Practice Note #3

INFILTRATION DEVICES

Water Smart design is the effective planning, design and building of homes, subdivisions, suburbs, towns and cities that are sensitive to the ecological needs of the waterways that are impacted by them.

Water Smart developments aim to mimic natural processes which reconnect neighbourhoods with local waterways and improve visual amenity and quality of life, make better use of all water within our urban areas, seek to protect the ecological health of urban waterways from the potential negative impacts of urban development, and to add value to our water and waterway management activities.

Each Practice Note in this series is designed to give greater detail and specific advice on different aspects of Water Smart developments and devices. The Practice Notes provide reviews of the main design features, advice on installation and maintenance issues, include diagrams and pictures to assist with implementation, and reference useful websites to assist with further research into Water Smart developments.

This Practice Note provides general guidance on how to design and construct various types of stormwater infiltration devices for smaller scale developments.

STORMWATER SYSTEM OVERVIEW

There is growing interest in infiltration as an alternative or supplement to constructed drainage systems, due to the potential for achieving many environmental and economic benefits including: reduced peak stormwater flows, reduced downstream flooding, reduced stormwater drainage costs, improved groundwater recharge and improved stormwater quality.

Traditional stormwater constructed drainage systems are highly effective for removing stormwater efficiently from a site, however they can also contribute to local flooding risks, increase in erosion and sedimentation, and decreased water quality 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 infiltration capacity.

Modern infiltration devices are much more efficient than their traditional counterparts. They are constructed to minimise clogging, and designed to overflow to landscaped areas for temporary detention, or to the street drainage system. An example of an infiltration basin combined with an above-ground detention is shown in **Figure 1.**

Infiltration devices also manage pollutants through adsorption, filtering and bacteria decomposition. If correctly designed, an infiltration device can remove approximately 90% of sediment, 60% of phosphorus and 60% of nitrogen from stormwater. Research by various Universities determined that infiltration is a practical mechanism to manage stormwater, when designed to compliment site conditions (such as slope and soil conditions).

Urban detention and infiltration basin under normal conditions.

The same basin during heavy rain.

Figure 1: Figtree Place integrated stormwater drainage design, Newcastle

INFILTRATION DEVICES

An infiltration device collects the rain that falls on site, stores it temporarily and then releases it slowly into the ground. There are three parts of an infiltration system which are illustrated in **Figure 2** and described below:

1. *Site drainage system* – including roof gutters, downpipes, paths and driveways, all of which collect and deliver stormwater to the infiltration device
2. *Treatment train* – a set of devices used to pre-treat stormwater prior to it entering the infiltration device. Treatment trains typically include directing water flows into pollutant/sediment traps, across vegetated areas and/or through porous pavements. A treatment train needs to consider the various pollutant types that are likely to be encountered. Table 1 outlines the pollutant types and methods to manage and treat the water. More information on treatment trains is available in Practice Note 1 – Water Smart Developments.
3. *Infiltration and retention devices* – which act to store and slowly release water to the soils. Typical systems used in small scale developments are leaky wells, retention trenches and infiltration basins.

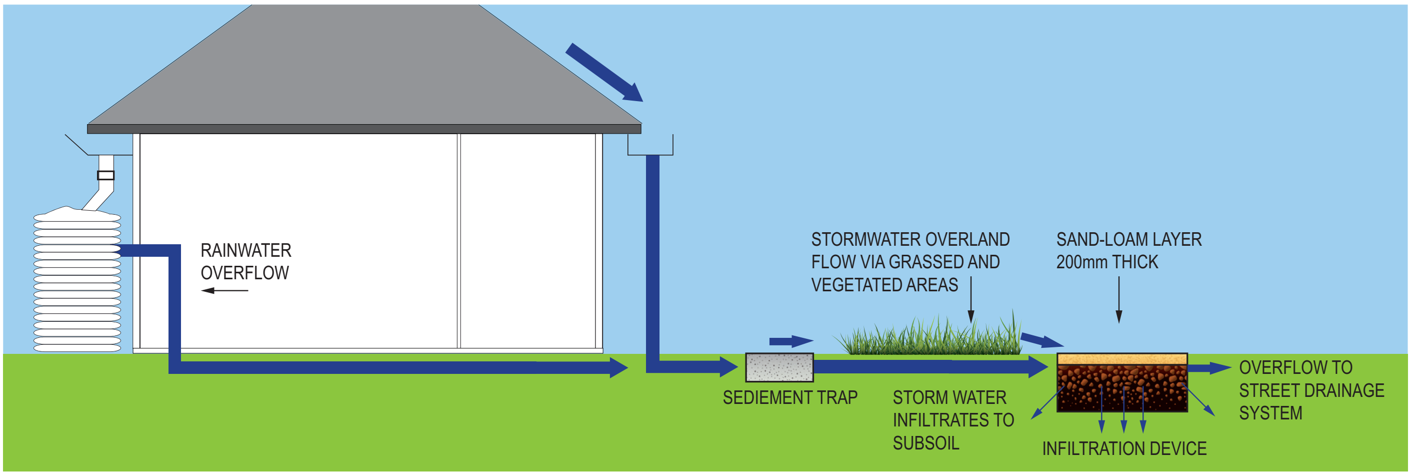

Figure 2: A Typical infiltration strategy

TYPES OF POLLUTANTS	ROOFWATER		STORMWATER		PROTECTION ENHANCEMENTS
	SYSTEM PROTECTION	ENVIRONMENTAL PROTECTION	SYSTEM PROTECTION	ENVIRONMENTAL PROTECTION	
GROSS (LARGE)	✔	✔	✔	✔	Leaf guards First flush device Leaf screen
SUSPENDED MATTER	-	-	✔	✔	Sediment trap Contour banks Vegetation
SOLUBLE (DISSOLVED)	-	-	-	As required	Grass swales Raingardens & biofiltration Wetlands

Table 1: Types of pollutants and mechanisms to protect infiltration devices.

INFILTRATION DEVICE OPTIONS

Leaky wells

Leaky wells store stormwater until it can percolate into the surrounding soils. 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 whilst an over-flow pipe directs excess stormwater to the drainage connection point. Holes in the walls and bottom of the well are covered with geo-textile fabric to filter stormwater as it percolates through, and into the surrounding soil (see **Figure 3**).

Leaky wells are easily maintained as the well can be accessed and any debris and sediment can be easily removed, reducing clogging and failure issues.

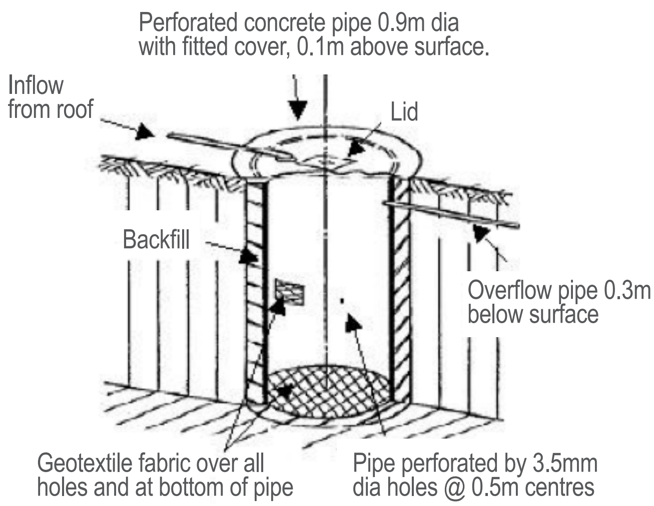

Table 1: Types of pollutants and mechanisms to protect infiltration devices. (Source: Engineers Australia 2006).

Retention Trenches

A retention trench consists of a trench lined with geo-textile fabric and filled with coarse gravel. Stormwater is conveyed to the trench via an inflow pipe after passing through a sediment trap (alternatively stormwater could enter the trench after passing through porous pavement). A perforated distribution pipe allows stormwater to percolate to the surrounding soil (unnecessary if sandy, well drained soils are present). An over-flow pipe can be used to direct excess flow to the street drainage system or designated overflow point. This system is illustrated in **Figures 4 and 5.**

The use of a sediment trap or porous pavement reduces the risk of clogging from sediment, leaves and debris, whilst the geo-textile fabric filters the stormwater as it percolates from the trench to the surrounding soil.

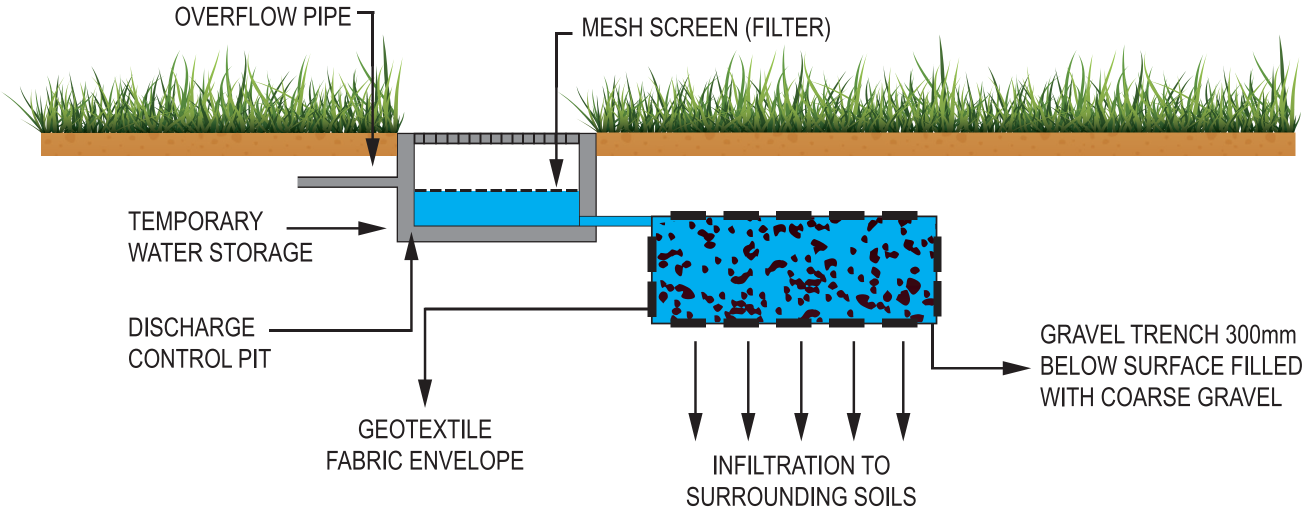

Figure 4: Concept design for a retention trench

Figure 5: Construction of an infiltration trench at Stringy Bark Creek, Victoria. Source: Melbourne Water (2010)

Infiltration basins

An infiltration basin generally collects stormwater from larger areas and then it treats and releases water to the surrounding soil. Infiltration basins reduce high-flow stormwater discharge volumes to downstream catchments and improve the quality of stormwater discharged to the receiving environment by capturing and retaining stormwater and allow sediment and other contaminants to settle and filter from the water prior to it being released to the surrounding environment.

An infiltration basin is typically installed as a geo-textile lined depression in a grassed area (size sufficient to deal with expected stormwater volumes). A 200 to 300 mm layer of topsoil is usually placed between the gravel layer and the grassed surface (see **Figure 6**).

Infiltration basins are suitable for use in larger lots where their design is integrated with other landscape measures (see Practice Note No. 7 – vegetated drainage devices).

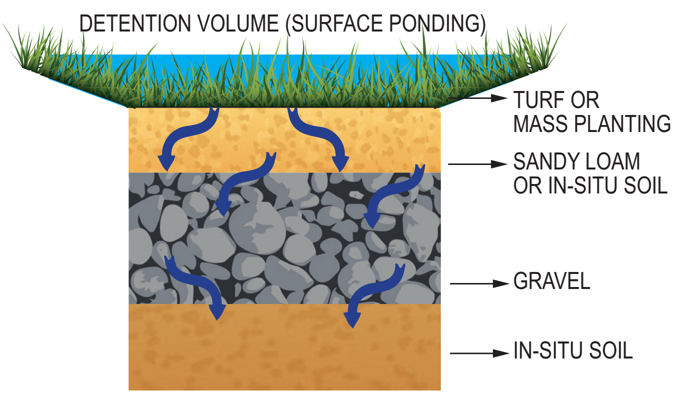

Figure 6: Profile of an infiltration basin (adapted from Water by Design, 2006)

MATERIALS USED IN INFILTRATION DEVICES

Void Materials

Infiltration devices operate by creating voids, which allow water to enter and be stored until it is discharged through pipes or overflow points. Common materials used to create the voids which also provide structural substance to the devices are: gravel; crushed concrete; sand; infiltration cells (similar to milk crates); tyres (filled with gravel); and commercially available products (such as Enviromedia which is a mix of sand, gravel and organic matter).

Sand, gravel, crushed concrete, infiltration cells and tyres, are inert (non reactive or contaminating) and operate as a filtration system for particulate-bound matter. Enviromedia is a reactive media that removes both particulate and soluble materials.

Table 2 provides a general indication of the performance of each material relative to its water storage capacity, weight bearing capacity, pollutant removal ability, and typical proportion of recycled materials to assist in determining which material is suitable for your development.

	VOID SPACE (maximise storage of water)	WEIGHT SUPPORT (if a structure is to be located above or near the device)	POLLUTANT REMOVAL ABILITY (if water quality is an issue)	RECYCLED MATERIAL (adopting sustainable ap-proach)
HIGH PERFORMANCE	Infiltration cells	Gravel / crushed concrete	Enviromedia	Tyres / crushed concrete
↓	Tyres	Sand	Sand	Infiltration cells / enviromedia
↓	Gravel / crushed concretet	Enviromedia	Gravel / crushed concretet	Gravel
↓	Enviromedia	Tyres	Tyres / infiltration cells	Sand
LOW PERFORMANCE	Sand	Infiltration cells		

Table 2: properties of void materials

Geotextile fabric

Geotextile is a synthetic engineered fabric used in in-line infiltration devices to filter water percolating into the surrounding soil and to prevent erosion during the construction phase.

Seepage or agricultural pipes

A seepage pipe, or subsurface drain, operates in a similar fashion to a retention trench, but is a pipe with holes or slots that allow water to filter into the surrounding soils. Seepage pipes are typically surrounded by sand or gravel in a trench and covered with sand or loam to a thickness of 300 mm and generally do not require a filter sock. **Figure 7** below shows a conceptual design for the use of agricultural pipes..

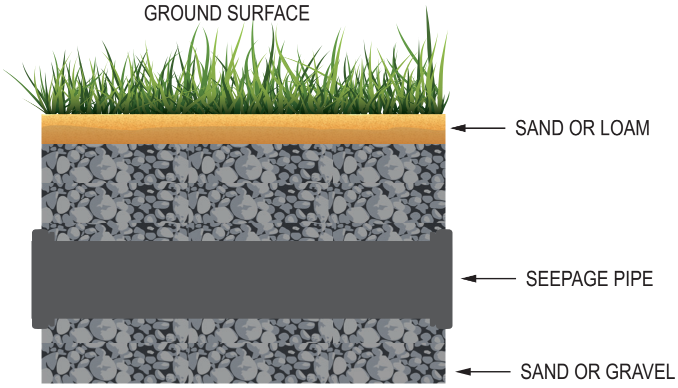

Figure 7: Seepage pipe with installation

INFILTRATION SYSTEM DESIGN

When designing infiltration devices it is important to consider the site features, particularly the slope, soil type and groundwater conditions. Infiltration is appropriate in many situations, however there are some circumstances where it is not feasible. Water Smart Practice Note 1, together with information below provides details on site assessment and key design features which will greatly assist installing an appropriate infiltration device.

Clearance from buildings

Soils can shrink or swell depending on the clay and moisture content. Ensure infiltration devices consider the minimum separation distances to reduce the risk of damaging buildings (through impact on foundations) and infrastructure due to soil movement related to moisture retention. **Table 3** provides a guide to minimum separation distances to buildings, please check with your local council for specific or local requirements.

SOIL TYPE	HYDRAULIC CONDUCTIVITY	RECOMMENDED MINIMUM BUILDING 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

**Note: the minimum clearance requirements should be verified with individual Local Councils*

*** Some Councils do not permit infiltration in reactive or heavy clays areas due to shrink/swell issues. Seek the advice of a qualified engineer.*

Unsuitable ground conditions

Infiltration devices should not be installed in:

- saline, sodic (high in sodium) or very shallow soils
- wind blown or loose sands
- clay soils that collapse in contact with water or have high shrink/swell characteristics
- soils with a hydraulic conductivity of less than 0.36 mm/hr

For larger developments (> 1 lot) soil assessment and permeability testing must be undertaken by a qualified technician. For single dwellings a simple soil assessment and classification is adequate in order to determine the soil type and characteristics. For further information discuss with a your builder or plumber.

Rock and shale

Infiltration devices should not be placed in rock that has little or no permeability i.e. does not allow the passage of water. Severely weathered or fractured rocks, such as sandstone, may be suitable, but field testing is recommended to ensure the device will function as intended.

Slope

Installation of infiltration devices on slopes greater than 5% is not recommended unless a detailed engineering analysis is undertaken at the design stage that ensures the device will accept and detain stormwater runoff adequately.

Water Tables

The use of infiltration devices in areas with high or fluctuating water tables is not recommended as the presence of a high water table can limit the potential effectiveness of infiltration devices. For areas where the water table <1m from the surface then a suitably qualified technician should be consulted. e.g. builder, landscape architect or an engineer. Infiltration devices are not recommended for use in areas where the water table is likely to rise due to Climate change and Sea level rise. Examples where this may be an issue is; low lying flood prone lands, foreshores of estuaries and coastal lagoons and Lakes, or if groundwater salinity is an issue. Refer to Practice Note 8 for further advice on Groundwater and infiltration.

Sediment & pre treatment

Adequate filter and pre-treatment systems are required to limit the amount of sediment that reaches any infiltration devices in order to avoid clogging and failure of the device. Management of sediment is imperative during the construction phase, but also sediment is an issue during the life of the device. Sediment is commonly generated from paths, roads and soils areas but it can also come from roof areas where in some situations approximately 2kg of sediment can be generated per 100 square metres of roof each year.

Sizing infiltration devices

Many local councils require infiltration devices to be designed with sufficient capacity to store the inflow for a one-in-three month Average Recurrence Interval (ARI) storm (see definition under Useful Websites), and with an emptying time of less than 24 hours.

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, or
- 3.8 cubic metres in a sandy-clay soil, or
- 4.5 cubic metres in a medium clay soil

In clay soils a low-level overflow pipe may need to be installed to ensure an emptying time of 24 hours (see ***Figure 8***).

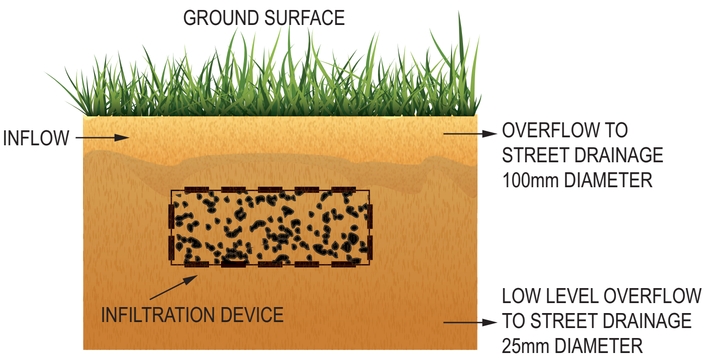

Figure 8: Infiltration with a low-level overflow for clay soils.

INFILTRATION SYSTEM MAINTENANCE

Maintenance of infiltration systems is required with the aim to:

- Ensure the system does not clog with sediments
- Maintain an appropriate infiltration rate
- Ensure pre-treatment measures are functioning adequately

Most infiltration devices utilise pre-treatment to screen and capture large matter such as coarse sediment and gross pollutants. These measures such as upstream pits and screens/filters require regular monitoring and removal of sediment - this should be undertaken yearly. If adequate maintenance is not undertaken then the infiltration device is likely to fail – see an example in **Figure 9** showing accumulation of litter and debris that requires removal.

Excessive ponding and standing water may indicate a reduced infiltration rate. Generally infiltration measures, with adequate performing pre treatment, will require the surface layer of filter media to be replaced each 5-10 years (see **Figure 10).**

Figure 9 – accumulated sediment and rubbish requiring removal (source: Storm Consulting)

Figure 10: Large infiltration trench construction. (Source: Temple Villanove Sustainable Stormwater Initiative).

EXAMPLE ONE: MURRAY BEACH

Small infiltration basins on each house lot are used as part of the overall Water Smart approach for the Murrays Beach Estate in Lake Macquarie local government area (see ***Figure 11***). These devices, together with rain water tanks, help to manage stormwater at a lot-scale which achieves the overall aim of reducing runoff to the streetscape. This results in reduced infrastructure in the streetscape and improved quality of water quality entering Lake Macquarie.

The basins are designed to capture stormwater runoff from roof and hard surfaces such as paving, driveways and also rain tank overflows. This allows the majority of the smaller but more frequent rainfall events to be infiltrated to the surrounding soil, whilst overflows from larger storm events are directed to the street drainage. Water Smart Measures such as these basins require some maintenance to be undertaken by the home owners. Short term tasks include: routine inspection for sediment and debris build-up in inlet and out let pipes, and removal of weeds. Periodic work may comprise removal of sediment from the basin.

This Water Smart measure helps to restore the natural water cycle by reducing storm water runoff from each lot and by re-establishing the surface - groundwater connection which can be lost through development and urbanisation.

Figure 11: Left: Infiltration basin located in the front yard. Right: overflow pit with grate and inflow pipe (source: HCCREMS)

EXAMPLE TWO: NOBBY'S BEACH SAND FILTER AND INFILTRATION

The Nobbys Beach sand filter is situated on a sandy peninsula in Newcastle which exhibits high permeability. The infiltration device receives runoff from a neighbouring car park and roadway. The aim of the device is to treat contaminated stormwater runoff generated from road and car parking areas. Pictures of the catchment and device are shown in ***Figure 12***.

Figure 12: (Left) Nobby's Beach car-park (source: HCCREMS)
Figure 13: (Right) Nobby's Beach sand filter (source: HCCREMS)

Crucial to the functioning of the infiltration system is an appropriate selected treatment-train which comprises:

- coarse screening at inlet drainage pits (located along the roadway and car park (see ***Figure 14***)
- flow speed reduction and settling of heavy particles within the detention component which consists of course sand (see ***Figure 13***)
- further filtration through a series of detention bays (see rock work in ***Figure 13***)
- constructed sand filter (background in ***Figure 13***) and absorption bed which overlies the in-situ marine sands

Maintenance of the various components of the treatment train is vital to ensure correct pre-treatment of the stormwater which will prolong the life of the sand filter and ensure the design filtration rate is maintained. Street sweeping is undertaken weekly which reduces the debris and sediment at the pit entrances (see ***Figure 14***). The sediment traps are regularly cleaned to ensure sufficient capacity is available for subsequent storm events.

Figure 14: stormwater pits draining to sand filter with specially fabricated screens (source: urbanwatersite.info)

USEFUL WEBSITES & GUIDES

Simple and concise explanation of WSUD and infiltration – go to Treatment Measures in following Melbourne Water website link: http://wsud.melbournewater.com.au/

WSUD Technical Guide for Western Sydney— Infiltration investigation, design and maintenance: www.wsud.org/tools-resources/

Technical Design Guidelines for South East Queensland—Chapter 7 Infiltration. Go to Guidelines and Resources: www.waterbydesign.com.au/

Technical information: National Guidelines for Evaluating Water Sensitive Urban Design— Appendices: http://www.environment.gov.au/water/publications/urban/water-sensitive-design-national-guide.html

Raingarden and Infiltration Trench construction: Little Stringy Bark Creek – keeping Stormwater in the Catchment. Source – Melbourne Water. http://www.youtube.com/watch?v=AYJNcky_4fw

Nobbys Beach Sand filter—project and design information: http://www.urbanwatersites.info/

Murrays Beach infiltration devices — project and design information: http://www.urbanwatersites.info/

Murrays Beach Estate by Stockland www.stockland.com.au/home-and-land/nsw/murrays-beach.htm

Bureau of Meteorology www.bom.gov.au ARI is defined as: "The average, or expected, value of the periods between exceedances of a given rainfall total accumulated over a given duration." It is implicit in this definition that the periods between exceedances are generally random.

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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)

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