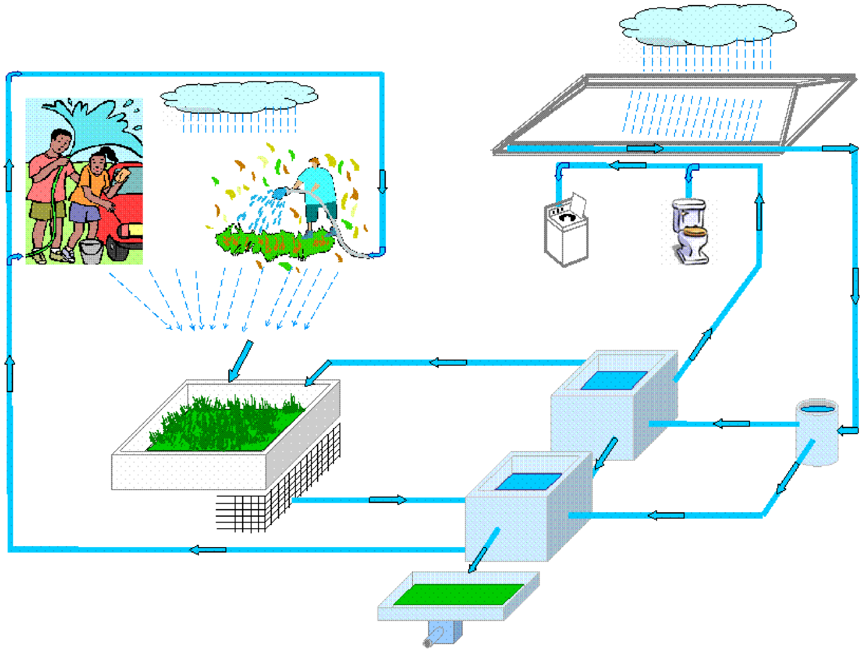
Hunter's Hill Council



Sustainable Water

Development Control Plan

Part III

Design Guidance: Practice Notes

- Practice Note 1: Rainwater Tanks
- Practice Note 2: Paving
- Practice Note 3: Bioretention
- Practice Note 4: Grassed Swale
- Practice Note 5: Infiltration Devices

(copy of the Water Sensitive Urban Design in the Sydney region)

- Practice Note 6: On-site Detention
- Practice Note 8: Landscape Practices

(copy of the Water Sensitive Urban Design in the Sydney region)

- Practice Note 9: Wastewater Re-use

(copy of the Water Sensitive Urban Design in the Sydney region)

Hunter's Hill Council

Rainwater tanks

Sustainable water DCP: Practice Note 1

In urban areas, domestic water supply is typically met by importing large volumes of treated water from neighbouring catchments, often at considerable cost. At the same time, similar volumes of roof water are discarded unused via stormwater drainage systems that may have significant erosion, sedimentation and flooding impacts.

This Sustainable Water Practice Note explains how to design and configure domestic rainwater tanks.

- **Gravity & pressure systems**
- **Dual supply systems**
- **How to configure tanks**

Introduction

Whilst all mains water is treated to drinking water standards, as little as 1% of domestic water consumption is actually used for drinking. Toilet flushing, laundry, outdoor uses and hot water represent the bulk of domestic water consumption (about 90%), but these uses do not require water to be treated to such a high standard. Such uses can be satisfactorily supplied using rainwater collected from roofs and stored in tanks. Benefits include significant water supply cost savings and substantial reductions in stormwater discharges.

Using rainwater for various uses (such as toilet flushing and garden watering), each with different usage patterns, can result in optimum mains water savings and large reductions in stormwater discharges.

System overview

A rainwater harvesting system consists of the following key elements (see Figure 1):

- House roof
- Roof gutters
- First flush device
- Rainwater tank
- Pump
- Overflow to garden areas, infiltration trenches and street drainage system.

Depending on site conditions, user requirements and budget, rainwater tank systems can be installed using a variety of different configurations, including:

- Installing tanks above- or below-ground
- Using gravity or pressure systems
- Using dual supply systems
- Including a detention volume inside the tank for additional stormwater management.

Gravity systems

Gravity systems involve placing the tank on a stand (see Figure 1). Such systems are widely used in rural areas for household supply, and are also increasingly being installed in urban areas for supplying water for indoor and garden watering purposes.

In gravity systems, rainwater is collected from the roof and directed to the tank via a first flush device. All connections to outdoor and household fixtures depend on gravity alone. Water pressure at each fixture is governed by the difference in height between the tank and the fixture.

To achieve a water pressure similar to that of normal mains water, the tank needs to be positioned 20 metres vertically above fixtures. This is generally not practicable. However, many household water uses such as toilets, laundry tubs and garden hoses do not require such high water pressures. Gravity systems are often quite adequate for these purposes.

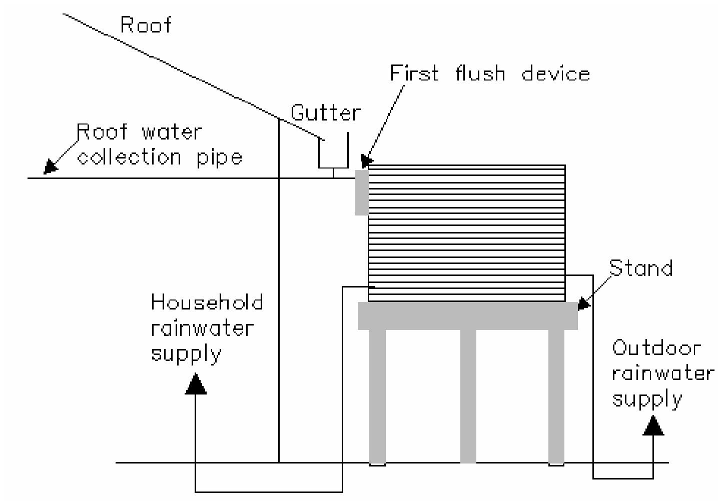


Fig 1: Configuration for a gravity system

Pressure systems

A pressure system involves using a pump to deliver rainwater to household or garden fixtures. Pressure systems are required where the tank cannot be installed at a sufficient height to provide acceptable pressure or if the tank is installed underground (see Figure 2).

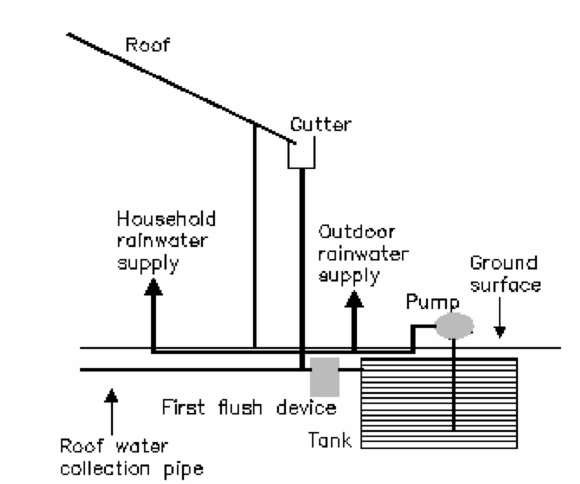


Fig 2: Configuration for a pressure system

Rainwater tanks

Required tank capacity will depend on the number of persons in the household, water use, rainfall and roof area, but 5,000–15,000 litres is generally sufficient. Smaller tank sizes can also provide considerable benefits. When designing the tank system, provision should be made for each of the following storage components (see Figure 3):

- Minimum storage (or mains water top up zone) to ensure that water supply is always available
- Rainwater storage zone
- Air gap for additional stormwater management
- Anaerobic zone (water is drawn from above this zone to ensure that sediment is not entrained).

The minimum storage volume (mains water top up zone) is the maximum daily water use that is expected from the tank, less the potential daily volume of mains water (about 250–750 litres). If the volume of stored water falls below the minimum storage volume, the shortfall can be overcome by topping up the tank with mains water to the required level. A simple float valve system can be installed to do this automatically.

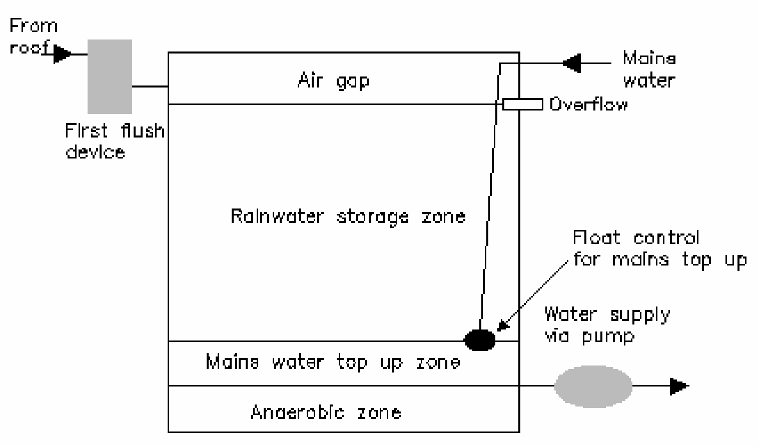


Fig 3: Storage components for a dual supply system

The rainwater storage zone comprises the total volume available in the tank to store rainwater below the overflow pipe. The air gap between the overflow pipe and the top of the tank can be used to provide 'stormwater detention', thereby delaying the delivery of excess roof water to the drainage system. The rainwater storage zone and the overlying air gap provide both stormwater retention and detention.

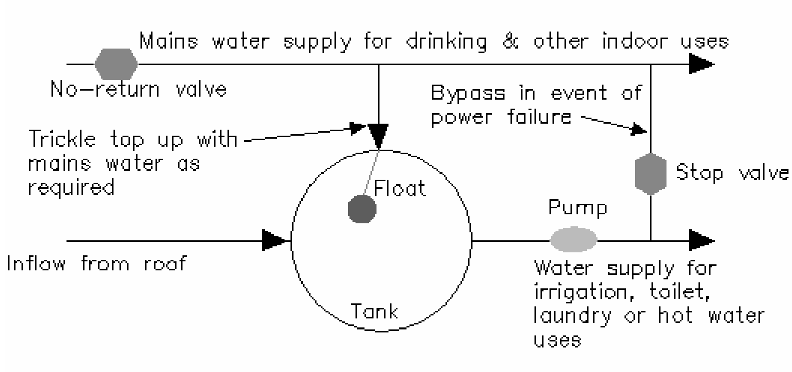


Fig 4: Configuration for a dual supply system

The plumbing configuration for a dual supply system is shown in Figure 4. Tank water is directed to fixtures via a small pump. When tank levels are low (such as during prolonged dry weather), the tank is topped up with mains water via a trickle system. This reduces peak demand on the mains water distribution network. The tank can be bypassed in the event of a pump or power failure.

When designing an above-ground tank, it is important to take into account the amount of site area required for the tank. A 5,000 litre tank will occupy an area of about 2 square metres, whilst a 15,000 litre tank will occupy 6 square metres.

First-flush devices

A first-flush device separates the first part of rainfall from entry to the rainwater tank (see Figure 5). This is required to prevent dust or other material on roof or gutters surfaces from contaminating tank water. The device operates by filtering roof runoff through a mesh screen to capture leaves and debris. The first part of runoff is stored in the chamber to slowly trickle through a small hole whilst cleaner water at the top of the chamber passes into the rainwater tank.

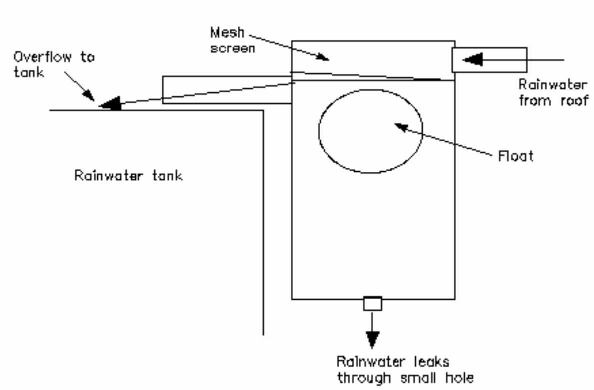


Fig 5: Basic design features of a first flush device

Roofs & gutters

Rainwater should not be collected from roofs painted with lead-based or tar-based paints, or from asbestos roofs. Galvanised iron, Colorbond™, Zincalume™, slate or ceramic tiles provide acceptable water quality. Special roof guttering is not required. Normal guttering is sufficient provided that it is kept clear of leaves and debris.

Water quality

There is growing scientific evidence to confirm traditional knowledge and practice that water sourced from rainwater tanks is acceptable for most household uses. For example, research undertaken by the University of Newcastle has shown that domestic roofwater is of acceptable quality for toilet, hot water and outdoor uses. This research also showed such water, when used in hot water systems, complied with the Australian Drinking Water Guidelines provided that temperature settings greater than 50°C were maintained. (Relevant Australian Standards require domestic hot water systems to be set at 60°C, and hot water to be delivered to the house at 50°C).

It is not recommended that rainwater be used for drinking unless it is passed through an approved filtration system. This should be sufficient to remove possible contamination from accumulated soil and leaves in gutters, faecal material (deposited by birds, lizards, rodents and possums) and dead animals in gutters or tanks. Acceptable water quality can be maintained by:

- Installing mesh screens over all inlets and outlets to prevent leaves, debris and mosquitoes from entering the tank
- Installing a first-flush device to discard the first part of rainfall
- Regularly cleaning gutters of leaves and debris.

Regulatory issues

Health departments

State government health departments do not prohibit the use of rainwater for drinking or other purposes. They do however recommend proper use and maintenance of rainwater tanks, and provide guidelines for this (see Cunliffe, 1998). The focus of published guidelines is on drinking water quality. No guidelines exist for outdoor, toilet, laundry and hot water uses.

Water supply authorities

Water supply authorities cannot prohibit the reuse of rainwater or stormwater on private land.

However, they do require the installation of an appropriate backflow prevention device to prevent contamination of mains water by rainwater or stormwater (see 'Design Standards' below).

Rainwater tanks

Hunter's Hill Council policy

HH Policy is in accordance with the provisions of State Environmental Planning Policy (SEPP) No.4 - development without consent, exempt and miscellaneous exempt and complying development. Rainwater tanks and stormwater retention device may require development consent if they exceed certain requirements relating to size, height, siting and other matters, as specified in the 'exempt development' provisions under State Environmental Planning Policy No.4. If a development application is required (for example, for a tank with a capacity exceeding 10,000 litres), details should be provided as to:

- Location and relationship to nearby buildings
- The configuration of inlet/outlet pipe and overflow pipe
- Storage capacity, dimensions, structural details and proposed materials
- The purposes for which the stored water is intended to be used.

For further details, contact Hunter's Hill council.

Design standards

Chapter 7 of the Australian Drinking Water Guidelines (NHMRC, 1996) contains guidance on the management of small potable water supplies. Cunliffe (1998) provides a complete coverage of the topic. There are no recognised standards for the reuse of stormwater for secondary quality purposes.

Australian Standard AS/NZ 3500.1.2-1998: National Plumbing and Drainage - Water Supply – Acceptable Solutions provides guidance on the design of stormwater and rainwater reuse systems. The standard categorises cross connection between mains water supply and a domestic roofwater tank as a low hazard connection. This requires a nontestable backflow prevention device, such as:

- No physical connection between the tank and the mains water system
- An air gap
- A reduced pressure zone device (RPZD)

An air gap refers to a physical separation between the mains water and rainwater supplies within the tank. This is a simple, reliable and maintenance-free solution. A RPZD is a mechanical device that separates mains and other water supplies. It requires regular servicing and replacement. Under AS/NZ 3500.1.2-1998, dual supply systems that utilise an air gap or a RPZD can be configured as shown in Figures 6 and 7 respectively.

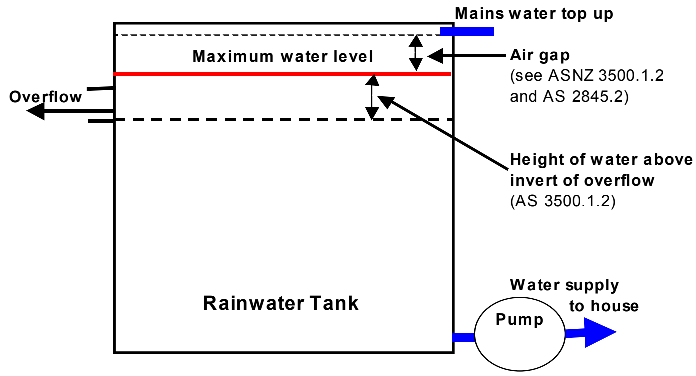


Fig 6: Backflow prevention using an air gap

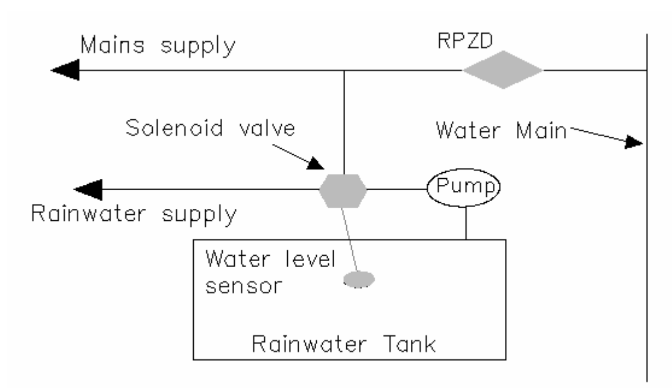


Fig 7: Backflow prevention using a RPZD

Materials & products

Concrete

Concrete tanks can be purchased in a ready-made form or constructed on-site. They can be placed above- or below-ground. Concrete tanks can be subject to cracking although careful construction techniques will minimise the potential.

Fibreglass & plastic

Fibreglass tanks are constructed from similar materials as fibreglass boats and can be used in above-ground installations. Plastic or poly tanks are constructed using food-grade polyethylene that has been UV-stabilised and impact modified. These tanks are strong and durable.

Metal

Galvanised iron tanks are constructed from steel with a zinc coating, and can be used in-above ground installations. This tank is strong and durable, but can be subject to corrosion if copper pipe for the household water service is connected to the tank. The first section of plumbing connected to the tank should be UPVC or other non-metallic material. Zincalume™ tanks are constructed from steel with a zinc/ aluminium coating. They are similar to galvanised iron tanks. Aquaplate™ tanks are made from Colorbond™ lined with a food-grade polymer. They can be used in above-ground installations. This tank is strong, durable and corrosion resistant. When cleaning the tank, it is important to avoid damaging the polymer lining.

Maintenance

A rainwater tank system requires very little maintenance. Regular maintenance tasks are:

- Cleaning the first flush device every three to six months
- Removing leaves and debris from the inlet mesh on the tank every three to six months
- Removing leaves and debris from the gutters every three to six months
- Checking the level of sediment in the tank every two years.

Tanks require occasional cleaning. The frequency of cleaning will depend on the amount of sediment and debris that enters the tank. A first flush device and adequate mesh screens on all tank inlets and outlets will ensure that the majority of sediment and debris does not enter the tank. This will reduce the frequency of cleaning to every 10 years or so.

Costs & savings

Tank costs vary from place to place. Indicative 2002 prices (without installation) are as follows.

Material	Capacity	
	4,500 Litres	9,000 Litres
Aquaplate™	$450	$860
Galvanised iron	$440	$640
Polymer	$670	$1,150
Concrete	$1300	$1,800

Small household pumps with pressure controllers can be purchased for $300 to $400.

Installation costs are also highly variable. The cost to fully install a 4500 litre above-ground rainwater tank for indoor and outdoor use can range from $1300 to $2100. Underground installation will usually add about $2000 to the cost. This system can provide the home owner with a water saving of about $50 to $110 per year, reduce stormwater discharges to the environment, reduce water demand on rivers and dams, and improve water quality in downstream stormwater catchments.

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Hunter's Hill Council

Paving

Sustainable water DCP: Practice Note 2

Urbanisation causes a significant increase in the area covered with paved (or 'impervious') surfaces, such as roads, driveways, courtyards, etc. Paved surfaces can have significant adverse impacts on the water cycle. They contribute to increased peak and total stormwater discharges, increased downstream flooding, streambank erosion, sewer surcharges, and the need for expensive drainage infrastructure. Paved areas also reduce infiltration to the subsoil. Using porous paving systems can help to reduce these impacts.

This Water Sensitive Practice Note describes how to design and install paving so that it manages and treats stormwater.

- **Grid & modular paving (Gravel, sand or soil/grass)**
- **Asphalt porous paving**
- **Design & maintenance**

Paving

Sustainable water DCP: Practice Note 2

Introduction

Porous paving is an alternative to conventional impermeable pavements with many stormwater management benefits. These surfaces allow stormwater to be filtered by a coarse sub-base, and may allow infiltration to the underlying soil.

A number of porous paving products are commercially available including:

- Concrete, ceramic or plastic modular pavements (filled with gravel, sand or soil/grass).
- Pavements made from special asphalts
- Concrete grid pavements

Grid & modular paving

More recent porous paving designs overcome the deficiencies of the earlier asphalt porous paving products. They include:

- Concrete grids poured in-situ
- Precast concrete grids
- Concrete, ceramic or plastic modular pavers.

These products generally contain surface voids that are filled with sand, gravel or soil/grass. Stormwater filters through these voids to a sand or gravel sub-base, thereby cleansing the stormwater. Gravel retention trenches and geotextile fabric can also be installed, thereby creating a very effective stormwater treatment chain. During heavy rain, excess stormwater overflows to the street drainage system when the trench becomes full.

Fig 1: Gravel grid pavement

Grass may also be grown in voids, but this is generally unsuccessful due to insufficient soil depth and nutrients, heavy wear and tear and retained heat in the pavers. In very low traffic areas, consider using turf rather than porous paving.

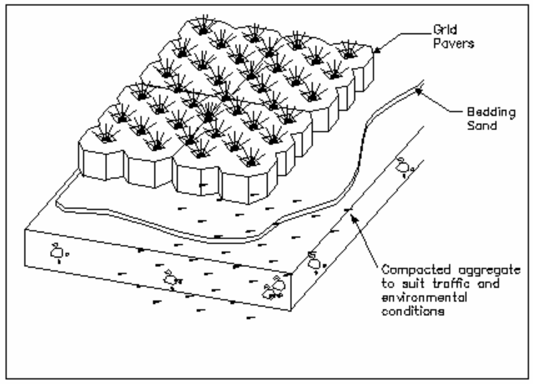

Fig 2: Typical Components of a Concrete Grid Pavement

Plastic modular block pavers retain less heat than concrete ones, making them more suitable in hotter locations or climates.

Porous paving is an excellent stormwater management measure for low-traffic surfaces in driveways and car parks. Unfortunately history has shown many failures due to poor design, construction and maintenance practices. Consequently, the following design and maintenance issues need to be carefully addressed.

Asphaltic paving

Asphaltic porous paving is laid on a sand/gravel sub-base over natural soil (see Figure 3).

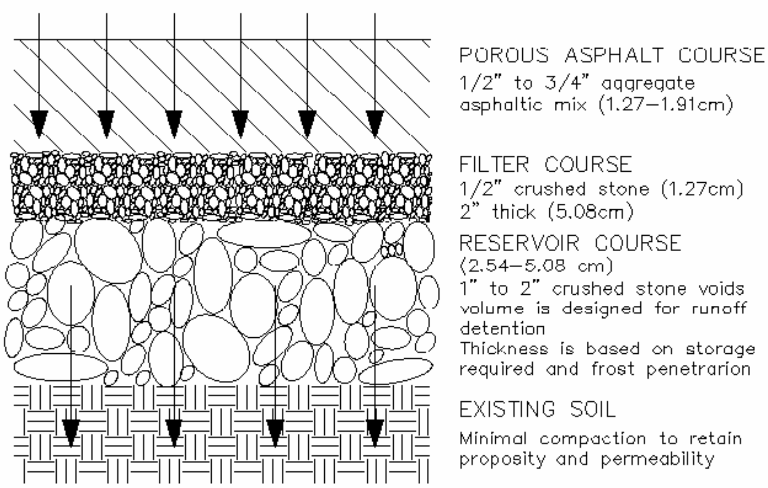

Fig 3: Asphaltic porous paving systems

Paving

Rainfall percolates through a porous asphalt layer to the road sub-base, where it is stored until it infiltrates to the surrounding soil. When installed in impermeable soils, subsoil drainage pipes are placed below the road sub-base to allow stormwater to overflow into the street drainage system.

Early porous paving, typically asphalt, relied on percolation of stormwater through the pavement and storage in the sub-base prior to infiltration to the soil. They were often subject to failure due to sediment clogging, and are less recommended than newer porous paving products.

Clogging

Partial or total clogging with sediment and oil is a major potential cause of failure, and must be avoided. Clogging can occur during or immediately after construction, or through long-term use. The likelihood of clogging can be avoided by the following measures.

Do not install porous paving in positions that are likely to receive large quantities of sediment and debris washed down by stormwater, or windblown sand or other material.

- Carefully protect porous paving from sediment inputs during construction.
- Do not use porous paving for accessways with high traffic volumes or with regular heavy vehicle traffic.
- Undertake regular vacuum sweeping or high pressure hosing to remove sediment (direct runoff to grassed areas).
- Install sediment traps, vegetated filter strips or specially designed gutter systems to pre-treat stormwater inputs to remove sediments.

Infiltration capacity

Porous paving sometimes has a poor reputation of having insufficient infiltration capacity. In most cases this can be attributed to sediment-induced clogging, soils with insufficient infiltration capacity and designs with insufficient storage volume. These problems can be readily overcome by using modern design practices to:

- Provide a retention trench below the sub-base
- Provide an overflow to the street drainage system or other stormwater management measure
- Limit the runoff area contributing stormwater to the porous paving surface.

Aquifer contamination

Porous paving can, in some cases, result in a risk of contamination of shallow aquifers by toxic materials derived from asphalt, vehicular traffic and road use. This risk can be minimised or eliminated by following the following deign principles:

- Do not construct porous paving over shallow aquifers.
- Do not use porous paving on streets with high traffic volumes.
- Install a sand sub-base over a retention trench with geotextile fabric lining to capture contaminants.

Structural integrity

If properly installed, porous pavements have similar load bearing and design life performance to conventional pavements. Impairment of the structural integrity of porous paving by traffic loads or heavy vehicles can be avoided by adhering to relevant design and construction specifications.

Slopes

Porous paving should not be constructed on slopes greater than 5% unless an engineering design is completed to assess the impact of the paving system on downstream environments and the stability of surrounding areas.

Rock & shale

Porous paving should not be placed over rock that has little or no permeability. Studies have shown that infiltration is possible in severely weathered or fractured rock (for example, sandstone). Engineering testing is essential in these circumstances to ensure that the rock will accept infiltration. In the case of shallow soil cover, testing is required to ensure that seepage does not cause any hazards or nuisance to downstream sites.

Salinity

Infiltration techniques must be avoided or carefully planned in areas affected or potentially affected by groundwater salinity.

Suitable locations

Porous paving can be utilised in streets with low traffic volumes (such as cul-de-sacs), car parks and for paving within residential and commercial development. Acceptable performance can be achieved provided that the correct design and construction procedures are followed, including any manufacturer's recommendations.

Maintenance

Concrete grid, ceramic and modular plastic block pavers require less maintenance than asphaltic porous paving as they are less easily clogged. They are also easier to repair. The performance and life of these pavements can be increased by regular vacuum sweeping or high pressure hosing (once every three months) to remove sediments.

As with traditional pavements, asphalt porous paving requires occasional resurfacing. Concrete grid, ceramic and plastic modular blocks require a maintenance schedule similar to that for conventional road surfaces. This involves retaining the pavers and replacing part of the sand layer to remove contaminants.

Costs

Construction cost of porous paving is similar to that of traditional pavement and is less than the cost of traditional paving when savings in stormwater infrastructure in considered. Research shows that porous paving can be up to three times less expensive than traditional road and stormwater management approaches.

Construction costs for porous paving are similar to that for traditional paving materials, and are less than the cost of traditional paving when savings in stormwater infrastructure are considered. When installed as part of an integrated stormwater management system, porous paving can be up to three times less expensive than traditional road and stormwater management approaches.

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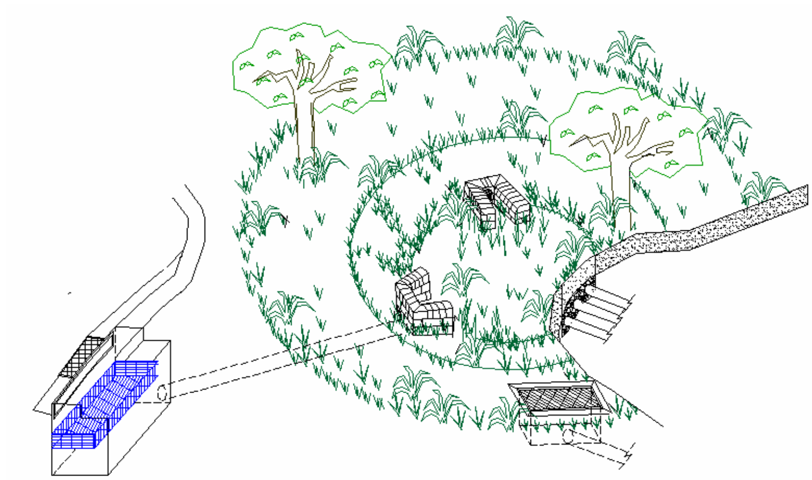
Hunter's Hill Council

Bioretention

Sustainable water DCP: Practice Note 3



Paved surfaces increase runoff volume for regular rainfall events (with an average recurrence interval of up to 6 months). This runoff flushes pollutants that have been deposited on paved and other impermeable surfaces during the preceding dry period, leading to a greater pollutant load reaching streams and waterways.

Bioretention systems are landscaping features adapted to effectively treat stormwater runoff on the development site.

This Water Sensitive Practice Note describes how to design and install bioretention systems to manage and treat stormwater.

- **System overview**
- **Bioretention system types**
- **Design & maintenance**

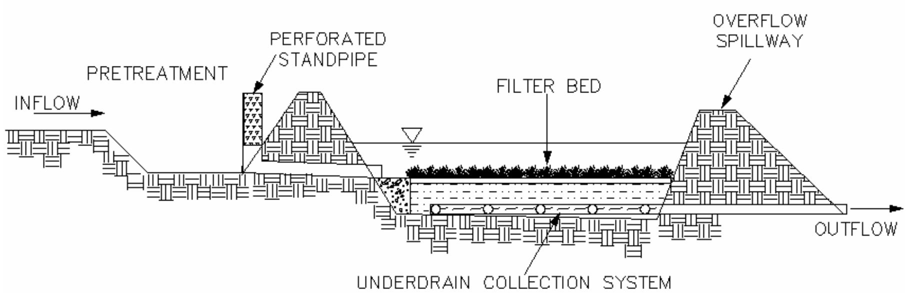
Introduction

Bioretention devices are constructed to temporarily store and filter stormwater runoff from regular storm events. The water is passed through a filter medium of sand, organic matter, soil or other media. After exiting the filter device, the stormwater may be returned to the conveyance system through an underdrain or be allowed to infiltrate into the soil. Stomwater runoff from larger storm events is generally diverted past the facility to the stormwater drainage system.

They are designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. They are usually very effective in treating stormwater pollution and are applied to land use with a high percentage of impermeable surfaces. Stormwater is conveyed to the filtering device as piped flow or as overland flow. Many of these overland flow paths can be integrated into the landscaping for the site.

Bioretention can also be used as a stormwater retrofit- management measure put into place after development has occurred- by modifying existing landscaped areas, or if a parking lot is being resurfaced.

Types of devices



The concept of bioretention can be applied to a number of filtering media namely, sand, organic matter or planting soil.

Sand filters

A surface sand filter consists of a sand bed that can be covered by a layer of topsoil, allowing grass to cover the filter medium. Geotextile surrounds the filter medium on all sides. Under the filter medium is a gravel layer with an underdrain, allowing drainage of filtered stormwater.

Before entering the filter medium, stormwater runoff passes through an open sedimentation chamber to remove litter and corse sediments. Surface sand filters are the type of filter devices that can treat the largest drainage area.

Organic filters

A surface organic filter is similar to the sand filter but instead of sand, organic material such as leaf compost or similar is used as filter medium. The organic filter is used when removal of nutrients and trace metals is of major concern.

Planting soil filters

Stormwater enters the bioretention unit by overland flow or as piped flow. The runoff should be passed through pre-treatment in the form of sedimentation ponds and/or filter strips before entering the bioretention system. The filter medium consists of a thick layer of planting soil, covered by a thinner layer of mulch. The unit is usually covered with vegetation. The filter medium may or may not be surrounded by a sand filter layer and/or gravel curtain drains. Filter fabric should line the unit. As in the case of sand and organic filters, planting soil systems are equipped with a gravel layer and a drainage pipe at the bottom.

The unit should further be constructed so that ponding of 15-30 cm of water is allowed, thus increasing the volume of water that is allowed to pass through the filter medium. At the bottom of the unit there is a drainage pipe that will convey the filtered water away from the unit.

Design Issues

Hydraulic design

If the stormwater is delivered to the device through pipes or is along the main conveyance system, the filtering device should be designed off-line.

Overflow must be provided for flows exceeding the design flow. This should be designed so that downstream erosion is prevented. Most stormwater filtering devices require (600-1800) mm of head.

The system should be designed so that the stormwater runoff volume from regular design storms (3 months to 1 year ARI) is retained for (24-48) hours in the provided retention storage.

The underdrain should be a 100 mm perforated pipe underdrain (150mm is preferred) in a gravel layer.

Pre-Treatment

It is necessary to have some sort of pre-treatment of the runoff entering the filter medium to remove litter and corse sediments. This could otherwise have a negative impact on the performance of the filtering device. A sand pit, sediment bay (equivalent to at least 25% of the provided retention storage volume), or filter strips are examples of acceptable pre-treatment techniques.

Retention Storage

The retention storage volume of the filter devices is essential for the sustainable management of the bioretention system. It evens out the flow rate through the filter and provides some measure of pre-treatment. The retention storage should be sized based on the hydraulic design criteria described earlier. A (300-500) mm depth is recommended. This can be increased to 1200mm provided that side slopes of the basin are 1:6 or more. Ponding depths in excess of these should be fenced off.

Filter Bed

The filter medium in sand and organic filters should have a depth of about 450 mm, covered by an approximately 100 mm thick layer of topsoil. For planting soil systems the filter medium should be thicker, approximately (750-1200) mm, covered by a (50-100) mm thick layer of mulch. The gravel layer should have a depth of about (150-200) mm.

The surface area of the filtration device is determined by the permeability of the filter medium, the designed retention time of the device, design water volume to be treated, average ponding depth and the depth of the filter medium. Area of filter bed is calculated based on the following equation:

$A_f = (WQ_v)\,(d_f) / [\,(k)\,(h_f + d_f)\,(t_f)]$ where:
A_f = Surface area of filter bed (m^2)
WQ_v = water quality volume (m^3)
d_f = filter bed depth (m) = 0.46
k = coefficient of permeability of filter media (m/day):
 1.07 m/day for sand
 0.6 m/day for peat
 0.15 m/day for planting soil
h_f = average height of water above filter bed (m) = 0.4
t_f = design filter bed drain time (days) = 1.5 days

Landscape Design

Landscaping is critical to the performance and function of bioretention areas. Therefore, details of landscaping elements and planting should be included in the landscaping plan required by Council.

Sand and organic filters may have a grass cover to aid in pollutant adsorption. The grass should be capable of withstanding frequent periods of inundation and drought. Planting recommendations for bioretention facilities are as follows:

- Native plant species should be specified over non-native species.
- Vegetation should be selected based on a specified zone of hydric tolerance.
- A selection of trees with an understory of shrubs and herbaceous materials should be provided.
- Woody vegetation should not be specified at inflow locations.

Bioretention

Maintenance

Sediment should be cleaned out of the pre-treatment device when it accumulates to a depth of more than 150mm. When the filtering capacity of the filter diminishes substantially (e.g., when water ponds on the surface of the filter bed for more than 72 hours), the top of discoloured material shall be removed and shall be replaced with fresh material. The removed sediments should be disposed in an acceptable manner (e.g., landfill). Silt/sediment should be removed from the filter bed when the accumulation exceeds 25mm.

Organic filters or sand filters that have a grass cover should be mowed a minimum of 3 times per growing season to maintain maximum grass heights less than 300 mm. Trash and debris shall be removed as necessary.

References

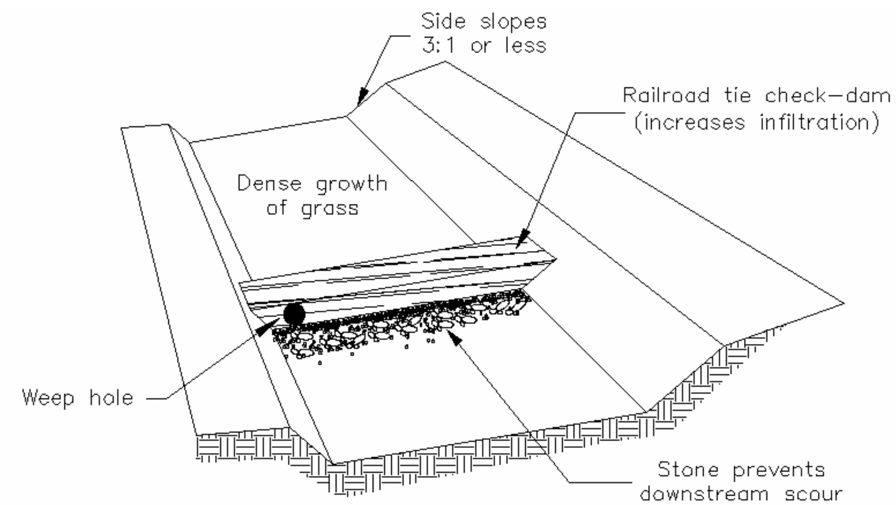
The Maryland Stormwater Design Manual (2000), prepared by the Center for Watershed protection and the Maryland Department of the Environment.

MUSIC (Model for Urban Stormwater Improvement Conceptualisation), User Manual, Version 1.00 (2002), prepared by the CRC for Catchment Hydrology.

Hunter's Hill Council

Grassed swale

Sustainable water DCP: Practice Note 4



Schematic of an enhanced grassed swale (source: Schueler, 1987)

Paved surfaces increase runoff volume for regular rainfall events (with an average recurrence interval of up to 6 months). This runoff flushes pollutants that have been deposited on paved and other impermeable surfaces during the preceding dry period, leading to a greater pollutant load reaching streams and waterways.

Grassed swales or vegetated swales are landscaping conveyance systems adapted to remove pollutants from stormwater runoff by filtration through grass and infiltration through the soil.

This Water Sensitive Practice Note describes how to design and install grassed swale systems to manage and treat stormwater.

- **System overview**
- **Design issues**
- **Maintenance considerations**

Hunter's Hill Council

Grassed swale

Sustainable water DCP: Practice Note 4

Introduction

Grassed swales are conveyance systems for stormwater in which removal of pollutants can be achieved by filtration through grass and by infiltration into the ground. The purpose of a grassed swale may be to:

- Convey stormwater
- Divert stormwater around potential pollutant sources
- Reduce runoff volumes and peak flows by attenuating runoff velocities and provide an opportunity for infiltration
- Reduce sediments and other pollutants in runoff, and hence provide pre-treatment of stormwater for other treatment measures

System overview

Vegetated swales are most applicable in residential area where the percentage of impervious cover is relatively small such as low density urban areas. Swales are usually located in a drainage easement at the back or side of a residential lot. They can also be part of a treatment train, i.e. in conjunction with other measures for stormwater treatment or used along roads in place of curb and gutter.

Stormwater is directed to the swale through pipes or overland flow. If stormwater is piped to the swale, energy dissipaters and flow spreader must be installed, not to cause scouring.

The swale itself consists of a grass-lined, trapezoid channel, in which the stormwater is conveyed. As the water passes through the channel, pollutants are removed through filtration by the vegetation of the swale. Swale vegetation could well be local native grasses and ground covers and not necessarily lawns.

If properly maintained, a grassed swale can be expected to have a high removal rate of sediments, oil and grease and bacteria, while the removal rate for litter and nutrients are relatively low.

Design Issues

Hydraulic design

A 1 year ARI event can be used as a guideline when designing the swale. The maximum velocity in the swale should not exceed 0.3-0.5 m/s and the swale's depth is preferably (0.3-0.5)m. Manning's Equation can be used to design the swale with the following 'n' values:

0.2 for mowed grass.
0.24 for natural or infrequently mowed grass.

Sump overflows to pipe system can be used to bypass major storms (exceeding the design storm) away from the grassed swale as shown in the figure below. If no overflow arrangement is considered, swales should be designed to safely convey the 1 in 10 year ARI storm with a 75mm freeboard. The 100 year ARI design storm should also be considered and all habitable floor levels are to be a minimum of 200mm above the maximum water surface level for the 100 year ARI storm.

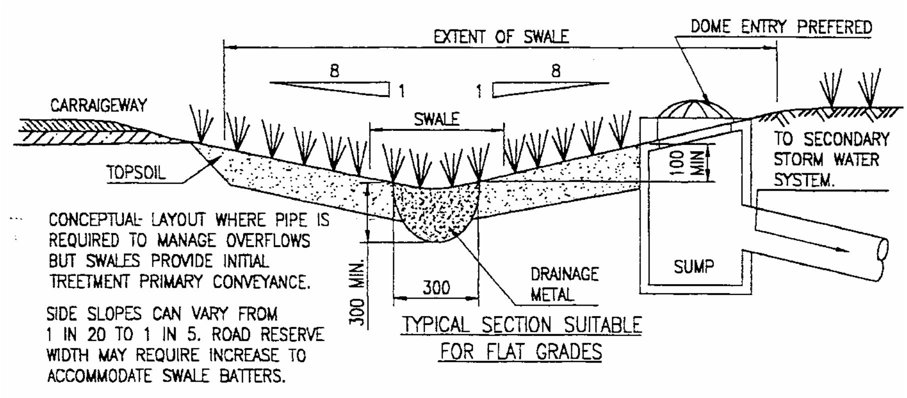


Figure showing Swale drain and sump overflow to pipe system (Source North Shore City Infrastructure Design Standards 2002).

Slope

Grassed swales can be constructed on slopes of 4% or less. If small check dams are installed, swales can be constructed on slopes up to 6%. The purpose of these dams is to decrease velocity, and by doing so, making pollutant removal more efficient. For slopes of less than 2% it is recommended that a subsoil drainage system is installed to ensure effective drainage, and minimise the risk of standing water that can have a negative impact on vegetation establishment and growth. For steeper ground, swales should be installed parallel to the contour lines.

The swale should have a uniform longitudinal grade to ensure a constant non-scouring flow.

Dimensions

A trapezoid shape is recommended for the grassed swale, due to ease of maintenance and construction. The bottom width should be between 0.6 and 2.5 metres. The sides of the swale are to be constructed with a grade of 3(h):1(v) or less, or if permanent stabilisation is adopted, 2(h):1(v).

In order to minimise the risk of short circuiting, a grassed swale should not be less than 30 metres long

Pre-treatment

Pre-treatment of stormwater entering the swale is desirable, and it is recommended that a sediment bay be installed at the inlet of the swale.

Grassed swale

Retention Storage

The retention storage will be increased if check dams are installed. This will also promote infiltration. If this approach is chosen it is important that the dams are constructed of durable material so that they will not erode. The area downstream from the check dams should also be protected from erosion. Further, the dams should be constructed so that ponded water will infiltrate within 24 hours or less.

Landscape Design

A grassed swale is more aesthetically appealing than kerb and gutter, and can easily be integrated into the landscape design.

It is important that soil stabilisation measures are taken during the establishment of a vegetation cover. If not, water entering the swale might cause scouring and increased sediment loads in the stormwater runoff. Mats, blanket or mulch can be used to cover the swale while an adequately vegetation cover is established. Native grasses and groundcovers are encouraged to be used for vegetating the swale and not necessarily just lawns.

Maintenance

A grassed swale will demand more maintenance than kerb and gutter. The vegetation has to be cut to maintain the effectiveness of the swale, and litter and sediment should be removed. Further, any erosion that has occurred must be repaired.

Swales should be maintained solely by mowing and trimming. However, it is best to allow swale grasses to grow and develop a healthy sward. The vegetation cover should not be higher than 300 mm, as high grass is more likely not to remain upright during a storm event. This will significantly reduce the effectiveness of the swale. It is recommended that the hight of the vegetation be kept between (150-200) mm to ensure effective filtration.

Any spraying undertaken shall only be spot spraying, where required, of plant pest species. Any chemicals used shall be applied in accordance with the manufacturer's recommendations

References

The Maryland Stormwater Design Manual (2000), prepared by the Center for Watershed protection and the Maryland Department of the Environment.

MUSIC (Model for Urban Stormwater Improvement Conceptualisation), User Manual, Version 1.00 (2002), prepared by the CRC for Catchment Hydrology.

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WSUD
Water Sensitive Urban Design in the Sydney Region

PRACTICE NOTE 5

Infiltration devices

Infiltration basin under normal conditions (above), and during heavy rain (left).

Water sensitive development involves simple design and management practices that take advantage of natural site features and minimise impacts on the water cycle. It is part of the contemporary trend towards more 'sustainable' solutions that protect the environment.

This Water Sensitive Practice Note explains how to design and configure stormwater infiltration devices.

- **Leaky wells**
- **Retention trenches**
- **Infiltration basins**

Infiltration devices

Introduction

This Practice Note describes various types of stormwater infiltration devices for dwellings and other small-scale development. There is growing interest in infiltration as an alternative or supplement to conventional drainage techniques (where site conditions permit) due to its many environmental and economic benefits. These may include reduced peak stormwater flows, reduced downstream flooding, reduced stormwater drainage capital costs, improved groundwater recharge and improved stormwater quality.

For locations within a salinity hazard area, please consult your local council before undertaking design work as some infiltration techniques may not be appropriate within such areas.

Conventional stormwater practice typically involves discharging stormwater to a constructed street drainage system. Such systems are highly effective for removing stormwater from the site, but can also contribute to flooding risk, erosion and sedimentation and water quality decline in downstream catchments. Prior to the construction of urban drainage systems in the late 19th Century, one of the most common methods for managing stormwater was on-site gravel infiltration pits. These provided temporary storage, and allowed stormwater to percolate to the surrounding soil at a rate limited by the soil's hydraulic conductivity.

Modern infiltration devices are much more efficient than their traditional counterparts. They are constructed so as to minimise clogging by silt material, and can be designed to overflow to landscaped areas or the street drainage system when their storage capacity is exceeded during major storms. A number of pollutant removal mechanisms operate within infiltration devices, including adsorption, filtration, microbial decomposition in the gravel layer and trapping of sediment in the pre-treatment areas. If correctly designed, an infiltration device can remove approximately 90% of sediment, 60% of phosphorus and 60% of nitrogen from stormwater.

This Practice Note draws upon the latest design and performance research for Australian conditions (see References below). The research results confirm that infiltration is a very practical option for managing stormwater provided that site conditions such as slope, soil salinity, soil permeability and reactivity to water are correctly taken into account.

System overview

Infiltration devices can be used to manage stormwater runoff from roofs, paved surfaces, rainwater tank overflows and grassed and vegetated areas (see Figure 1). Runoff from each of these sources can be directed by pipes and overland flow to an infiltration device. Prior to entering an infiltration device, the stormwater must receive pre-treatment. This removes sediment and other material, improves the quality of runoff and helps minimise the risk of clogging the infiltration device.

Infiltration is best applied as part of an overall strategy for managing stormwater on the property. The effectiveness of infiltration is improved with the use of complementary measures such as rainwater tanks, porous paving and landscape measures (see Practice Notes 4, 6 and 7 respectively). For example, mulching, contour banks, garden beds, vegetation and other landscape measures can be used to encourage infiltration and provide pre-treatment of runoff.

There are a number of options for using stormwater infiltration on residential properties. The most commonly used devices are:

- leaky wells
- retention trenches
- infiltration basins
- infiltration cells
- seepage pipes.

These devices are described below.

Infiltration devices

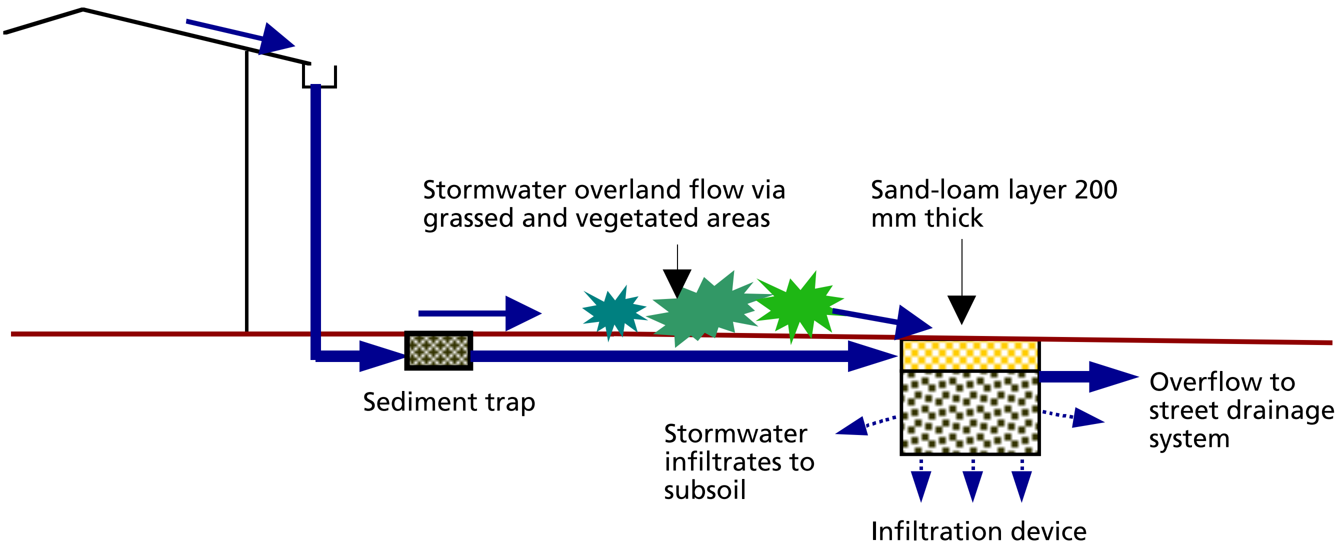

Fig 1: A typical infiltration strategy

Types of devices

Leaky wells

A leaky well consists of a vertical perforated pipe with a lid at the ground surface and an open bottom. Stormwater enters via an inlet pipe at the top and an overflow pipe caters for excess stormwater. The holes in the walls and the open bottom are covered with geotextile fabric to cleanse stormwater as it percolates into the surrounding soil (see Figure 2).

Leaky wells store stormwater until it can percolate to the surrounding soil. Before entering the device, all stormwater should be filtered by a sediment trap to remove sediment, leaves and debris. An advantage of the leaky well is that the accessible chamber allows sediment to be readily removed. Consequently it is more resistant to failure due to clogging. Note that the dimensions shown in Figure 2 are nominal.

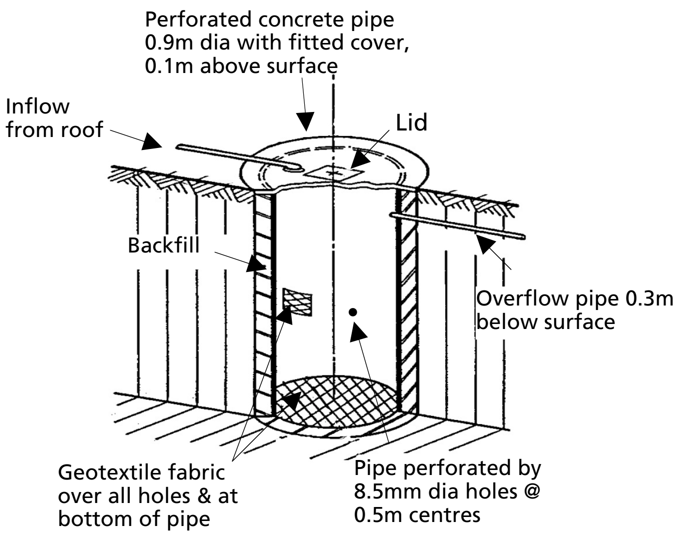

Fig 2: The leaky well infiltration system

Infiltration devices

Retention trenches

A retention trench consists of a trench lined with geotextile fabric and filled with coarse gravel, and placed under a 300 mm layer of sand or loam. Stormwater is conveyed to the trench via an inflow pipe after passing through a sediment trap. A perforated distribution pipe allows stormwater to percolate to the gravel. An overflow pipe directs excess flow during very heavy rain to the street drainage system (see Figure 3).

The sediment trap prevents clogging of the trench with sediment, leaves and debris, whilst the geotextile fabric cleanses the stormwater as it percolates from the trench to the surrounding soil. The detailed design for a retention trench can vary provided it includes the basic elements referred to above. Note that the dimensions shown in Figure 3 are nominal.

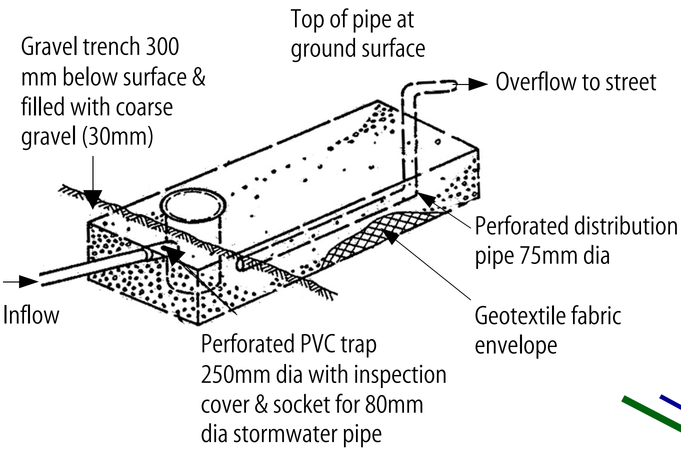

Fig 3: Design for a retention trench

Infiltration basins

An infiltration basin collects and stores stormwater runoff until it infiltrates to the surrounding soil and evaporates to the atmosphere. By removing a portion of stormwater runoff, infiltration basins reduce stormwater peak discharges and volumes to downstream catchments. They also improve the quality of stormwater discharged to the receiving environment.

An infiltration basin is designed as a depression with good grass coverage over a layer of coarse gravel surrounded by geotextile fabric. A 300 mm layer of topsoil is usually placed between the gravel layer and the grassed surface. Stormwater entering the basin is filtered to remove sediment, leaves and debris by sediment traps, vegetated areas or specially designed gutter systems. Stormwater fills the basin and the gravel layer, percolates to the soil and overflows to the street drainage system when the basin fills.

A schematic diagram for an infiltration basin is shown in Figure 4. Infiltration basins are more suitable for larger lots where there is plenty of space. Their design should be well-integrated with landscape measures (see *Practice Note No. 7*).

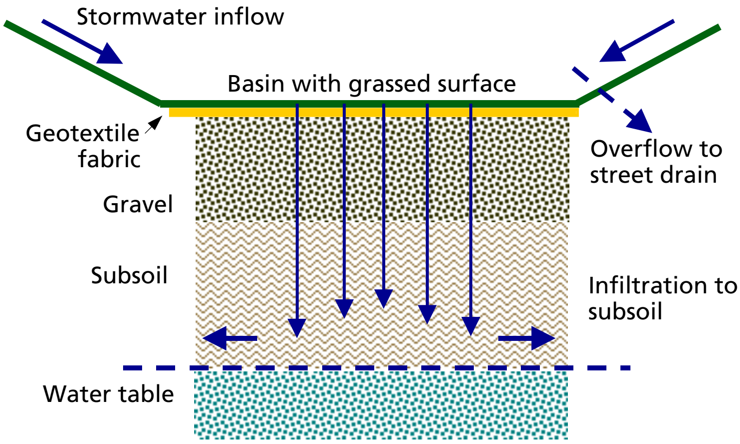

Fig 4: Design for an infiltration basin

Infiltration devices

Infiltration cells

An infiltration cell is a modular plastic cell (similar to a milk crate) that can be used in a retention trench instead of gravel fill. As with a retention trench, infiltration cells are surrounded with geotextile fabric and placed under a 300 mm layer of sand or loam. An infiltration cell generally has a greater volume of void space than a conventional gravel-filled retention trench. Consequently it can provide a greater storage volume per unit of area.

Seepage pipes

A seepage pipe is a pipe with pervious walls that allows stormwater to percolate into the surrounding soil. Seepage pipes are installed in a similar fashion to retention trenches. The pipe is surrounded by sand or gravel in a trench and covered with sand or loam to a thickness of 300 mm (see Figure 5).

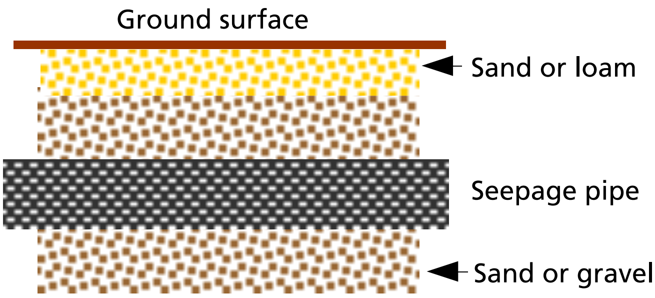

Fig. 5: Design for a seepage pipe

Design issues

Unsuitable soils

Infiltration devices must be avoided or carefully designed in areas with:

- high water table levels
- soil salinity hazard
- wind blown or loose sands
- clay soils that collapse in contact with water
- soils with a hydraulic conductivity of less than 0.36 mm/hr.

Soil assessment and permeability testing must be undertaken as part of the design process for infiltration devices. For details about the location of soil salinity hazard areas, contact your local council.

Clearance from buildings

Soils can shrink or swell depending on their clay and water content, presenting potential problems for building foundations. However, research shows that only minimum soil movement is associated with the intermittent release of stormwater from infiltration devices. The possibility of an infiltration device impacting on the structural integrity of a building can be eliminated by observing minimum clearances. The recommended minimum separation between an infiltration device and a building for various soil types is shown in the following table.

Soil type	Hydraulic conductivity	Clearance
Sand	>180 mm/hr	1 m
Sandy clay	180 – 36 mm/hr	2 m
Medium clay	36 – 3.6 mm/hr	4 m
Reactive clay	3.6 – 0.036 mm/hr	5 m

Infiltration devices

Slope

Infiltration devices should not be installed on steep slopes. An upper limit of 5% slope has been imposed under British conditions. Installation of infiltration devices on slopes greater than 5% is not recommended unless a detailed engineering analysis is undertaken at the design stage.

Rock & shale

Infiltration devices should not be placed in rock that has little or no permeability. Studies have shown that infiltration is possible in severely weathered or fractured rock (for example, sandstone). Engineering testing is essential in these circumstances to ensure that the rock will accept infiltration. In the case of shallow soil cover, testing is required to ensure that seepage does not cause any hazards or nuisance to downstream sites.

Water tables

The presence of a high water table can limit the potential effectiveness of infiltration devices. Infiltration devices can be successful in areas with high water tables provided the water table is stable. Infiltration is not recommended for areas where the water table is rising or the salinity of ground water is increasing.

Sediment

Sediment can be deposited on roofs from the atmosphere at approximately 2 kg per 100 square metres of roof area per annum. It can also be deposited from runoff on other surfaces in established suburbs at about 0.7 tonnes per allotment per year. The management of sediment is therefore a very important issue in the design and construction of infiltration devices.

Special measures must be implemented to provide pre-treatment for stormwater containing sediment, leaves or other debris before it enters an infiltration device. For example, runoff from roof downpipes should be directed to an effective sediment trap. Runoff from impervious surfaces such as paved areas, courtyards, walkways and driveways should be directed to grassed surfaces, vegetated areas or a sand-loam layer that is at least 200 mm thick. The only direct input to an infiltration device should be overflow from a roofwater tank, since the tank serves to remove sediment and other matter (see *Practice Note 4: Rainwater Tanks*).

Sizing infiltration devices

Many councils require infiltration devices to be designed with sufficient capacity to store the inflow for a one-in-three months average recurrence interval design storm, with an emptying time of less than 24 hours. For example, in the Newcastle area, an infiltration device filled with gravel (30 mm nominal particle size) and a catchment roof area of 150 square metres will need to have the following volumes:

- 2.5 cubic metres in a sandy soil
- 3.8 cubic metres in a sandy-clay soil
- 4.5 cubic metres in a medium clay soil.

Contact your local council for specific design requirements in your area.

In medium clay soils a low-level overflow pipe may need to be installed to ensure an emptying time of 24 hours. This is illustrated in Figure 6.

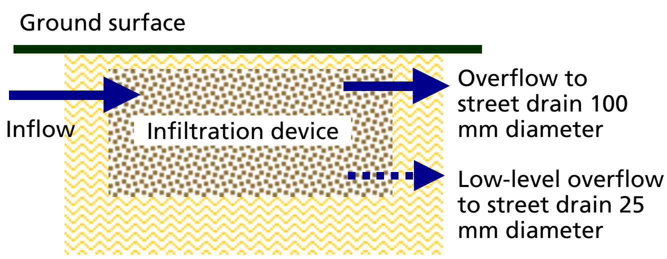

Fig 6: Low-level overflow for clay soils

Costs

The cost to install a retention trench can vary considerably. However, an indicative cost is about $80 per cubic metre (2002). This includes gravel and backfilling ($30 per cuubic metre), excavation ($30 per cubic metre) and geotextile fabric and plumbing ($20 per cubic metre).

Useful Websites

Atlantis: www.atlantiscorp.com.au

Rocla Pipes: www.rocla.com.au

James Hardie Industries: www.jameshardie.com.au

University of South Australia: www.unisa.edu.au

University of Newcastle: www.eng.newcastle.edu.au/~cegak/Coombes

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Other practice notes

Other Water Sensitive Practice Notes are available in this series:

No. 1	Water Sensitive Homes
No. 2	Site Planning
No. 3	Drainage Design
No. 4	Rainwater Tanks
No. 5	Infiltration Devices
No. 6	Paving
No. 7	Landscape Measures
No. 8	Landscape Practices
No. 9	Wastewater Reuse
No.10	Groundwater
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Principal Author: Peter Coombes. Design and Layout by Planning Plus.

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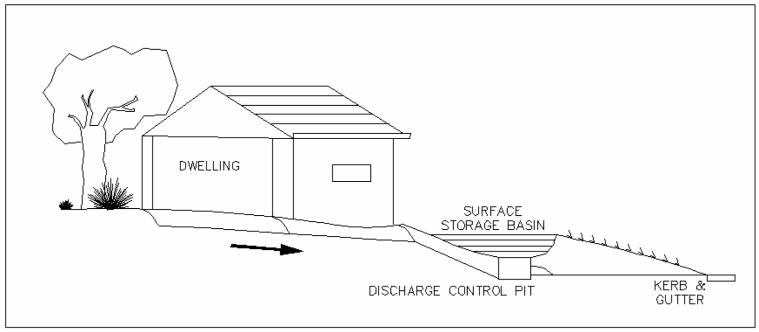
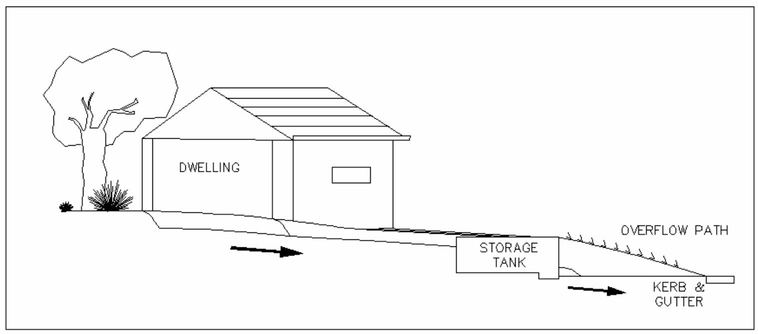
Infiltration devices

On-site Detention

Sustainable water DCP: Practice Note 6





Paved surfaces increase stormwater peak flow rates during extreme rainfall events, leading to growing frequency and severity of stormwater surcharge and flooding of downstream properties. This impact can be mitigated by providing 'detention storage' that temporarily stores stormwater before slowly releasing it in a controlled manner.

This Water Sensitive Practice Note describes how to design and install On-site Detention (OSD) systems to manage stormwater runoff peaks generated within a site and release them downstream in a controlled way.

- **System overview**
- **Detention storage types**
- **Storage and discharge control requirements**
- **Design & maintenance**

Hunter's Hill Council

On-site Detention

Sustainable water DCP: Practice Note 6

Introduction

New development and redevelopment proposals generally increase the impervious surfaces within the property due to building bigger houses plus more intensive urban use of the site such as for footpaths, driveways and paved courtyards. These impervious surfaces act to reduce the quantity of rainwater infiltration at point of interception with the result that rainfall is converted into run-off, which increases peak run-off rates and the consequent frequency of these peaks. This impact can be mitigated by providing 'detention storage' that temporarily stores stormwater before slowly releasing it in a controlled manner.

System overview

On-site stormwater detention (OSD) is an element incorporated into the property drainage system, whereby discharge of stormwater during large storm events is restricted by an outlet control that allows excess stormwater runoff to be temporarily stored within the site. The provided storage could be in the form of a holding tank (part of a rainwater tank), oversized pipe or surface depression. This storage is called the site storage requirement, while the stored runoff discharge into downstream drainage system is called the permissible site discharge. This discharge is estimated so that a development does not increase the risk of flooding on downstream properties or erosion of downstream waterways.

OSD systems are best integrated into other adopted site stormwater management measures such as rainwater tanks and bioretention systems. Remaining additional storage requirements can be provided separately, once integrated options are exhausted.

Detention storage types

On-site detention systems are mainly introduced to serve two purposes:

Flood control detention
Detention storage is provided to limit peak flood discharges throughout Hunter's Hills catchments to existing rates for the 1 in 100 year Average Recurrence Interval (ARI) storm event. This event is the major contributor to surcharge of the downstream drainage system and flooding of downstream properties.

Erosion control extended detention
Extended detention storage is provided to limit peak discharge from the site to existing rate for the 1 in 1.5 year ARI storm event. This is considered the bank-full or near bank-full discharge for natural creeks. Increasing the frequency and peak flow of such events would lead to creek widening, erosion and sedimentation, loss of pool/riffle structure and degradation of habitat structure.

On-site Detention

Storage and discharge control requirements

Site storage requirements

Site storage requirements are measured based on the total impervious area of the site. The following volumes of site storage are required (catchment zones are presented in Appendix A of the Sustainable Water DCP):

Zone	Flood control detention site storage volume $m^3/100m^2$ of impervious area	Erosion control extended detention site storage volume $m^3/100m^2$ of impervious area
1	3.04	1.2
2	2.63	1.1
3	2.47	1.0

The above flood control and extended detention storage requirements could be met partially or totally through other adopted site stormwater management measures such as rainwater tanks and bioretention. Details of how to calculate these storage credits are presented in the Technical Appendix of the Sustainable Water DCP.

If an integrated storage facility is used for both flood control and extended detention, an additional 15% of the flood control storage should be provided for extended detention purposes.

Site discharge control requirements

Permissible site discharge (PSD) requirements are measured based on the total impervious area of the site. The following PSDs are required (catchment zones are presented in Appendix A of the Sustainable Water DCP):

Zone	Flood control detention PSD $L/s/100m^2$ of impervious area	Erosion control extended detention PSD $L/s/100m^2$ of impervious area
1	1.80	0.41
2	2.20	0.57
3	2.40	0.64

Design and maintenance issues

Providing storage

- Storage may be provided below ground in tanks or oversized pipes, or above ground as a shallow pond on a driveway, landscaped area, or combination of above and below ground storage.
- The following design issues for below ground storage need to be considered:

- The storage facility must be designed to withstand all service loads.
- A sediment trap and trash screen must be installed immediately upstream of the outlet pipe. An area of 600mm x 600mm and depressed 200mm below the invert level of the outlet pipe is recommended.
- The storage facility should be graded to drain completely. Unless used as part of a rainwater tank, long-term ponding of water over the floor of the basin is not acceptable.
- The storage facility should contain an overflow outlet, an inspection/access grate (600mm x 600mm) over the outlet and if the tank depth is more than 1.2m, step irons should be provided.
- All below ground OSD tanks must be accessible for maintenance purposes in accordance with the provisions for safe working conditions in confined spaces.

- The following design issues for above ground storage need to be considered:
  - Maximum ponding depth should not exceed 200mm in driveways and car parking areas.
  - Maximum ponding depth should not exceed 500mm in landscaped areas. This can be increased to 1200mm provided that side slopes of the basin are 1:6 or more. Ponding depths in excess of these should be fenced off.
  - Storage volumes in landscaped areas should include an allowance for 10% additional storage for vegetation growth and construction inaccuracies.
  - Desirable minimum slope for landscaped storage is 1% and for paved storage areas is 0.7%.
  - Storage facilities should not be located across properties or restrict pedestrian access to the buildings.

Assessment of external flows

A floodway/overland flowpath maybe be provided to ensure the runoff from outside the site, bypass the on-site detention storage. If external flows enter the storage, it will take less time to fill, causing it to surcharge more frequently than designed and creating a nuisance to occupiers. External flows can be divided into two categories:

- Overland flowpaths

  These are drainage systems which collect relatively minor sheet flows from upstream properties and convey them around the storage or allow them to pass across the site without interference. Examples include dish drains and grassed swales.

- Floodways

  These are surface drainage systems used to convey relatively major concentrated surface or surcharge flows from an upstream catchment around the storage. Examples are natural gullies or surcharge paths for drainage lines.

General considerations

- An overland flow route is to be provided in the event that the OSD device malfunctions. The overland flow route should be designed to carry the flows for a 1 in 100 year ARI event, assuming that the outlet to the OSD device is fully blocked.
- All habitable floor levels adjacent to the OSD storage, or the overland flowpath from the OSD storage, are to be a minimum of 200mm above the maximum design storage water surface level.
- Water surface level calculations and pipe hydraulic gradeline analysis should recognise the effect of downstream controls. The 1 in 100 year ARI levels of the external system are to be used for this purpose.
- The starting hydraulic gradeline level for connections, whether to the underground drainage system or to the kerb and gutter, is the top of the kerb and gutter at the discharge point to the street drainage system. All active storage should be above this level.

Discharge control pits

This is the component of the detention system that controls the rate of discharge for the storage facility.

Outflow discharges from the detention storage can be controlled by:

- Orifice plates machined to the required dimension from 3mm thick stainless steel cast in the pit walls or permanently fixed in the pit so that they cannot be easily removed.
- A 150mm long outlet choke pipe as shown in Figure X below.

All outflow controls must be enclosed by a rustproof screen or wire cage to protect them against blockage. A sediment collection sump is to be provided below the orifice outlet to the stormwater detention system. This sump is to have a minimum depth of 200mm below the invert of the orifice as shown in Figure 5.

Multi-staged outlets can be used to control outflow discharges for integrated OSD systems for flood control and extended detention. This can be achieved using separate pits connected by the 5 year ARI capacity pipe.

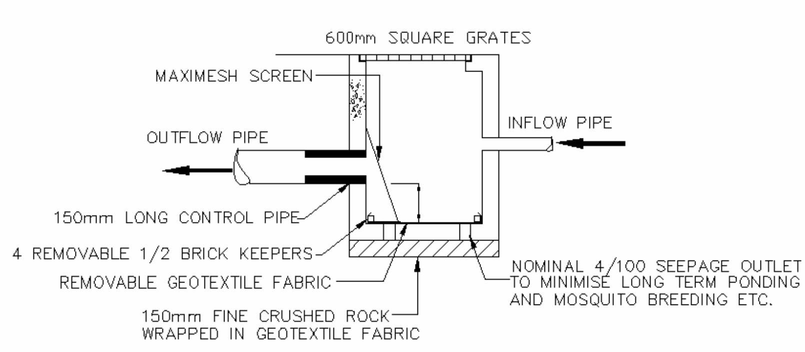


Figure 5.1 typical discharge control pit arrangement

Hydraulic calculations

The following equations can be used to calculate the size of the outlet pipe:

a) Orifice (submerged pipe outlet):

$Q_{max} = A \times C_d \times \sqrt{2gh}$

where
A = orifice area
h =depth to centreline of Orifice
$C_d = 0.61$

b) Weir Outlet (Broad crested):

Q_{max} = 1.67 x Weir Length x (Flow depth over weir) ^1.5

c) Choke Pipe:

$Q_{max} = A \times C_d \times \sqrt{2gh}$
where
A = pipe area
h =depth to centreline of pipe
$C_d = 0.61$

For this formula, the outlet pipe must have a minimum diameter of 1.5 x the choke pipe diameter.

Runoff bypassing the storage facility

Where possible, the drainage system should be designed to direct runoff from the entire site to the OSD system. Sometimes, because of ground levels, the receiving drainage system or because of other circumstances, this will not be feasible. In these cases up to 25% of the site area may be permitted to bypass the OSD systems, provided that as much as possible of the runoff from impervious site areas is drained to the OSD system, while the rest should not drain directly to Council's drainage system.

Other site drainage issues

- When full or partial redevelopment of a site is taking place then On-site detention must be provided to cover all the development. No credit will be given for existing impervious area.
- If gravity drainage to Council's drains or gutters cannot be achieved, the following options are considered:
  - An easement (preferred option).
  - Charged systems
  - Absorption system
- Pump-out will only be considered for basement ramp runoff.

References

On-site Stormwater Detention Handbook (1999), The Upper Parramatta River Catchment Trust.

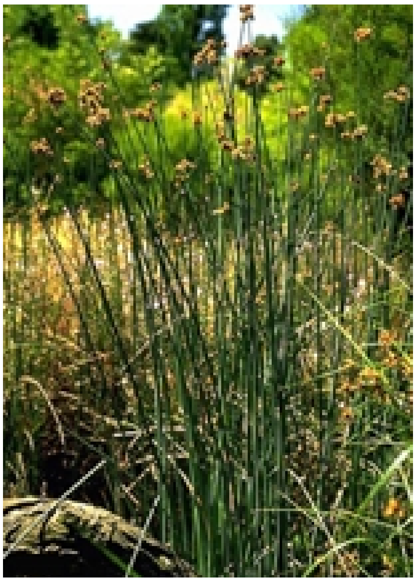
Local Policy for On-site Stormwater Detention (1995), Willoughby City Council.

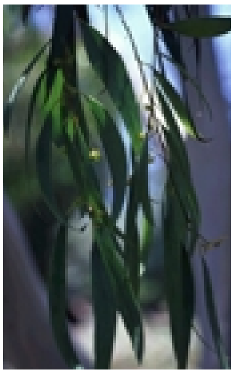
Stormwater Management Development Control Plan (2001), Ryde City Council.

Water Sensitive Urban Design in the Sydney Region

PRACTICE NOTE 8

Landscape practices





Water sensitive development involves simple design and management practices that take advantage of natural site features and minimise impacts on the water cycle. It is part of the contemporary trend towards more ‘sustainable’ solutions that protect the environment.

This **Water Sensitive Practice Note** explains how to undertake landscape practices that promote efficient water use and good plant growth.

- **Soil preparation**
- **Planting, mulching & plant care**
- **Ongoing landscape maintenance**

Landscape practices

Soil preparation

Preparation of the soil is dependent on soil type and site conditions. There are three main types of soil:

- sandy soils that drain rapidly
- clay soils that hold water
- loamy soils containing a mixture of coarse and fine particles.

Soil texture determines the soil's ability to retain water for use by plants. Fine-textured clay soils hold the most water due to the greater surface area around soil particles. These soils may be unsuitable for some types of plants. Sandy soils may dry out quickly in dry weather. Loamy soils that contain plenty of organic matter are ideal for plant growth. Check with your local plant nursery for advice on local soil types and soil testing.

It is best to use plants that are suited to the site's soil conditions. Adding a veneer of the best 'garden mix' is not recommended as this will discourage roots to penetrate deeply into the soil below. Hardy, deep rooted plants can help break up poor soils. Organic matter can be added to soil to encourage microbial and worm activity, thereby improving soil condition and moisture retention.

Potential acid sulfate soils and salinity are major soil problems. Check with your local council to see if your site could be affected, and whether any specialised strategies are required. Careful design, construction and on-going management techniques for building, drainage and landscaping works are necessary in these situations.

If soils have been compacted by construction work or vehicles, remediation can be undertaken to open up pore spaces, promote aeration, and improve water infiltration and holding abilities.

There are a number of soil additives that can be used to improve general soil performance. Always seek specialised advice as to the correct rates and situations for application. Common soil additives include the following.

- **Wetting agents** for hydrophobic ('non-wetting') soils, including some sandy soils and soils with lots of organic matter. Watering results in beads of water running-off rather than soaking into the root system. The wetting agent can be mixed with backfill at planting times, or applied later.
- **Gypsum** may be added to dispersive or sodic clay soils. Always test the soil to see if it is needed and to determine the correct application rate.
- **Water-storing crystals** can hold hundreds of times their weight in water. When mixed with water they form a soft gel and retain water. This provides a reservoir of moisture for plant roots during dry periods.

Where construction or landscaping works cut into the soil subgrade, apply the saved topsoil (scraped and stockpiled prior to commencement of work) to a depth of at least 150 mm for turf areas, or 400 mm for garden beds. Roughen the surface before applying the topsoil layer, and water with a fine spray prior to planting to eliminate air pockets.

To avoid compaction of heavy clay soils after rain, allow 2-3 days for free drainage before tilling or using mechanical means to work the ground.

Any additional soil required for landscaping works should be specified to satisfy Australian Standard AS 4419 *Soils For Landscaping and Garden Use*, or current standard. This sets requirements for bulk density, organic matter, weed content, wettability, pH, electrical conductivity, ammonium toxicity, phosphorous content, dispersibility, toxicity, nitrogen drawdown, permeability, soil texture and large particles.

Select the range that suits the proposed type of plants for the site. For example, Australian native plants have different requirements and tolerances. As a guide do not use any soil with more than 20% organic matter in it

Pre-planting

Those parts of the site that are to be landscaped should have all weeds removed prior to the commencement of landscaping work. Use hand tools on smaller weeds. As a last resort, apply herbicide by spot application to larger, perennial or vigorous weeds.

Backfill retaining walls and make other garden beds after brickwork, electrical and drainage works and adjoining pavements have been completed. Apply water to settle the soil down and eliminate air pockets. This must be done with a fine gentle spray to prevent surface erosion.

Mulch should be applied to each area left unplanted in the event that planting is delayed by more than one week from backfilling or other soil preparation.

Planting

Stock selection

The key issues in selecting trees are:

- the trunk has adequate stem taper and is self-supporting in its container
- good root occupancy of the root ball
- no girdling or kinking of roots within the root ball
- roots fill the container without being over-grown
- trees are free from included bark (unless this is typical of the species and is known not to lead to structural failure)
- there is adequate root volume to support and sustain the above-ground sections.

Stock selection should be based on Clarke (1996) *Purchasing Landscape Trees: a Guide to Assessing Tree Quality*.

Tubestock generally give faster growth, but semi-mature seedlings need less watering.

Hardening off plants

Arrange delivery of plants to a location within the locality of the site at least four weeks before planting out. Maintain plant root systems moist at all times, giving particular attention to watering during the on-site installation period before and during planting.

Planting guidelines

To avoid damage to trunks and root zones of retained vegetation, use hand tools and barrows in adjacent areas. Undertake planting according to any landscape plans and drawings for the site and observe the following guidelines.

- Ensure that there is an adequate depth of drained soil for the stock size to be used.
- Do not plant if the air temperature is over 35°C or if the soil is waterlogged.
- Relocate existing turf or mulch. At each planting site set aside mulching materials if already applied.
- The planting holes are to be a minimum of twice the width of the container and to the depth of the root ball. For tube stock excavate to a depth equal to the root column and, if possible, to a width of 500 mm.
- The sides of the hole should be rough (not smooth) to promote new root growth.
- Organic matter must not be placed in the bottom of the hole or in the backfill.
- Ensure that all containers are fully removed from the root ball and the hole. No part of the plant should be damaged during this process.
- Depending on container size, remove or gently roughen the outer 5-10 mm of the root ball of trees.
- The plant should be centred in the hole and then backfilled with site soil in good tilth.
- The top of the root ball must be level with the finished level of the soil and must remain so.

Landscape practices

- If fertiliser is to be added it should be placed in the upper section of the backfill. The type of fertiliser, rate of application and area should be to the manufacturer's instructions.
- The backfill must be placed around the root ball to ensure good root contact without being overly compacted.
- Place remaining excavated soil as a mound around the edge of the root ball to create a watering well. This helps retain water.
- Water each plant within one hour of planting. As a rule of thumb, apply one litre of water for every litre of container volume. Apply the water through the root ball, but not so as to damage the plant or dislodge the root ball. For containerised stock up to 45 litres, water the plant bringing the growing medium to container capacity within one hour of planting. For stock over 45 litres ensure that the root ball is moist and that plants are not wilting.
- Depending on soil moisture conditions, additional water may be applied to the soil surrounding the root ball.
- Apply organic mulch to a minimum radius of 500 mm from the trunk, and to a depth of 75 mm.
- If tree protection measures are required such as tree guards or marker stakes, these must be installed so that no damage is done to the trees. In most situations, trees should not be tied to stakes (that is, trees should be self-supporting when purchased—see *Stock Selection* above). Where additional support is required, two or three stakes should be used. These should be driven into the soil beyond the root ball and not interfere with branches or foliage. Trees should be attached with jute webbing or other flexible material that will not damage the plant. The ties must be low enough to allow trunk movement but high enough to provide support for the root ball.
- Remove all other ties and labels from the plants.

On-going plant care

Maintenance period

Specify a pre-determined maintenance period (up to two years from completion of landscaping works) for establishment of landscaping. During this period, missing, dead or unhealthy plants should be replaced with identical species of similar size and quality at the contractor's expense.

Watering

Deeply water all new plantings at least once a week for the first three months, once a fortnight for the next six months and once a month for the subsequent six months. Adjust this frequency to suit local soil, climatic and weather conditions, such as falls of heavy rain. Water should be applied to the root ball and surrounding soil.

Weed removal

Undertake periodic weed removal at least once a month. Hand weeding young plants is recommended as it causes less ground disturbance. Removing weeds whilst still immature limits their ability to establish a wide root network, set seed and spread vegetatively. Herbicide could be used selectively to control the re-emergence of persistent weeds by using cut-and-paint techniques or an applicator where appropriate.

Moderating plant growth

Lightly tip-prune flowering shrubs at the end of their main flowering period to encourage bushy growth. Keep groundcovers 150 mm from tree trunks to allow inspection of the tree trunk. Grasses need to be kept approximately 1m away from new plants for one to two years to prevent competition.

Removing tree stakes

Remove stakes from newly planted trees after the completion of their first growing season. Take care not to cause any damage to the trees.

Landscape practices

Mulching

Mulching has many benefits to plant health and water conservation. As well as reducing evaporation, it suppresses weed germination and growth (by reducing light penetration to the soil surface) and stabilises soil temperature (beneficial to root development and soil organisms). Organic mulch slowly breaks down to supply soil nutrients. Use the following guidelines to help ensure efficient water use and good plant growth.

- Apply 75-100 mm of organic mulch over the surface as a blanket on massed plantings. Top up annually. Keep mulch at least 150 mm away from trunks and stems to prevent rot.
- Use a mixture of textures to allow water to pass through. A combination of chipped bark and leaves decomposes at different rates and supplies a variety of minerals and nutrients.
- Avoid introducing pests and diseases from mulch imported to the site. Obtain materials that satisfy Australian Standard AS 4454 *Composts, Soil Conditioners and Mulches,* or current standard.
- Do not apply fresh organic products directly to the soil (such as sawdust, woodchips and pinebark). These materials extract soil nitrogen ('nitrogen drawdown'), competing with plant uptake and causing sickly plants. Add fertiliser (manure or blood and bone) before application, or compost the material before use.
- Inorganic mulch can be used, but does not add humus and nutrients to the soil. Use crushed rock, gravel and brick, silicon chip, coarse river sand, scoria or river pebbles to complement landscape themes or where loose materials may be blown away. Avoid blue metal as this can alter soil pH. Use to a depth of about 50 mm to allow water penetration.
- Mulch matting can be used on slopes where other mulches may slip. When pegged in position, the mat forms a stable surface whilst trees, shrubs and groundcovers establish. Plants can be pocket planted through the matting. Use 100% organic matting, such as jute. The matting must not contain inorganic fibre such as nylon.
- If using an irrigation system, install an underground or surface drip system to make sure the water reaches the soil below the mulch.
- Avoid using mulch in areas where it is likely to be washed away by surface flow during heavy rain.

Maintenance regimes

After rain

Avoid walking or driving over wet ground as heavy soils are easily compacted when wet. Soil compaction significantly reduces infiltration rates.

Avoid disturbing plant foliage immediately after rain as plant diseases are more easily transmitted into damaged leaf tissue when moist.

Check for soil erosion, and repair erosion points before they magnify. Identify the cause and undertake corrective measures (redirect drainage, disperse flow and reduce velocity). Check for sediment build-up in vegetated filter strips, drainage swales, soak areas and ponds. Collect sediment and stabilise in areas that are less prone to erosion.

Weeding

Regularly control weeds to reduce competition for both soil moisture and nutrients. Hand-pull or hoe weeds when they are young. Remove weeds before they set seed for the next generation.

Avoid broad-scale herbicide application as this may wash-off into water courses and affect aquatic fauna. If persistent woody weeds do not respond to manual methods, cleanly cut near the stem base stem and paint with herbicide on the fresh wound. Use herbicides only in accordance with the manufacturer's instructions.

Landscape practices

Watering

Newly planted areas will require more water than established plants. The first growing season is the most crucial for good root establishment. New plants need to be monitored, especially in weather extremes. Use the following guidelines to help ensure efficient and effective watering.

- Apply slow waterings to encourage deep root penetration
- Decrease watering frequency as plants settle in.
- For maximum watering efficiency, group plants together that have similar watering needs together ('hydrozoning').
- Take care that the underlying subsoil is not saturated as this can be a cause of wilting leaves. Rectify by improving subsoil drainage or using species that can cope with the conditions.
- Water according to soil moisture and plant needs rather than to a fixed schedule. Test the soil 50 mm below the mulch to see if it is dry before applying water.
- Divide garden beds into sections and alternate between them at watering times, concentrating on one with deep soakings.
- Minimise evaporation by watering in the early morning or late afternoon. Apply water to the roots rather than the foliage, as some plants are susceptible to pest and fungal diseases if left with damp leaves, especially overnight.
- Avoid watering in windy conditions as much water is lost to spray drift.
- If using a handheld hose, use a trigger-operated nozzle to control flow whilst moving between plants.

Care of plants

Protect young plants, especially ornamentals that have large or soft leaves, by shading from strong sun or wind. Use shade cloth or a tee-pee of branches cut from prunings. This reduces moisture loss from their leaves.

Thin out fruit on deciduous trees. Thin apples, peaches, plums to about 20-30 cm apart.

Let cane berries and fruit trees go dry after harvest and water only if the leaves wilt. Well-established and mulched plants should be able to withstand this regime. Let roses develop hips by not dead-heading flowers.

Avoid excessive use of nitrogen-rich fertilisers as this stimulates leaf growth and increases water demand.

Pruning

Minimise pruning by not forcing plants with lush lengthy growth that becomes wayward. This soft growth is more prone to drying out in hot winds and, if not hardened by the end of the growing season, can be damaged in the colder months.

Pruning may be necessary for shaping, crown lifting or the removal of dead or diseased limbs on trees. For a useful guide, see Australian Standard AS 4373 *Pruning of Amenity Trees*.

Recycle any disease-free prunings back into the landscape as mulch so as to return the stored nutrients to the soil.

Grassed areas - watering

Grassed areas are the biggest user of water. Consider reducing size of lawns, substituting with other groundcovers or converting to a less water-dependent garden bed. For further details, see *Practice Note 7: Landscape Measures* in this series.

Give lawn areas a good soaking rather than frequent shallow waterings. During prolonged dry periods it may be necessary to water every third day to the equivalent of 15 mm of rain. Use a cup to measure how much water has been applied.

For summer-dormant turf species, restrict foot traffic whilst the turf is dormant.

Grassed areas - mowing

Mow less often. Where possible, use a hand-pushed mower—a great incentive to reduce lawn areas!

Set mower blades higher. Aim to cut only the top one-third of the grass. Mowing too low weakens the grass, increases susceptibility to weeds and pest damage, and increases evaporation from the soil.

Use a mulching mower to recut the grass finely, self-mulch the lawn and return soil nutrients.

Mow when the grass is dry to allow clippings to filter down to the soil for self-mulching without clumping.

Avoid fertiliser application as this stimulates leaf growth, increasing moisture loss and nutrient-enriched run-off. It also requires more frequent mowing.

Grassed areas - maintenance

- Aeration helps water penetrate to the root zone. This can be done by inserting the prongs of a garden fork to a depth of at least 10 cm in a regular pattern over the surface of the lawn, or use a motorised roller with spikes.
- De-thatch the lawn. Lawns that grow by creeping stems sometimes form a thick layer of stems and leaves under the green parts, called thatch. Remove this layer using a special mower (available for hire) to improve water penetration. This is best done between spring and early summer or in autumn.
- Organic fertilisers, such as fishmeal, seaweed extracts and pelletised poultry manure help stimulate microbial activity that removes thatch naturally.

Other issues

Swimming pools

Swimming pools loose an enormous quantity of water through evaporation. In a shaded wind-protected setting evaporative loss may be about 15 mm per week over the surface. For a 60 m^2 pool this is about 3700 litres per month! The same sized pool in a hot, sunny, windy site looses about four times that amount. A pool cover can cut potential losses by more than 90%, and reduce the need for chemical additions and pump and filter use. Pool covers are commercially available as either floating or fixed covers that satisfy budget, use and safety needs.

Gutters

Prune back overhanging branches and remove leaf and other debris from roofs and gutters to reduce possible contamination of water collection tanks and systems.

Car washing

Washing cars or boats on lawns prevents water and detergent from entering the stormwater drainage system. Lawns and garden beds have a limited ability to absorb nutrients contained in detergents. Wash the car in a different location each time. If the lawn deteriorates or becomes water-logged, your vehicle may be compacting the soil or the nutrient levels may be too high. Aerate the soil and rest it by taking the car to a commercial car wash for a few months. Select a car wash that recycles water and detergent.

Regular maintenance

Sweep paths and driveways rather than using a hose. Maintain and repair leaking taps, hoses and other fittings of watering systems.

Landscape practices

Useful websites

Environment Australia (2001). *Your Home: Technical Manual and Consumer Guide*: www.greenhouse.gov.au/yourhome

Friends of the Earth (Sydney): www.homepages.tig.com.au/~foesyd/SustainableConsumption/garden/gardenhome

Australian web site dedicated to promoting better water conservation: www.savewater.com.au

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Other practice notes

Other Water Sensitive Practice Notes are available in this series:

No. 1	Water Sensitive Homes
No. 2	Site Planning
No. 3	Drainage Design
No. 4	Rainwater Tanks
No. 5	Infiltration Devices
No. 6	Paving
No. 7	Landscape Measures
No. 8	Landscape Practices
No. 9	Wastewater Reuse
No.10	Groundwater
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No.12	Urban salinity
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www.wsud.org

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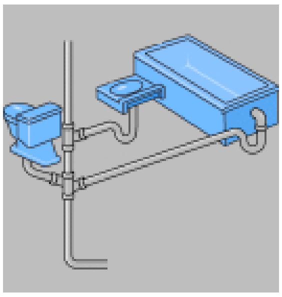
WSUD Water Sensitive Urban Design in the Sydney Region

PRACTICE NOTE 9

Wastewater reuse



On-site waste water treatment options include septic tanks, aerated wastewater treatment systems and composting toilets.

Water sensitive development involves simple design and management practices that take advantage of natural site features and minimise impacts on the water cycle. It is part of the contemporary trend towards more 'sustainable' solutions that protect the environment.

This Water Sensitive Practice Note gives a general introduction to the options available for on-site waste water treatment and re-use.

- **Septic tanks**
- **Aerated wastewater systems**
- **Greywater reuse systems**

Wastewater reuse

Introduction

The majority of water used for indoor domestic purposes is discharged after use as 'wastewater'. Wastewater can be collected by a reticulated sewage system and treated at a conventional wastewater treatment plant. Alternatively, it can be collected, treated and re-used on-site, thereby promoting more efficient water use. This has many significant economic and environmental benefits for the community. However, on-site reuse of domestic wastewater is subject to various restrictions due to concerns about effluent quality, maintenance and health issues.

Types of wastewater

There are two main types of domestic wastewater:

- blackwater - wastewater from the toilet
- greywater - all other domestic wastewater, including wastewater from bathrooms, kitchens and laundries.

A typical household discharges approximately 35 litres of blackwater, and 105 litres of greywater, per person per day. The potential for on-site treatment and reuse will depend on its quality. Greywater contributes about 65% of the volume of domestic wastewater, 70% of the phosphorus, and 63% of the BOD (biological oxygen demand), whilst blackwater contributes about 35% of the volume of wastewater, 61% of suspended solids, 82% of nitrogen and 37% of BOD.

The potential presence of pathogens in greywater is substantially lower than in blackwater. However, several authors have shown that greywater may contain pathogens. Thus, both greywater and blackwater require adequate treatment before on-site reuse.

On-site treatment and reuse options include septic tanks, aerated systems, and greywater reuse systems. These options are mainly applicable to rural and rural-residential locations.

Septic tanks

Septic tanks are widely used throughout Australia in areas without reticulated sewerage. About 12% of all households nationally rely on septic tanks. The conventional system involves the underground installation of a concrete tank and an absorption trench (see Figure 1).

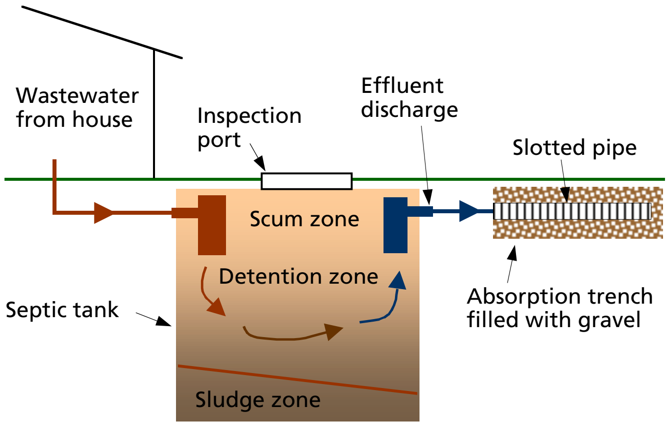


Figure 1: Septic tank & absorption trench

Wastewater is partially treated in the septic tank by anaerobic processes. These remove about 30% of phosphorus, 20% of nitrogen, 60% of suspended solids, 50% of BOD, and reduce the concentration of biological contaminants. Final treatment occurs via an absorption trench. The effluent then percolates to the soil where it is subject to further contaminant removal processes by soil organisms before reaching surface or ground waters.

Guidance for the design of septic tanks and the disposal of effluent from on-site wastewater treatment systems is provided in Australian Standards AS1546 and AS1547 respectively. Installation of a septic tank requires approval from the local council. Ongoing operation also requires council approval and regular inspection.

About 40% of septic systems have been found to be not operating correctly, thereby contributing nutrients to waterways and causing significant water management problems. Common reasons for failure of septic tank and absorption trench systems are:

- the volume of wastewater discharged to the septic tank is greater than its design volume
- failure to periodically remove sludge from the septic tank
- insufficient area of absorption trench to accept effluent from the septic tank
- inappropriate soil type for absorption of effluent.

Aerated systems

There are a number of different aerated wastewater treatment systems available for on-site management and reuse of wastewater. These systems rely on mechanical devices to mix, aerate and pump the effluent, subjecting it to accelerated aerobic and anaerobic decomposition using one or two tanks (see Figure 2).

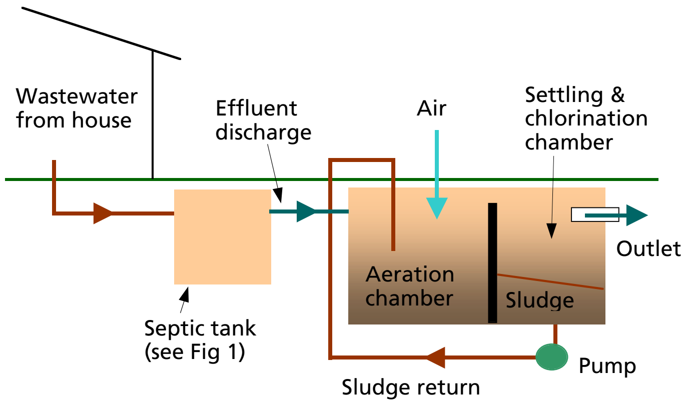


Fig 2: Aerated wastewater treatment system

Provided that the required management and maintenance regimes are adhered to, including periodic sludge removal, the effluent should be clear and odourless, and meet NSW Department of Health guidelines. Effluent quality should be better than 30 mg/l suspended solids concentration, 20 mg/l BOD_5, 0.5 mg/l free residual chlorine and 10 organisms per 100 ml for faecal coliforms. It can then be disposed of by surface or underground irrigation. A minimum irrigation area of 200 m^2 is usually required.

Greywater reuse systems

There are two main types of greywater reuse systems: primary and secondary systems In a primary system, greywater is collected and distributed by gravity or a pump for underground lawn and garden watering (see Figure 3).

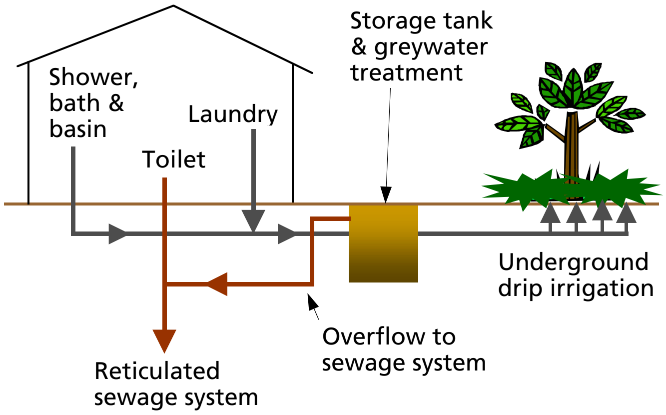


Fig 3: Primary greywater reuse system

Careful selection of detergents and washing products is required to minimise possible harmful impacts on plants or soil due to accumulation of salts, nutrients and trace metals. A guide to suitable detergents is provided by Mobbs (1998). As untreated greywater may contain harmful bacteria, it should not be applied directly to vegetables.

Secondary systems incorporate a storage tank for greywater treatment. This supplies greywater for toilet flushing and garden irrigation via a pump (see Figure 4). The system can also supply underground drip irrigation of garden areas.

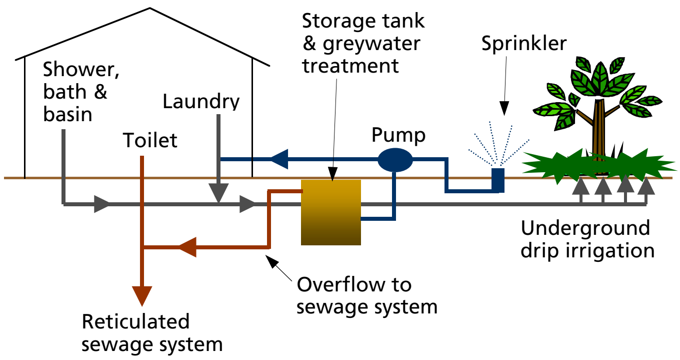


Fig 4: Secondary greywater reuse system

Wastewater reuse

Costs

Construction costs for wastewater systems can vary considerably. Palmer *et al* (2001) found that the average cost to install a septic system is $4,300, and the average cost of traditional reticulated sewage systems is $13,800 per allotment. The cost to install an aerated wastewater system is approximately $6,000-$8,000 with a maintenance cost of $260 per annum.

Useful contacts

CSIRO Urban Water Program: www.dbce.csiro.au/urbanwater

Michael Mobbs: www.sustainablehouse.com.au

BDP Environment Design Guide: The Royal Australian Institute of Architects

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