*Water Sensitive Urban Design Strategy*

# BEST PLANNING AND MANAGEMENT PRACTICES

## BOOK TWO

*January 2004*

LANDCOM
Creating Better Communities

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## INTRODUCTION

The Water Sensitive Urban Design (WSUD) approach calls for an enhanced, or more considered, approach to the integration of land and water planning at all levels in the urban development process (i.e. strategic and concept planning to detailed design). Consequently, achieving WSUD objectives is more than simply constructing a lake or wetland system. Fundamental to the philosophy of WSUD is the integrated adoption of Best Planning Practices and Best Management Practices.

This book provides an overview of WSUD practices such as:

- Best Planning Practices (BPPs) – land-use techniques or concepts that provide a development layout that maximises opportunities for WSUD elements. An example of a BPP is road layout and streetscaping design; and
- Best Management Practices (BMPs) – individual WSUD elements or tools designed to achieve the guiding principles of WSUD. Examples of BMPs include rainwater tanks and vegetated swales.

There are both technical and non-technical issues associated with the successful implementation of WSUD principles and practices and these are drawn out in the case studies in Book Three.

# 1. Best Planning Practices (BPPs)

WSUD BPPs are land-use planning techniques and concepts that provide a development layout that maximises opportunities for implementing WSUD Best Management Practices (BMPs), outlined in Section 2. BPPs need to be considered at the initial site planning phase of an urban development and can enhance the aesthetic, amenity and recreation opportunities of an area as well as protecting its environmental values.

## 1.1 Public Open Space Layout

Integration of Public Open Space (POS) through conservation corridors, stormwater management systems and recreational facilities is a fundamental objective of WSUD. POS areas can potentially incorporate stormwater conveyance and treatment systems such as landscape features within a Multiple Use Corridor[1] This can provide a recreation focus (such as a linear park with bike path or an urban forest) as well as enhancing community understanding and regard of stormwater as a valuable resource.

Key principles to be considered in locating POS are:

- Align POS along natural drainage lines.
- Protect/enhance areas containing natural water features (such as creeks and wetlands) and other environmental values by locating them within POS.
- Use POS to provide links between public and private areas and community activity nodes.

Examples of matching public open space with drainage features

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[1] Multiple Use Corridor – refers to a linear open space which intergrates drainage function as well as community, environmental and recreational values.

## 1.2 Road Layouts and Streetscaping

Roads account for a significant percentage of the overall impervious area created within a typical urban development and therefore can significantly change the way water is transported through an area. Roads also generate a number of water borne stormwater contaminants that adversely impact on receiving waterway health (e.g. fine sediments, metals and hydrocarbons). Consequently, it is important to mitigate the impact of stormwater runoff generated from road surfaces. By carefully planning road alignments and streetscapes, WSUD drainage elements such as bioretention systems and vegetated swales (see Section 2.2.1) can be used to collect, attenuate, convey and treat the runoff before discharge to receiving waterways.

Key principles in selecting road alignments and streetscapes for WSUD are:

- Where the natural topography has grades less than 4% (1 in 25) the majority of roads should be aligned, where practicable, perpendicular to the contours. This allows lots on either side to drain towards the road and be collected by the road drainage system, thus avoiding “low-side” lots that require back of lot stormwater collection systems (which limit treatment opportunities).
- Where the natural topography has grades between 4% (1 in 25) and 7% (1 in 15), the majority of roads should be aligned, where practicable, at an angle across the contours to ensure the longitudinal grade of the roads does not exceed 4%. Natural topography with grades steeper than 7% will generally only allow limited WSUD drainage elements to be installed within road reserves, unless road grades are kept to less than 4% and retaining walls are provided on the “high-side” lots.
- Conventional pipe drainage systems would normally be provided along roads with longitudinal grades steeper than 4% unless additional flow control features such as check dams are used to promote uniform flow conditions.
- Where practicable, dual carriageway roads should be incorporated along trunk drainage routes to allow use of the centre medians for WSUD drainage systems.
- Single carriageway roads should be designed to provide for implementation of WSUD drainage systems such as bioretention swales within the “high-side” footpath reserve. Where the road is running perpendicular to the contours and there is no discernable “high-side” then either footpath reserve can be used for bioretention swales. While not essential, conventional footpaths and services can be located on the opposite side of the road.

## 1.3 Lot Layouts

WSUD promotes the use of smaller, more compact housing lots adjacent to POS areas that typically have high amenity value. This allows greater community access to POS and WSUD elements, such as natural and landscaped water features forming the local stormwater drainage system. Where practicable, natural landscape features such as significant remnant vegetation and natural waterways should be incorporated within POS with housing lots configured around the POS and designed to encourage views over, and access to, the POS. The connectivity of the lots to the POS allows the creation of smaller lots through provision of less lawn and garden area on the lot. The reduced lot size is balanced by the lots direct connectivity to the adjoining POS. Experience suggests that lots with direct access to POS and water features have elevated values compared to conventional lot designs.

## 2. BEST MANAGEMENT PRACTICES (BMPs)

### 2.1 Potable Water Demand Reduction

Mechanisms for improving the adoption of water conservation and reducing potable water use include:

- Education to encourage behavioural change in water use practices.
- Incentives to adopt water demand management initiatives.
- Pricing frameworks to help reduce demand.
- Regulation to provide a framework and timetable for the adoption of water conservation initiatives.

Mechanisms for improving urban water cycle management and the adoption of water recycling initiatives include:

- Education to better match available water sources to appropriate uses.
- Pricing frameworks to encourage the use of "fit for purpose" water sources.
- Incentives for the adoption of water reuse initiatives in developed areas.
- Regulation to provide a framework and timetable for the adoption of water reuse initiatives in greenfield areas.
- Uniform guidelines for reclaimed water use and standardise procedures for approvals for water reuse initiatives.

### 2.1.1 Water Conservation

In general, water conservation initiatives are not particularly contentious and are reasonably easy to introduce. Mechanisms such as education, incentives and regulation can be used to promote the adoption of water conservation initiatives. Initiatives could include:

1. Education to achieve behavioural change with regard to:
   a. Tap maintenance
   b. Efficient garden watering practices
   c. No hosing of paths and driveways

   d. Use of swimming pool blankets to reduce evaporation
   e. Reduced domestic water use (shower times, etc.).
2. A mix of education, incentives and regulation to achieve:
   a. The use of AAA plumbing fittings
   b. The use of AAA and AAAA appliances (e.g. dishwashers and washing machines)
   c. 6/3 dual flush cisterns
   d. Pressure regulation (at the household–applicability will depend on the type of household appliances)
   e. Garden design incorporating low water requirement vegetation and mulching
   f. Scheduled irrigation systems for garden watering based on soil moisture levels.

A recent Sydney Water Corporation paper found that the adoption of AAA rated showerheads and dual flush toilets (40% 9/4.5 and 60% 6/3) reduced indoor potable water consumption by 15-20%. A recent study by Coomes (2002)[2] for the Urban and Regional Land Corporation (Victoria) found the combined use of AAA fittings and appliances can be expected to reduce indoor potable water consumption by 23%.

### 2.1.2 Matching Water Source to End Use

Integrated water cycle management matches available water sources with the most appropriate uses. This is a way to reduce the demand on the highest quality potable water. Uses such as irrigation and toilet flushing do not require potable standard water and alternative sources (possibly from reuse) can be found.

In most urban developments there are three major water sources:

1. Potable water
2. Wastewater
   a. Blackwater
   b. Greywater
3. Stormwater
   a. Roof runoff
   b. Surface run off

As shown, the wastewater component can be further split into greywater (shower, bathroom and laundry sinks, and washing machine water) and blackwater (kitchen and toilet). Stormwater can also be divided into roof runoff and runoff from ground level surfaces (roads, paths and pervious surfaces such as lawns, etc.).

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[2] Coomes Consulting Group, 2002, Integrated Water Management – Epping North Project, April

The major objective of water reuse initiatives is to replace potable water use with other water sources where the quality is fit-for-purpose. Table 2.1 shows a suggested hierarchy of source to use matchings for typical household uses in an attempt to match the quality of available water sources to appropriate uses.

|  | Garden | Kitchen |  | Laundry |  | Toilet | Bathroom |  |
|---|---|---|---|---|---|---|---|---|
| SOURCE |  | Cold | Hot | Cold | Hot |  | Cold | Hot |
| Potable | 3 | 1 | 2 | 1 | 2 | 3 | 1 | 2 |
| WASTEWATER |  |  |  |  |  |  |  |  |
| Treated Black | 1 | 4 | 4 | 4 | 4 | 1 | 4 | 4 |
| Greywater | 2 | 4 | 4 | 4 | 4 | 2 | 4 | 4 |
| STORMWATER |  |  |  |  |  |  |  |  |
| Roof | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 1 |
| Non-roof | 2 | 4 | 4 | 4 | 4 | 2 | 4 | 4 |

Table 2.1 Compatibility of water source (and typical quality) and appropriate use
1. Preferred use; 2. Compatible use; 3. Non-preferred use; 4. Not compatible

Figure 2.1 presents the distribution of the current water use for typical residential developments in Sydney. This figure suggests that current potable water use in Sydney could be significantly reduced by using non-potable water for toilet flushing and garden use (up to 48% of total water use). Potable quality water is clearly not required for these uses. Only 10% of current total household use in Sydney is used in the kitchen where the primary use would be associated with human consumption (e.g. drinking, food preparation etc.) and where the high quality of potable water is required.

Greywater reuse can save significant quantities of potable water. Its effective use requires additional infrastructure (underground tanks, pumps, on-site disposal system) from conventional houses as well as the active participation and involvement of residents. However, separation and reuse of greywater can have significant benefits, including reducing wastewater volumes that require treatment as well as reducing potable water demand. However, reduced wastewater flows on a large scale can have some implications for sewer design and solids transport (e.g. steeper grade requirements). A combination of greywater reuse, a blackwater interceptor and small diameter sewer (SDS) technology can potentially address these issues and provide a more sustainable solution.

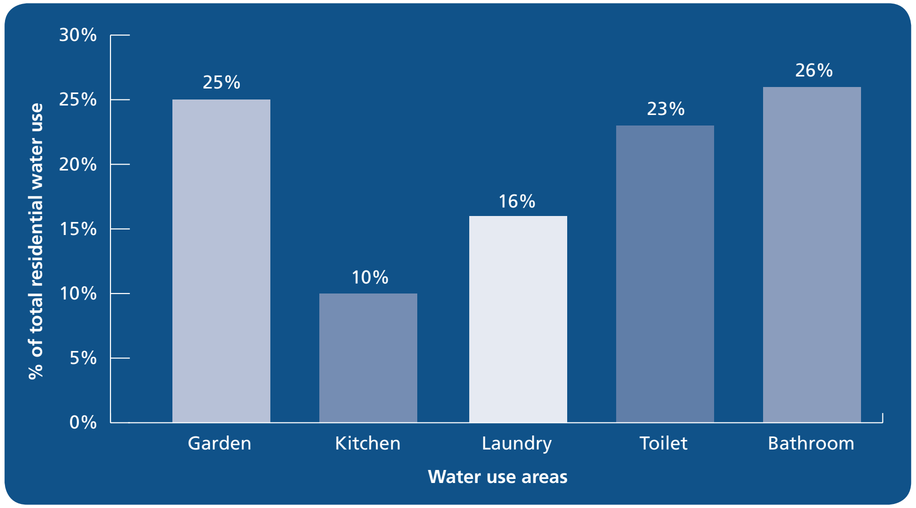


Figure 2.1 Typical Sydney Residential Water Use Breakdown (Source: Sydney Water Corporation).

Figure 2.2 presents the expected potable water savings for a range of demand management and water reuse options for typical residential households in Sydney. As it suggests, the single greatest saving can be made by toilet flushing and garden watering with treated wastewater or greywater. The greatest water saving is with a combination of demand management, using treated wastewater or greywater for toilet flushing and garden watering, and using rainwater in hot water systems. Hot water demand is assumed to be about 40% of indoor water use. While these are preliminary estimates the hierarchy of water savings can clearly be seen in Figure 2.2.

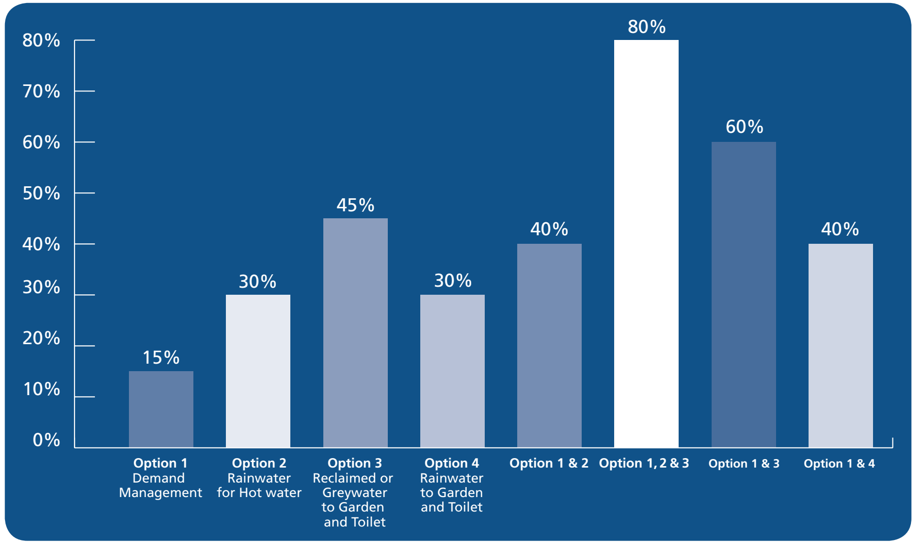


Figure 2.2 Expected % potable water savings for a range of demand management and reuse options.

From an ease of adoption perspective the following sequence of implementation is suggested:

1. Option 1 (demand management)
2. Option 1 plus 4 (demand management and the use of rainwater for toilet flushing and garden watering)
3. Option 1 plus 2 and 3 (demand management, the use of reclaimed wastewater or greywater for toilet flushing and garden watering, and the use of rainwater for hot water).

These options provide potable water savings of 15%, 40% and 80% respectively. These findings are consistent with extensive modelling undertaken by Coomes (2002) for the Urban & Regional Land Corporation in Victoria.

In the absence of a reticulated reclaimed water system, the opportunity for cost-effective reuse of wastewater will be restricted to the separation of greywater and blackwater to enable the storage and reuse of greywater for toilet flushing and garden irrigation. Laundry water may also be excluded from the greywater stream (making it "light greywater") to reduce risks of pathogen contamination, however this will reduce the volume available for reuse. The consequence of this may be that light greywater is only applicable for toilet flushing and some opportunistic irrigation.

Options for potential water demand reduction need to be considered on a case by case basis, taking into account the development scale, layout, proximity to wastewater treatment facilities and climate conditions.

## 2.2 Stormwater Management

Best practice in stormwater management encompasses elements at the site, precinct (estate) and regional levels, which can be combined to provide a strategic framework for integrated catchment management. Many of the concepts and types of treatment measures adopted in formulating stormwater management plans are applicable at all three scales as illustrated in Table 2.2.

| Local Elements ⟷ | Precinct Elements ⟷ | Regional Elements |
|---|---|---|
| Allotment Density and Layout | Local Street Layout and Streetscape | Major Road Layout<br>Public Open Space and Multiple use Corridors |
| On-site Retention (Infiltration) | Precinct Retention (Infiltration) | |
| Porous Pavement | Porous Pavements | |
| Sand Filter | Sand Filter | |
| Buffer Strips | Buffer Strips | |
| Vegetated Swales | Vegetated Swales | |
| Bioretention System | Bioretention System | |
| Rain Garden | Urban Forest | |
| On-site Retention | Retarding Basins | Retarding Basins |
| Rainwater Tank for Stormwater Reuse | Constructed Wetlands and Ponds | Constructed Wetlands and Ponds |
| | Stormwater Reuse | Stormwater Reuse |

Table 2.2 Inter-relationship between site-precinct-regional stormwater management measures

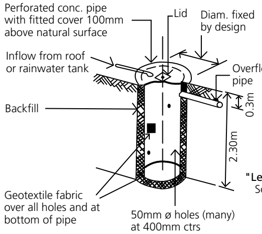
Precinct plans implemented at a residential estate level are a means of implementing municipal stormwater management plans at a detailed, local level. These will be prepared by Landcom as part of its development proposal with much of the infrastructure ultimately transferred to council ownership after the development.

### 2.2.1 Stormwater Treatment Measures

The following stormwater management measures form a "tool kit" from which individual measures can be selected to create a stormwater treatment train (see Section 2.2.3) that suits the characteristics of each development and treats the range of likely pollutants generated in an urban area.

**Gross pollutant traps (GPTs)**: A constructed treatment device for the removal of gross solids within a conventional drainage system. GPTs come in many forms, but all are designed to retain litter and debris from stormwater yet not retard flows considerably. They can be installed in drain entrances, underground pipe systems, at pipe outfalls or on open channels.

**On-site infiltration**: A shallow, excavated trench or "leaky" well capable of draining stormwater into surrounding soils. It includes a rock or gravel filled trench or porous pavements.



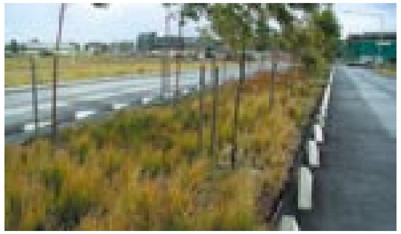
**"Leaky" well with overflow**
Source: Assoc. Prof. John Argue (UniSA)

**Sediment basins**: A constructed basin used to slow flow velocities and settle coarse sediment. Many types of basins are used, some as temporary basins during construction and others as pre-treatments for other WSUD measures.

**Rainwater tanks**: A sealed tank capable of collecting stormwater directly from a roof or other above ground surface. It is designed to allow reuse of the collected water and can be located either above or below ground. Provision of temporary flood storage can reduce peak flow rates up to two year average recurrence intervals (ARI). Tanks also provide some treatment through settlement of suspended solids

**Vegetated swales**: A grassed or vegetated channel used to convey runoff as an alternative to kerb and gutters. Contaminants contained in the runoff are filtered as they pass through the vegetation. Further treatment can also be achieved with the incorporation of bioretention systems into the base of swales.

**Buffer strips**: A wide grassed or vegetated filter capable of treating shallow overland flow before it enters a drainage network. Coarse pollutants are retained in the vegetation, while flows pass downstream.



**Bioretention systems**: A combined vegetated swale or stormwater detention basin with a stormwater filtration system. Stormwater is filtered through a prescribed media (e.g. sandy loam) before being collected by an underlying perforated pipe for subsequent discharge to a stormwater system. If overlying a deep sand deposit, it may be desirable to allow the filtered stormwater to exfiltrate from the bioretention system. In areas affected by urban salinity, bioretention systems can be designed to minimise the likelihood of exfiltration from the trench thus minimising the potential impacts of development on urban salinity.

**Wetlands**: A constructed wetland system can be a recreational focus, wildlife habitat and provide stormwater treatment and flood control. The system generally comprises:

- a sedimentation pond: a relatively deep open water body with vegetated edge to collect coarse sediment
- a wetland: a macrophyte zone, or a permanent or ephemeral shallow water body with extensive vegetation that filters finer particulates from the water.

**Ponds**: An open water body used as storage of stormwater runoff for reuse and/or to serve as an ornamental lake. A pond can also act to settle out sediment in the relatively still open water. Ponds also promote biological removal for stormwater pollutants.

**Retarding basins**: An area created to provide temporary flood storage for stormwater flows (typically up to the 100 year ARI event). Can be kept dry by providing a low flow bypass pipe (and used as a parkland) or can integrate stormwater quality treatment measures within the floor of the basin such as constructed wetlands (as shown) or bioretention systems.

### 2.2.2 Site Conditions Suitable for Stormwater Management Measures

Table 2.3 presents some conditions that influence the suitability of various stormwater treatment measures. The table provides a quick reference to assess treatment measures that may suit a particular development.

| Treatment Measure | Potential Benefits | Suitable Site Conditions | Unsuitable Conditions |
|---|---|---|---|
| Gross pollutant traps | Reduces litter and debris<br>Can reduce sediment<br>Pre-treatment for other measures | Conventional drainage systems | Sites larger than 100 ha<br>Natural channels |
| On-site infiltration | Reduced runoff<br>Pollutant removal<br>Passive irrigation | Sandy to sandy-clay soils (k>36 mm/hr)<br>Flat terrain (<2%)<br>Deep groundwater table | Silty clay to clay soils<br>Steep terrain<br>Shallow groundwater table<br>Saline groundwater<br>Highly polluted runoff |
| Sediment basins | Coarse sediment capture<br>Temporary installation<br>Pre-treatment for other measures | Available land area | Proximity to airports |
| Rainwater tanks | Storage for reuse<br>Sediment removal in tank<br>Frequent flood retardation | Proximity to roof<br>Suitable site for gravity feed<br>Incorporate to urban design | Non-roof runoff treatment |
| Vegetated swales | Medium and fine particulate removal<br>Streetscape amenity<br>Passive irrigation | Mild slopes (<4%) | Steep slopes |
| Buffer strips | Pre-treatment of runoff for sediment removal<br>Streetscape amenity | Flat terrain | Steep terrain |
| Bioretention systems | Fine and soluble pollutants removal<br>Streetscape amenity<br>Frequent flood retardation | Flat terrain | Steep terrain<br>High groundwater table |
| Ponds | Storage for reuse<br>Fine sediment settling<br>Flood retardation<br>Community and wildlife asset | Steep terrain with confined valleys | Proximity to airports, landfill |
| Wetlands | Community asset<br>Medium to fine particulate and some soluble pollutant removal<br>Flood retardation<br>Storage for reuse<br>Wildlife habitat | Flat terrain | Steep terrain<br>High groundwater table<br>Acid sulphate soils |
| Retarding basins | Flood retardation<br>Community asset | Available space | Limited available space<br>Very flat terrain |

Table 2.3 Site conditions and benefits of stormwater treatments

### 2.2.3 Developing Stormwater Treatment Trains

Stormwater can carry a wide range of pollutant types and sizes. The vast range of pollutants means that no single treatment measure can effectively treat all pollutants carried by stormwater. The physical composition and pollutant removal processes of various stormwater treatments predisposes them to a specific range of stormwater pollutants. A combination of treatments is therefore required to reduce the suite of pollutants contained in stormwater.

A series of treatment measures that collectively address all stormwater pollutants is termed a "treatment train." The selection and order of treatments is a critical consideration in developing treatment trains. The coarse fraction of pollutants generally requires removal so that treatments that target fine pollutants can operate effectively. Other considerations when determining a treatment train are the proximity of a treatment to its source as well as the distribution of treatments throughout a catchment.

As a general rule, site conditions and the characteristics of the target pollutant(s) influence the selection of an appropriate type of treatment measure, while climate conditions influence the hydrologic design and ultimately the overall pollutant removal effectiveness of the measures.

An overriding management objective can help determine what treatment process is likely to be feasible. Figure 2.3 shows a relationship between management issues, likely pollutant sizes and appropriate treatment processes to address those pollutants.

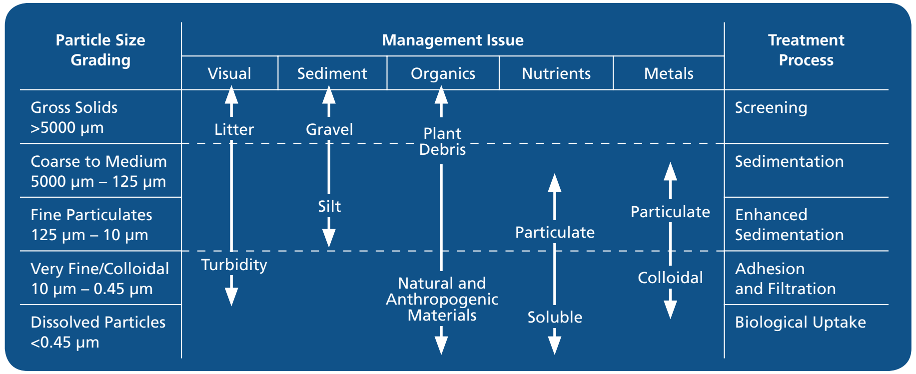


Figure 2.3 Stormwater management issues, pollutants and likely treatment processes

Figure 2.4 shows the inter-relationship between stormwater pollutant particle size, suitable types of treatment measures (based on their treatment process) and appropriate hydraulic loading (measured as design flow divided by the plan area of the treatment measure and can be used to provide an indicative land requirement for a given treatment flow).

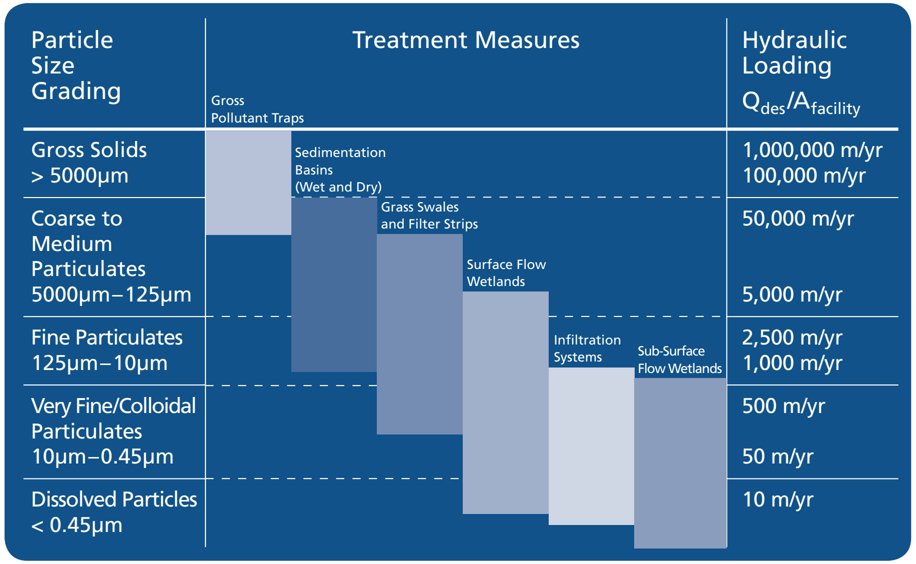


Figure 2.4 Pollutant size ranges for various stormwater treatment measures

It can be seen from Figure 2.4 that stormwater treatments that target the removal of gross pollutants and coarse sediments, such as GPTs and sediment basins, can operate under high hydraulic loading. This means they can treat high flow rates for a given size of unit. This is reflected by the process of pollutant removal used involving either sedimentation or physical screening which is a rapid process (refer to Figure 2.3).

As a target pollutant particle size reduces (e.g. for treatment of nutrients and metals) the nature of the treatment changes to include enhanced sedimentation, bio film adsorption and biological transformation of the pollutants. These treatments use vegetation to provide the filtering surface area, spread and reduce flow velocities to enhance sedimentation as well as providing a substrate for biofilm growth and hence biological uptake of soluble pollutants. These measures, such as grass swales, vegetated buffer strips, surface wetlands and infiltration systems, require longer detention times than for GPTs, to allow various pollutant removal processes to occur. Consequently, the hydraulic loading on these treatment measures is small relative to gross pollutant removal measures (and therefore require a larger proportion of land for treatment).

A treatment train consists of a combination of treatment measures that can address the range of pollutant particle sizes found in stormwater. A treatment train therefore employs a range of processes to achieve pollutant reduction targets (such as physical screening, filtration and enhanced sedimentation).

### 2.2.4 Operation and Maintenance

There is currently limited cost data available for the operation and maintenance of WSUD stormwater management elements. It is, however, envisaged that well-designed and constructed systems will not necessarily incur additional operation and maintenance costs above that required to maintain conventional stormwater infrastructure and associated public open space. Poor construction and damage during the development phase can often result in escalated maintenance cost of many WSUD elements.

Maintenance activities associated with vegetated swales and bioretention systems are principally landscape maintenance activities related to weed control and occasional pruning of the vegetation. Lloyd et al. (2002)[3] reported maintenance costs data over a seven-year period of a vegetated swale system at a residential estate in Melbourne and clearly showed that following an initial high maintenance cost during the vegetation establishing phase of such systems, the maintenance cost reduced significantly from approximately $9/m$^2$ to $1.50/m$^2$ which, is less than what would normally cost in mowing of an equivalent grassed area.

The annual maintenance costs of constructed wetland systems have been estimated to be approximately $14,000 per hectare by Lloyd et al. (2002) for wetlands in Melbourne.

### 2.2.5 Managing Land Salinisation

The Department of Infrastructure Planning and Natural Resources (DIPNR) of NSW has identified parts of western Sydney as areas with an extensive salinity hazard. The cause of the salinity problem is a combination of high (saline) groundwater tables, saline soil and the presence of sodic soils. The relative dominance of these factors are site specific.

Soil salinity problems are often most prevalent along the beds of creeks and low lying areas, these are envisaged to be possibly caused by three factors:

1. Rising groundwater to the surface, bringing saline water into pools along a creek
2. "Leaching" of salt by stormwater interflow through a sodic soil layer caused by excessive infiltration of surface runoff.
3. Erosion of the creek banks, exposing sodic soil layers. Salt is mobilised by dispersion and destruction of the soil structure. This results in an increase in salinity in surface runoff and the development of saline pools under low flow conditions.

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[3] Lloyd, S.D., Wong, T.H.F. and Chesterfield, C.J. (2002), Water Sensitive Urban Design – A Stormwater Management Perspective, Industry Report 02/10, Cooperative Research Centre for Catchment Hydrology, ISBN 1 876006 91 9, 38p.

Bank erosion of watercourse has led to the exposure of the B-horizon sodic soil.

Destruction of the sodic soil structure when exposed to saturation conditions.

Riparian vegetation providing necessary bank stabilisation.

Management options for mitigating soil salinity problems in these areas can be based on the following management principles:

- Separation of urban stormwater runoff pathways from groundwater system so as not to (i) introduce further inflow into the groundwater system and/or (ii) create the potential for interflow conditions. This approach excludes all infiltration measures for stormwater treatment (other than bioretention systems that are designed to transfer and recover filtered water by a slotted pipe underdrain thus preventing flows from reaching the groundwater system).
- Reducing the exposure of sodic soil layers by erosion prevention measures–including flow management and rehabilitation of existing watercourses. Vegetation can stabilise and mitigate bank erosion and a landscape strategy for the rehabilitation of waterways can be guided by a combination of peak flow reduction of frequent events and bank and riparian zone vegetation.

### 2.2.6 Stormwater Treatment Assessment Methods

Urban stormwater quality improvement systems in urban areas are predominantly driven by climatic factors such as the occurrences of storm events and dry weather conditions. These factors are highly variable in terms of the seasonality of the occurrences of storm events, their magnitudes and durations. The performance of an urban stormwater quality improvement strategy is not determined by any individual storm event but is the aggregate of a continuous period of typical climatic conditions. Water quality sampling of a small number of storm events is normally not sufficient to define system performance.

Performance assessment of stormwater treatment strategies will often be based on estimating mean annual pollutant loads exported from a catchment following development. Modelling using well-established computer models of urban stormwater management systems is a recognised method for determining their long-term performance. Modelling will involve the use of historical or synthesised long-term rainfall data and algorithms that can simulate the performance of stormwater treatment measures to determine stormwater pollution control outcomes.

Often the performance of a proposed stormwater quality management strategy will need to be benchmarked against conventional drainage design. Modelling techniques allow for this comparison by simulating the likely performances of the development for the two scenarios of the urban stormwater management systems based on a conventional and a water sensitive urban design approach.

The NSW Environment Protection Authority (NSW EPA) has nominated stormwater treatment objectives which are based on the mean annual load reduction of some key urban pollutants, expressed as a percentage of what would normally be expected in urban catchments in the absence of any stormwater treatment initiatives. Many local governments have similarly based their local policies on stormwater quality objectives on the NSW EPA guidelines.

The Cooperative Research Centre for Catchment Hydrology (CRCCH) has recently developed stormwater management evaluation software named MUSIC, an acronym for Model for Urban Stormwater Improvement Conceptualisation[4]. The software serves as a planning and decision support system, and packages the most current knowledge of the performance of a range of stormwater treatment measures into an easily used tool. MUSIC is designed to operate at a range of temporal and spatial scales, suitable for modelling stormwater quality treatment systems for individual lots up to regional scales.

Importantly, MUSIC allows Landcom's consultants to first estimate an expected pollutant load from catchments following development in the absence of any stormwater treatment initiatives (to set a baseline condition). It can then be used to compare alternative stormwater treatment strategies for compliance to state and local government stormwater quality objectives.

There are other computer models that allow a user to model the performance of a group of treatments or an individual treatment measure. Phillips and Thompson (2002) describe an application of XP-AQUALM in the development of a management strategy for drainage and stormwater, as part of an overall Water Cycle Management Strategy for Homebush Bay, Sydney's Olympic Games Village. Currently, MUSIC and XP-AQUALM are the two most widely used tools for modelling urban stormwater quality improvement systems.

[4] For more details – www.catchment.crc.org.au

The application of computer models to predict the performance of individual or a group of stormwater treatment measures is not a simple exercise and requires a level of modelling expertise. Most models used in the industry are capable of providing reliable predictions of likely water quality performance of the treatment measures when used correctly.

## 2.3 Wastewater Management

Wastewater management involves the collection, treatment, and disposal/reuse of the wastewater stream (flows from toilets, bathrooms, laundries and kitchens). Best practice can be employed in all phases of wastewater management.

### 2.3.1 Collection System

A well-designed wastewater collection system is intended to:

- Reduce sewer infiltration from stormwater (during wet weather).
- Eliminate illegal/accidental cross-connections between sewers and stormwater.
- Minimise the need or engagement of emergency relief overflows from the sewer system.
- Provide temporary storage or treatment for sewer overflows prior to discharge to local waterways.

### 2.3.2 Wastewater Treatment Systems

A wide range of wastewater treatment systems and devices are available ranging from relatively simple biological systems (constructed ponds and wetlands) to highly technological mechanical devices (micro-filtration and reverse osmosis). Wastewater treatment systems aim to:

- Best match treatment system performance to the water quality requirements of reuse opportunities or receiving waters.
- Best match treatment system operational requirements to available operational resources.

### 2.3.3 Reuse and Disposal Systems

The best approach to wastewater management is to optimise wastewater reuse and minimise treated wastewater discharge to receiving waters. Best practice reuse and disposal aims to:

- Maximise opportunities for wastewater reuse (as a replacement for potable water) by providing infrastructure to deliver treated wastewater to where it is required.
- Minimise discharges to receiving waters.
- Best match the quality of reclaimed water with intended reuse opportunities.
- Protect the sustainability of natural resources associated with reclaimed water use (e.g. soil structure under reclaimed water irrigation).

### 2.3.4 Wastewater Splitting

The separation of wastewater into greywater and blackwater can provide useful reuse opportunities in developed areas using existing infrastructure. For example, greywater can be temporarily stored and used for toilet flushing and in some circumstances garden watering (depending on the application technique). The relatively continuous supply of greywater means storage can be short-term, which avoids the need for significant treatment or risk of water quality problems in the storage. Excess greywater can be discharged to sewer routinely to avoid water quality problems in storage tanks.

Further separation of greywater into `light greywater´ (shower and hand basin only) can further reduce the risk of water quality issues with its storage and reuse. This will reduce the volume available for reuse, but can be matched to an appropriate reuse (e.g. toilet flushing).

Where wastewater splitting is undertaken on a large scale some consideration of the existing sewerage system to process higher strength lower volume wastewater is required.

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