a fine mesh filter to improve water quality – periodic maintenance is required
- use an inline UV sterilising lamp – periodic maintenance is required
- rainwater pipe should be clearly marked at intervals not exceeding 1 m with the contrasting coloured wording ‘RAINWATER’
- water outlets should be identified as ‘RAINWATER’ with a label or a rainwater tap identified by a green coloured indicator with the letters ‘RW’
- use a mains switchover device that incorporates backflow prevention to allow continued operation of internal uses if the rainwater tank runs dry
- plumbing must comply with the National Construction Code (NCC) of Australia[10].

Rainwater tanks can also be connected to hot water services that include a water storage component, and these systems must also comply with the National Construction Code (NCC) of Australia[11]. Additional considerations for connecting rainwater to hot water services are:

- ensure hot water system can uniformly heat hot water to 60° to ‘sterilise’ it for contact use
- ensure good quality pump is used to prevent fluctuation of water pressure and hence maintain a constant shower temperature
- install backflow prevention valve(s) as per NCC requirements.

Additional treatment of rainwater

[10] NCC Plumbing Code of Australia PCA (Volume Three), Australian Building Codes Board, latest version https://www.abcb.gov.au/

[11] NCC Plumbing Code of Australia PCA (Volume Three), Australian Building Codes Board, latest version https://www.abcb.gov.au/

Additional treatment is generally required when rainwater is to be used for internal non-potable (non-drinking) uses. Leaves from trees adjacent to your house and other airborne debris can make their way into your rainwater tank and cause the water to become discoloured. There are several ways to improve the quality of the rainwater you harvest from your roof, including installation of:

- GUTTER MESH (6 mm wire mesh) to prevent leaves and debris from blocking gutters.
- RAIN HEADS to downpipes to stop gutters blocking. Rain heads deflect leaves and debris and keep mosquitoes out of pipes that hold water. See Figure 5.
- WATER DIVERTER fitted prior to the tank storage, to prevent the first flush of most contaminated rainwater from entering the tank. Also known as "first flush diverters". See Figure 5.
- MOSQUITO SCREENS fitted at the end of all pipes

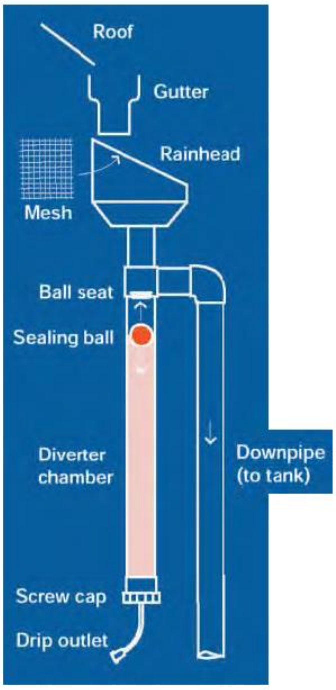

Figure 4: Rainhead and first flush diversion device
(Source: City of Unley)

It is important that all engineering and architectural plans and specifications for new developments state the above requirements to ensure WSUD measures are implemented at the time of construction.

Combined retention and detention rainwater tanks

Rainwater tanks can include stormwater detention capabilities. These systems are referred to as combination retention/detention systems. The detention storage component is typically located at the top of the tank, with a restricted outlet orifice provided at a calculated height above the base of the tank to control peak flows. The detention component remains empty except during a rain event. The retention component is the volume of stormwater stored at the bottom of the tank (below the restricted outlet orifice) that is available for use. Further information regarding detention systems is below.

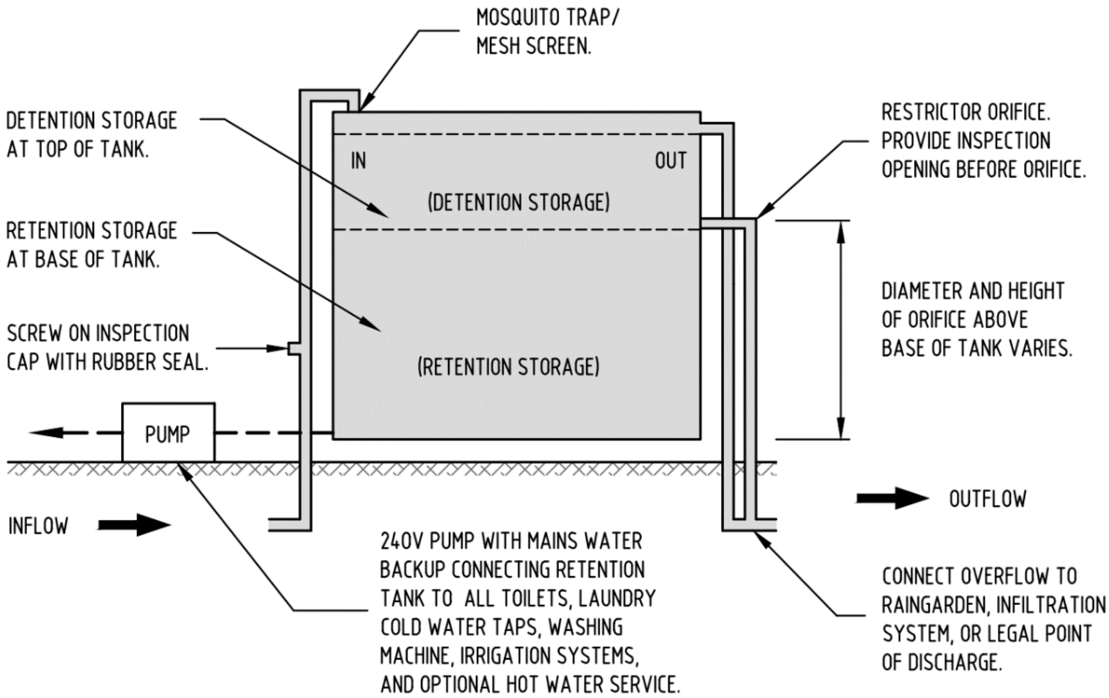

Figure 5: Combination retention and detention tank

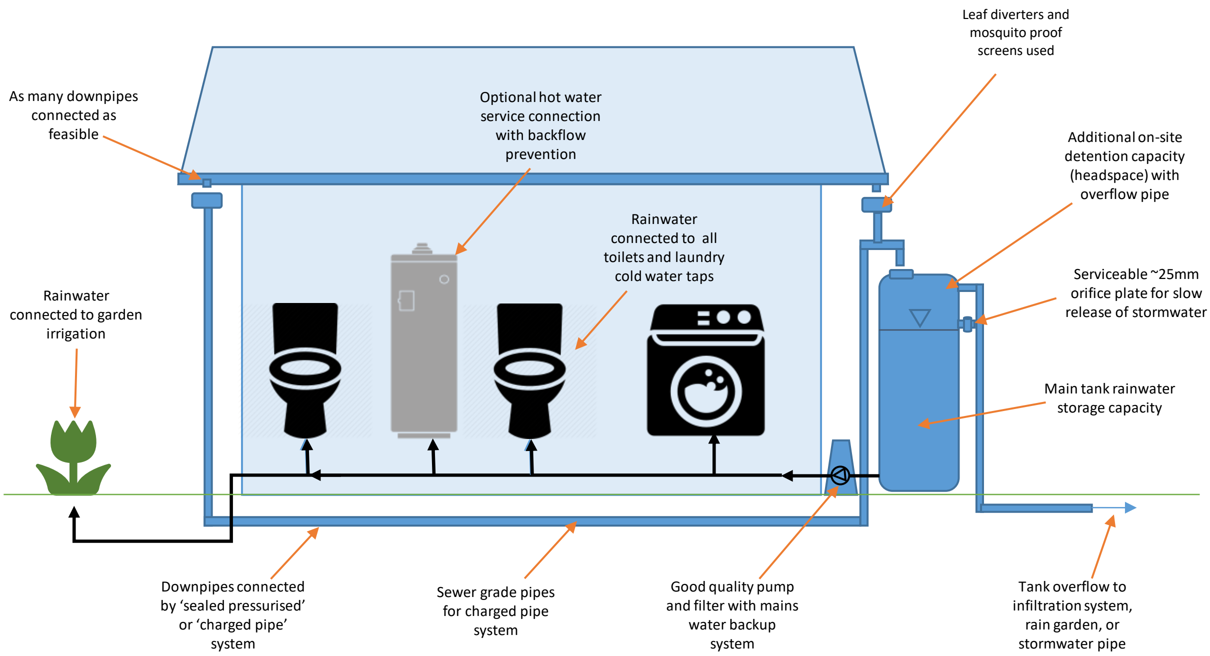

Figure 6: Simplified diagram of a common rainwater tank installation

3 Infiltration systems

Infiltration systems consist of a shallow excavated trench, soakage well or tank, designed to retain a certain volume of stormwater runoff. The stored water permeates into surrounding soils, significantly reducing runoff volumes, having provided a pathway for treated runoff to recharge local groundwater aquifers and, in turn, surface water resources.

There are several different types of infiltration systems that are available to the designer, each of which suit different sites and applications. These are:

- infiltration trenches
- infiltration basins
- soakage wells or pipes
- permeable pavement
- infiltration swales.

Infiltration systems function best when high-infiltration soil types are present (sand or mildly reactive clays). Many suburbs within the metropolitan Adelaide area are characterised by reactive clays not suited to these systems. An estimation of a sites soil type can be determined by referring to the Department of Environment and Water Nature Maps[12] and the Soil Association Map of the Adelaide Region[13]. Alternatively, for more accurate results, a geotechnical engineer can be engaged to undertake site soil classification and percolation testing.

Design and application

Guidance for the use of infiltration trenches and infiltration wells is outlined in *WSUD: Basic procedures for 'source control' of stormwater – a handbook for Australian practice*[14].

The use of on-site gravel trenches or soakage well infiltration systems in proximity to buildings and other structures is restricted to soil types classified as class A (Stable, non-reactive), Class S (Slightly reactive clay), class M (Moderately reactive clay) or class M-D (Deep moderately reactive clay).

To protect nearby footings, slabs and other structures from cracking due to movement, the surface movement due to soils should be equal to or less than 25 mm, as defined in *AS 2870-2011 – Residential Slabs and Footings*[15] and where the following conditions exist:

- the slope of the natural ground does not exceed 1 in 10
- the depth to rock is 1.2 m or greater
- the groundwater table is permanently below 1.5 m from the natural ground surface or the final ground surface, whichever is the lowest.

Pre-treatment of water for removal of debris and sediment is essential. Pre-treatment measures include leaf filters for roof runoff, and sediment sumps, vegetated swales, bioretention systems or sand filters for surface runoff.

[12] Department of Environment and Water Nature Maps https://data.environment.sa.gov.au/NatureMaps/Pages/default.aspx
[13] Soil association map of the Adelaide region. Adelaide: Geological Survey of South Australia 1972
[14] Argue JR (2004/2013) WSUD: Basic procedures for 'source control' of stormwater – a handbook for Australian practice. Urban Water Resources Centre, University of South Australia.
[15] AS 2870-2011 – Residential slabs and footings available from SAI Global https://infostore.saiglobal.com/

The use of on-site infiltration devices is not usually recommended on sites classified as reactive soils of type H/H-D, H1/H1-D, H2/H2-D, E/E-D and P as defined in *AS 2870-2011 – Residential slabs and footings*[16], unless in accordance with advice from a structural engineer. For a description of these soil types see the Glossary.

Table 2: Infiltration characteristics of common soil types

Soil type	AS 2870 Classification	Soil hydraulic conductivity (K_h)[17]	Minimum recommended clearance from structures & boundaries[18]
Sandy soils and sandy loam	Class A	5 × 10-5 m/s (180 mm/hr) or greater	1 metre
Sandy clay	Class S	between 1 × 10-5 and 5 × 10-5 m/s (36–180 mm/hr)	2 metres
Weathered or fractured rock	Class A	between 1 × 10-6 and 1 × 10-5 m/s (3.6–36 mm/hr)	2 metres
Medium clay	Usually Class M/M-D	between 1 × 10-6 and 1 × 10-5 m/s (3.6–36 mm/hr)	4 metres
Heavy clay	Usually Class M/M-D	between 1 × 10-8 and 1 × 10-6 m/s (0.036–3.6 mm/hr)	5 metres

Infiltration pit sizing

Details for engineers for sizing an infiltration pit can be found in:

- *WSUD: Basic procedures for 'source control' of stormwater – a handbook for Australian practice*[19]
- Minister's Specification SA 78AA September 2003 – *On-site retention of stormwater*[20]
- *Australian Runoff Quality: Guide to Water Sensitive Urban Design*[21]

[16] AS 2870-2011 – Residential slabs and footings available from SAI Global https://infostore.saiglobal.com/
[17] Melbourne Water. *WSUD Engineering Procedures: Stormwater: Stormwater* (Kindle Locations 6606-6609). CSIRO Publishing. Kindle Edition.
[18] Wong THF (2006) *Australian runoff quality: Guide to water sensitive urban design,* Engineers Australia available from https://www.eabooks.com.au/Australian-Runoff-Quality-Guide-to-Water-Sensitive-Urban-Design
[19] Argue JR (2004/2013) *WSUD: Basic procedures for 'source control' of stormwater – a handbook for Australian practice*. Urban Water Resources Centre, University of South Australia.
[20] Minister's Specification SA 78AA September 2003 – *On-site retention of stormwater*, https://www.sa.gov.au/__data/assets/pdf_file/0017/7046/SA_78AA_Onsite_retention_of_stormwater.pdf
[21] Wong THF (2006) *Australian runoff quality: Guide to water sensitive urban design*, Engineers Australia available from https://www.eabooks.com.au/Australian-Runoff-Quality-Guide-to-Water-Sensitive-Urban-Design

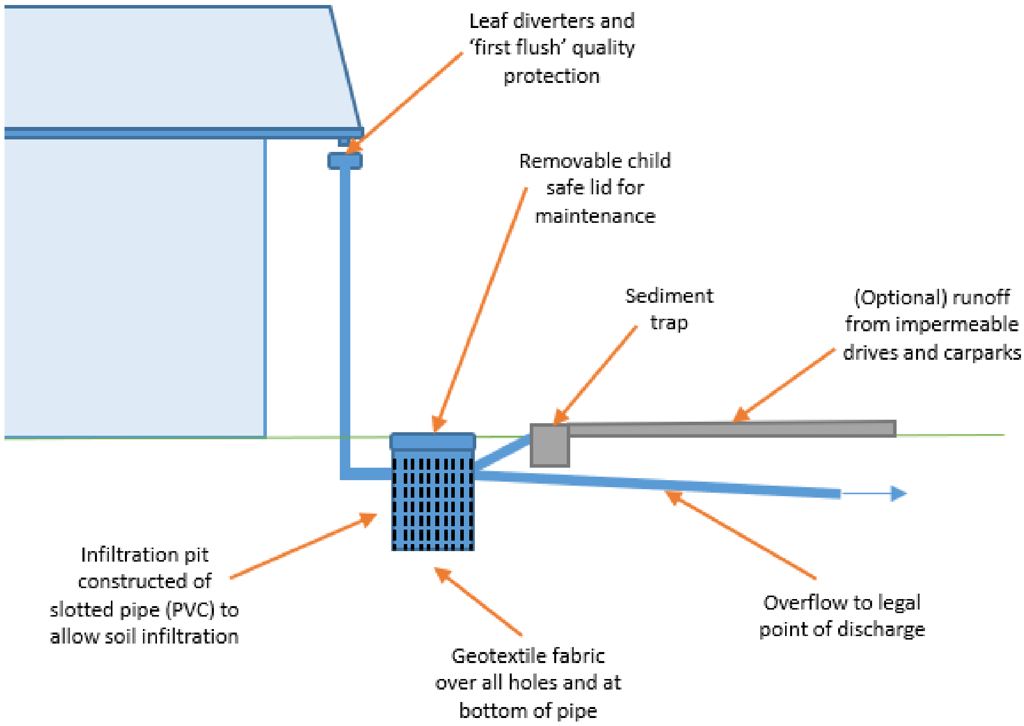

Figure 7: Example infiltration pit

Infiltration trench sizing

Details for sizing an infiltration pit can be found in:

- *WSUD: Basic procedures for 'source control' of stormwater – a handbook for Australian practice*[22]
- Minister's Specification SA 78AA September 2003 – *On-site retention of stormwater*[23]

[22] Argue JR (2004/2013) *WSUD: Basic procedures for 'source control' of stormwater – a handbook for Australian practice*. Urban Water Resources Centre, University of South Australia.
[23] Minister's Specification SA 78AA September 2003 – *On-site retention of stormwater*, https://www.sa.gov.au/__data/assets/pdf_file/0017/7046/SA_78AA_Onsite_retention_of_stormwater.pdf

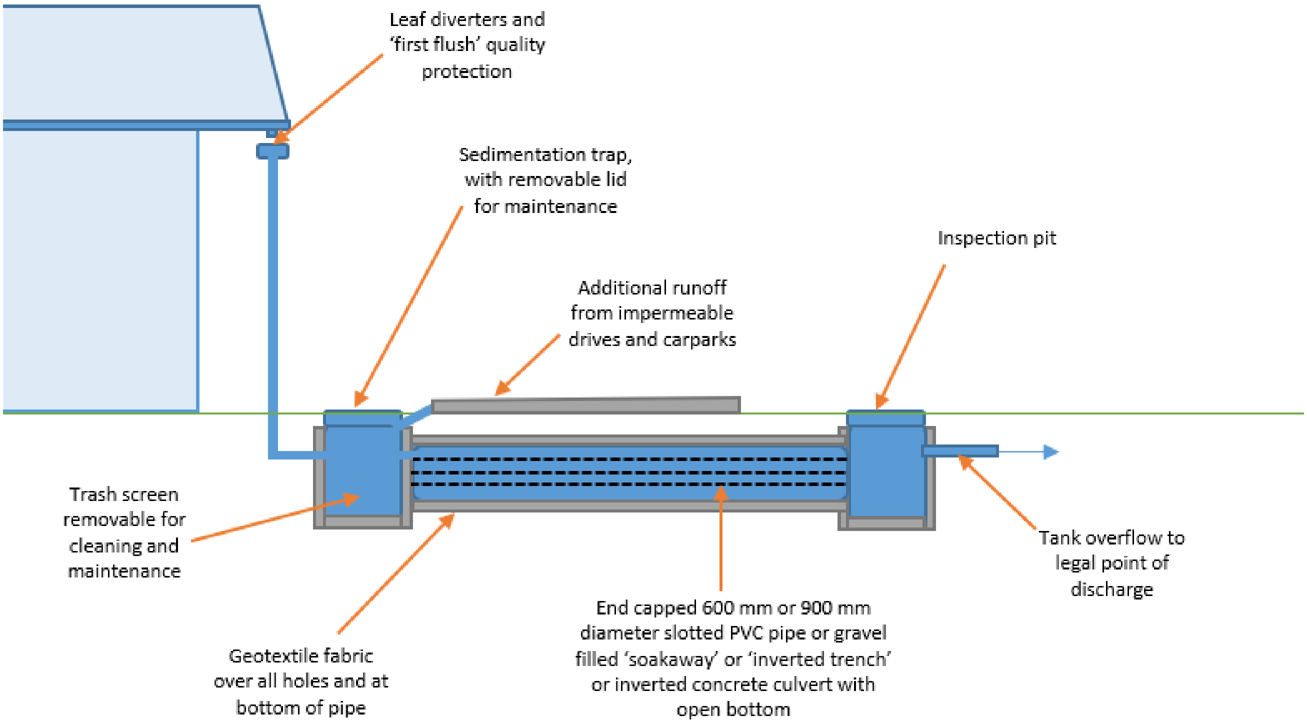

Figure 8: Example infiltration trench

Figure 9: Infiltration trench, Doncaster Avenue, Colonel Light Gardens, City of Mitcham

4 Pervious pavement systems

Overview

Pervious pavement systems are pavement systems that allow stormwater to percolate through to a sub-surface course, from where it either infiltrates to the soil or is filtered back to the drainage system to subsurface soils or storages to reduce stormwater runoff. Underlying pavement layers can also include perforated pipes that allow the release of stormwater runoff into the receiving drainage system.

Permeable pavement systems provide two main advantages over regular impervious pavements: Improved water quality through filtering, interception and providing biological treatment; and reduced stormwater flow through infiltration and storage.

Permeable pavement systems commonly include interlocking block paving, porous concrete or plastic grids that provide structural stability to gravel or grassed paths, driveways and car parks. Single-sized gravel can also be used as an effective method of reducing stormwater runoff in low-traffic footpath and driveway areas. Permeable surfaces that receive stormwater runoff in excess of the rain that falls directly on the pavement itself, for example stormwater redirected from downpipes, rainwater tank overflows, etc., may require additional design considerations.

Figure 10: Laura Avenue, St Marys porous asphalt surface in the , City of Mitcham and Cowandilla Community Hall carpark, City of West Torrens

Design and application

Pervious pavement systems fall into two distinct categories:

- Porous surfaces: Comprising a layer of highly porous material (e.g. specially designed concrete or asphalt).
- Permeable pavements: Comprising a layer of interlocking paving blocks (either made with porous material or specially shaped to allow the ingress of water by way of vertical slots) to allow runoff through to the underlying surface.

Other design considerations include:

- Interlocking pavements or other systems rated to handle traffic are recommended where high traffic loads can be expected.
- Storage volume under paving should be sized to contain a 1-in-3-month ARI (4 EY) storm volume for water QUALITY treatment or a 5-year ARI (0.2 EY) for flood FLOW prevention.
- Some overland flow can occur with intense rainfall, so paving should be shaped away from buildings, property boundaries, or where surface flows could cause damage.

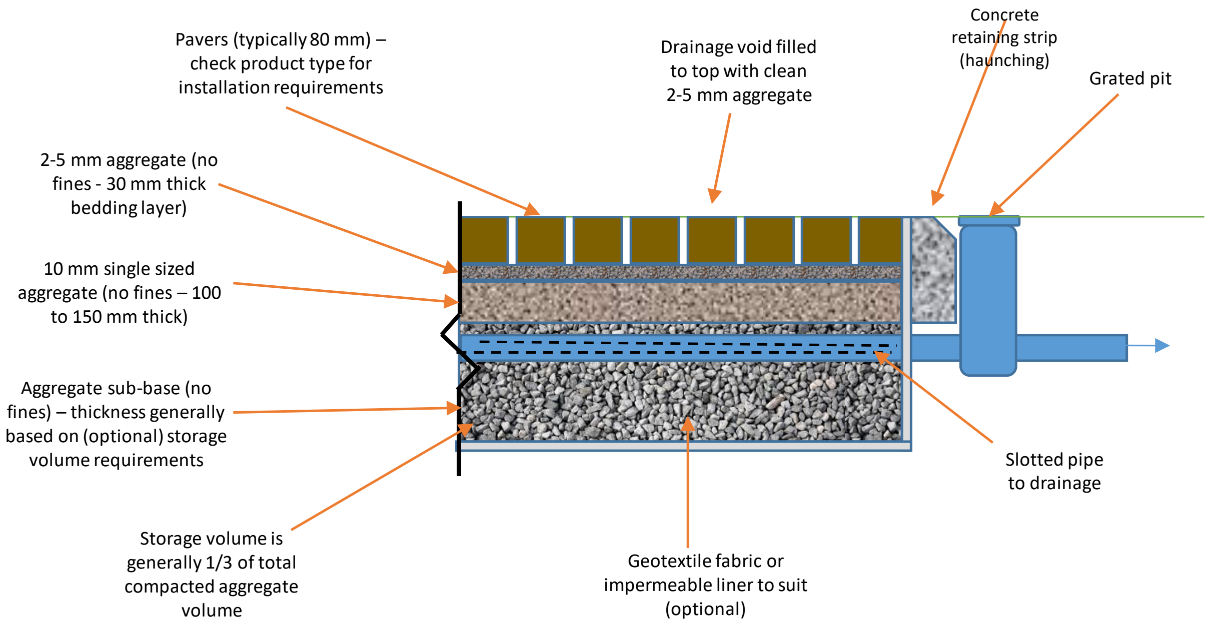

Figure 11: Example cross section of permeable pavement

Figure 12: Permeable paving Kegworth Road, Melrose Park, City of Mitcham

5 Bioretention systems (raingardens, bioswales and bioretention)

Overview

Bioretention systems are also known as raingardens, biofilters, bio-infiltration systems and bioremediation systems.

Raingardens improve stormwater water quality by slowly filtering water through the soil layer to the drainage pipe at the base. Stormwater flows are diverted and pollutants removed through the processes of settlement (sedimentation) binding with components in the filter media, and by the action of specially selected plants and the associated microbial community.

Bioretention basins are shallow planted depressions that assist in redistributing excess rain and stormwater runoff from the roof of a development, as well as pervious and impervious surfaces. The process assists the rainwater and stormwater runoff to infiltrate the underlying soil, recharge the groundwater and reduce peak flows from the development.

Bioretention swales and bioretention buffer strips serve an identical purpose as bioretention basins in that they reduce the volumetric flow of stormwater and improve stormwater quality. Bioretention swales usually include gravel storage volume. The void spaces in gravel helps store runoff from impervious areas (i.e. a carpark or driveway).

Figure 13: Typical raingarden barrel/tank (top left), bioretention basin/raingarden (top right) and bioretention swale (bottom) installations

Design tips

For South Australian conditions, a rule of thumb guide is for the area of your raingarden to be between 0.5-2.0% of the area of the contributing catchment (e.g. area of roof or other impervious surfaces draining to the raingarden)[24]. The smaller raingarden areas for Adelaide as a percentage of the contributing catchment relative to other Australian cities is necessary to aid plant survival given the longer periods without rainfall over the summer months.

For sizing a raingarden refer to the Tool. A raingarden should have a minimum extended detention depth of 300 mm. The extended detention depth is the depth between the surface level of the system and the top of the overflow pit. A larger extended detention depth will result in more pollutant treatment, however it is important that the detention depth is designed to suit the expected flows into the system.

For further guidance on design and plantings in a raingarden or bioretention system see the Water Sensitive SA Guide to raingarden plant selection and placement[25]

Other design considerations include:

- Lined raingardens should be at least 300 mm from footings and foundations
- Unlined raingardens have the same basic design considerations as infiltration systems, and spacing from footings or foundations are outlined in Table 2: Infiltration characteristics of common soil types.

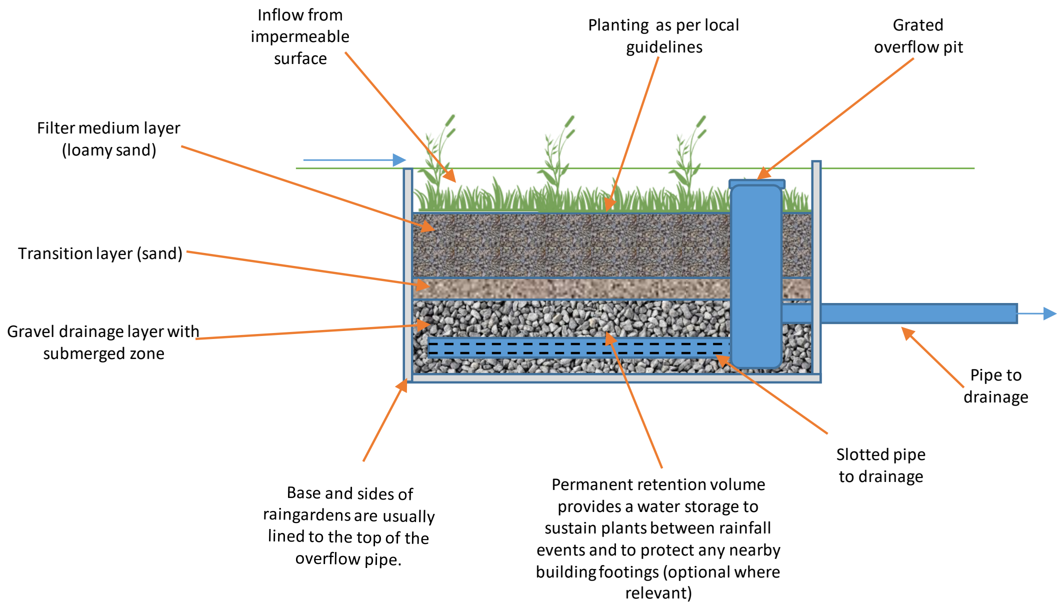

Figure 14: Bioretention raingarden

[24] As a starting point, a biofiltration system with a surface area that is 2% of the impervious area of the contributing impervious catchment, a ponding depth of 100-300 mm and a hydraulic conductivity of 100-300 mm/hr would be a fairly typical design in order to meet regulatory load reduction targets for a temperate climate. Size the system appropriately to avoid a shortened lifespan from sediment clogging (area – 2% of impervious catchment, Melbourne climate; or 4%, Brisbane climate, and sufficient ponding depth).
Payne EGI, Hatt BE, Deletic A, Dobbie MF, McCarthy DT and Chandrasena GI, 2015. *Adoption Guidelines for Stormwater Biofiltration Systems*, Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities

[25] Refer to Water Sensitive SA Guide to raingarden plant selection and placement http://www.watersensitivesa.com/resources/publications-2/guidelines/bioretention/

6 Grass buffers and swales

Grass buffers are vegetated strips that convey hard runoff from an impermeable surface to a downstream drainage system. Buffers are effective in removing coarse and medium-sized sediment from stormwater.

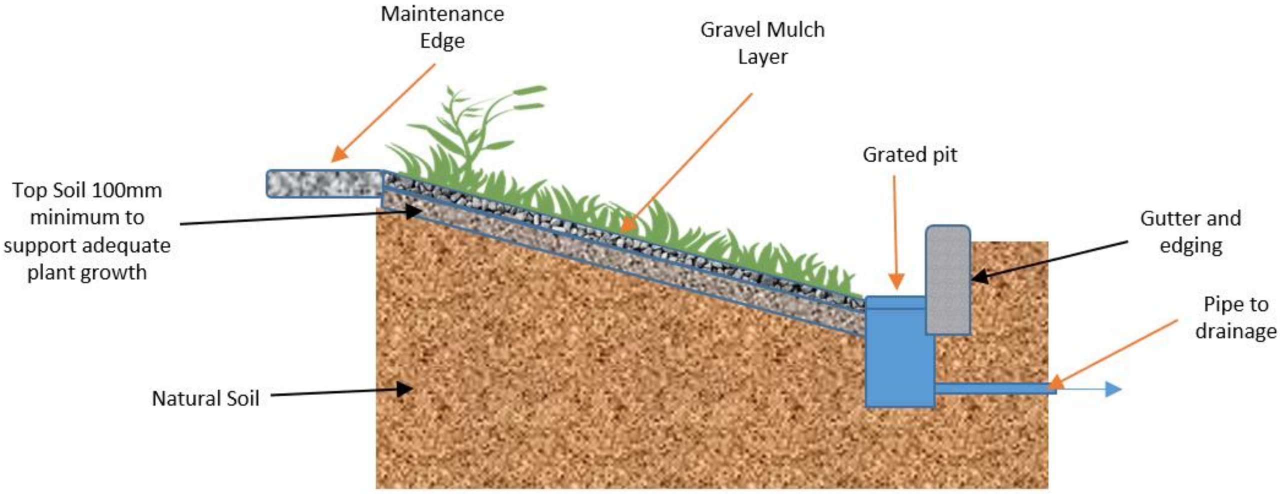

Figure 15: Grass buffer simplified diagram

Grass swales are formed, vegetated channels that are used to convey runoff from impervious areas. They are typically shallow, linear and wide. Grass swales can become features in the landscape, require minimal maintenance once established, and are hardy enough to withstand large flows. Grass swales differ from bioretention swales in that they normally have no underlying gravel and drainage layers.

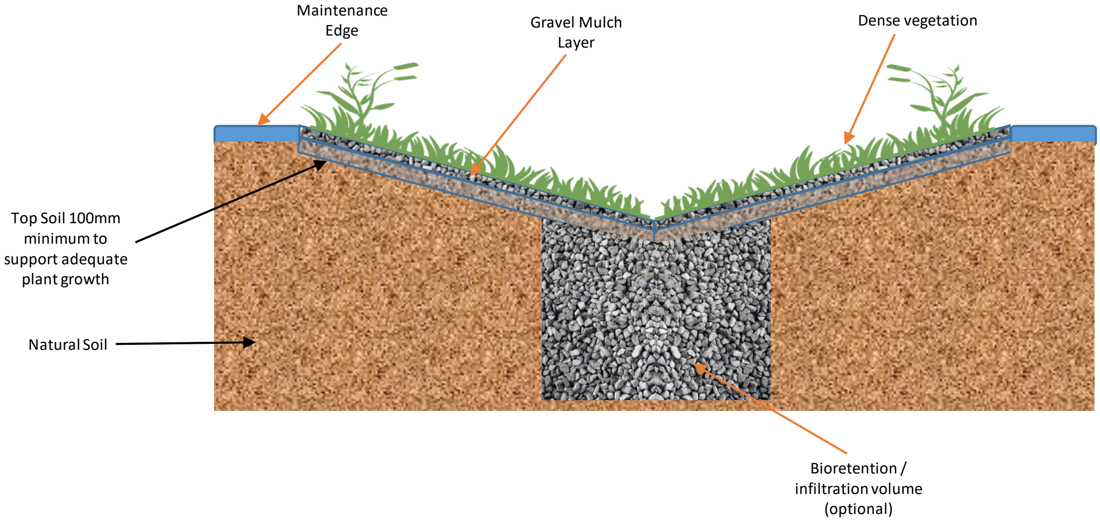

Figure 16: Swale simplified diagram

Design tips

Ensure levels are correct so that runoff can enter the buffer unimpeded. Buffer strips are typically grassy areas although a range of species could be used.

More detailed technical advice on the design on these systems can be found in *Water Sensitive Urban Design – Greater Adelaide Region Technical Manual*, Chapter 11 (Swales and Buffer Strips) and the *WSUD Engineering Procedures: Stormwater*, which can be purchased at www.publish.csiro.au/book/4974

7 Green roofs and living walls

Overview

Green roofs and living walls can provide reduced energy costs, natural insulation, establish peaceful areas for individuals and a place for wildlife, as well as, absorb and treat stormwater. Additionally, green roofs improve air quality and aid in reducing the urban heat island effect – a condition in which cities and suburban developments absorb and trap heat.

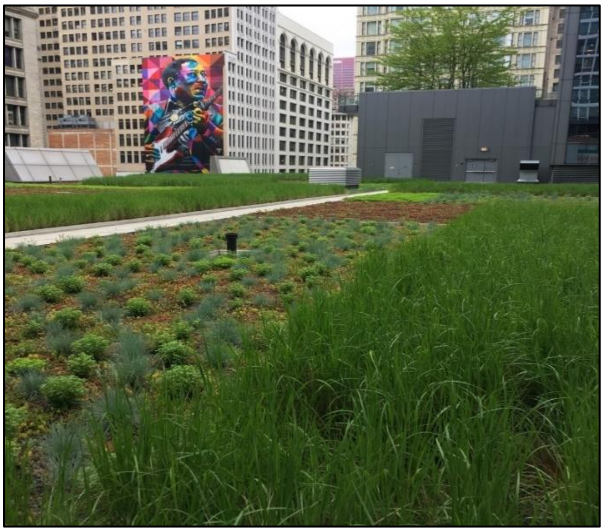

Figure 17: Example rooftop garden and living wall

Design and application

Green roofs and living walls consist of a series of substrate layers to support drainage on top of built structures, provide thermal insulation and can ameliorate the urban heat island effect[26]. The layers incorporated within green roofs and living walls must accommodate drainage and protect the built structure from moisture and water ingress. This is achieved through the inclusion of a waterproof membrane in the design. High-quality root repellent systems are also required for green roofs and living walls to further protect the surrounding structures. A typical cross section of a green roof is shown in Figure 18.

The most appropriate green roof for the Greater Adelaide region is a deeper substrate, which consists of depths between 150 and 600 millimetres of growing medium. Care should be taken that a structural engineer certifies that the building design can support a green roof, and that the design is resistant to heatwaves, as green roofs can 'cook' in high temperatures, killing the vegetation. Design responses to improve performance in high temperatures can include deeper growing medium; water storage crystals; effective irrigation; partial shading with vegetation or structures, e.g. solar panels; and the use of annual native grasses and other summer heat resistant species.

[26] For more information see the *Growing Green Guide: A guide to green roofs, walls and facades in Melbourne and Victoria* http://www.growinggreenguide.org/

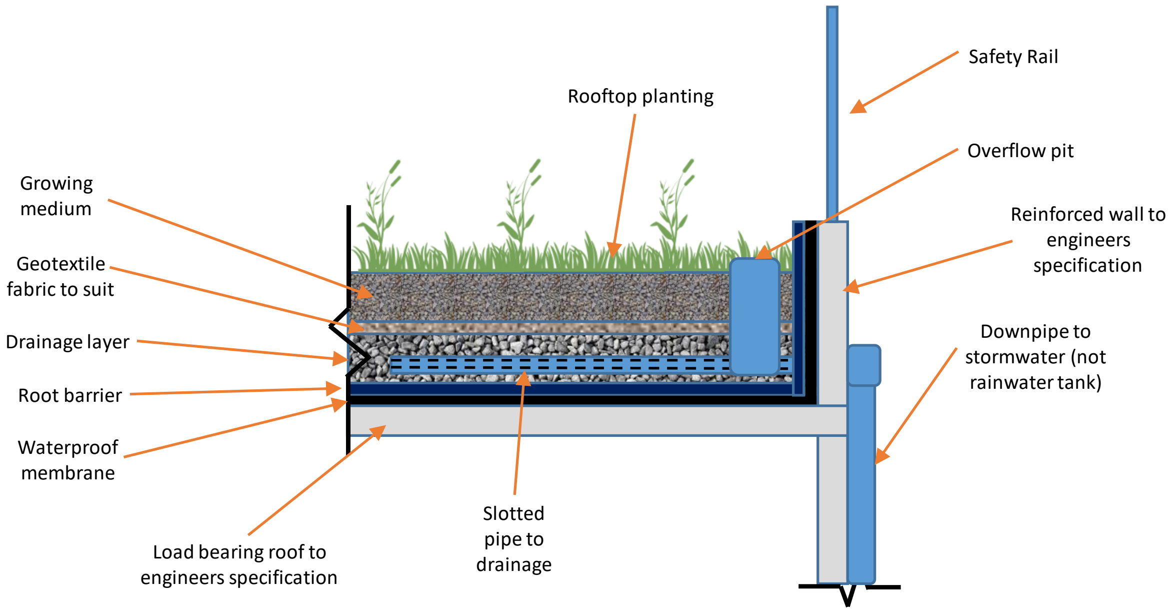

Figure 18: The various layers constituting a green roof design

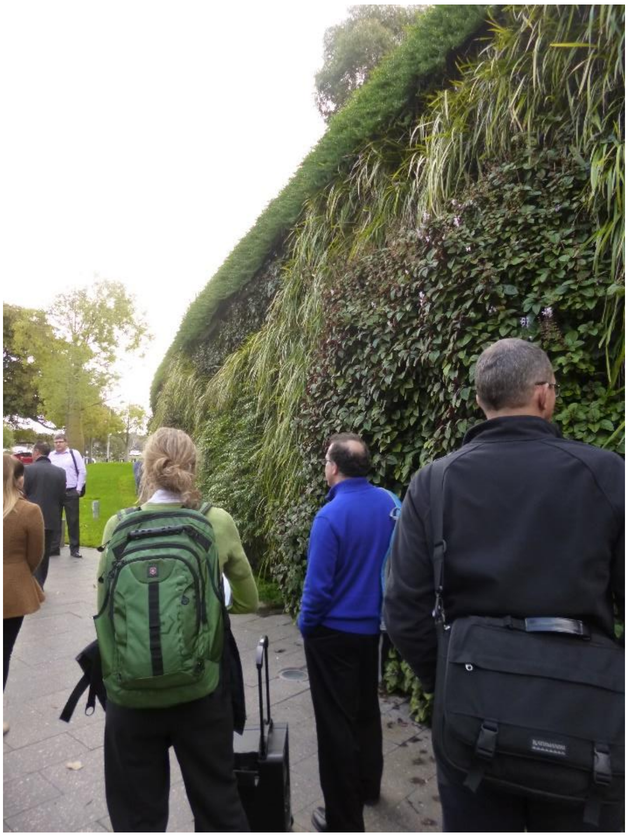

Figure 19: St Bernards Road Green Wall and Adelaide Zoo green wall
Source: Water Sensitive SA

8 On-site detention (OSD) tanks

Overview

Detention systems are similar to retention systems, however the captured stormwater runoff is only temporarily detained for a short period of time, with stormwater discharged at a controlled (reduced) outflow rate. This helps to limit impacts on the capacity of the receiving drainage system. Stormwater detention systems remain empty at all times, except during or immediately after a rain event.

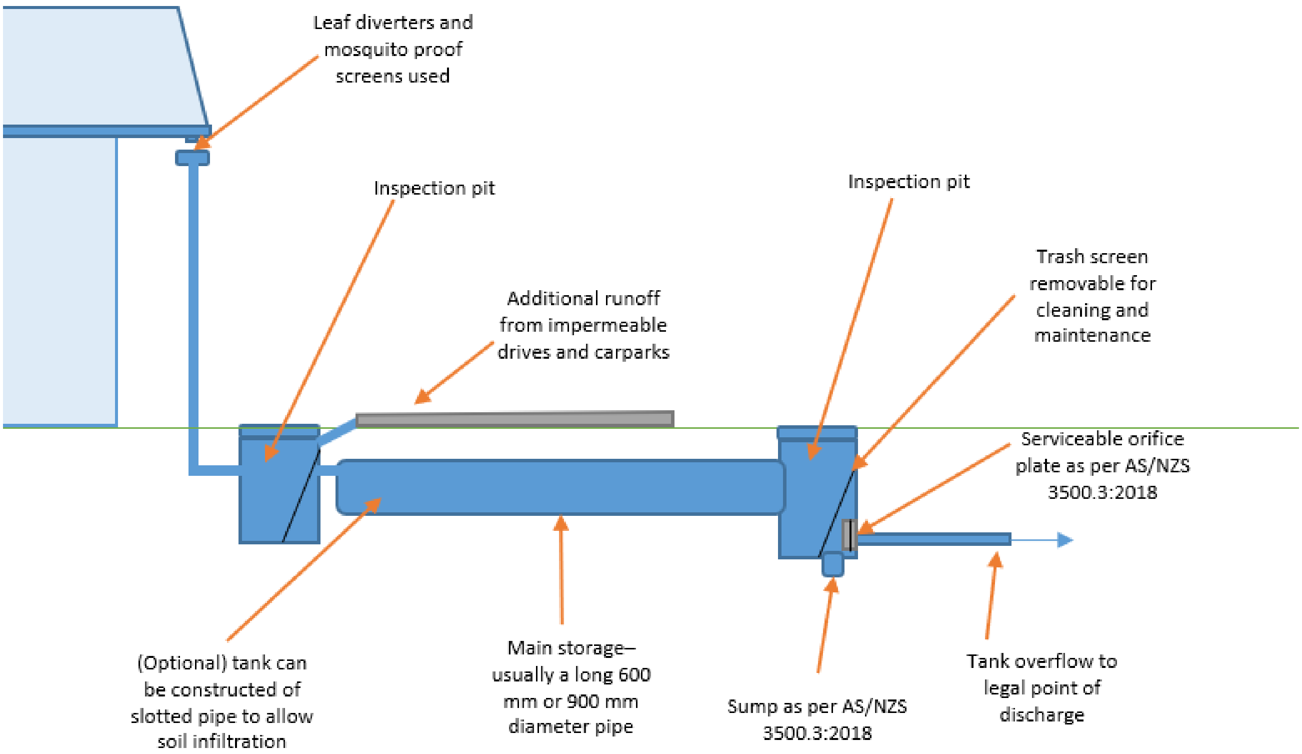

Figure 20: Typical underground stormwater detention tank

Design and application

Detention tanks are useful in areas where current stormwater infrastructure has aged – particularly where urban areas have densified over time, increasing impermeable areas connected to existing drainage systems. The installation of a detention tank aims to reduce local drainage overcapacity in existing infrastructure.

The effect is usually only locally beneficial, with overall catchment flood volumes remaining the same. The flow rate from the tank may be regulated by the size of the tank and orifice outlet. Onsite detention tanks must be designed to suit the requirements of the proposed building development and its location in the catchment. For more information see local Council and stormwater authority guidelines and AS/NZS 3500.3:2018 (Stormwater Drainage).

9 Water efficient fixtures and appliances

Overview

Developments must incorporate water efficient appliances and fixtures such as showerheads, dishwashers, washing machines, basins, kitchen taps and toilets. The Australian Water Efficiency Labelling and Standards (WELS) scheme is an Australian Federal system established to rate appliances based on their water efficiency. It works by assigning a relevant WELS rating (WELS Star rating) label to certain products.

Design and application

Projects should aim to meet best practice water efficiency standards wherever possible. The below recommended WELS ratings performance criteria has been specified in comparison with the industry benchmark.

Table 3 Water efficient appliances and fixtures – WELS Rating and associated water savings against industry benchmark, performance criteria and best practice

Typical fixture	Minimum requirements (used in the Tool)	Best practice
Basins	4 Star WELS	6 Star WELS
Kitchen taps	4 Star WELS	6 Star WELS
Toilets	4 Star WELS	6 Star WELS
Showerheads	3 Star WELS (with flow between 7.5–9 litres/minute)	3 Star WELS (with flow between 4.5-6.0 litres/minute)
Urinals	4 Star WELS	6 Star WELS or waterless
Dishwashers	3 Star WELS	6 Star WELS
Washing machines	3 Star WELS	6 Star WELS
Baths	Medium sized contemporary bath	Small square tub/combined shower

The 25% potable (mains) water reduction performance target compared to a building that has no water saving features can generally be met by using a combination of efficient water fittings and a rainwater tank to supply water for appropriate household uses.

The Tool can aid selection of water efficient fittings and choosing an appropriate rainwater tank design to meet water saving targets in accordance with the Australian Water Efficiency Labelling and Standards (WELS) for water efficiency of fittings[27]. In the Tool, there is the option to meet water savings targets with an alternative water source such as recycled water. If there is supply available via a purple pipe scheme, demand will be assumed to always be met by that alternative supply. However, if the supply is via a rainwater retention tank, then the model will assume irrigation demand is met by supply from the tank if the tank has sufficient storage.

Design considerations

Refer to the *Water Sensitive SA InSite Water User Manual* for further information on selecting water efficient fittings and appliances and details of how use of alternative water (rainwater or treated stormwater/ recycled wastewater provided through a purple or third pipe scheme) can be modelled in the Insite Water Tool).

[27] See http://www.waterrating.gov.au/ for more information on WELS ratings

Glossary of common stormwater design terms

Term	Definition
AEP	**Annual exceedance probability** is defined as: The probability that a given rainfall total accumulated over a given duration will be exceeded in any one year. With ARI expressed in years, the relationship is: AEP = 1 – exp (-1/ARI). Further discussion of stormwater terminology can be found in Book 1; Chapter 2; Section 2.2 Terminology of ARR 2016 http://arr.ga.gov.au/arr-guideline. The diagram below shows which terminology should be used with the coloured in number boxes.

Australian Rainfall and Runoff terminology

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI	Uses in Engineering Design
Very frequent	12				
	6	99.75	1.002	0.17	Water sensitive urban design
	4	98.17	1.02	0.25	
	3	95.02	1.05	0.33	
	2	86.47	1.16	0.50	
	1	63.2	1.58	1.00	
Frequent	0.69	50.00	2	1.44	Stormwater/pit and pipe design
	0.5	39.35	2.54	2.00	
	0.22	20.00	5	4.48	
	0.2	18.13	5.52	5.00	
	0.11	10.00	10.00	9.49	Floodplain management and waterway design
Infrequent	0.05	5.00	20	20.0	
	0.02	2.00	50	50.0	
	0.01	1.00	100	100	
Rare	0.005	0.50	200	200	
	0.002	0.20	500	500	
	0.001	0.10	1000	1000	
Extremely Rare	0.0005	0.05	2000	2000	
	0.0002	0.02	5000	5000	Design of high-consequence infrastructure (eg major dams)
			↓		
Extreme			PMP		

Diagram sourced online from the Bureau of Meteorology
http://www.bom.gov.au/water/designRainfalls/ifd/ifd-faq.shtml

Term	Definition
ARI	**Average recurrence interval** is defined as: The average, or expected, value of the periods between exceedances of a given rainfall total accumulated over a given duration. The ARR 2016 discourages the use of ARI, however as it is still commonly used in the stormwater industry this guide provides both ARI and the equivalent AEP / EY value.
ARR 2016 ARR 2019	**Australian Rainfall and Runoff** (Engineers Australia 2016, published at http://arr.ga.gov.au) is a national guideline document, data and software suite that is the default national standard for the estimation of design flood characteristics in Australia. Note an updated version was published in March 2019.
Deemed-to-satisfy	A simplified checklist approach to achieving compliance targets (as opposed to a custom designed or software modelled approach).
Detention storage	The component of a rainwater tank used to store water harvested from rooftops (rainwater) or stormwater runoff from hard surfaces "detained" in a tank for a limited period. Stormwater detention tanks are intended to remain empty, except during periods of rainfall and for a short time thereafter. Unlike retention rainwater storages, the distinguishing feature of a stormwater detention tank is that it is specially fitted with a valve to slowly release water over time.
EY	**Exceedances per year** is the number of times an event is likely to occur or be exceeded within any given year.

Term	Definition
Infill growth	Growth occurring through densification of existing developed areas.
InSite Water	An integrated water cycle management design toolkit focused on Council approvals for infill growth www.insitewater.com.au
OSD	**On site detention** A common practice of slowing down stormwater release rates into stormwater drains by using a detention tank with a known outflow rate.
PMP	**Probable maximum precipitation** The greatest depth of precipitation for a given duration meteorologically possible for a given size storm area at a particular location at a particular time of year, with no allowance made for long-time climatic trends (World Meteorological Organization).
Rainwater	Rainfall collected from the roofs of buildings.
Rainwater tank	A water tank that is used to collect and store rainwater runoff, typically from rooftops via rain gutters.
Retention storage	The component of a rainwater tank used to store water harvested from rooftops (rainwater). The water retained is used inside the home (e.g. toilets, laundry or hot water services) or for reticulated irrigation OR The component of stormwater runoff from hard surfaces (stormwater) retained in infiltration systems to provide passive irrigation to the surrounding soils, rather than simply discharging to the drainage system.
Soil site classification	Soils site classification is according to *Australian Standard AS 2870/2011 – Residential slabs and footings*[28] Site classifications and movement are based on soil reactivity **Class A** (0-10mm) Stable, non-reactive. Most sand and rock sites. Little or no ground movement likely as a result of moisture changes. **Class S** (10-20mm) Slightly reactive clay sites. May experience slight ground movement as a result of moisture changes. **Class M / M-D** (20-40mm) Moderately reactive clay or silt sites. May experience moderate ground movement as a result of soil conditions and moisture changes. **Class H1 / H1-D** (40-60mm) Highly reactive clay sites. May experience a high amount of ground movement as a result of soil conditions and moisture changes. **Class H2 / H2-D** (60-75mm) Highly reactive clay sites. May experience very high ground movement as a result of soil conditions and moisture changes. **Class E / E-D** (75mm+) Extremely reactive sites. May experience extreme amounts of ground movement as a result of soil conditions and moisture changes. **Class P** (this is approximately 70% of building sites in Australia) Problem sites. Sites may be classified as 'Class P' as a result of mine subsidence, landslip, collapse activity or coastal erosion (e.g. dunes), soft soils with a lack of suitable bearing, cut and/or filled sites, or creep areas. Ground movement as a result of moisture changes may be very severe. If you are building on a Class P site you will need to consult a structural engineer. The '**D**' inclusion (i.e. M-D, H1-D, H2-D or E-D) The 'D' in these classifications refers to 'deep' movements in soil due to deep variances in moisture. These classifications are mostly found in dry areas.
Stormwater	Rainfall that runs off all urban surfaces such as roofs, pavements, car parks, roads, gardens and vegetated open space.
WELS	Australian Water Efficiency Labelling Standards scheme.
WSUD	**Water sensitive urban design** Design principles that aim to reduce the impact of interactions between the urban built form and the urban water cycle including surface water, potable water, groundwater, urban and roof runoff, wastewater and stormwater.

[28] AS 2870-2011 – Residential slabs and footings available from SAI Global https://infostore.saiglobal.com/