

Infiltration devices



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

WaterSmart 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 and cost less.

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

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

Infiltration devices

Introduction

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

Conventional stormwater practice typically involves discharging stormwater from residential properties 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, straining, 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 results for Australian conditions. Research undertaken at the University of Newcastle

(Coombes *et al* 1999, Coombes 2002) and the University of South Australia (Allen and Argue 1992, Argue *et al* 1998, Argue 2002) shows that infiltration is a very practical option for managing stormwater provided that site conditions such as slope, 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.

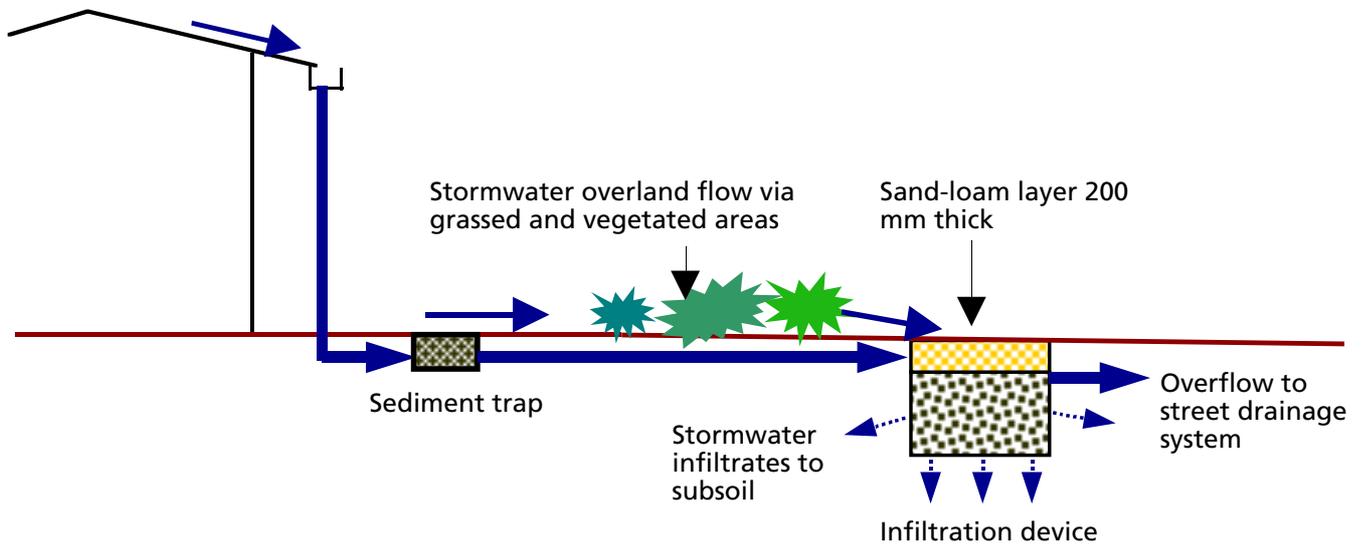


Fig 1: A typical infiltration strategy

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.

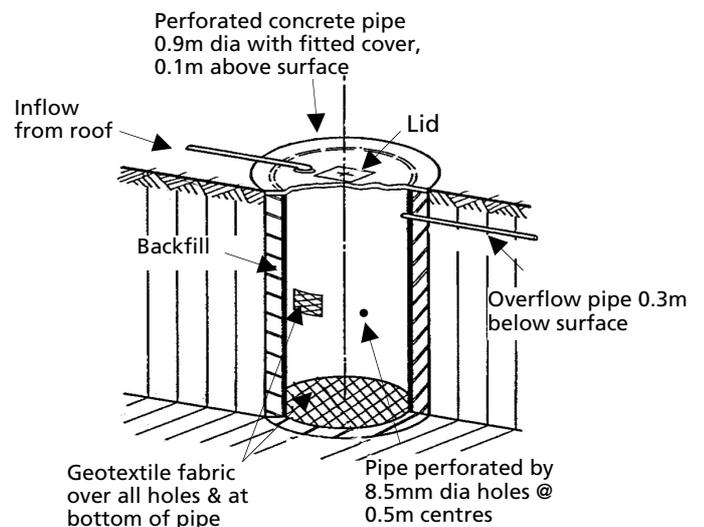


Fig 2: The leaky well infiltration system

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.

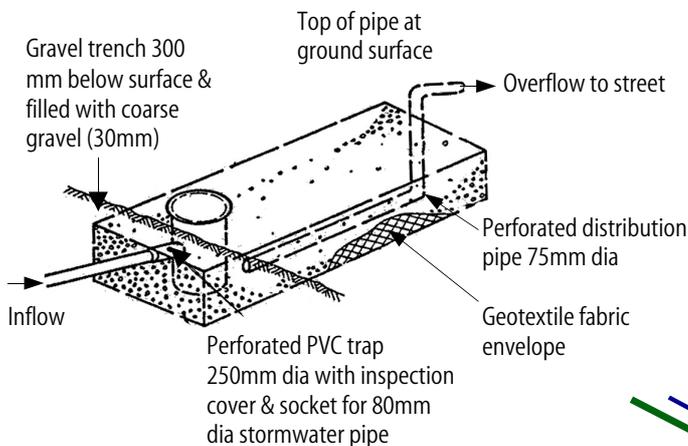


Fig 3: Design for a retention trench

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*).

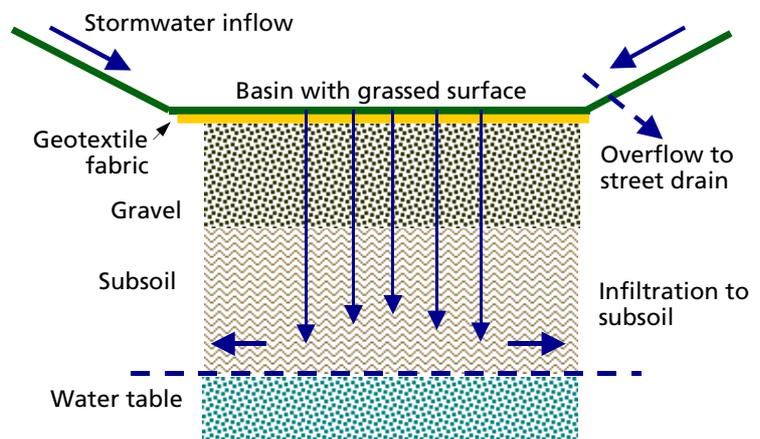


Fig 4: Design for an infiltration basin

Infiltration 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).

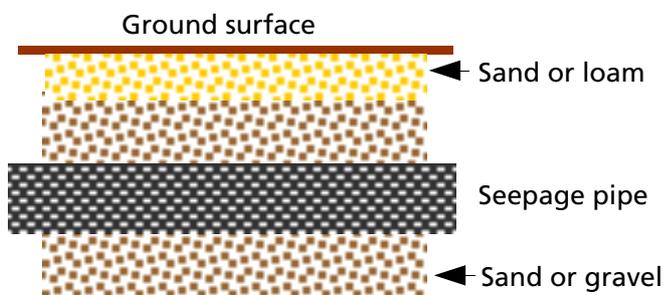


Fig. 5: Design for a seepage pipe

Design issues

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

Unsuitable soils

Infiltration devices should not be installed in:

- 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.

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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 hazard 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. In order to satisfy this design criteria 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.

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.

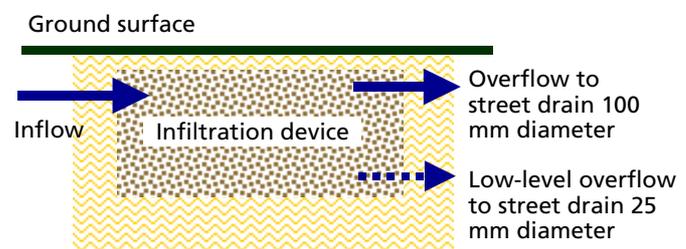


Fig 6: Low-level overflow for clay soils

Costs

The cost to install a retention trench can vary considerably. However, an indicative cost is about \$80 per cubic metre. This includes gravel and backfilling (\$30 per cubic 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 Newcastle:
www.eng.newcastle.edu.au/~cegak/Coombes

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

Product Suppliers

Seepage pipes: HydroCon, tel. 0411 644 463

Infiltration cells: Atlantis, tel. 02 9419 6710

Geotextile fabric, slotted pipes and plumbing fittings: Saddingtons, tel. 02 4969 6222

Gravel: Rock-Inn, tel. 02 4968 2541

References

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