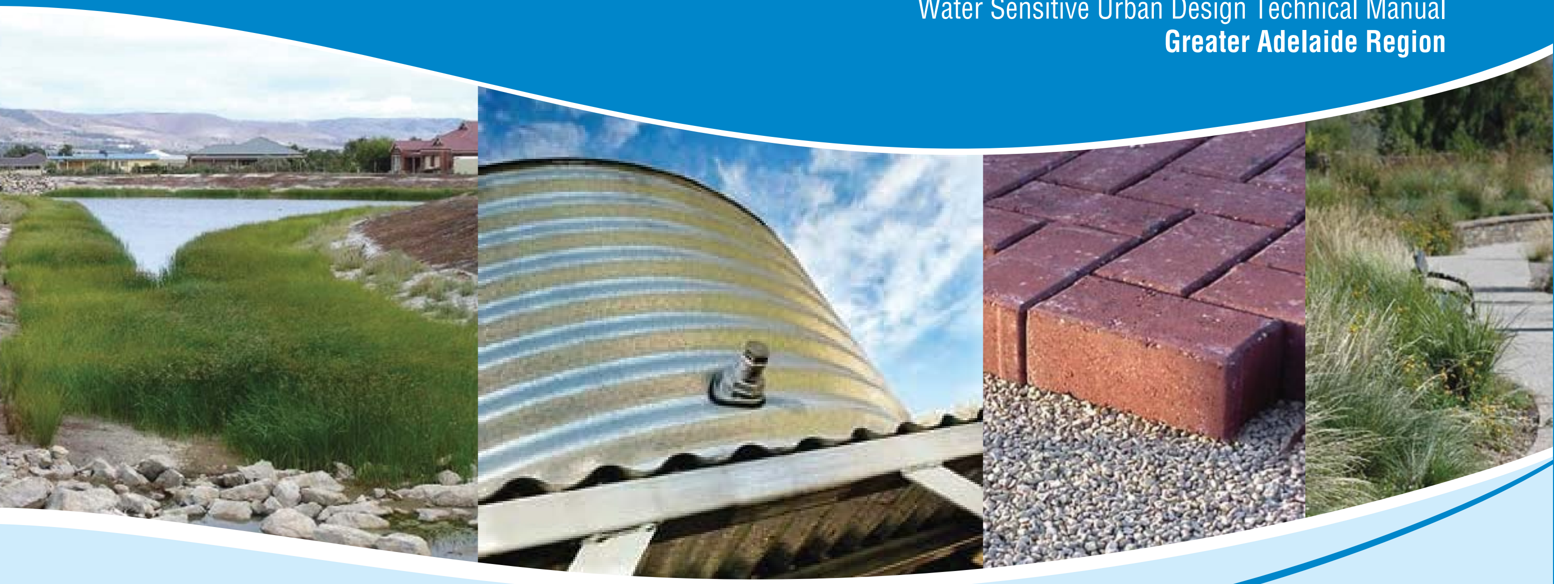
December 2010

Chapter 1

Introduction

Water Sensitive Urban Design Technical Manual
Greater Adelaide Region



Government of South Australia

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Water Sensitive Urban Design

Water Sensitive Urban Design (WSUD) is an approach to urban planning and design that integrates the management of the total water cycle into the urban development process. It includes:

- Integrated management of groundwater, surface runoff (including stormwater), drinking water and wastewater to protect water related environmental, recreational and cultural values;
- Storage, treatment and beneficial use of runoff;
- Treatment and reuse of wastewater;
- Using vegetation for treatment purposes, water efficient landscaping and enhancing biodiversity; and
- Utilising water saving measures within and outside domestic, commercial, industrial and institutional premises to minimise requirements for drinking and non drinking water supplies.

Therefore, WSUD incorporates all water resources, including surface water, groundwater, urban and roof runoff and wastewater.

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The project partners gratefully acknowledge all persons and organisations that provided comments, suggestions and photographic material.

In particular, it is acknowledged that material was sourced and adapted from existing documents locally and interstate.

Overall Project Management

Christine Lloyd (Department of Planning and Local Government)

Steering Committee

A group of local government, industry and agency representatives provided input and feedback during preparation of the Technical Manual. This group included representatives from:

- Adelaide and Mt Lofty Ranges Natural Resources Management Board;
- Australian Water Association (AWA);
- Department for Transport, Energy and Infrastructure (DTEI);
- Department of Water, Land and Biodiversity Conservation (DWLBC);
- Environment Protection Authority (EPA);
- Housing Industry Association (HIA);
- Local Government Association (LGA);
- Department of Planning and Local Government (DPLG);
- South Australian Murray-Darling Basin Natural Resources Management Board;
- South Australian Water Corporation;
- Stormwater Industry Association (SIA); and
- Urban Development Institute of Australia (UDIA).

Technical Sub Committee

A technical sub committee, chaired by Dr David Kemp (DTEI), reviewed the technical and scientific aspects of the Technical Manual during development. This group included representatives from:

- Adelaide and Mt Lofty Ranges Natural Resources Management Board;
- City of Salisbury;
- Department for Transport, Energy and Infrastructure (DTEI);
- Department of Health;
- Department of Water, Land and Biodiversity Conservation;
- Department of Planning and Local Government; and
- Urban Development Institute of Australia.

From July 2010, DWLBC was disbanded and its responsibilities allocated to the newly created Department For Water (DFW) and the Department of Environment and Natural Resources (DENR).

Specialist consultant team

Dr Kylie Hyde (Australian Water Environments) was the project manager for a consultant team engaged for its specialist expertise and experience in water resources management, to prepare the Technical Manual.

This team comprised Australian Water Environments, the University of South Australia, Wayne Phillips and Associates and QED Pty Ltd.

Beecham and Associates prepared Chapter 16 of the Technical Manual.

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Chapter 1 Introduction

1.1 What is Water Sensitive Urban Design?

Water Sensitive Urban Design (WSUD) is an approach to urban planning and design that integrates the management of the total water cycle into the urban development process. It includes:

- Integrated management of groundwater, surface runoff (including stormwater), drinking water and wastewater to protect water related environmental, recreational and cultural values;
- Storage, treatment and beneficial use of runoff;
- Treatment and reuse of wastewater;
- The use of vegetation for treatment purposes, water efficient landscaping and enhancing biodiversity; and
- The utilisation of water saving measures within and outside domestic, commercial, industrial and institutional premises to minimise requirements for drinking and non-drinking water supplies.

WSUD recognises all water streams in the total water cycle as valuable resources:

- Rainwater (collected from the roof);
- Runoff (including stormwater, collected from all impervious surfaces);
- Potable mains water (drinking water);
- Groundwater;
- Greywater (from bathroom taps, showers and laundries); and
- Blackwater (from kitchen sinks and toilets).

By applying appropriate measures in the design and operation of development, it is possible to:

- Maintain and restore the natural water balance;
- Reduce flood risk in urban areas;
- Reduce erosion of waterways, slopes and banks;
- Improve and protect water quality of surface and groundwater;
- Make more efficient use of water resources;
- Reduce the cost of providing and maintaining water infrastructure;

- Minimise demand on the reticulated water supply system;
- Protect and restore aquatic and riparian ecosystems and habitats;
- Protect the scenic, landscape and recreational values of streams;
- Minimise treated wastewater discharges to the natural environment;
- Integrate water into the landscape to enhance visual, social, cultural, biodiversity and ecological values; and

- Reduce greenhouse gas emissions by reducing water consumption, increasing rainwater harvesting and 'natural' treatment alternatives.

1.2 Water Sensitive Urban Design Objectives and Principles

Objectives

The overarching objective (or vision) of WSUD in the Greater Adelaide Region is to stabilise and improve the health of the Greater Adelaide Region's coastal waters, inland watercourses and groundwater systems, while maintaining and enhancing human health and reducing the ecological footprint of the Greater Adelaide Region.

Other key objectives of implementing WSUD are to:

- Move towards a natural flow regime (for example, lower flows to reduce erosion of creeks and improve or maintain ecological value);
- Manage risk in relation to drought, flood, climate change and public health;
- Protect, enhance, value and conserve water resources;
- Encourage leading practice in the use and management of water resources so as to increase water efficiency, reduce reliance on imported water and apply at-source reduction of impacts on water quality, flooding, erosion and sedimentation;
- Raise awareness and catalyse change in the design, construction and management of urban development and urban infrastructure; and
- Recognise and foster the significant environmental, social and economic benefits that result from sustainable and efficient use of water resources.

Further information about objectives is contained in **Appendix C** of **Chapter 3**.

Principles

There are a number of guiding principles that underpin the objectives for water management and the implementation of WSUD in the Greater Adelaide Region. These principles should be addressed when undertaking the planning and implementation of water management on a site, catchment or regional scale.

The guiding principles include to:

- Incorporate water resources as early as possible in the land use planning process;
- Address water resource issues at the catchment and sub-catchment level;
- Ensure water management planning is precautionary, and recognises inter-generational equity, conservation of biodiversity and ecological integrity;
- Recognise water as a valuable resource and ensure its protection, conservation and reuse;

- Recognise the need for site-specific solutions and implement appropriate non-structural and structural solutions;
- Protect ecological and hydrological integrity;
- Integrate good science and community values in decision making; and
- Ensure equitable cost sharing.

Further information about principles is contained in **Appendix D** of **Chapter 3.**

1.3 Purpose, Target Audience and Scope of the Technical Manual

Purpose

WSUD promotes innovative integration of urban water management technologies into an urban environment.

The aim of the Technical Manual is to:

- Demonstrate how WSUD can be successfully incorporated into a range of projects, illustrating example measures;
- Provide a consistent approach to the planning and design of WSUD measures for urban developments across the Greater Adelaide Region;
- Inform and guide urban management decision making processes;
- Help increase awareness and appreciation of WSUD; and
- Encourage the consideration of factors including landscaping, biodiversity and greenhouse gas emissions early in the design process.

The Technical Manual outlines a WSUD planning process, design procedures, simplified design tools and checklists for individual WSUD measures that can be used by a range of audiences.

The Manual is not meant to be prescriptive, rather it provides a range of opportunities and techniques that can be employed to achieve the consenting authority's primary objective(s) and also assist in achieving regional and state targets.

Target Audience

The successful incorporation of WSUD into urban activities and development requires a multi-disciplinary approach to ensure a sustainable design and layout of a development. Typically this would involve all, or a combination, of a range of the following professions:

- Engineers;
- Planners;
- Urban designers;
- Architects;
- Landscape architects; and
- Environmental scientists/ecologists.

The target audience for the Technical Manual is therefore wide ranging and includes the above professions as well as:

- Applicants (or developers);
- Development assessment staff involved in the formulation and evaluation of WSUD strategies;
- Local government staff and those from the professions listed above; and
- South Australian Government agency staff.

It has been assumed that the reader is familiar with the land development process, the planning framework for land rezoning and the development approval process in their local area. Further information on the planning and development system in South Australia can be obtained from the Department of Planning and Local Government website, www.planning.sa.gov.au

Use of the Technical Manual by Applicants

The purpose of the Technical Manual for applicants is to:

- Provide a tool for developing design responses that incorporate better water management and biodiversity practices and which meet defined performance standards; and
- Help in the preparation of conceptual and detailed designs for WSUD systems as part of a development proposal.

Chapter 2 should be used in the selection, location and conceptual design of WSUD measures. This section should be applied as early as possible to the development design process to ensure:

- Impacts on the water cycle are minimised;
- WSUD is considered in the initial development design and layout; and
- Suitable WSUD measures are identified to adequately address and meet applicable water quality and quantity objectives and targets.

Chapter 3 should be used to assist in determining the requirements of councils for documentation of conceptual and detailed options.

Use of the Technical Manual by Local Government

Local government can use the Technical Manual to provide:

- Better advice to actively guide WSUD planning, design and installation in the Greater Adelaide Region in a consistent manner; and
- A clear and transparent development assessment process for WSUD measures and promotion of the achievement of water quality and quantity objectives and targets.

Specifically councils can use:

- Design Assessment Checklists which provide a template for checking development submissions, ensuring a sufficient level of detail is presented for assessment; and

- Inspection Forms and Maintenance Checklists to help ensure WSUD measures are built as designed, are maintained and are in good operating condition prior to asset handover to council.

Scope of the Technical Manual

This Manual aims to provide WSUD leading management practice information for a range of WSUD measures suitable for application at different scales. In particular the WSUD measures outlined in this document are based upon innovative WSUD methods which have proven environmental, aesthetic and economic outcomes and are applicable to the local environment of the Greater Adelaide Region. However, it should be noted that the WSUD measures outlined is not an exhaustive list of all possible WSUD components that could be used in urban areas. Nonetheless, the documents do include those measures that are most likely to be used in the Greater Adelaide Region.

Managing urban runoff as a resource, for the protection of receiving ecosystems and for flood prevention are key elements of WSUD, and in this first version of the Technical Manual, urban runoff (including rainwater and stormwater) is the main focus of the tools presented. However, opportunities for on-site and community treated wastewater reuse should also be encouraged, so general information has also been included. It is envisaged that future editions of the Technical Manual will include more comprehensive coverage of treated wastewater reuse as this becomes more widely accepted and practical for general application.

1.4 Structure of the Technical Manual

This Technical Manual is comprised of 16 chapters.

- **Chapter 1 – Introduction and Snapshot of WSUD Measures (the 'WSUD Toolkit')**

Introduces WSUD and provides an introductory overview of 11 WSUD management strategies, including technologies and design features, detailed in this Manual.

- **Chapter 2 – WSUD Measures for Different Types and Scales of Development**

Presents various WSUD options for different types and scales of development, ranging from single residential houses through to residential subdivisions, multi-unit developments, open space and commercial and industrial sites.

Research and experience demonstrates that WSUD measures can be designed for all types of development, including in the inner city where limited space is available. A design response may utilise a single WSUD measure or it may combine several to achieve the necessary outcomes.

- **Chapter 3 – Designing a WSUD Strategy for Your Development**

Outlines a 12 step design process required to successfully incorporate WSUD measures into a development or redevelopment.

- **Chapters 4 to 14**

Outline in detail the 12 WSUD tools contained within this Technical Manual.

These are:

- Demand Reduction – **Chapter 4**
- Rainwater Tanks – **Chapter 5**
- Rain Gardens, Green Roofs and Infiltration Systems – **Chapter 6**
- Pervious Pavements – **Chapter 7**
- Urban Water Harvesting and Reuse – **Chapter 8**
- Gross Pollutant Traps – **Chapter 9**
- Bioretention Systems for Streetscapes – **Chapter 10**
- Swales and Buffer Strips – **Chapter 11**
- Sedimentation Basins – **Chapter 12**
- Constructed Wetlands – **Chapter 13**
- Wastewater Management – **Chapter 14**
- Siphonic Roofwater Systems – **Chapter 16**

- **Chapter 15 - Modelling Process and Tools**

Provides an overview of the modelling process and the modelling tools that are available and applicable to the Greater Adelaide Region.

The Technical Manual will be a 'living document' and will be reviewed and updated regularly.

The Technical Manual complements existing local and interstate resources, in particular the *WSUD: Basic Procedures for 'Source Control' of Stormwater* (Argue, Ed., 2009).

1.5 Snapshot of 12 WSUD Measures

This section introduces the 12 WSUD measures described in **Chapters 4 to 14 and Chapter 16** of the WSUD Technical Manual for the Greater Adelaide Region.

Included is a table summarising the focus and suitability of each measure to certain circumstances.

1.5.1 Demand Reduction

(See **Chapter 4** of the WSUD Technical Manual)

Description

New development, redevelopment and alterations to existing buildings can contribute to environmental sustainability by incorporating a variety of water efficiency (or demand reduction) measures.

Purpose

The purpose of demand reduction is to conserve water supplies.

Application / Scale

Demand reduction applies to residential, commercial, industrial, community service and recreational developments, redevelopments and retrofitting. Demand reduction is applicable at the allotment level.

Example Measures

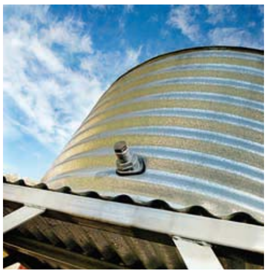
The following measures can be applied:

- Water-efficient fixtures and appliances;
- Rainwater tanks;
- Landscape practices;
- Treated runoff and wastewater reuse; and
- Education and incentives.

1.5.2 Rainwater Tanks

(See **Chapter 5** of the WSUD Technical Manual)

Description



A rainwater tank is designed to capture and store roof runoff (i.e. rainwater) from gutters or downpipes on a building and does not generally collect water other than roof runoff or mains water. Harvested water is then available for toilet flushing, laundry uses, hot water uses, outdoor irrigation or drinking (following filtration).

Purpose

Rainwater tanks provide a simple means of achieving several environmental benefits, including:

- Potential reduction in peak runoff rates and volumes and the consequent negative environmental impacts (including flooding, pollution and erosion);
- Reduction in importation of water from distant catchments; and
- Reduction in drinking water (or mains water) consumption.

Application / Scale

Rainwater tanks are generally applied at the allotment scale, but can be applied at the street scale in larger development projects.

Rainwater tanks can be utilised on residential, commercial, recreational, institutional and industrial development sites. Adelaide currently has the highest adoption rate of rainwater tanks of any state capital city in Australia.

Example Measures

Rainwater tanks come in a variety of shapes and sizes including standard exterior tanks made from galvanized steel (or similar), plastic or fibreglass and wall-cavity tanks, subsurface tanks, special rainwater storage guttering and under-floor water storage pillows. In addition, indoor modular tanks and underground storage systems are now readily available. Slimline tanks and integrated fence systems that incorporate rainwater storage are also useful in restricted spaces.

1.5.3 Rain Gardens, Green Roofs and Infiltration Systems

(See **Chapter 6** of the WSUD Technical Manual)

Overview

Source control is one of the most effective ways of managing runoff in an urban catchment. Managing runoff at the source provides more opportunities to achieve a hydrological cycle that is closer to the predevelopment (natural) regime. WSUD measures that can be implemented at the site level include rain gardens, green roofs and infiltration systems. They have the ability to intercept runoff, treat it and promote infiltration to the soil with subsequent recharge of the groundwater system.

Rain gardens, green roofs and infiltration systems are discussed in the same chapter of the Technical Documents as all on-site measures with similar functions.

Rain Gardens

Description

Rain gardens resemble a regular garden with one major difference – they have runoff directed into them from downpipes or paved areas. They assist in the infiltration of runoff into underlying soils.

Purpose

Rain gardens retain runoff for infiltration into the soil. In doing so, rain gardens reduce the amount of runoff that would otherwise wash pollutants quickly into the stormwater drainage system. Rain gardens also treat the runoff while providing habitat for native fauna.

Application / Scale

Rain gardens can be applied at the allotment scale as well as being incorporated into landscaping within major developments. They are appropriate for commercial, industrial, institutional, recreational and residential sites, and can be incorporated into new construction or added to existing gardens during renovation.

A wide range of native species are suitable for rain gardens.

Green Roofs

Description

Green roofs are also known as rooftop gardens, vegetated roof covers, living roofs, eco-roofs and nature roofs.

Green roofs are a series of layers consisting of living vegetation growing in substrate over a drainage layer on top of built structures, either new or retrofitted. Under the substrate is usually a range of protective barriers that prevent the penetration of water and roots.

There are four types of green roofs. The primary difference is the depth of the substrate, which has a direct relationship to runoff holding capacity.

Purpose

The benefits of green roofs include:

- Managing runoff;
- Improving water quality;
- Reducing impervious areas;
- Reducing the Heat Island Effect;
- Reducing air pollution;
- Increasing biodiversity;
- Improving insulation;
- Increasing carbon dioxide/oxygen exchange; and
- Additional living space.

Application / Scale

Green roofs are appropriate for commercial and industrial structures as well as residential buildings. They can be installed on flat roofs but also can be built on roofs with slopes up to 30 degrees. Green roofs can be incorporated into the design of new construction or retrofitted into existing buildings.

Infiltration Systems

Description

Infiltration systems generally consist of a shallow excavated trench or 'tank', designed to detain (and retain) a certain volume of runoff and subsequently infiltrate the stored water to the surrounding soils. They reduce runoff volumes by providing a pathway for treated runoff to recharge local groundwater aquifers.

Purpose

The main purpose of infiltration systems is to facilitate infiltration of surface waters to groundwater.

Application / Scale

Infiltration systems are highly dependent on local soil characteristics and are best suited to sandy soils with deep groundwater. Infiltration measures generally require pre-treatment of runoff before infiltration to avoid clogging of the surrounding soils and to protect groundwater quality.

Infiltration systems are required to have sufficient setback distances from structures to avoid any structural damage from the wetting and drying of soils (e.g. from soil shrinkage). These setback distances depend on local soil conditions.

1.5.4 Pervious Pavements

(See **Chapter 7** of the WSUD Technical Manual)

Description

Pervious pavements (also known as porous and permeable pavements) are pavements that allow the ingress of water and flow through to the paving substrate and eventually into the underlying subsoil.

More recent developments have seen storage systems being incorporated underneath pervious pavements so that the filtered water can be recovered and reused.

Purpose

The purpose of pervious pavements is to:

- Provide for on-site retention of runoff, thereby reducing peak flows;
- Reduce the overall volume of runoff from a site; and
- Minimise the export of sediments and pollutants from a site.

When coupled with underlying or offline storages (and associated reuse) their effectiveness can be significant.

Application / Scale

Pervious paving can be used as an alternative to conventional paving and hardstand surfaces within urban developments to reduce runoff velocity and volume. They are most appropriately used in residential situations where vehicle traffic is low and where there are low sediment loads.

Example Measures

A number of pervious paving types are available, each with advantages and disadvantages for various applications, including:

- Porous asphalt or concrete (monolithic structures) – open graded asphalt or concrete with reduced or no fines and a special binder that allows water to pass through the pavement by flowing through voids between the aggregate.
- Modular pavers – these pavers may be made from porous material or from non-porous clay or concrete. They are usually installed with gaps between the pavers to allow water to penetrate into the subsurface.
- Grid or lattice systems – these are made of concrete or plastic grids filled with soil or aggregate through which water can percolate. These systems may also be vegetated (usually with grass).

1.5.5 Urban Water Harvesting and Reuse

(See **Chapter 8** of the WSUD Technical Manual)

Description

Urban water harvesting and reuse refers to the collection and reuse of various water sources for drinking and non-drinking water substitution purposes.

Purpose

The purpose of urban water harvesting and reuse schemes is to:

- Conserve water;
- Prevent increased stream erosion;
- Maintain water balance;
- Provide on-site detention (and retention) and therefore reduce peak runoff rates and volume; and
- Improve water quality.

An integrated urban water harvesting and reuse scheme should provide at least five core functions: (a) collection; (b) treatment; (c) storage; (d) flood and environmental flow protection; and (e) distribution to the end user.

Figure 1.1 Grange Golf Course, Stormwater Harvesting and Reuse

Source: Courtesy of Adelaide and Mt Lofty Ranges Natural Resources Management Board

Application / Scale

Urban water harvesting and reuse schemes can be applied at the street, precinct or catchment scale and can utilise various sources of water including rainwater, stormwater and, at the subdivision scale, occasionally treated wastewater.

One of the greatest challenges facing water harvesting and reuse is the storage of water for subsequent use. Water harvested can be stored using, for example, underground or above ground storage tanks, in a basin or in an aquifer.

Example Measures

Typical measures include:

- Wetlands;
- Managed aquifer recharge (otherwise known as aquifer storage and recovery);
- Rainwater tanks;
- Ponds and lakes;
- Pervious pavement systems with underlying or offline storages; and
- Underground or subsurface tanks.

1.5.6 Gross Pollutant Traps

(See **Chapter 9** of the WSUD Technical Manual)

Description

Gross pollutant traps (GPTs) are constructed devices designed to remove solids (usually greater than 5 millimetres in diameter) from the stormwater drainage system. They remove the large debris washed into the stormwater system before the stormwater enters the receiving waters. GPTs are also known as litter traps or trash racks. It should be noted that trash racks often target solids greater than 60 millimetres in diameter.

Purpose

The use of GPTs for pre-treatment can be for either improved aesthetics in receiving waters or to maintain the integrity of additional treatment devices located further downstream within an integrated treatment train.

Application / Scale

GPTs are generally applied on the catchment scale.

Example Measures

There are many differing types of GPTs that are commercially available. They can range from simple to complex constructions including:

- Simple grated entry pits, suited to preventing large litter items from entering the drainage system;
- Side entry pit inserts, formed by simple baskets or screens placed at, or close after, the throat entry. They typically have screen sizes between 5 and 20 millimetres;
- Proprietary manufactured traps which fall into three broad types:
  - Boom diversion systems (e.g. CSR Humes);
  - Return flow litter baskets (e.g. Ecosol);
  - Continuous deflection separation (e.g. CDS Technologies).

These devices vary greatly, though in general GPTs should be designed to capture gross pollutants and coarse sediment up to a three month average recurrence interval (ARI) flow.

1.5.7 Bioretention Systems

(See **Chapter 10** of the WSUD Technical Manual)

Bioretention systems refer to both bioretention swales and bioretention basins, which are both vegetated WSUD systems. A particular challenge in Adelaide is to provide sufficient water to maintain the vegetation during the long interstorm dry periods commonly experienced in South Australia. In summer, in particular, the vegetation not only suffers from water shortage but often heat stress as well. Another consequence of these long hot periods is that vegetated systems often leach nitrogen following microbial and plant die-off (Kim et al, 2003). Chapter 10 describes how to incorporate design features to ameliorate these effects.

Bioretention Swales

Description

Sometimes called biofiltration trenches or bioretention trenches, bioretention swales are a subsurface water filtration system capable of holding runoff to allow it to infiltrate and/or be temporarily detained to achieve some water quality improvement.

Figure 1.2 Bioretention Swale, Mawson Lakes, SA

Source: Courtesy of University of South Australia

Runoff is 'filtered' through a prescribed filter media (for example a sandy loam) as it percolates downwards under gravity. This filtered runoff is then collected at the base of the filter media via perforated pipes and flows to downstream waterways or to storages for potential reuse. Should in-situ soil conditions be favourable, infiltration can be encouraged from the base of a bioretention swale to recharge local groundwater and to reduce surface runoff volumes.

Purpose

Bioretention swales can provide the following functions:

- Provide infiltration of runoff into the ground;
- Provide on-site detention and retention capacity;
- Conveyance;
- Improve water quality discharging from the swale; and
- Reduce the peak flow of a storm event in the system.

Concerns are often raised in relation to such devices in clay or rocky soils. Unlike infiltration systems, bioretention swales are well suited to a wide range of soil conditions, including low hydraulic conductivity 'clay' soils and areas affected by soil salinity and saline groundwater, as their operation is often designed to minimise or eliminate exfiltration from the filter media to surrounding in-situ soils.

Vegetation that grows in the filter media of bioretention swales is an integral component of these treatment systems. Both the vegetation and the filter media have functional roles in the treatment of runoff and it is the intrinsic relationship between the two that ensures the long-term functional performance of the system.

Application / Scale

Bioretention swales can form attractive streetscapes and provide landscape features in an urban development. They are commonly located in the median strip of divided roads, in carparks and in parkland areas. Bioretention swales offer opportunities in both new construction and retrofit situations.

Bioretention Basins

Description

Bioretention basins operate with the same treatment processes as bioretention swales except they do not have a conveyance function. High flows are either diverted (bypassed) away from the basin or are discharged into an overflow structure.

Purpose

Like bioretention swales, bioretention basins can provide efficient treatment of runoff through fine filtration, extended detention treatment and some biological uptake, particularly for nitrogen and other soluble or fine particulate contaminants.

Application / Scale

Bioretention basins have an advantage of being applicable at a range of scales and shapes and therefore provide flexibility for locations within a development.

They are equally applicable to redevelopment sites and greenfield sites. Smaller systems may take the form of 'planters' that can be located within allotments (e.g.

gardens) and along roadways at regular intervals (e.g. in traffic calming devices) to create a boulevard aesthetic. All of these systems treat runoff close to its source and prior to entry into an underground drainage system.

Larger bioretention basins may be located at outfalls of a drainage system (e.g. in the base of retarding basins) to provide 'end-of-pipe' treatment to runoff from larger subcatchments where 'at source' applications may not be feasible. The positioning of large size bioretention basins and the resultant delivery of runoff into the basin needs to be considered to avoid scour and to ensure even distribution over the full surface area of the filter media.

A wide range of vegetation can be used within bioretention basins, allowing them to be easily integrated into the landscape theme of an area. As for bioretention swales, vegetation that grows in the filter media of bioretention basins is an integral component of these treatment devices. Bioretention basins are however sensitive to any materials that may clog the filter medium or damage the vegetation and therefore vehicles, building materials and construction washdown wastes should be kept away from bioretention basins.

Figure 1.3 Bioretention Basin, Palmer Road, Aldinga Beach

Source: Courtesy of City of Onkaparinga

1.5.8 Swales and Buffer Strips

(See **Chapter 11** of the WSUD Technical Manual)

Swales

Description

Swales are linear depressions that are used for the conveyance of stormwater runoff. They can be grassed or more densely vegetated with a variety of species.

Purpose

Swales provide a number of functions, including:

- Reducing the speed of runoff;
- Capturing sediments and attached pollutants;
- Reducing total runoff through infiltration (this is often only significant when coupled with an infiltration trench);
- Accommodating pedestrian movement across and along them when grassed; and
- Adding to the local amenity.

Figure 1.4 Swale at Pine Lakes, City of Salisbury

Source: Courtesy of City of Salisbury

Swales are used to convey runoff in lieu of, or in association with, underground pipe drainage systems and can be used to capture coarse and medium sediment. They are commonly used as part of an overall treatment train to deliver acceptable quality for discharge to aquatic ecosystems or for potential reuse applications.

Swales can be particularly useful for conveying overland flow into other downstream WSUD components such as bioretention basins or wetlands.

Swales also disconnect impervious areas from hydraulically efficient pipe drainage systems. This is important for protecting aquatic ecosystems in receiving waterways by managing the frequency of damage to aquatic habitats by storm flows. This is due to slower travel times for flows along swale systems compared with efficient pipe drainage systems. This reduces the rapid response from impervious areas, particularly for frequent storm events, and reduces the impact on natural receiving waterways.

Application / Scale

Swales can be incorporated into urban designs along streets (within the median strip or footpaths), in parklands and between allotments where maintenance access can be preserved. In addition to their treatment function, these systems can add to the aesthetic character of an area. Careful consideration is required with the establishment phase and irrigation requirements during prolonged dry spells.

Buffer Strips

Description

Buffer strips are broad sloped areas of grass or other dense vegetation, capable of withstanding shallow sheet flow stormwater runoff.

Purpose

Buffer strips:

- Remove sediment and pollutants from runoff prior to entering a drainage system;
- Provide some reduction in runoff volume through infiltration; and
- Offer a small reduction in peak volumes through attenuated runoff.

The vegetation used in buffer strips is important as grass density and length affect performance.

1.5.9 Sedimentation Basins

(See **Chapter 12** of the WSUD Technical Manual)

Description

Sedimentation basins (otherwise known as sediment basins) can take various forms and can be used as either permanent systems integrated into an urban design or used as temporary structures to reduce sediment discharge during construction activities.

Sedimentation basins are used to retain coarse sediments from runoff and are typically the first element in a treatment train. Within a treatment train they play an important role by protecting downstream elements from becoming overloaded or smothered with sediments, thus optimising treatment performance and minimising ongoing maintenance costs.

Figure 1.5 Brookes Bridge Sedimentation Basin

Source: Courtesy of Australian Water Environments

Purpose

Sedimentation basins operate by reducing flow velocities and encouraging sediments to settle out of the water column.

They can also be designed as ephemeral systems, allowing them to drain during periods without rainfall and then to refill during runoff events.

Sedimentation basins are typically installed to perform two key roles:

- Coarse sediment removal; and
- Flow regulation.

Application / Scale

Within a treatment train, sedimentation basins are typically installed upstream of a constructed wetland or a bioretention basin. In some cases a sedimentation basin can be converted to a wetland when receiving sediment loads have reduced to an appropriate level.

Sedimentation basins are also often used on construction sites.

Example Measures

Sedimentation basins can have various configurations including hard edges and base (e.g. concrete), or a more natural form with edge vegetation.

1.5.10 Constructed Wetlands

(See **Chapter 13** of the WSUD Technical Manual)

Description

Constructed wetlands are created, constructed versions of a natural wetland system that use vegetation, enhanced sedimentation, fine filtration and biological pollutant uptake processes to improve water quality.

Figure 1.6 Laratinga Wetlands, Mt Barker

Source: Courtesy of the District Council of Mt Barker

Constructed wetlands generally comprise:

- A sedimentation basin in the form of a deep open pond at the stormwater entry point to remove coarse sediments;
- A range of shallow (but variable depth) water areas containing dense macrophytic planting to remove fine particulates and to provide uptake of soluble pollutants; and
- A high flow bypass channel (to protect the macrophyte zone from high velocity flood flows).

Purpose

Wetlands function to improve water quality by:

- Removing sediments and suspended solids, together with their attached pollutants; and
- Removing a range of dissolved nutrients and contaminants.

In addition to playing an important role in water treatment, wetlands can also have significant community benefits. They provide habitat for wildlife and a focus for recreation, such as walking paths and other passive recreational pursuits. They can also improve the aesthetics of a development (and therefore the value) and be a central feature in a landscape.

The detailed design and construction of wetlands is a relatively complex task.

Application / Scale

Wetlands can be constructed on many scales, from housing estate scale to large regional systems. In highly urbanised areas they can have a hard edge form and be part of a streetscape or used in the forecourts of buildings. In regional settings they can be over 10 ha in size and provide significant habitat for wildlife. Wetlands are commonly associated with managed aquifer recharge (MAR) schemes, as a form of pre-treatment and temporary storage.

1.5.11 Wastewater Management

(See **Chapter 14** of the WSUD Technical Manual)

Overview

The majority of water used for indoor purposes is discharged after use as wastewater. Wastewater can be collected by a reticulated sewerage system and treated at a conventional wastewater treatment plant (WWTP). Alternatively, it can be collected, treated and reused on site, thereby promoting more efficient water use. While this has many economic and environmental benefits for the community, it needs to be balanced against potential health risks.

On-site reuse of treated domestic wastewater is subject to various restrictions due to concerns associated with effluent quality, maintenance of the treatment system and public health issues.

Appropriately utilising treated greywater for non-drinking purposes can save significant quantities of mains water. It can also reduce wastewater volumes requiring treatment at conventional WWTPs.

For reuse schemes, extensive treatment of wastewater is often required for water to be used for toilet flushing and garden irrigation.

Purpose

Sustainable water management is an important goal and a key element of urban development. Government authorities and the land development industry are increasingly seeking to use alternative sources, such as treated wastewater, to conserve drinking water supplies and minimise wastewater disposal to the marine environment.

Application / Scale

Treated wastewater should be considered in the context of the specific development and management of the total water cycle. The potential for treatment and reuse of wastewater will depend on:

- The scale and location of the development;
- The volume, quality and timing of wastewater generated; and
- The volume, quality and timing of treated wastewater demand.

Options for treatment and reuse of wastewater are applicable at a range of scales including on site, community and regional and for a range of types of development including residential, commercial and industrial.

Before developing a wastewater treatment and reuse system it is important to check whether there are any planning regulations, building regulations or local health requirements that apply to wastewater in your area, through consultation with your local council.

1.5.12 Siphonic Roofwater Systems

(See **Chapter 16** of the WSUD Technical Manual)

Description

Siphonic roofwater systems are an efficient way to harvest roofwater falling on high – rise, multi storey residential buildings or large commercial and industrial buildings. Instead of draining the roof through a high number of vertical downpipes, siphonic systems utilise the height of the building to generate pressurised flow which can then be used to direct the harvested water at roof level to often a single downpipe. This greatly facilitates rainwater harvesting and allows designers to incorporate smart storage solutions in high density developments.

Figure 1.7 Construction of a New Building at Mawson Lakes Incorporating a Siphonic Roofwater Harvesting System

Source: Courtesy of University of South Australia

Purpose

Siphonic roofwater harvesting systems provide one of the few opportunities to harvest rainwater in central business districts and other high density developments. In addition to the benefits associated with harvesting and reuse, such as reduced demand on potable supplies, siphonic systems also help reduce flash flooding effects that are otherwise common in highly urbanised areas.

Application / Scale

Siphonic roofwater harvesting systems are equally applicable to tall residential buildings as they are to commercial and industrial developments. The main restriction is the height of the building rather than its use. Because siphonic systems use the height of the building to generate pressurised pipe flow, they are generally restricted to buildings greater than 4.5m in height.

1.5.13 Summary Table

Table 1.1 contains a summary of the WSUD measures including:

- The focus of each measure (water quality and/or water quantity);
- Potential benefits;
- Suitable site conditions; and
- Unsuitable conditions.

Table 1.1 WSUD Measures: Role, Focus, Site Conditions and Benefits

Measure	Focus of WSUD Measure		Potential Benefits	Suitable Site Conditions	Unsuitable Conditions
	Water Quality	Water Quantity			
Demand Reduction (Chapter 4)	Low	High	Reduction in mains water supply	Residential, commercial and industrial sites	Where water quality does not meet end use requirements
Rainwater Tanks (Chapter 5)	Low	High	Storage for reuse. Sediment removal in tank. Frequent flood retardation	Proximity to roof. Suitable site for gravity feed. Need to incorporate into urban design	Non-roof runoff treatment. Where tank water is not used on a regular basis
Rain Gardens (Chapter 6)	Medium	High	Volume retention. Water quality improvement	Allotment scale	Reactive clay sites. Near infrastructure
Green Roofs (Chapter 6)	Medium	Medium	Retention of water. Biodiversity	Flat roofs, slopes up to 30 degrees	Roofs that are not structurally suitable
Infiltration Systems (Chapter 6)	High	Medium	Volume retention. Water quality improvement	Precinct scale	Non-infiltrative soils. High groundwater levels
Pervious Pavements (Chapter 7)	High	Medium	Retention and detention of runoff	Allotments, roads and car parks	Severe vehicle traffic movement and developing catchments with high sediment load
Urban Water Harvesting and Reuse (Chapter 8)	Medium	High	Reduction in mains water supply	Residential, commercial and industrial, generally more viable for precinct scale sites	Locations where demand is limited or adverse impacts to downstream users

Measure	Focus of WSUD Measure		Potential Benefits	Suitable Site Conditions	Unsuitable Conditions
	Water Quality	Water Quantity			
Gross Pollutant Traps (Chapter 9)	High	Low	Reduces litter and debris. Can reduce sediment. Pre-treatment for other measures	Site and precinct scales	Sites larger than 100 ha. Natural channels. Low lying areas
Bioretention Systems (Chapter 10)	High	Low	Fine and soluble pollutants removal. Streetscape amenity. Frequent flood retardation	Flat terrain	Steep terrain. High groundwater table
Swales (Chapter 11)	Low	Low	Medium and fine particulate removal. Streetscape amenity. Passive irrigation	Mild slopes (< 4%)	Steep slopes
Buffer Strips (Chapter 11)	High	Low	Pre-treatment of runoff for sediment removal. Streetscape amenity	Flat terrain	Steep terrain
Sedimentation Basins (Chapter 12)	High	Medium	Coarse sediment capture. Temporary installation. Pre-treatment for other measures.	Need available land area	Where visual amenity is desirable
Constructed Wetlands (Chapter 13)	High	Medium	Community asset. Medium to fine particulate and some soluble pollutant removal. Flood retardation. Storage for reuse. Wildlife habitat	Flat terrain. Need available land area	Steep terrain. High groundwater table
Wastewater Management (Chapter 14)	Medium	High	Nutrient reduction to receiving environments. Fit for purpose substitution	Where adequate treatment and risk management can be ensured	
Siphonic Roofwater Systems (Chapter 16)	Low	High	Frequent flood retardation. Reduction in mains water supply.	High density residential, commercial and industrial buildings	Buildings lower than 4.5m in height

Source: Adapted from City of Yarra (2006)

1.6 References

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