

1. *General SuDS guidance*

This guidance is a brief over-view of best practice design and construction practice for stormwater drainage.

The contents of the brief report are:

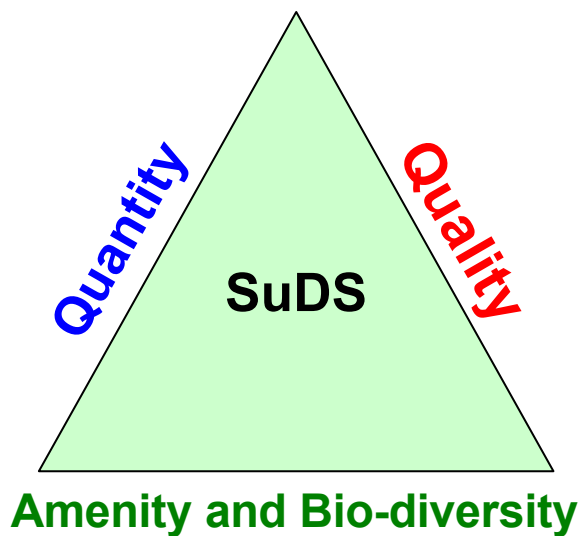
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1.1 GENERAL

The general principle behind the use of SuDS for any site is to comply with the following:

- runoff volumes should be minimised
- runoff rates should be minimised
- the stormwater effluent is treated appropriately before discharge from the site bearing in mind the requirements of the receiving watercourse
- groundwater must be protected

in addition it is desirable to maximise the amenity potential and ecological benefits where there is an opportunity to provide this.



The SuDS triangle – reducing the impact of urban drainage on the environment

The various SuDS components should not be treated as individual options, but should be seen as providing a set of drainage features which are appropriate at various scales. It is always desirable to have a mix of SuDS components to take opportunity of their respective benefits than to have a single component at the bottom of the site.

SuDS techniques - their hydraulic, water quality and amenity capabilities

SuDS Technique	Key to symbols: ⊗ Primary process × Secondary process SuDS Description	Hydraulic Performance				Water Quality Treatment								Amenity Benefits		
		Conveyance	Attenuation	Infiltration	Water Harvesting	Sedimentation	Filtration	Adsorption	Biodegradation	Volatilisation	Precipitation	Uptake by plants	Nitrification	Aesthetics	Amenity	Ecology
Rainwater harvesting (Water butts etc)	Storage for irrigation or domestic use (toilets etc).		×		⊗									×		
Pervious pavements	Car parks (and potentially minor roads) and other paved surfaces which provide storage of rainwater in the underlying construction.		⊗	⊗	×		⊗	⊗	⊗				×	×		
Filter trenches	Linear drains/trenches filled with a granular material, often with a perforated pipe in the base of the trench.	⊗	⊗	×			⊗	⊗	⊗				×			
Filter strips	Vegetated strips of gently sloping ground designed to drain water using sheet flow from roads and parking areas.	×	×	×			⊗	⊗	⊗		×		×	×		
Swales	Shallow vegetated channels that conduct and infiltrate runoff. The vegetation filters sediments.	⊗	⊗	×			⊗	⊗	⊗		×		×	×		
Ponds	Areas of permanent water used for storing and treating runoff. They are also used to attenuate runoff. They have a permanent pool and usually some aquatic vegetation.	×	⊗		×		⊗	⊗	⊗				⊗	×	⊗	
Wetlands	Similar to ponds, but the runoff flows slowly and preferably continuously through aquatic vegetation. They tend to be less suited to use as attenuation structures, depending on the types of plants used.	×	⊗				⊗	⊗	⊗				⊗	×	⊗	
Detention basin	Vegetated depressions designed to store water to meet specific attenuation requirements.		⊗	×							×			×	×	
Soakaways	Sub-surface structures that infiltrate runoff.		×	⊗												
Infiltration trenches	As soakaways, but provided as a trench.		×	⊗												

SuDS Technique	SuDS Description	Hydraulic Performance				Water Quality Treatment				Amenity Benefits						
		Conveyance	Attenuation	Infiltration	Water Harvesting	Sedimentation	Filtration	Adsorption	Biodegradation	Volatilisation	Precipitation	Uptake by plants	Nitrification	Aesthetics	Amenity	Ecology
Infiltration basins	Depressions that store and dispose of water via infiltration.		⊗											×	⊗	×
Green roofs	Vegetated roofs that reduce the volume and rate of runoff and remove pollution.		×					⊗	⊗		⊗	⊗		×	⊗	×
Bioretention areas	Vegetated areas similar to swales, but with emphasis on a variety of vegetation including the use of wetland plants. Greater emphasis on treatment.		⊗	⊗				⊗	⊗	⊗	⊗	⊗		×	⊗	×
Underground storage	Attenuation tanks to reduce stormwater runoff rate		⊗		×											
Proprietary drainage units	Range of units: screens, proprietary sedimentation units etc															
Pipes and manholes	Conduits and their accessories normally underground as conveyance measures.															⊗

1.2 SUMMARY OF SUDS BENEFITS


The following table provides an overview of the various advantages and disadvantages of all SuDS components.

Summary of performance characteristics for SuDS components

Priority	Hydraulic benefits - small events	Hydraulic benefits - large events	Water Quality Benefits	Amenity Benefits	Ecological Benefits	Land Take	Land Availability	Construction & Operation
Water butt	Useful	Poor	N/A	Useful	Poor	Best	Best	Useful
Pervious pavement	Best	Best	Best	Useful	Poor	Best	Best	Useful
Filter trench	Useful	Useful	Useful	Poor	Poor	Useful	Useful	Useful
Filter strip	Useful	Poor	Useful	Useful	Useful	Poor	Poor	Useful
Swales	Best	Useful	Best	Useful	Useful	Poor	Useful	Useful
Ponds	Useful	Useful	Useful	Best	Best	Useful	Poor	Best
Linear ponds	Useful	Useful	Useful	Best	Useful	Useful	Useful	Best
Wetlands	Best	Useful	Best	Useful	Best	Poor	Poor	Useful
Detention basins	Best	Best	Useful	Useful	Useful	Useful	Useful	Best
Soakaways	Useful	Useful	N/A	Poor	Poor	Best	Best	Useful
Infiltration trenches	Best	Best	N/A	Poor	Poor	Best	Best	Useful
Infiltration basins	Best	Useful	N/A	Useful	Useful	Poor	Poor	Poor
Green roofs	Useful	Poor	Best	Useful	Useful	Best	Best	Useful
Rainfall harvesting*	Best	Best	Best	Poor	Poor	Best	Best	Best
Bio-retention	Best	Useful	Best	Best	Useful	Poor	Useful	Useful

* with enhanced storage

Key:

	Poor
	Useful
	Best






Water quality benefits are not included for infiltration units as they are not part of the surface runoff system. It is presumed that they are only used where the potential for groundwater pollution is minimal.

1.3 THE USE OF INFILTRATION

In general infiltration should be utilised wherever possible, even in marginal situations (where infiltration rates are low). However care needs to be taken with regards to two aspects: the first is that consideration of ground saturation and related problems, while the second is ensuring that infiltration does not pollute the groundwater or mobilise contaminated material. The following figure illustrates how SuDS might be used to cater for various situations where there is a risk of groundwater pollution.

Catchment Groundwater status		Roof drainage	Residential area, amenity area	Small car park	Large car park	Lorry park, garage forecourt - outside canopy	Major road	Industrial site, major commercial site	Surface water sewer
		Non-aquifer (infiltration possible to soil)				□	□	□	□
Other areas of aquifer outcrop	Deep water table			□	□	□	□	□	□
	Shallow water table			□	□	□	□	□	□
Groundwater protection zone II, outer zone	Deep water table			□	□				
	Shallow water table			□	□				
Groundwater protection zone I, inner zone									

Key

-  Shallow infiltration to the soil zone, discharge to a soakaway or discharge to a borehole soakaway may be acceptable
-  Shallow infiltration to the soil zone or discharge to a conventional soakaway may be acceptable
-  Shallow infiltration to the soil zone only may be acceptable
-  No discharge to the ground; runoff must be conveyed to a more suitable area or discharged to a surface water body after treatment
-  Treatment required before infiltration; this will be discussed at the planning stage, but as a guide the length of the bar shows where more treatment will probably be necessary

1.4 DESIGN OF SUDS

The following section summarises the key issues for the various SuDS components that need to be considered when designing SuDS schemes.

1.4.1 Ponds

Ponds are bodies of largely open water into which stormwater runoff is passed for treatment and attenuation. There are two categories and these are referred to as Detention ponds and Retention ponds, the difference being the duration that runoff is retained in the pond, which is largely a function of the volume of the permanent pool.

Ponds have a number of good drainage characteristics. These are summarised in the following table. However it should be noted that safety issues are very important to consider when designing these structures.

Pond characteristics

Performance	Hydraulic benefits - small events	Hydraulic benefits - large events	Water Quality Benefits	Amenity Benefits	Ecological Benefits	Land take	Safety Issues
High							
Medium							
Low							
None							

Pond sizing

A Detention pond is a wet pond where runoff is retained for some days to allow settlement and biological treatment of some pollutants, as well as providing attenuation of the stormwater flows. The permanent pond volume is based on an effective rainfall depth of around 15mm. Retention ponds can have permanent pool sizes up to 60mm. These are provided where a higher level of water quality treatment provision is needed and where there is a perceived enhanced risk of accidental spillage of pollutants in the catchment.

Pond side slopes, berms and depth

Side slopes are kept shallow for a number of reasons. These are:

1. Safety;
2. aesthetic; and
3. maintenance reasons.

Safety - It is important to provide shallow slopes to prevent slipping and to make it easy to get out of the pond. Slopes should always be less than 1:3 gradient, but should preferably be relatively flat at the water's edge. A relatively flat berm with a minimum width of 1m should be provided for the first metre into the pond and the subsequent slope into deeper water should be gradually increased. A high

density planting barrier around the edge of the pond, both on the bank and in the water, is normally provided to deter people from access into the water. However this should not be so impenetrable so as to prevent assistance being given when needed.

Aesthetics – Irregular and shallow banked areas are very much better from an aesthetic aspect. Ponds are very much a focal feature of a development and detailed consideration of the visual effect of a pond is very important. It should be noted that aesthetics can dictate the size of a pond, as areas of the pond which are shallower than 1m in depth will eventually be covered in vegetation (subject to maintenance activities). As open water is very important aesthetically, it is desirable to have a large proportion of the pond with depths which are in the range of 1 to 2m.

Maintenance – The slopes around a pond will affect the type of equipment that can be used for cutting grass and other regular management activities.

Hydraulic performance (small and large events)

Ponds provide very little volume reduction, but some losses through infiltration and evaporation will take place, unless specific design is made to encourage infiltration around the edge of the pond. However their main hydraulic benefit is their facility for limiting discharge flow rates. This advantage applies to all sizes of event. For small catchments, where permitted, outflow structures may need to be based on the principle of a riser pipe with a limited number of small perforations. Great care is needed to provide protection against blockage from floating debris and algae.

Hydraulic design

The hydraulic design of a pond outlet needs to consider the head-discharge relationship including any downstream backwater effects where the receiving water level can rise sufficiently to affect the outflow rate.

Ground water levels (in winter) need to be established to determine the depth to which ponds or basins can be excavated, or choosing the permanent pool water level. Groundwater should be at least 1m below the base of the pond unless it is lined.

The use of a liner should be considered where water levels need to be maintained or there is a perceived risk to groundwater.

Water quality treatment

The water quality treatment efficiency of ponds is high assuming they are well designed to prevent short-circuiting. Long narrow ponds or ponds in series provide better water quality, more wildlife diversity and higher levels of attenuation than a single pond of the same volume.

Amenity (social and ecology)

Amenity value of ponds is high for well designed ponds, both aesthetically as well as providing good ecological benefits. Safety issues must be addressed by good design and education using information boards. Appropriate safety equipment should be provided.

Land take and availability

The land take of ponds is significant. They require large areas of public open space, in the region of 5% of the area of development. In addition, they may be required to be located some distance from any property for reasons of safety. However, ponds placed close to properties and in view of residents are safer than ponds that are not overlooked. As ponds are normally located at the downstream end of the drainage system, there is a need to ensure that large areas of public open space are suitably located.

Designing for maintenance

The design of the pond should specifically cater for future maintenance requirements. All year round access around the whole pond needs to be provided for the type of equipment which will be needed for its maintenance.

An area adjacent to the pond should specifically be provided for temporary storage to allow the excavated vegetation to drain back to the pond and for fauna to return to the water.

Multiple ponds in series are preferable to a single large pond for maintenance reasons as the need for specialist (large) equipment / plant required for maintenance is avoided.

Design issues requiring resolution of potential conflicting requirements

There are a number of issues where there are potentially contradictory requirements and compromises need to be arrived at. The following table draws attention to these issues.

Summary of safety, amenity and environmental factors and issues requiring compromise in design

Pond Design	Aesthetics	Safety	Environment	Hydraulic	Water Quality
Location	Close-enhances property values	Distant	Near “natural” rural land	Backwater effects if close to river	-
Depth	Greater than 1m to maintain open water	Minimise depth	Extensive shallow zone with variations	-	Stratification, thermal warming
Vegetation	Variety	Barrier planting	Natural local plants	Increased risk of blockage and reduction in volume	Enhanced treatment
Fences	Undesirable	Desirable	Undesirable	-	-
Signs	Negative effects of safety signs	Essential	Educational	-	-
Slopes	Gentle	Gentle	As flat as possible at normal depth margin	Steep and deep to minimise land use	Shallow for improved treatment
Maintenance/ Management	Regular	Regular	Minimal	Regular	Infrequent
Safety equipment	Negative impacts	Essential	-	-	-

significant potential contradictory requirements

minor contradictory requirements

no contradictory requirements

1.4.2 Detention Basins

Detention basins are dry depressions, normally grassed, aimed primarily at providing attenuation storage, but they also provide reasonable treatment of stormwater runoff. Their advantages over detention ponds are:

- they have higher volume loss due to infiltration;
- they require smaller areas to provide equivalent attenuation benefits to stormwater runoff; and
- they may be considered to be slightly less of a health and safety risk.

Detention basin characteristics

Performance	Hydraulic benefits - small events	Hydraulic benefits - large events	Water Quality Benefits	Amenity Benefits	Ecological Benefits	Land Take	Safety Issues
High							
Medium							
Low							
None							

Hydraulic performance (small and large events)

The maximum depth of attenuation storage is usually greater and initial runoff losses are higher compared to ponds. This means that there is a significant proportion of stormwater runoff reduction for small rainfall events.

Hydraulic design

The hydraulic design of a basin outlet needs to consider the head-discharge relationship including any downstream backwater effects where the receiving water level can rise sufficiently to affect the outflow rate.

Ground water levels (in winter) need to be established to determine the depth to which a basin can be excavated. Groundwater should be at least 1m below the base of the basin unless it is lined.

The use of a liner might be considered where there is a perceived risk to groundwater, but the consequences of not allowing the basin to dry out will result in saturated conditions to prevail with consequences for both maintenance and vegetation characteristics.

Water quality treatment

The water quality of the stormwater is generally not as good as for ponds, but it is generally quite effective, subject to shape. A problem particular to basins is the difficulty of avoiding sediment deposits being re-mobilised and washed out, possibly causing a pollution incident.

Amenity (social and ecology)

The amenity value of basins is not as high as ponds, though they still provide pleasant green open spaces if designed well. However, the debris left in the bottom of the basin tends to be unsightly,

making their use more suited to less visible locations. Vegetation growth tends to look unattractive unless well managed.

Ecological benefits are provided, although these are generally less than for wetlands and ponds.

Land take and availability

The land take of basins is relatively small compared to ponds and wetlands. Because they can be effective in smaller areas, they can be located around a site.

Designing for maintenance

The design of a basin should specifically cater for future maintenance requirements. All year round access around the whole basin and into it needs to be provided for the type of equipment which will be needed for its maintenance.

1.4.3 Pervious pavements

Pervious pavements are now becoming common-place in Ireland. They are frequently used for car parks or pedestrianised areas and private driveways. They are not normally used for roads, though they are used for cul-de-sac's. They function by allowing rainfall to pass between the blocks (or through pervious asphalt) into the sub-base for temporary storage, and infiltration where ground conditions allow. The blocks themselves are not permeable.

Pervious pavement characteristics

Priority	Hydraulic benefits - small events	Hydraulic benefits - large events	Water Quality Benefits	Amenity Benefits	Ecological Benefits	Land Take	Safety Issues
High							
Medium							
Low							
None							

Pervious pavements are often constructed using coloured concrete blocks to enhance or add value to the paved area (such as delineation of car parking bays).

The sub-base normally comprises granular material of specific size grading, but plastic high voids plastic media is used sometimes due to storage volume efficiency gains. The depth of construction is designed to provide structural support as well as provide surface water storage. The granular fill is normally around 350mm deep, although depths can be designed to be more or less than this value.

Hydraulic performance (small and large events)

Pervious pavements have good hydraulic properties with high levels of attenuation when granular fill is used. Runoff volume reduction is very high for small events in dry periods though not particularly good for large events and in very wet periods. Due to the high volume of storage provided, pervious pavements are sometimes used to store and attenuate adjacent roof runoff.

Hydraulic design

Throttles with very small apertures can be used as the risk of blockage is small. Granular fill normally provides a voids ratio of around 0.33. Plastic units offer in the region of 95% voids and therefore provide larger storage volumes for any given area.

The Building Regulations Part H requires infiltration systems to be located 5m from any foundations. However pervious pavements that are serving private car parking areas can be located close to the buildings as they are acting in the same way as if the area had been grassed. If the pervious pavement is receiving additional runoff from roof areas then a lined section for the first metre away from the foundations may be required.

Water quality treatment

Water quality from pervious pavements is normally very good with minimal sediment load, and low pollutant concentrations especially if a geotextile is used below the bedding layer for the blocks. Water quality treatment is not significant for plastic high voids units.

Amenity (social and ecology)

Amenity value is limited, but its use is generally not unattractive, especially if coloured blocks are used. Vegetation can be incorporated with appropriate design, as the pervious surface allows the runoff to be passed to, and support, the plants.

Land take and availability

As car parking and other hardstandings are essential elements of developments, there is usually no need for additional land to be made available. It is flexible in being able to be used for small or large areas.

Designing for maintenance

The design of pervious pavements should specifically cater for future maintenance requirements. There is some concern over their design lives and therefore designs should take a precautionary approach to maximised performance and ease of maintenance if it is found to be needed.

1.4.4 Swales

Swales are vegetated shallow depressions normally located beside roads. Their purpose is to both convey and treat runoff.

Swale characteristics

Performance	Hydraulic benefits - small events	Hydraulic benefits - large events	Water Quality Benefits	Amenity Benefits	Ecological Benefits	Land Take	Safety Issues
High							
Medium							
Low							
None							

The term “swale” covers a range of different drainage designs, though they all have in common the dual features of storage and conveyance. Briefly these are:

The standard or conveyance swale - is a shallow vegetated channel of around 400mm deep, up to 5m wide at ground level and 1m wide across the base. This receives sheet flow off roads and hardstandings and conveys it to a point where it is discharged into a pipe network or other structure. The length of the swale is limited primarily by its conveyance capacity and characteristics, as erosion of the base needs to be avoided.

The mini-swale - is similar to the standard swale, but much smaller, around one metre wide, 100mm deep and usually built in short lengths. It receives runoff and stores the first few millimetres of runoff for infiltration, but once it is full, any additional water is discharged into the primary drainage system through an inlet of some kind.

The storage or under-drained swale - is similar in size to a standard swale but, instead of having an outfall, it is served by a small perforated pipe located immediately below the swale with the bed of the swale specifically designed to be fairly porous. This design provides good storage of runoff and allows percolation of flow into the pipe and the adjacent ground.

Hydraulic performance (small and large events)

The hydraulic performance of all the swales is good for small events, but only the under-drained swale is likely to be effective in providing good attenuation and volume reduction for large events.

Hydraulic design

Swales do not normally need designing for conveyance capacity. Their ability to store water depends on their catchment area, gradient and any outlet restriction. They are not used to serve large drainage areas.

Under-drained swales are most suitable for dense urban areas as conveyance difficulties of passing water under roads and driveways are avoided. Small connecting pipework is highly susceptible to blockage.

The mix of soil is important. A mix of sand with soil is normally used to encourage good infiltration, however concerns over road pollution and accidental spillage tends to result in the alternative position of using liners or clays below the swale. Where these are used, there is a significant risk of vegetation die-off during drought conditions. In general the soil will adsorb road runoff pollutants.

Erosion is an issue and gradients steeper than 1:20 are not normally considered. Very flat swales can result in marshy conditions unless soils are designed to drain freely.

Water quality treatment

Water quality of the stormwater for small events is good for all swale types. The under-drained swale is likely to be the most effective, particularly for larger events when a standard swale may have problems with erosion and sediment load if gradients are significant. Mini-swales will still provide significant water quality benefits in spite of their limited hydraulic capacity.

Amenity (social and ecology)

Amenity value is positive in providing green open areas. There is limited ecological benefit due to the regular maintenance requirement.

Land take and availability

The land take is very significant for standard and under-drained swales. Although very desirable for treating road runoff, the demands of site planning for meeting high density housing requirements may often preclude their use for much of a site. However their importance in addressing both the volumes of runoff for small events and improving water quality from road runoff, makes these components very desirable in terms of protecting the receiving environment from the most polluting urban surfaces.

Designing for maintenance

There is a need to balance the requirement to have sheet flow runoff into a swale with protecting the structure from vehicles. The use of kerbs results in point flow inputs, which can cause erosion problems.

Design to allow ease of grass cutting needs to be provided.

1.4.5 Infiltration trenches

An infiltration trench is a subsurface structure into which surface water, normally from roofs, is passed. Infiltration trenches are linear structures and are shallow. They are a trench constructed with a geotextile and filled with granular material.

Infiltration trench characteristics

Performance	Hydraulic benefits - small events	Hydraulic benefits - large events	Water Quality Benefits	Amenity Benefits	Ecological Benefits	Land Take	Safety Issues
High							
Medium							
Low							
None							

N.B. Water quality benefits are “none” in that they do not contribute runoff to surface waters. They are only used where the risk to groundwater pollution is minimal.

Hydraulic performance (small and large events)

Infiltration trenches are normally designed to provide at least a 10 year return period level of service. In practice the conservative design assumptions (such as 100% runoff and a safety factor applied to the infiltration percolation rate) mean that a higher level of service is commonly provided. The use of these units, even in marginal soils (assuming provision for overflows), provide significant stormwater volume reduction of runoff for both small and large events.

Hydraulic design

Infiltration trenches have two significant benefits over traditional soakaways. The first is the greater surface area for percolation per unit storage volume which results in a smaller volume of excavation. The second is that where the groundwater level may preclude the use of a soakaway, an infiltration trench might still be feasible.

To protect the component from blockage it is useful to provide a trap to prevent detritus and sediment passing into it.

It is not advised to serve a large number of houses with one infiltration unit. Failure of the unit will result in one of the properties (at the lowest point) suffering at the expense of all the others if flooding occurs.

Water quality treatment

The water quality of roof runoff into the ground is usually not a pollution concern for groundwater. Use of infiltration trenches for other paved surfaces is rare and needs to consider issues of groundwater sensitivity (groundwater zones), and the characteristics of the runoff.

Amenity (social and ecology)

There is no amenity or ecological benefit from the use of infiltration trenches. However, recharging of groundwater is important and meets the Building Regulations requirements to consider the use of infiltration before other drainage options.

Land take and availability

The land take for infiltration trenches is relatively small. However Document H of the Building Regulations requires soakaways to be located 5m from foundations. High density developments may have some difficulty in complying with this stipulation. Infiltration trenches, with their reduced depths, could have this distance requirement relaxed. Some of the reasons for this rule include:

- Certain soils are susceptible to shrinkage through the wetting and drying process.
- Softening of soils can occur when water is present.
- There is a loss of fines caused by wash out and consolidation of loose soils by water percolation.

It is therefore quite likely that in very high density developments, incorporation of infiltration trenches may be difficult.

Designing for maintenance

Leaf litter, sediments and other detritus can be washed off roofs and other surfaces draining to infiltration trenches. It is important to provide suitable protection to prevent this debris from entering the unit.

1.4.6 Soakaways

A soakaway is a subsurface structure into which surface water, normally from roofs, is passed. Soakaways are normally circular structures constructed with concrete rings with holes in, surrounded by granular material. Soakaways constructed for houses usually dispense with the concrete rings and are just filled with shingle.

Soakaway characteristics

Performance	Hydraulic benefits - small events	Hydraulic benefits - large events	Water Quality Benefits	Amenity Benefits	Ecological Benefits	Land Take	Safety Issues
High							
Medium							
Low							
None							

N.B. Water quality benefits are “none” in that they do not contribute runoff to surface waters. They are only used where the risk to groundwater pollution is minimal.

Hydraulic performance (small and large events)

Soakaways are normally designed to provide at least a 10 year return period level of service. In practice the conservative design assumptions (such as 100% runoff and a safety factor applied to the infiltration percolation rate) mean that a higher level of service is commonly provided. The use of these units, even in marginal soils (assuming provision for overflows), provide significant stormwater volume reduction of runoff for both small and large events.

Hydraulic design

Soakaways should be designed to provide a minimum 1m unsaturated zone below the base of the unit to protect groundwater. This can preclude the use of these units as groundwater would generally need to be greater than 3m below ground level.

To protect the component from blockage it is useful to provide a trap to prevent detritus and sediment passing into it.

It is not advised to serve a large number of houses with one infiltration unit. Failure of the unit will result in one of the properties (at the lowest point) suffering at the expense of all the others if flooding occurs.

Water quality treatment

The water quality of roof runoff into the ground is usually not a pollution concern for groundwater. Use of soakaways for other paved surfaces is rare and needs to consider issues of groundwater sensitivity (groundwater zones), and the characteristics of the runoff.

Amenity (social and ecology)

There is no amenity or ecological benefit from the use of soakaways. However, recharging of groundwater is important and meets the Building Regulations requirements to consider the use of infiltration before other drainage options.

Land take and availability

The land take for soakaways is relatively small. However Document H of the Building Regulations requires soakaways to be located 5m from foundations. High density developments may have some difficulty in complying with this stipulation. Some of the reasons for this rule include:

- Certain soils are susceptible to shrinkage through the wetting and drying process.
- Softening of soils can occur when water is present.
- There is a loss of fines caused by wash out and consolidation of loose soils by water percolation.

It is therefore quite likely that in very high density developments, incorporation of soakaways may be difficult.

Designing for maintenance

Leaf litter, sediments and other detritus can be washed off roofs and other surfaces draining to soakaways. It is important to provide suitable protection to prevent this debris from entering the unit.

1.4.7 Green roofs

Green roofs are a multi-layer system that covers the roof of a building with vegetation over a drainage layer. They have a number of benefits (insulation for noise, heat and cold) and not just drainage where it provides some stormwater runoff attenuation and volume reduction.

Green roofs can be used on both flat and pitched roofs, although the roof pitch is normally less steep than a traditional domestic roof. The construction involves light weight growing media and a water proof liner. The plants normally used are Sedums which are extremely robust in coping with both drought and a big temperature range.

Green roofs, though still rare in Ireland are stipulated in planning in some other European countries. As roofs comprise a large proportion of the urban hard surface, green roofs are likely to play an increasingly important part in providing a more sustainable urban environment.

There are two main types of green roof:

Extensive roofs – where the entire roof area is covered in low-growing, low maintenance plants.

Intensive roofs – these are landscaped highly managed environments that can even include trees.

Green roofs characteristics

Performance	Hydraulic benefits - small events	Hydraulic benefits - large events	Water Quality Benefits	Amenity Benefits	Ecological Benefits	Land Take	Safety Issues
High							
Medium							
Low							
None							

Hydraulic performance (small and large events)

Green roofs are effective in providing both attenuation and reduction of runoff for small events. These advantages are small for larger events in terms of volume reduction and attenuation. Green roofs are not appropriate when rainfall harvesting is proposed as runoff volumes are significantly reduced and water quality of the runoff is an issue.

Water quality treatment

The water quality from green roofs tends to have higher levels of BOD and pathogens due to the fauna supported by the roof. Treatment is required if this water is to be used within properties. Infiltration of the runoff is not perceived as being a problem.

Amenity (social and ecology)

For sedum only roofs there is limited ecological value as they provide a limited environment for flora and fauna. Green roofs are positive aesthetically once they become accepted by the public.

Intensive type roofs are often designed to be accessible and may also include water features and storage of rainwater for irrigation. These types of roofs have a higher amenity value, but have high maintenance costs.

Land take and availability

Green roofs require no land take.

Designing for maintenance

Green roofs generally require regular maintenance on an annual basis. This means that facilities for access to the roof are needed.

To maximise the robustness of the green roof, care is needed in designing edge details to ensure the roof does not degrade in these areas.

Designing for safety

As green roofs require maintenance, the roof should be designed with safety features (fixing points) and safe access.

1.4.8 Rainwater harvesting

Rainwater harvesting is the collection of runoff from roofs, though other paved surfaces can be used. Although the use of water butts is covered by this description, the volume stored is generally insufficient to provide the potential benefits that can be gained from collecting larger amounts of runoff.

The size of the storage tank needed to provide water for toilet flushing and possibly water for washing machines is around 0.5m³ per person. Significantly more storage needs to be provided if rainwater harvesting is to be used for car washing and garden watering.

Benefits can also be provided in terms of reduction of stormwater runoff, however this requires between 2 and 3 times the amount of storage that is provided for water supply reasons.

Rainwater tanks are normally buried adjacent to the house and pumps passed water back to a header tank. Treatment of the runoff in the form of filtering is needed, but additional treatment is normally not needed, though there are no definitive standards on this issue.

Rainwater harvesting characteristics

Performance	Hydraulic benefits - small events	Hydraulic benefits - large events	Water Quality Benefits	Amenity Benefits	Ecological Benefits	Land Take	Safety Issues
High	Blue	Blue with diagonal lines					
Medium	Blue	Blue					
Low	Blue	Blue	Green	Green			Red
None	Blue	Blue	Green	Green	Green	Red	Red

N.B. Water quality benefits are “none” in that they do not contribute treatment to the surface runoff. They are only used where the risk to groundwater pollution is minimal.

Hydraulic performance (small and large events)

Water butts have no value in providing a reduction in stormwater flows downstream from major events, as they cannot be assumed to have any spare storage space to attenuate runoff from a large storm event.

Rainwater harvesting which is used on a daily basis for domestic use does provide stormwater benefits.

Hydraulic design

Sizing of these units requires detailed hydrological analysis, normally using time series rainfall, to ascertain the likely level of stormwater benefits and define the possible reduction of stormwater management provision downstream.

Provision needs to be made for an overflow to operate. This may need to be piped to a drainage system.

Systems can be designed on a communal or individual household basis. Ownership issues, treatment and delivery pipework is more of an issue where communal systems are built.

Water quality treatment

Rainwater harvesting provides indirect benefits in that runoff volumes are significantly reduced (of the order of 40%) thus reducing the volume into downstream treatment systems and subsequently in the receiving water.

Amenity (social and ecology)

There is no amenity or ecological benefits unless garden watering and its consequences is seen as an amenity and ecological benefit. In addition there are potentially significant benefits in reducing water supply demand, especially in water scarce regions.

Land take and availability

Virtually no land is required for these components to be used.

Design for maintenance

Domestic use systems must be robust and easy for homeowners to operate and maintain.

Design for safety

The risk of cross-connections with the mains water supply system must be minimised.

Any buried chamber with access into it is a hazard and design should avoid the use of access structures through which children can fall.

1.4.9 Bio-retention

Bio-retention areas are effectively small storage basins largely back-filled with humus with forms of vegetation other than grass. At the base of the storage unit is a collection pipework system. Conveyance is not normally an aspect of bio-retention, so an overflow structure is usually provided to address larger volumes of runoff.

They are often provided in the form of an attractive border adjacent to the paved area that they serve.

Bio-retention characteristics

Performance	Hydraulic benefits - small events	Hydraulic benefits - large events	Water Quality Benefits	Amenity Benefits	Ecological Benefits	Land Take	Safety Issues
High	Blue		Green			Red	
Medium	Blue	Blue with diagonal lines	Green	Green	Green	Red	
Low	Blue	Blue	Green	Green	Green	Red	Red
None	Blue	Blue	Green	Green	Green	Red	Red

Hydraulic performance (small and large events)

Bio-retention sites tend to provide effective storage for small events and a degree of attenuation for large events. Their hydraulic effectiveness depends very much on their hydraulic design.

Hydraulic design

Hydraulic design is quite complex with a low voids storage area with percolation through the humus, a shallow storage area on the surface and an overflow to the drainage system to cater for extreme events. Design guidance is available in SuDS manuals.

Water quality treatment

The water quality from bio-retention areas can often be better than for swales. However where it is used as a vegetated border, horticultural practices will affect the water quality to some degree, especially if nutrients are added.

Amenity (social and ecology)

The amenity value is potentially high, depending on its design and management. The ecological benefits will also vary for the same reason.

Land take and availability

Bio-retention areas are generally limited to relatively flat areas. However, they can be any size to suite the environment. As they are relatively flat depressions, the land take is large relative to the hydraulic benefits provided.

Design for safety

As open water will exist during and immediately after significant rainfall, although shallow and temporary, there are issues of safety to consider.

Designing for maintenance

Bio-retention areas are normally designed to provide high quality aesthetic areas which mean that frequent management of vegetation will usually be needed. Access which is suitable for operation and maintenance should be considered.

1.5 CONSTRUCTION ISSUES

Detailed guidance on the construction related issues for SuDS is available in the SuDS Manual and the associated Construction Site handbook (CIRIA, 2007). SuDS are a combination of civil engineering structures and landscaping practice. Due to the limited experience of building SuDS in the water industry, there are a number of key issues which need to be particularly considered as their construction requires a change in approach to some standard practices.

Summary of construction considerations for SuDS

1. The phasing of construction may need to be modified to ensure constructed SuDS components operate properly. For many SuDS, the final construction should take place towards the end of the development programme, unless adequate provision can be made to protect the component.
2. The contractor and all relevant operatives should have an understanding of the mechanism and purpose of the SuDS components to ensure appropriate construction practice and protection is carried out.
3. Appropriate operative skills with an understanding of all aspects of vegetation should be obtained. In particular, the use of nutrients and mulches should be minimised and a particular soil mix will often be needed for the SuDS component.
4. It should be recognised that vegetation takes time to become established. Adoption by the authorities / owners may be delayed until the SuDS systems are mature.
5. The seasonal and physical requirements of planting and establishing vegetation and prevention of soil erosion must be programmed appropriately.
6. Traditional car parking and other paved areas are usually partially constructed during the initial stages of the development to provide storage and access on the site. However, if pervious pavements and infiltration are proposed for these areas, the construction process needs to be modified to prevent sediments from clogging the structure or the soil base.
7. Sensitive ground, such as chalk, may require the use of total exclusion zones to prevent compaction and other damage of the ground that will affect the infiltration performance of any infiltrating SuDS component. This may include protection from runoff during construction if the component is located at a low point on the site.
8. The construction of swales, basins and ponds at an early stage in the construction will assist in managing runoff and help settle out the high volumes of sediments created during construction. However, complete reinstatement of these components will be required once construction is finished. It should be noted that the maintenance period is likely to stipulate establishment of landscaping vegetation, and sediment removal some time after site works have been completed.
9. The importance of good landscaping is emphasised. As SuDS systems are surface systems, attention to detail and aesthetics must be given a high priority.

1.5.1 Pond construction

Ponds can be very useful in providing protection to the environment during construction of the development by trapping the high loads of sediment in stormwater runoff. If they are used for this purpose, rehabilitation and sediment removal needs to be incorporated into the programme.

1.5.2 Basin construction

Basins provide an opportunity to manage site pollution, although rehabilitation will be required once the site is established.

1.5.3 *Pervious pavements*

Fundamental to the construction of residential developments, is the use of the site road system to provide access within the site to assist in the construction process. Not only is this a construction necessity, it can also be a requirement of the highway authority, to mitigate the deposition of mud onto the public highway. It can also be a condition of planning.

To prevent damage to the pervious pavement and its long term operation, protective measures need to be introduced. The following is suggested.

- Following the construction of deeper services such as sewers (below formation), install the sub-base layers.
- In lieu of the top geotextile layer (if designed) and the bedding and paving, an additional tarmac running layer is installed. This provides support for construction and residential traffic and protects the permeable base of the road.
- Following the completion of construction activities on the dwellings, at the time when final wearing courses are normally applied, the tarmac layer is normally removed. Leaving the tarmac layer in-situ and puncturing it at a minimum of 1.0m centres is sometimes practised, but as this concentrates the flows, the risk of blockage is increased and is therefore not recommended. It also adds to hydrocarbon contamination of the runoff passing through to the soil below. It also provides a horizontal plane reducing the friction resistance to horizontal forces (braking).
- Finally the geotextile, bedding layer and paving are installed as normal.

Note that if the tarmac layer is retained, the difference between temporary and final surface level is significant and should be specifically considered in the design. If removed (sacrificial layer), the difference is much less.

If a pervious pavement is to be lined, the use of hardcore for structural purposes below the level of the liner can be applied, though the liner will need to be suitably protected. The use of hardcore is not advised if infiltration is intended, due to the high proportion of fines.

Ground levels adjacent to pervious pavements must be set such so as to prevent any overland sediment washoff during high intensity rainfall events, or groundwater seepage during prolonged wet periods.

No traffic should be allowed on to the pavement if it is likely to introduce sediments on to the pavement surface from dusty or muddy areas.

1.5.4 *Swales*

As swales are vegetated structures, their construction in terms of season to ensure good germination is an important consideration. Provision to minimise erosion immediately after construction is needed. Turf is an alternative to ensure against these potential problems.

There is a significant risk of damaging the pipe-work in under-drained swales during the construction period. It is advised that suitable precautions are taken to avoid the possibility of any construction vehicle traffic passing over the area.

If swales are built early in the construction programme it is likely that rehabilitation will be required prior to vesting.

Very careful attention to detail on inlet levels to swales are needed to avoid ponding near inlets or build up of sediments as the flow passes off the road to the verge.

The soil mix is important and should comprise a high proportion of coarse sand to encourage infiltration.

1.5.5 Infiltration trenches

The areas in which infiltration trenches are to be built must be protected from ground compaction by construction traffic.

The infiltration trenches should not be connected until late in the construction period to avoid the risk of sediments being introduced into them.

1.5.6 Soakaways

The areas in which soakaways are to be built must be protected from ground compaction by construction traffic.

The soakaways should not be connected until late in the construction period to avoid the risk of sediments being introduced into them.

1.5.7 Green roofs

Construction of green roofs requires the involvement of expert organisations.

The season should be considered and factored into the construction programme to ensure rapid development of the roof vegetation.

The time needed to build a green roof is slightly longer than for a standard roof and provision should be made for this.

Access to the roof by other trades should be completed prior to the commencement of vegetation planting.

1.5.8 Rainwater harvesting

Care is needed in ensuring cross-connections are not made with the water supply pipework during construction.

As header tanks will be placed in roofs, loading of the roof structure must be explicitly considered.

Connection to the tank of roof runoff should only be made towards the end of the construction period to avoid detritus entering the tank.

1.5.9 Bio-retention

The fill material must be specifically designed to suit the vegetation proposed for the area and also provide the porosity required for drainage to the under-ground pipework.

Mulches should not be used, as they reduce available storage and can block overflows and downstream systems.

Nutrients should be used sparingly or not at all.