Sustainable Drainage Explanatory Design & Evaluation Guide

2022

Comhairle Contae
Átha Cliath Theas
South Dublin County Council

Preface

Why this guide is needed

The impacts of conventional drainage are now well understood.

Pipe drainage collects and conveys water away from where it rains, as quickly as possible, contributing to increased risk of flooding, increased likelihood of contaminated runoff polluting our watercourses and the loss of our relationship with water and the benefits it can bring to us all. South Dublin is under significant pressure with an ageing drainage system that is at capacity. As the pressures of climate change continue, we need to build resilience into our drainage systems to deal with both current and future pressures.

Sustainable Drainage, or SuDS, is a way of managing rainfall that mimics the drainage processes found in nature and addresses the issues with conventional drainage.

It is intended that this guide will facilitate the best possible SuDS designs.

Who this guide is intended for

This Guide is primarily intended for those designing SuDS for new developments within the SDCC region. The Guide will support the planning process, where SuDS schemes which form part of planning applications are assessed by SDCC against the Policies and Standards set out in the South Dublin County Development Plan and the requirements outlined by the SDCC Strategic Flood Risk Assessment and the Greater Dublin Strategic Drainage Study.

What the guide provides

This guide promotes the idea of integrating SuDS into the fabric of development using the available landscape spaces as well as the construction profile of buildings. This approach provides more interesting surroundings, cost benefits, and simplified future maintenance.

The three accepted design stages are described: Concept Design, Outline Design and Detail Design outlining the level of detail that should be considered at each stage of the design process.

Cover: Sean Walsh Park, photo is marked as ownership of Ben Ryan.

Right: Citywest campus, Dublin, Courtesy of Davy Hickey.

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This guide draws upon the author's 25 years of practical experience in the application of SuDS.

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Robert Bray has been a pioneer of UK SuDS since 1996. He has been at the forefront of demonstrating how SuDS can be fully integrated with the surrounding landscape. Bob has been a key tutor for the (CIRIA) National SuDS training workshops since 2003.

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Environment
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Roads and Transport
Heritage Planning
Housing
Traffic and Planning

Contents

Introduction
- Understanding Rainfall 7
- The Impact of Development 9
- The Role of SuDS in South Dublin 13

Policy
- SuDS Design Requirements. 17

Design Process
- SuDS and the design process 23
- Stage 1 - Concept Design. 25
  - Designers Checklist for Concept Design. 48
- Stage 2 - Outline Design 51
  - SuDS Calculation Checklist 70
  - Design Evaluation Checklist 92
- Stage 3 - Detailed Design 95

Design Detail
- SuDS Components 101

Maintenance and Management
- Management of the SuDS landscape. . 123
- Glossary & Acronyms 129

1.0 Introduction

Since 2000 there have been an increasing number of publications that identify the problems with traditional drainage and describe a different approach to managing rainfall called Sustainable Drainage Systems or SuDS.

1.1 The origins of SuDS in Ireland

During the late 1990s an awareness of better ways to manage rainfall runoff began to influence thinking in Ireland. Ideas of better ways to manage rainfall from the US and Sweden were initially introduced into the City West Business Park Scheme. The Greater Dublin Strategic Drainage Study (GDSDS) was published in 2005 and included a statement that mandated SuDS on new developments.

1.2 What are SuDS?

There have been a number of definitions of Sustainable Drainage over the years, but the following is based on the SuDS Manual 2015, which was published by the Construction Industry Research and Information Association (CIRIA):

> *'Sustainable Drainage or SuDS is a way of managing rainfall that minimises the negative impacts on the quantity and quality of runoff whilst maximising the benefits of amenity and biodiversity for people and the environment'.*

1.3 Why SuDS are required in South Dublin?

SDCC has identified SuDS through the Development Plan as the preferred way of managing rainfall from new development.

SuDS where well designed, will make a valuable contribution to South Dublin urbanised areas, making it a more pleasant and healthy environment in which to live, work and play.

Our drainage systems have been subject to increasing pressure over recent years both through climate change and additional hard landscape being connected to the sewer.

It is projected that by 2028, up to 46,500 additional people could be living in South Dublin. This additional demand means that the way that we deal with surface runoff will have to evolve and adapt as existing drainage networks have a finite capacity, whilst also tackling the effects of climate change and improving water quality in South Dublin's network of rivers.

Cover & below: Citywest campus, Dublin. Courtesy of Davy Hickey.

Development Plan Policy GI4: Sustainable Urban Drainage Systems

Require the provision of Sustainable Urban Drainage Systems (SUDS) in the County and maximise the amenity and biodiversity value of these systems.

GI4 Objective 1: To limit surface water run-off from new developments through the use of Sustainable Urban Drainage Systems (SuDS) using surface water and nature based solutions and ensure that SuDS is integrated into all new development in the County and designed in accordance with South Dublin County Council's Sustainable Drainage Systems (SuDS) Explanatory, Design and Evaluation Guide.

The likely impacts of climate change in South Dublin include increased risk and severity of flooding, deteriorating air and water quality within the river networks and biodiversity loss. Introduction of SuDS will assist in addressing these risks.

1.4 Background to this document

This guide considers design and evaluation of SuDS as complementary. It explains both, from the earliest iteration of Concept Design through to the Detailing stage, in order to successfully integrate SuDS into development.

The main objectives of this Design and Evaluation guide are:

- To create a shared vision around SuDS for all involved in design and evaluation.
- To enable the design and evaluation of SuDS to meet agreed standards.
- To ensure SuDS are maintainable now and in the future.

This guide supports the delivery of;

- South Dublin County Council Development Plan (2022-2028)
- South Dublin County Council Strategic Flood Risk Assessment (2022)
- South Dublin County Council Climate Change Action Plan (2019-2024)
- Working with Nature - Biodiversity Action Plan for South Dublin County (2020–2026)
- South Dublin County Council Green Infrastructure Strategy
- South Dublin County Council Parks and Open Space Strategy

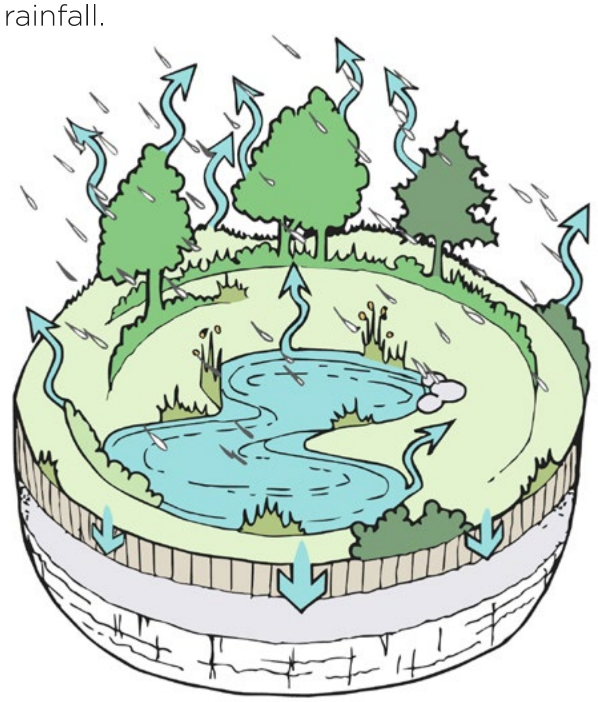
The Guide is complementary to the CIRIA 2015 SuDS Manual (C753) and the Greater Dublin Strategic Drainage Study (GDSDS) (2005) and the DHLGH Interim Guidance Document "Nature-based Solutions to the Management of Rainwater and Surface Water Runoff in Urban Areas - Water Sensitive Urban Design - Best Practice Interim Guidance Document".

2.0 Understanding Rainfall

It is important that everyone involved in the design and evaluation of SuDS has an understanding of the natural processes that occur in response to rain, so that proposed schemes can mimic these.

2.1 It begins to rain

In forests, flushes, and wetlands, when it rains, water can be lost in a number of ways. The rain is held on the foliage of trees and plants and evaporates into the air, falls to the ground to be absorbed by leaf litter and surface soil layers, or is ‘breathed’ back into the air by plants as transpiration. These losses are called **interception losses** and are the first part of the natural losses that occur during rainfall.

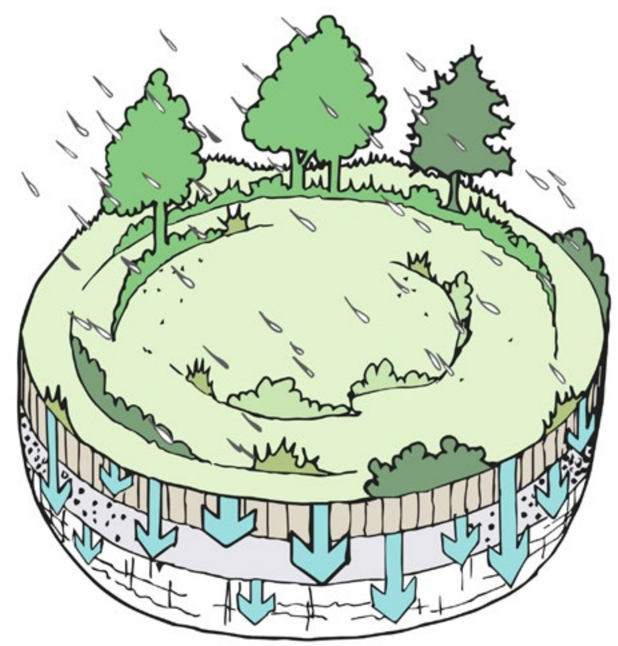


Interception losses in the natural landscape

2.2 The ground becomes saturated

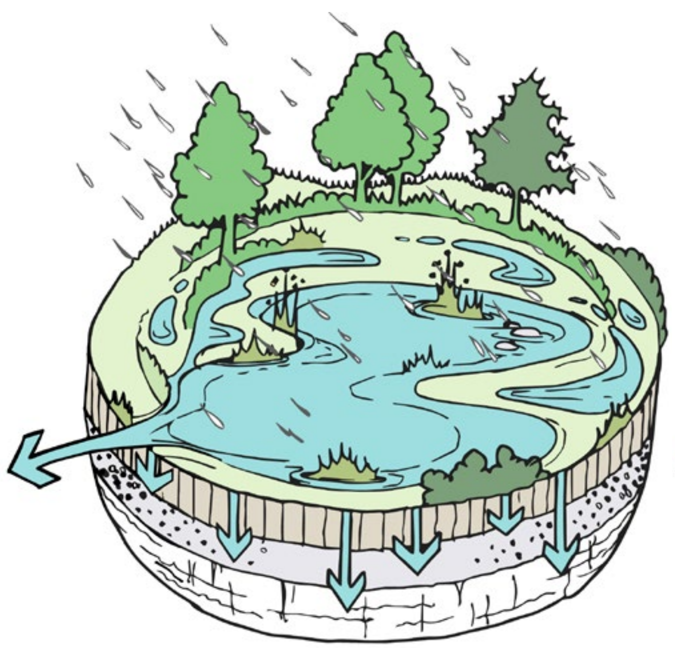
After a while the surface of the landscape can absorb no more water.

Where the ground is **permeable**, water begins to soak into lower soil profiles and then the underlying geology. This is called **infiltration** and is common on sandy, gravelly and limestone soils.



In landscapes with infiltrating soils, after interception losses have taken place, most rainwater is lost soaking into the ground.

Where the ground is **impermeable**, water begins to trickle and flow across the surface, collects in natural depressions, and is stored in wetlands. These natural features attenuate the rate and volume of flow of rainwater running off the landscape. These flows are called **natural** or **greenfield runoff**.



*Surface flow rates are small at first, but increase with higher **intensity** rainfall events. The **volume** of runoff will generally be greater with increased rainfall intensity and duration.*

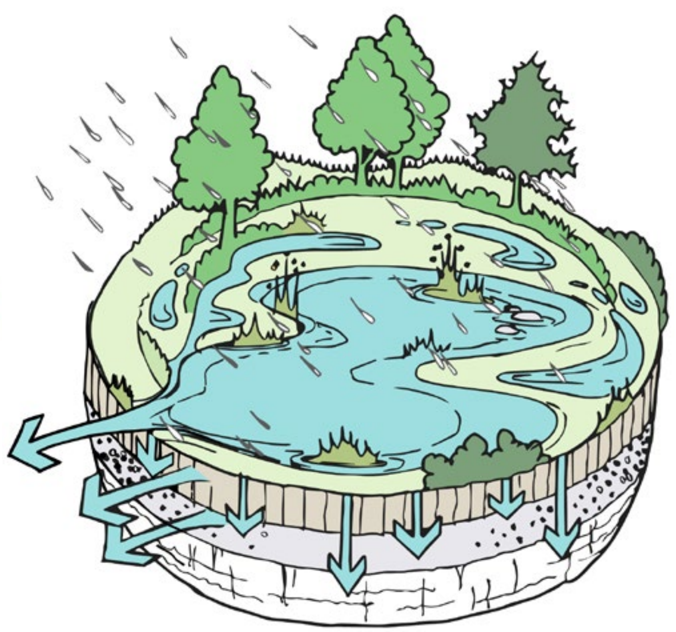
2.3 Natural losses continue during heavy rain

In many soils, both a degree of infiltration and surface runoff can occur simultaneously.

Once the ground is saturated there are ongoing natural losses that occur during rainfall, particularly where the ground has some permeability.

During warmer weather when the ground is relatively dry, interception and ongoing natural losses will occur during most rainfall events.

Interception and ongoing losses are the two elements of total natural losses.



This dynamics process varies in accordance with permeability, the preceding weather conditions and extent of ground compaction or vegetation cover.

3.0 The Impact of Development

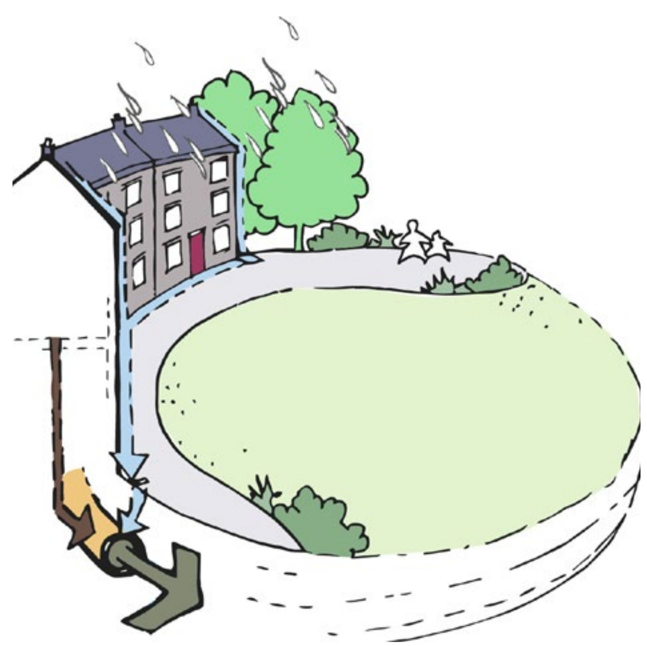
For millennia, people have been making changes to our landscapes which affect the fate of the rain that falls on the land. In recent history, the scale of urbanisation and our attitudes toward rainwater have caused serious problems to both the people of South Dublin and the remaining natural environments, rivers and coastal waters.

3.1 A rural landscape becomes urban

Before the universal use of piped drainage it was common to collect and convey runoff across the land surface directly into ditches, streams and local rivers. With the growth of Dublin and the development of piped drainage; human and industrial waste, together with rainwater runoff from buildings and streets, was directed into a single underground pipe called the **combined sewer**.

Whilst most of South Dublin is served by a separate sewer system (**foul sewer** for human waste and the **surface water sewer** for rainfall), there are some combined sewers across the county.

Unfortunately, rainwater still gets into the foul sewer and misconnections contaminate surface water sewers and receiving watercourses. The SuDS approach to managing rainfall can minimise these misconnections by keeping rainfall runoff at or near the surface.



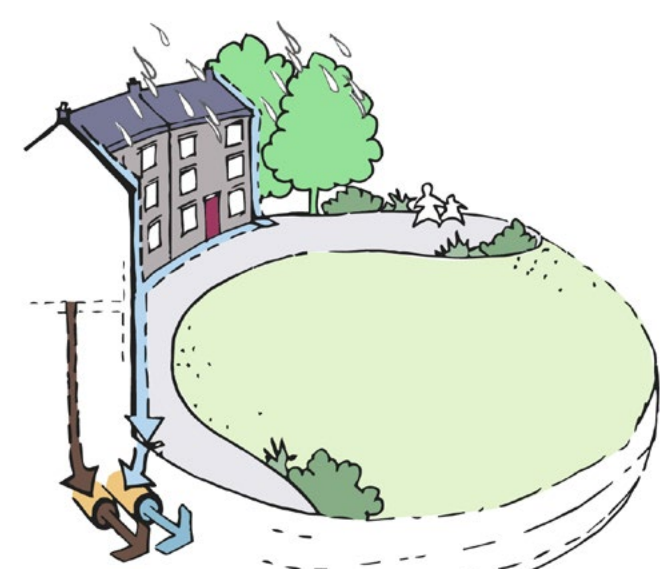
The Combined Sewer.

3.2 Consequences of piped drainage

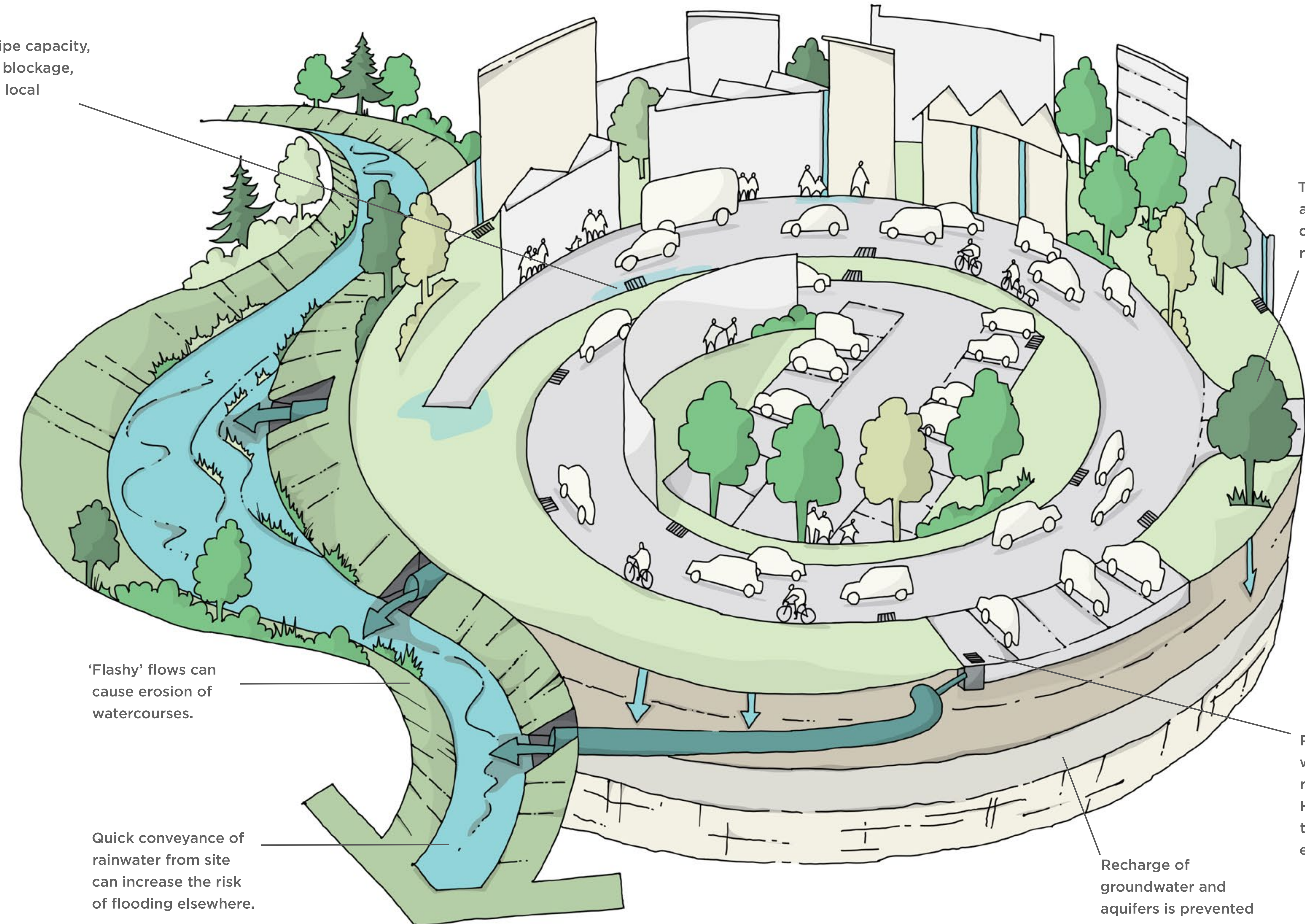
Piped drainage is designed to convey water away from developments as quickly as possible, and has become the default way to manage rainfall across the developed world. However, this is at a cost to the environment and developments themselves.

The disadvantages of traditional piped drainage are now becoming clear:

- Quickly carrying rainwater away from where it falls can increase the risk of flooding elsewhere.
- Limited pipe and network capacity, as well as blockage, can cause local flooding as water cannot get into the system.
- Pollution from roofs, roads and car parks is washed into the sewer when it rains, contaminating streams, rivers and the sea and adversely affecting wildlife.
- Recharge of groundwater and aquifers is prevented, and the natural 'baseflow' of water through the ground to watercourses is lost.
- 'Flashy' flows from urban areas can cause erosion of watercourses.
- Trees and plants in urban areas are at greater risk from drought stress, due to lack of access to rainwater.
- Wildlife is often trapped and killed by conventional drainage structures.



Separate pipes for foul sewage and surface water were introduced in the mid-twentieth century



The Impact of Development

4.0 The Role of SuDS in South Dublin

Sustainable Drainage is a way of managing rainfall that mimics natural drainage processes and reduces the impact of development on communities and the environment.

4.1 SuDS addresses community and environmental problems

Conventional drainage seeks to remove runoff from development as quickly as possible. In contrast, SuDS slow the flow and store water in both hard and soft landscape areas, thereby reducing the impact of large volumes of polluted water flowing from development.

SuDS uses components linked in series to trap silt and heavy pollution '**at source**'.

Many contaminants are broken down naturally as runoff passes from one SuDS component to the next.

Multi-functional SuDS components that manage water at or near the surface, can bring significant community benefits, adapting their function to the weather.

The loss of aquatic habitat is reversed when using the SuDS approach. It allows fauna and flora to flourish, and to connect with existing habitats.

Image: Adamstown Avenue Attenuation Ponds and Wetlands (Constructed c. 2005/6)

South Dublin County Development Plan 2022-2028

South Dublin County Strategic Flood Risk Assessment

South Dublin County Green Infrastructure Strategy

SuDS, delivered using nature based approaches will make a significant contribution to the objectives of the Green Infrastructure Strategy for South Dublin.

Policy GUR-2:

To promote the integration and provision for biodiversity within public open space provision and sustainable water management measures (including SuDS) where possible and appropriate.

4.2 SuDS objectives

Where SuDS are designed as an integral part of the urban fabric, they will help mitigate the contribution to flooding and the impact that development has on the natural landscape. They are also able to rehabilitate the hydrology of the urban environment through sustainable re-development and SuDS retrofit.

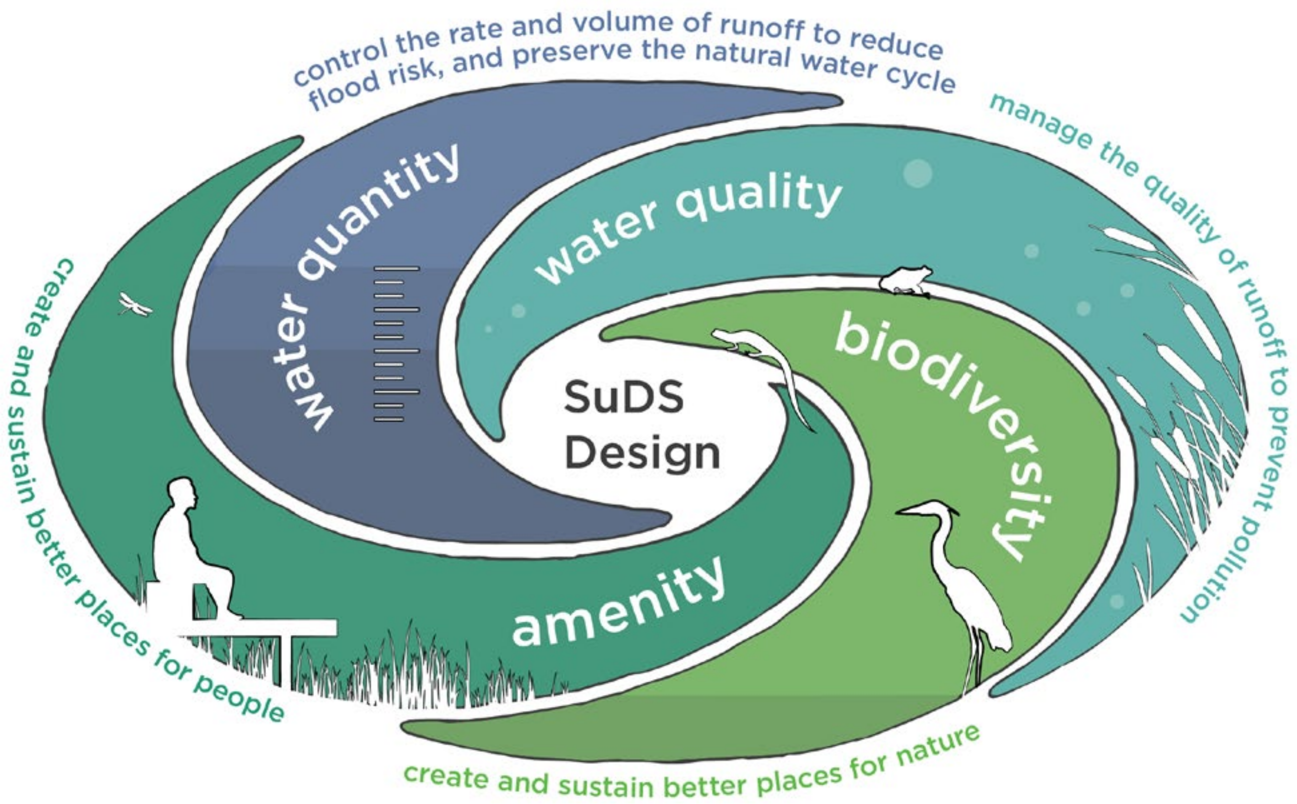
There are four critical objectives that SuDS seek to meet:

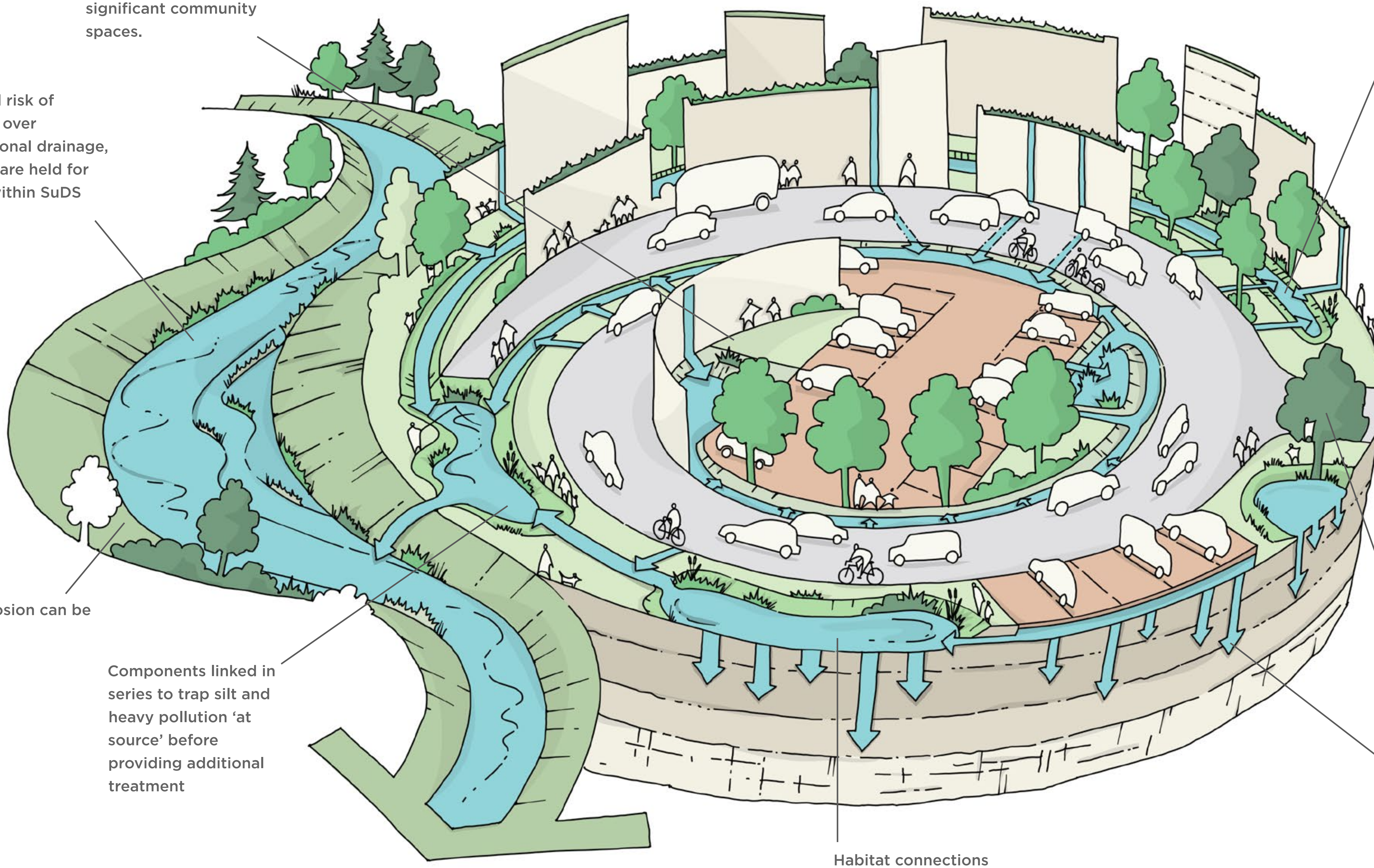
Quantity: managing flows and volumes to match the rainfall characteristics before development, in order to prevent flooding from outside the development, within the site and downstream of the development.

Amenity: enhancing people's quality of life through an integrated design that provides useful and attractive multi-functional spaces.

Quality: preventing and treating pollution to ensure that clean water is available as soon as possible to provide amenity and biodiversity benefits within the development, as well as protecting watercourses, groundwater and the sea.

Biodiversity: maximising the potential for wildlife through design and management of SuDS.




Multi-functional SuDS components can serve, when dry, as significant community spaces.
Hydrocarbons are remediated via biological processes. Robust planting is required to manage this.
Reduced risk of flooding over conventional drainage, as flows are held for longer within SuDS features
River erosion can be reduced
Components linked in series to trap silt and heavy pollution 'at source' before providing additional treatment
Habitat connections are made.
Trees and plants can benefit greatly from additional water inputs, particularly in stressful urban situations.
Recharge of groundwater and aquifers via infiltration.

5.0 SuDS Design Requirements

The following section sets out the SuDS design requirements which underpin delivery of the respective Development Plan policies and objectives.

5.1 SuDS and the South Dublin Development Plan

South Dublin Development Plan requires SuDS to be incorporated into new development. SDCC considers that SuDS is appropriate and reasonably practicable in all types of development.

Policy GI4: Sustainable Urban Drainage Systems

Require the provision of Sustainable Urban Drainage Systems (SUDS) in the County and maximise the amenity and biodiversity value of these systems.

GI4 Objective 1: To limit surface water run-off from new developments through the use of Sustainable Urban Drainage Systems (SuDS) using surface water and nature-based solutions and ensure that SuDS is integrated into all new development in the County and designed in accordance with South Dublin County Council's Sustainable Drainage Systems (SuDS) Explanatory, Design and Evaluation Guide.

GI4 Objective 2: To incorporate a SuDS management train during the design stage whereby surface water is managed locally in small sub-catchments rather than being conveyed to and managed in large systems further down the catchment.

GI4 Objective 3: To require multifunctional open space provision within new developments to include provision for ecology and sustainable water management.

GI4 Objective 4: To require that all SuDS measures are completed to a taking in charge standard.

GI4 Objective 5: To promote SuDS features as part of the greening of urban and rural streets to restrict or delay runoff from streets entering the storm drainage network.

GI4 Objective 6: To maintain and enhance existing surface water drainage systems in the County and promote and facilitate the development of Sustainable Urban Drainage Systems (SUDS), including integrated constructed wetlands, at a local, district and County level, to control surface water outfall and protect water quality.

Design note: Delivering high quality SuDS which are nature based and integrated with the development will support the delivery of wide range of the Development Plan policies.

5.2 Runoff destination

SuDS Designs should explore opportunities for; sustainable reuse of rainfall, recharge of aquifers and direct discharge to open watercourses; thus reducing the pressure on the sewer network. The following ways of managing or releasing surface runoff to the wider environment should be considered and are set out in order of preference:

1. Use surface water runoff as a resource
2. Provide nature-based SuDS features that promote interception losses
3. Where appropriate, infiltrate runoff into the ground
4. Discharge to an open surface water drainage system
5. Discharge to a piped surface water drainage system

Discharging runoff from a site may utilise one or more means of discharge. Full advantage should be taken with each method of discharge on the list in turn, prior to considering the next sequential option.

The majority of South Dublin is served by a separate sewerage system. In cases where there are no other available means of discharging runoff other than the combined sewer, then developer must obtain written agreement from Irish Water to do so.

This will support the delivery of a range of SDCC Development Plan Policies including; GI2: Biodiversity; Policy IE3: Surface Water and Groundwater; and, Policy IE4: Flood Risk.

5.3 Hydraulic requirements

Hydraulic requirements are as set out in the GDSDS and Regional Drainage Code of Practice.

Surface runoff from new development will be restricted to 2 l/s/ha for the 1 in 100 year rainfall event (with allowance for climate change and urban creep (see Section 8.4.7) where surface water leaving the site:

- poses a pollution risk to the environment arising from overflow from a combined sewer to a receiving watercourse;
- has the potential to impact upon property or infrastructure where property or infrastructure is identified as being at flood risk from a 1 in 100 year flood / rainfall event.

In all other instances the criterion tabled below shall apply.

Criterion	Sub-criterion	Return Period (Years)	Design Objective
Criterion 1 River Water Quality Protection	1.1	<1	Interception storage of at least 5mm, and preferably 10mm, of rainfall where run-off to the receiving water can be prevented.
Criterion 2 River Regime Protection	2.1	1	Discharge rate equal to 1-year greenfield site peak runoff rate or 2 l/s/ha, whichever is the greater. Site critical duration storm to be used to assess attenuation storage volume.
	2.2	100	Discharge rate equal to 1 in 100-year greenfield site peak run-off rate. Site critical duration storm to be used to assess attenuation storage volume.
Criterion 3 Level of Service (Flooding) for the Site.	3.1	30	No flooding on site except where specifically planned flooding is approved. Summer design storm of 15 or 30 minutes are normally critical.
	3.2	100	No internal property flooding. Planned flood routing and temporary flood storage accommodated on site for short high intensity storms (critical duration events).
	3.3	100	No internal property flooding. Floor levels at least 500mm above maximum river level and adjacent on-site storage retention.
	3.4	100	No flooding of adjacent urban areas. Overland flooding managed within the development.

Criterion	Sub-criterion	Return Period (Years)	Design Objective
Criterion 4 River Flood Protection (Criterion 4.1, or 4.2 or 4.3 to be applied)	4.1	100	"Long-term" floodwater accommodated on site for development run-off volume which is in excess of the greenfield run-off volume. Temporary flood storage drained by infiltration on a designated flooding area brought into operation by extreme events only. 100-year, 6 hour duration storm to be used for assessment of the additional volume of run-off.
	4.2	100	Infiltration storage provided equal in volume to "long term" storage. Usually designed to operate for all events. 100-year, 6-hour duration storm to be used for assessment of the additional volume of run-off.
	4.3	100	Maximum discharge rate of Qbar or 2 l/s/ha, whichever is the greater, for all attenuation storage where separate "long term" storage cannot be provided.

5.4 Water Quality

Policy IE3: Surface Water and Groundwater

Manage surface water and protect and enhance ground and surface water quality to meet the requirements of the EU Water Framework Directive.

SDCC will require demonstration that the drainage design provides sufficient number of SuDS techniques which are sufficiently sized and designed to manage pollution; to demonstrate protection of groundwater and surface waters and sensitive coastal waters.

SDCC will also assess whether designs demonstrate suitably clean water to SuDS components that are intended for amenity use and biodiversity benefit, through the use of source control and management trains.

SuDS Requirements

5.5 Amenity and Biodiversity

Policy COS5: Objective 12

To ensure that proposed SuDS measures are only accepted as an element of public open space where they are natural in form and integrate well into the open space landscape supporting a wider amenity and biodiversity value.

Amenity and biodiversity benefits can be achieved using SuDS through the creation of multi-functional places and landscapes.

5.6 SDCC taking in charge standards

SuDS structures should be designed and constructed to a taking in charge standards (**GI4 Objective 4**).

Design guidance for SuDS structures is outlined in Section 10. Further details and specification requirements are available from SDCC upon request.

Where SuDS are to be taken in charge by SDCC they must be;

- Within lands vested to SDCC
- Be accessible for maintenance
- Meet SDCC taking in charge requirements

SuDS features proposed by developers to be taken in charge by SDCC should demonstrate how they comply with SDCC taking in charge specifications set by SDCC for being taken in charge.

see SDCC website for details of current taking in charge

5.7 SDCC standard requirements

SuDS may be within curtilage of the property, within public open space or within the road. Depending upon the site layout and context, there are likely to be other requirements that SuDS will have to meet as part of the multifunctional landscape design. Consideration should also be given to requirements set out within;

- Greater Dublin Regional Code of Practice for Drainage Works
- Design Manual for Urban Roads and Streets
- Building Regulations Technical Guidance - Document H

Communication between the design team and SDCC during the design process will aide designers and developers to deliver successful and cost-effective SuDS projects.

SDCC Greater Dublin Regional Drainage Code of Practice Pre Planning Guidance

5.8 Designing SuDS to support delivery of other SDCC policies

Whilst the urban greening factor and public open space can be delivered completely separately to SuDS, a cohesive and integrated design should consider how SuDS can support the delivery of these SDCC policies.

5.8.1 Urban greening factor

A greening factor is a measurement that describe the quantity and quality of greening measures and green infrastructure interventions across a defined spatial area. Effectively, this measurement comprises a ratio that compares the amount of impermeable ‘grey’ space to the green space within a subject site. As a planning tool, this ratio can be used to assess both the existing green cover within a site and the impact of new development, based on the quantity and quality of new green space provided.

Landscape based SuDS features such as basins and swales along with green roofs SuDS tree pits and permeable surfaces can have the potential to contribute to the urban greening factor.

5.8.2 Public open space (POS)

Public open space standards are set out in the County Development Plan and development is required to implement these, where applicable.

As the County development Plan encourages that rainfall runoff is managed as part of the landscape, it is anticipated that areas of greenspace may be subject to temporary ponding particularly after significant rainfall. The designer should demonstrate how a range of rainfall events (i.e. 1 in 1, 5, 10, 30 and 100 year rainfall events) will be managed within the public open space area, detailing the extent of inundation and the likely duration of drain down for the range of design horizons.

In determining whether SuDS features contribute to public open space the following will be considered by SDCC.

- Use of source control to manage day to day rainfall
- Enhancement of amenity value
- Enhancement of biodiversity provision
- Available for use in most weather conditions.

6.0 SuDS and the design process

6.1 SuDS design is considered at the beginning

In the past, drainage was usually considered at the end of the design process, with a piped drainage solution superimposed onto a site layout. In many respects the pipe infrastructure was independent of the topography, geology and other hydraulic and environmental characteristics of the site.

To achieve integration of SuDS into the site layout, the design should reflect the topography, geology and drainage characteristics of the site together with the character of the landscape and have due consideration of any impact on heritage assets.

SuDS Concept Design ensures that SuDS can be properly considered as part of the layout of the development.

Design note ; SDCC expect the designer to consider SuDS at the earliest point in the scheme design.

6.2 Design and evaluation

This guide follows the process of design from the earliest consideration of potential development through to detailed design. Development of the SuDS design in parallel with the overall scheme design will minimise the risk of missed opportunities for integration of SuDS as part of the fabric of the development.

SDCC will facilitate pre-application discussions as appropriate. To inform any pre-application discussions a concept plan should be presented illustrating how SuDS will be integrated with the site layout.

Design note: Designers should satisfy themselves that the design adheres with SuDS Policy / requirements and that this is clearly demonstrated in the planning submission.

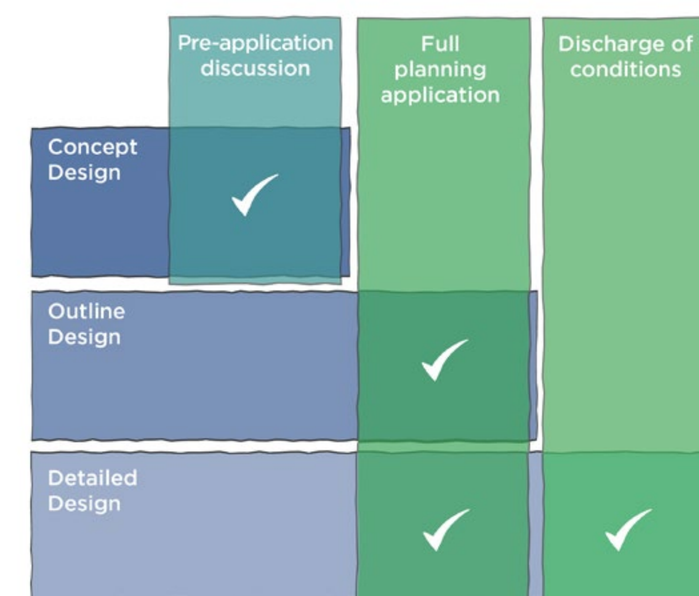
6.3 The objectives of evaluation

Throughout the various design stages the emerging designs should be evaluated by the designer against core design criteria relating to the four main objectives of SuDS design: quantity, quality, amenity and biodiversity.

The objectives of the evaluation process are to ensure that SuDS:

- meet requirements for water quantity and quality, amenity and biodiversity
- integrate into the development's layout and design
- demonstrate the use of appropriate source control measures, conveyance and other SuDS components and how these are arranged in a management train with discreet sub-catchments.
- maximise opportunities for multi-functionality and amenity use
- enhance biodiversity throughout the development
- take opportunities to conserve and enhance heritage assets and the historic environment
- are appropriate, cost-effective and robust
- are practical to maintain in the long term
- considered health and safety at each design stage, with confirmation that this has been achieved through the 'safety by design' principle (see Section 8.8).
- where the scheme is proposed to be taken in charge; meet the requirements of Greater Dublin Regional Code of Practice for Drainage Works, and Design Manual for Urban Roads and Streets and be in accordance with SDCC taking in charge standards.

The checklists contained within this Guide act primarily as a self-checking aide for the designer, to ensure that critical aspects of the design have been considered. These check lists are non-exhaustive and additional checks should be carried out by the designer dependant on the complexity and sensitivity of the scheme and receiving environment.



Level of information required for different parts of the planning process or types of planning application.

7.0 Stage 1 - Concept Design

SuDS Concept Design is used to express initial ideas for the management of rainfall within a development. It is also applied through masterplanning of Local Area Plans to ensure that sufficient consideration Is made for the conveyance and storage of rainfall runoff.

The retention and enhancement of existing features needs to be considered and assessed at the earliest possible stage of any proposed development. This approach cuts across many of the Council's other policies, objectives, plans and strategies;

- Developing climate resilient landscapes (Climate Change Action Plan)
- Retaining and enhancing existing ecological habitats and species (Biodiversity Action Plan)
- Enhancing ecological corridors through the site (Green Infrastructure Strategy)
- Providing opportunities for varied amenity provision (Parks and Open Space Strategy)

7.1 Objectives of SuDS Concept Design

Development of a SuDS Concept Design will ensure that SuDS opportunities are properly explored from the initial design stage.

Concept SuDS designs should seek to take advantage of the real opportunities that a site may already offer, rather than seeing a range of constraints that need to be overcome before a 'blank page' can be achieved on which the design can be developed.

The Concept Design plan and Preliminary Design Statement should be presented where discussions with SDCC are proposed at pre-application stage.

The development of surface water management strategies for Local Area Plans and masterplans will follow the SuDS concept design process.

7.2 Presentation of the Concept Design

The Concept Design information will usually be presented in two parts:

- a plan with all aspects of the design that can be shown graphically, and
- a short SuDS design statement including information such as hydraulic data providing an initial idea of storage volumes required and how these will be accommodated by the scheme layout.

The Concept Design will reflect the criteria and performance parameters set out in the Site Specific Flood Risk Assessment for the development (where present) along with the relevant policies within the Development Plan.

Key data and information will include:

- data to inform the design where relevant e.g. maps of site context, outline river, coastal and surface water flood risk, and ground water source protection zones
- a drawing to identify existing landscape and habitat features that may influence SuDS proposals
- information on utility services, as these may fundamentally affect the SuDS design, particularly on previously developed land or SuDS retrofit schemes
- a contour plan using the best source of topographical information available.

7.3 What Concept Design demonstrates

The SuDS Concept Design will enable the Designer to understand how proposed development will impact on:

- the site and its natural hydrology
- historical drainage elements where these are present
- the ecology of the site and its surroundings
- the landscape character of the locality
- natural flow routes.

Evaluation will begin with:

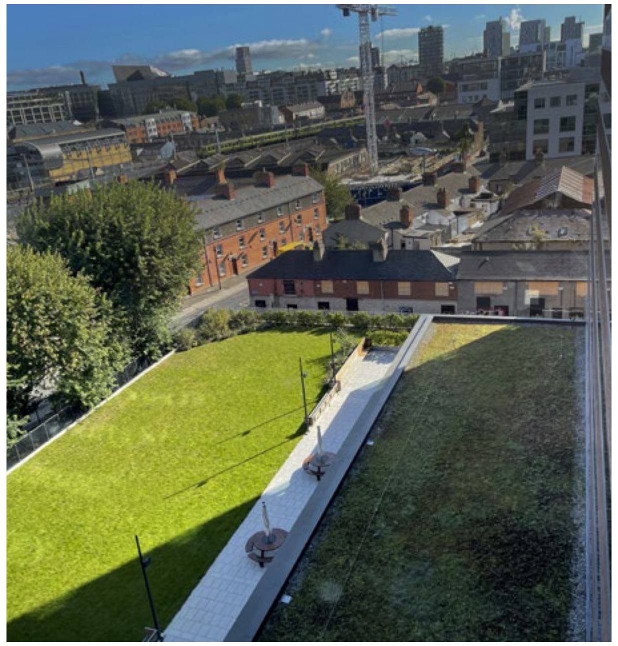
- existing flow route analysis for the existing site
- a modified flow route analysis for the proposed development.

Preliminary design will include:

- Runoff collection – how rainfall is collected and conveyed to source control features.
- Source control – runoff managed as close as possible to where rain falls.
- The management train – SuDS components and storage features linked in series, which convey flows along modified flow routes through the development.
- Sub-catchments – small discrete areas that manage their own runoff.
- Maintenance – effective performance and reasonable care costs.

Design note: As SuDS components don't hold water most of the time, avoid colouring them blue on plan. Blue is best used for denoting permanent water bodies, like ponds and wetlands.

Dublin biodiverse and amenity green roofs. Courtesy Dusty Gedge.



Concept Design

Concept Design

7.4 Concept Design process

7.4.1 Flow route analysis

The natural hydrology, and the way that a development affects how rainfall behaves on a site, are assessed initially by flow route analysis.

The first step in flow route analysis is to consider how a site behaves naturally before development. This analysis can be applied to re-development and retrofit sites and is informed largely by topography and geology. There may be a number of other factors influencing the analysis, including:

- historical drainage e.g. sewers or land drains
- discharge locations
- contamination issues
- existing landscape features
- habitat considerations.

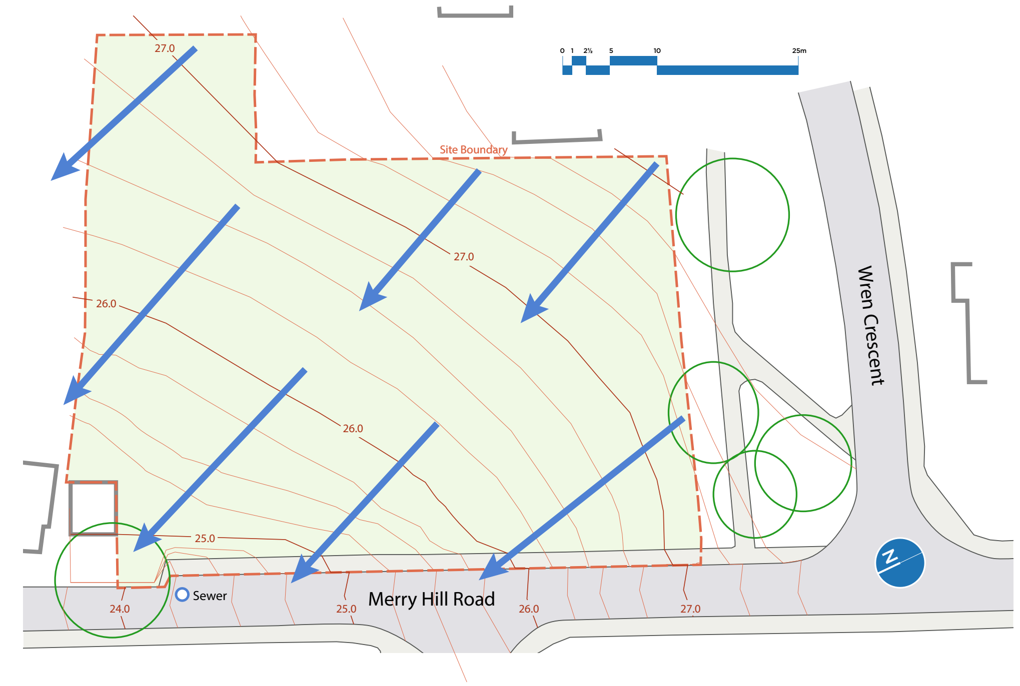
A topographical survey provides the basic template for determining existing and future flows. Geology indicates whether rainfall will flow from the site as runoff and / or infiltrate into the ground.

The site appraisal should consider what is happening on site in terms of water management particularly where existing habitats such as existing trees, hedgerows, wetland areas and open grassland are absorbing water. Development will bring further pressures on the natural systems already working on the site which appropriate SuDS measures should mimic and support.

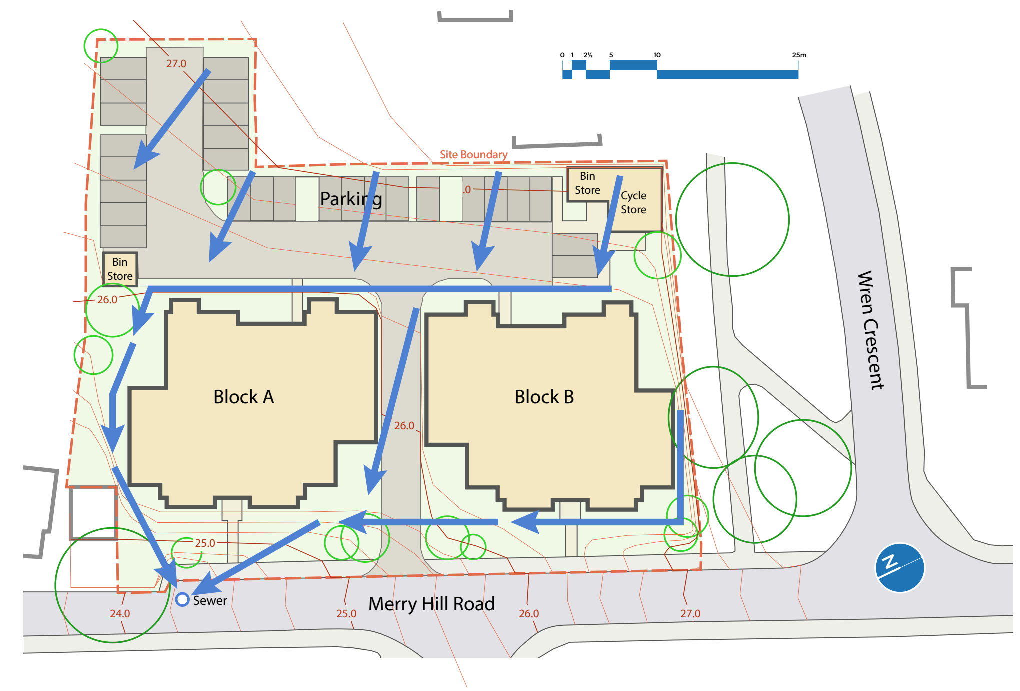
In highly urbanised areas of South Dublin the building often takes up the entire footprint of the site. Consideration as part of the modified flow route analysis should be given to how flows can be managed at or above ground level.

Design note: Designers should be mindful that a site that infiltrates naturally may not continue to infiltrate once it has been developed.

Existing flow route analysis



Modified flow route analysis



Concept Design

7.4.2 Building the management train

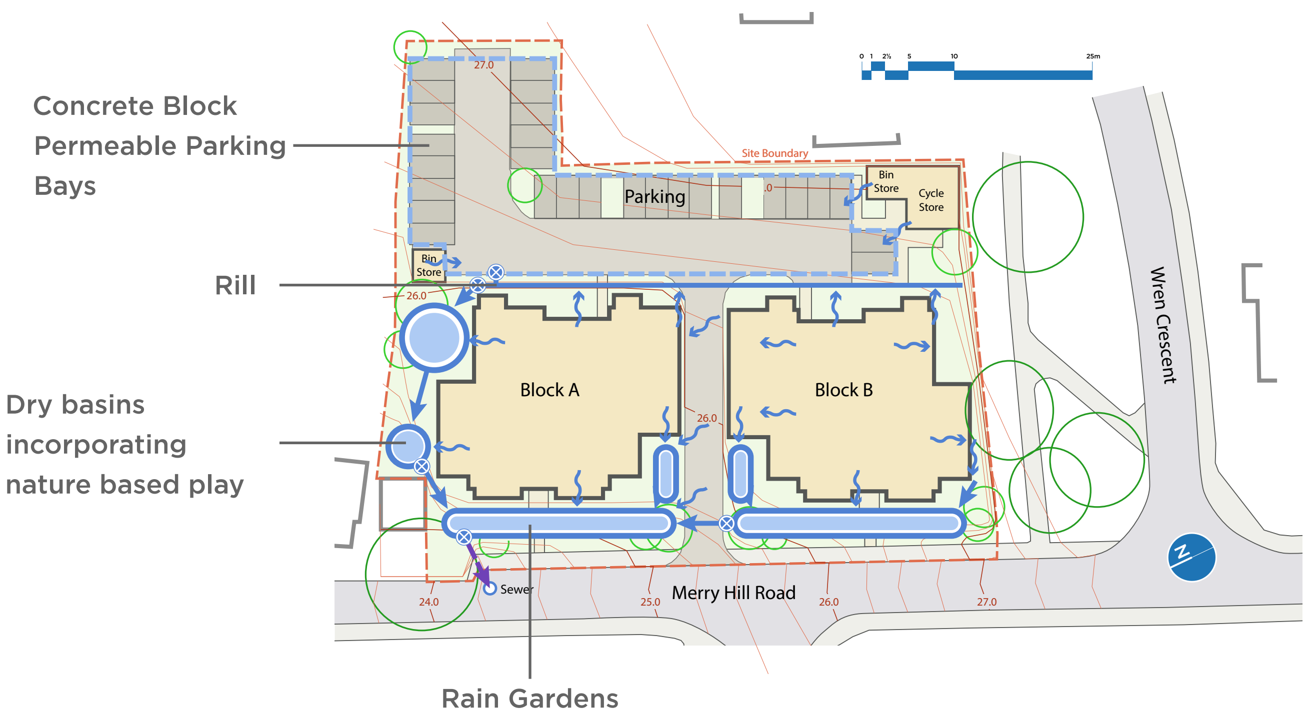
A management train begins with source control, and uses surface conveyance, wherever possible, to link subsequent SuDS components in series. Integration of the management train should be considered from the Concept Design stage and throughout the design process.

The management train provides potential for 'interception losses' along its whole length, as well as through soakage into the ground, evaporation, and transpiration through the leaves of vegetation. It also reduces the rate at which runoff flows through the site and provides treatment of runoff as it passes through each SuDS component.

Selecting SuDS components within the management train:

- **Source Controls**: green and blue roofs, permeable surfaces, filter strips, protected filter drains, together with swales and basins, provide the first stage of treatment, intercepting primary pollution and reducing runoff flow rates. Permeable surfaces can be used at source and will often store the whole attenuation volume for the site particularly on small sites negating the need for further storage.
- **Site Controls**: these features will normally be preceded by source controls and meet remaining storage requirements. Where the is insufficient storage at source, additional open conveyance and storage structures, such as basins and wetlands or ponds, will manage remaining runoff volumes on most sites.

Building a management train



7.4.3 Collection of rainfall runoff from hard surfaces

The way that runoff is collected from roofs, roads, car parks and other hard surfaces is a critical consideration in any SuDS design.

Conventional drainage techniques such as gully pots and pipes, take flows underground, so that management of runoff at or near the surface is more difficult to achieve.

Surface collection in channels, gutters and permeable pavements, or as sheet flow onto grass surfaces, keeps runoff at or near the surface, enabling cost-effective construction and maximising the opportunities for nature based SuDS.

Collection of runoff at or near the surface also reduces maintenance costs, and allows for simple removal of blockages.

Image shows Collection of 'sheetflow' rainfall runoff over flush kerb into a shallow swale. Strategic Housing Development, Newcastle, Co.Dublin

7.4.4 Source control – managing runoff at source

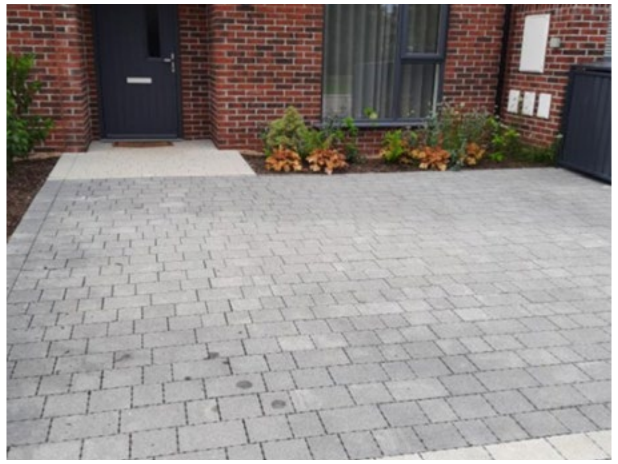
Source Control features include pervious surfaces, filter strips, green / blue roofs, SuDS treepits, raingardens, bioretention raingardens, basins and swales. Source control features slow the flow of runoff and remove pollution at the beginning of the management train.

Source control features protect the remaining parts of the management train, enhancing amenity and biodiversity within the development.

Providing Source control SuDS structures also ensures that SuDS components are less susceptible to erosion further down the management train, as runoff is not conveyed at peak flow rates along the system.

Design note: Source Control features, such as pervious pavements and blue-green roofs, can be designed to attenuate all of the 1 in 100 + CCA storage, with the introduction of a simple flow control device.

Permeable pavement managing runoff at source. Strategic Housing Development, Newcastle, Co.Dublin



7.4.5 Conveyance of runoff between SuDS components

Runoff should be conveyed along the management train at or near the surface wherever possible. The features commonly used for this purpose are swales or other vegetated channels and hard-surfaced channels such as rills, gutters or dished channels in a more urban context. Conveyance is also possible through permeable pavement sub-base as well as filter drains and under-drained swales.

Surface conveyance can provide the following benefits:

- a reduction in infrastructure costs
- increased interception losses
- treatment of pollution
- ease of maintenance
- easily understood SuDS operation – 'legibility'
- connectivity for wildlife
- attractive landscape features.

Where runoff is conveyed below ground through a pipe, for example connecting one SuDS component to the next to facilitate crossing under a road or pathway, the invert level of the pipe should be kept as shallow as possible to re-connect flow into surface SuDS features downstream without adversely affecting their depth. Pipes should ideally only be used as short connectors, without inspection chambers or bends, to reduce the risk of blockage and allow simple rodding or jetting when necessary.

Design note: Where shallow cover to pipework is proposed, this should be discussed with SDCC Roads Department to ensure that the proposed design will be structurally adequate.

The CIRIA SuDS manual (Page 876) notes that:

"SuDS design usually avoids use of below-ground structures such as gully pots, oil interceptors, and other sumps which are a wildlife hazard, often ineffective and expensive to maintain."

Identification of surface or shallow sub-surface conveyance at the Concept Design stage is important to ensure that these pathways are retained through the remaining design process.

Image shows shallow short piped connection under a driveway allowing the swale to remain shallow downslope.

7.4.6 Introducing sub-catchments

Many drainage designs adopt an approach where all flows are taken to the lowest point of the site and attenuated in a single location, often referred to as a 'pipe-to-pond' or 'pipe to box' approach.

The 'pipe to pond' approach can result in unsightly, polluted and sometimes hazardous pond or basin features that offer little amenity or wildlife benefit. The 'pipe to box' approach results in below-ground structures that provide no amenity or wildlife benefit at all. Where runoff is collected by pipe and conveyed directly to an attenuation tank or pond at the end of the system, the storage structure is likely to fill with silt over time and generate management problems.

When integrating SuDS into a development, the site should be divided into sub-catchments to maximise treatment and storage capacity.

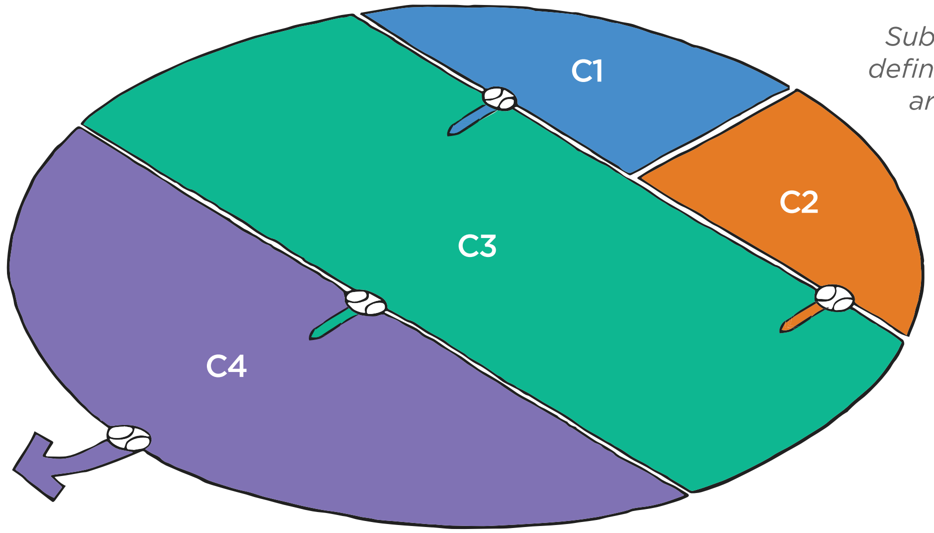
The sub-catchment boundary is usually defined as the surface area which drains to a particular flow control and can be considered as a mini-watershed.

Flows are conveyed from one sub-catchment to the next along one or more management trains, following the modified flow routes determined early in the design process.

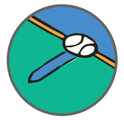
Each sub-catchment contributes flows to the following sub-catchment or to an outfall.

A flow control generally defines the downstream end of a sub-catchment, with the flow control situated at the lowest topographical point within the sub-catchment in locations that are accessible for inspection and maintenance.

Concept Design drawings should identify sub-catchment boundaries with associated storage and flow control locations throughout the development.



Sub-catchments are generally defined by flow controls. Flows are conveyed from one sub-catchment to the next.



Flow control with controlled discharge from one catchment to the next

Design note: Integrating storage within sub-catchments, as part of site layout, greatly reduces the land take requirement for attenuation, by exploiting the inherent storage capacity of individual SuDS features.

7.4.7 Managing pollution

The treatment required to mitigate pollution depends upon the level of pollution hazard. An adequate number (and type) of SuDS components is required to intercept or break down pollutants.

Source control components are introduced at the beginning of any management train to protect the development and meet amenity and biodiversity criteria within the site.

The following table is based on the requirements for discharge to surface waters set out in the SuDS Manual, Chapter 26, Water quality management: design methods, (CIRIA, 2015).

Image shows the effects of 'day to day' pollution.

Discharge to surface water (usually on impermeable soils)

Contributing Surface Type	Pollution Hazard Level	SuDS Components
Residential roofs	Very low	Discharge to any SuDS components
Normal commercial roofs	Low	Discharge to any SuDS components
Leachable metal roofs	Low but polluting	Bioretention or source control with one or two further SuDS components.
Driveways, residential, car parks, low traffic roads, low use car parks (schools and offices)	Low	Permeable pavement or source control with one SuDS component
Commercial yards, delivery areas, busy car parks, other low traffic roads (except trunk roads and motorways)	Medium	Permeable pavement or source control with one or two further SuDS components.
Haulage yard, lorry parks, waste sites, sites handling chemicals and fuels, industrial sites	High	Carry out detailed risk assessment and consult with the appropriate licencing authority.

Concept Design

Additional levels of treatment may be required where surface water discharges to protected waters or areas of environment sensitivity.

The Regional Spatial and Economic Strategy (RPO 7.15) states:

*'Local authorities shall take opportunities to enhance biodiversity and amenities and to **ensure the protection of environmentally sensitive sites and habitats, including where flood risk management measures are planned**.'*

Where potential for infiltration exists, additional considerations may be required

- Low pollution hazard level developments with infiltrating soils can be referenced in table 26.4 of the 2015 SuDS Manual (CIRIA C753). .
- Medium pollution hazard level developments will require risk screening to determine appropriate mitigation measures. Refer to table 26.5 and 26.6 of the 2015 SuDS Manual.

7.4.8 Method of discharge – how rainfall leaves the site

The way that rainfall leaves a development should follow the preferred hierarchy of

- rainwater harvesting
- infiltration
- watercourse
- surface water sewer
- combined sewer

Rainfall should not discharge into the foul sewer.

Depending on the site characteristics, drainage from different parts of the site can have different means of discharge.

7.4.9 Preliminary flow and volume calculations

It is convenient to consider flow and volume requirements at this stage in the design process to ensure that natural losses are replicated, and sufficient volumes of runoff can be temporarily accommodated to allow for discharge from site via a flow control and/or infiltration.

Storage volumes are usually presented as a single volume for the entire site. This form of expression encourages the 'pipe to pond' practice and prevents simple comparison of storage values between similar sites.

Concept Design

SDCC SuDS Explanatory, Design and Evaluation Guide
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Expressing storage as 'volume per m²' allows the designer to allocate storage throughout a site in discrete sub-catchments and provides a straightforward way for SDCC to check that calculated storage volumes are as anticipated.

Example – A 10000m² development is calculated to require 600m³ of attenuation storage. .

m^3 (for the entire site)	m^3/ of runoff stored /m^2 of development	mm depth of runoff stored / m^2 of development
600	0.06	60

Ideally each sub-catchment will manage its own runoff up to the 1-in-100 year return period rainfall event. Where this is not viable, part of the storage volume will be provided depending upon the opportunities for storage within the subcatchment, with all residual flows cascaded into an adjacent sub-catchment or 'site control'.

This approach maximises the opportunity for storage throughout the development.

7.4.10 Infiltration

After any allowances have been made for the potential to harvest runoff, the next consideration in managing flows and volumes is to assess the ability of a site to infiltrate rainfall completely, partially, or discharge largely as runoff.

The ability of a site to infiltrate water should be evaluated considering:

- the nature of the soil geology and capacity to infiltrate
- the risk to stability of the ground where infiltration is proposed
- the risk of pollution to groundwater
- the depth of seasonal groundwater
- the risk of unpredictable pathways being taken by infiltrating water.
- potential ingress to combined or foul sewers.

Building Regulations Part H indicates that:

Soakaways should not be constructed within 5m of a building or road or in areas of unstable land.

This 'rule' is usually applied where infiltration within the 5m offset from the foundation is not permitted. The 5m guidance was originally intended for **point infiltration 'soakaways'** in susceptible soils and near structures. SuDS design encourages '**blanket infiltration**' features that are less likely to affect soil conditions, as they mimic grass surfaces around buildings. For blanket infiltration the geotechnical risk is greatly reduced and the distance offset for infiltration from adjacent buildings or structures will be at the professional judgment of a suitably qualified engineer.

Additional site investigations will be necessary to assess risks associated with infiltration, and design / assessment should follow guidance in the CIRIA SuDS Manual 2015, Chapter 25 p543.

Using SuDS Close to Building

Risks Associated with Infiltration: CIRIA SuDS Manual 2015, Chapter 25

7.4.11 Managing runoff from site

If the site does not infiltrate effectively over all return periods, then rainfall will leave the site as outflow to a watercourse, surface water sewer or combined sewer.

New hard surfaces that are introduced through development increase both the rate and volume of runoff. This is because runoff flows more quickly from the site, and natural losses do not happen as they did before development. **Attenuation storage** is required when the rate of runoff being generated by a rainfall running off a developed surface (**inflow**) is greater than the flow control rate (**outflow**).

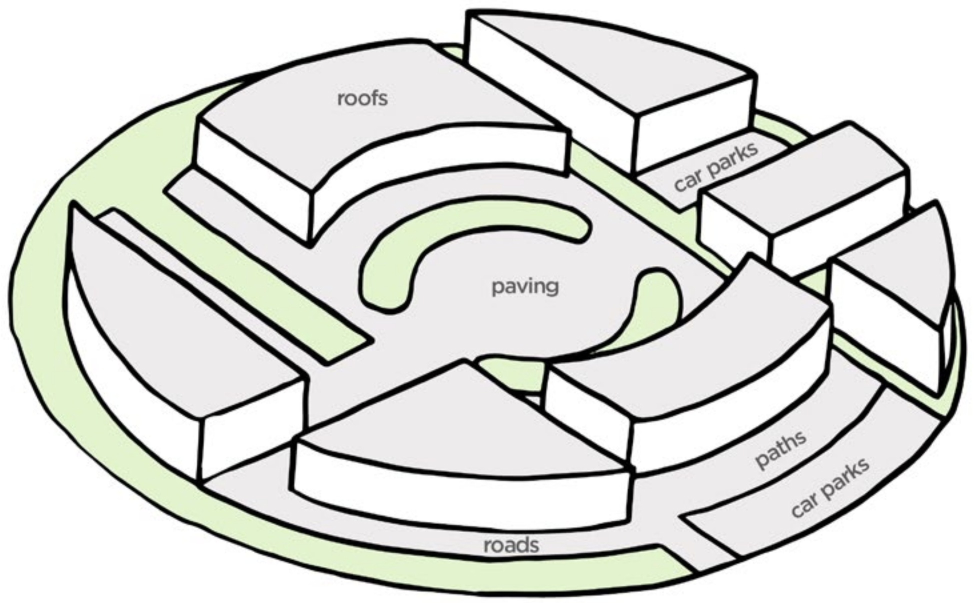
Design note: The website www.uksuds.com provides estimation tools for the calculation of 'greenfield runoff rates', 'attenuation' volumes and 'long-term storage' volume losses.

7.4.12 Defining areas of runoff

The inflow to the drainage system is calculated by multiplying the design rainfall by the developed area.

The area of development may change during the design process, but it is important to have an initial estimate of the amount of storage, to inform the layout of the SuDS design.

The area generating increased runoff is the developed area of the site, and comprises roofs and hard surfaces (roads, car parks, paving, footpaths etc.) proposed for the site. Permeable surfaces should also be accounted for within calculations where they connect to the drainage system.



Concept Design

7.4.13 Defining flow control rates

The maximum outflow from the site will be controlled to greenfield runoff rates (discharge is to the surface water sewer / watercourse) or 2l/s/ha (discharge to a combined sewer). **Qbar** and **Qmed** are terms used to describe the average Greenfield runoff rate.

Rainfall runoff is required to be managed (attenuated and contained on site) up to the 1 in 100 year rainfall event with allowance for climate change and urban creep. The term '1 in 100 year rainfall event' is used to define rainfall (intensity and duration) that statistically has a 1% chance of occurring in any given year. This can also be expressed as a 1 in 100 year event or 1% Annual Event Probability (AEP).

Discharge from the SuDS feature is restricted by a '**flow control**' which allows the stored water to drain down slowly.

Flow Control Discharge Limits

	1-in-1 year rainfall (maximum outflow rate)l	1-in-100 year rainfall (maximum outflow rate)	Long term storage-volume control
Discharge to a combined sewer	2 l/s/ha	2 l/s/ha	No
Discharge to a surface water sewer or watercourse GDSDS Criterion 4.3	Qbar / Qmed or 2l/s/ha whichever is the greater	Qbar / Qmed or 2l/s/ha whichever is the greater	No
Discharge to a surface water sewer or watercourse GDSDS Criterion 2.1, 2.2, 4.1, 4.2	1 in 1 year greenfield rate	1 in 100 year greenfield rate	Yes

7.4.14 Initial storage calculations

The approach to managing flows and volumes from developments - set out previously in the GDSDS seeks to minimise the impact of the additional volume and rate of rainfall runoff generated by development to pre-development patterns.

Estimating the volume of runoff to be stored on site at concept stage will ensure that this aspect can be considered in the development of site layout and locating of SuDS storage.

A useful online tool for estimating Greenfield runoff rates for concept design stage can be found at **www.uksuds.com**. SAAR values should be sourced from Met Eireann (See Section 8.4.6). Soil values should be based upon site investigation (where available).

Calculations will need to be re-assessed in latter design stages as the scheme design develops.

In SuDS design it is useful to use a range of return periods to identify everyday rainfall (e.g. 1 in 1 or 1 in 2 year events), occasional rainfall (e.g. 1 in 10 year events) and exceptional rainfall (e.g. 1 in 30 or 1 in 100 year events). This enables the allocation of different volumes in different places and encourages the use of sub-catchment design.

7.4.15 Long term storage

SuDS design seeks to mimic the natural losses that occur across natural catchments. The volume of post development runoff should match that of the natural catchment.

Some of the volume losses can be mimicked by using SuDS components to demonstrate interception losses and ongoing losses (Long Term Storage). Other methods such as rainwater harvesting will further reduce the additional volume of rainfall runoff generated by the development.

Design note: Storage volumes derived at Concept Design stage will be approximate and should demonstrate that the scheme is sensibly proportioned. The Designer should identify how attenuation storage will be distributed across the site at concept design stage.

Concept Design

7.5 Integrating SuDS as part of the development

Designers should consider opportunities within the fabric of the building, within public open space and as part of the streetscape to provide collection, treatment and storage of surface runoff prior to controlled release.

7.5.1 Integrating SuDS as part of building fabric

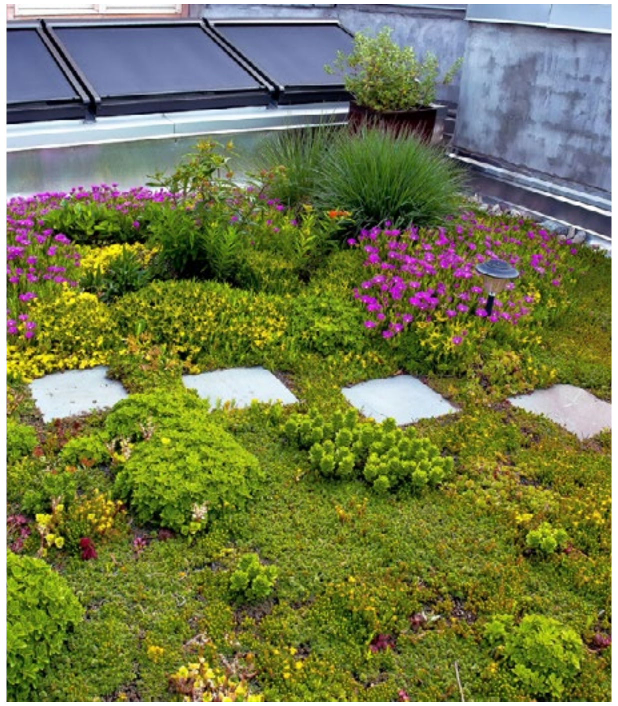
On very high density developments particularly where the building takes up most or all of the footprint of the site, opportunities for storage of rainfall runoff as part of the building fabric will need to be utilised. The primary opportunities for storage will be part of green blue roofs, within permeable surfaces and as part of raised planters and tree pits.

Permeable pavement courtyard constructed over a podium deck.

7.5.2 SuDS as part of streetscape

The methods that are used to collect and treat runoff such as permeable pavement, SuDS treepits and bioretention should also be considered for potential attenuation storage. Simple flow controls such as orifice plates can be placed on the outlets from these systems, as the filtering mechanism through the system ensures that the outlet is protected from blockage.

*Green roofs can attenuate rainfall runoff where the outlet has a flow control (**Blue roof**).*



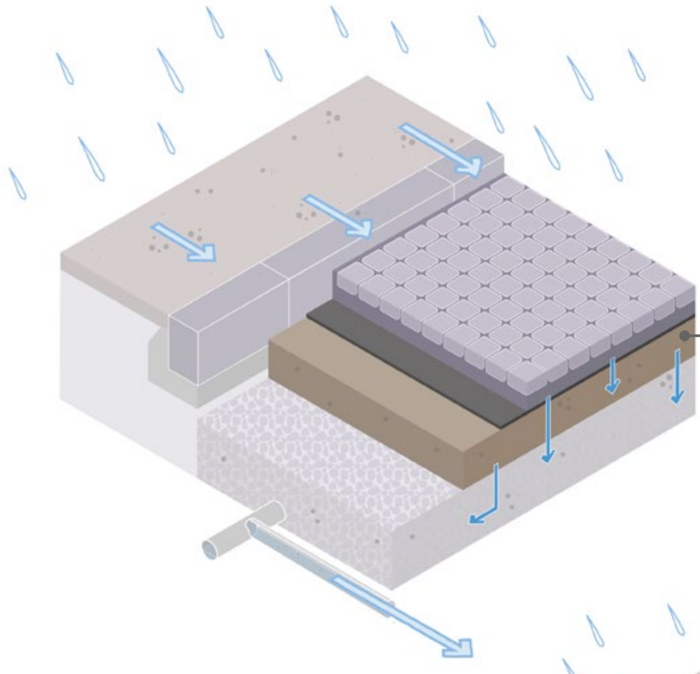


Diagram of a permeable paving

Diagram of a bioretention raingarden

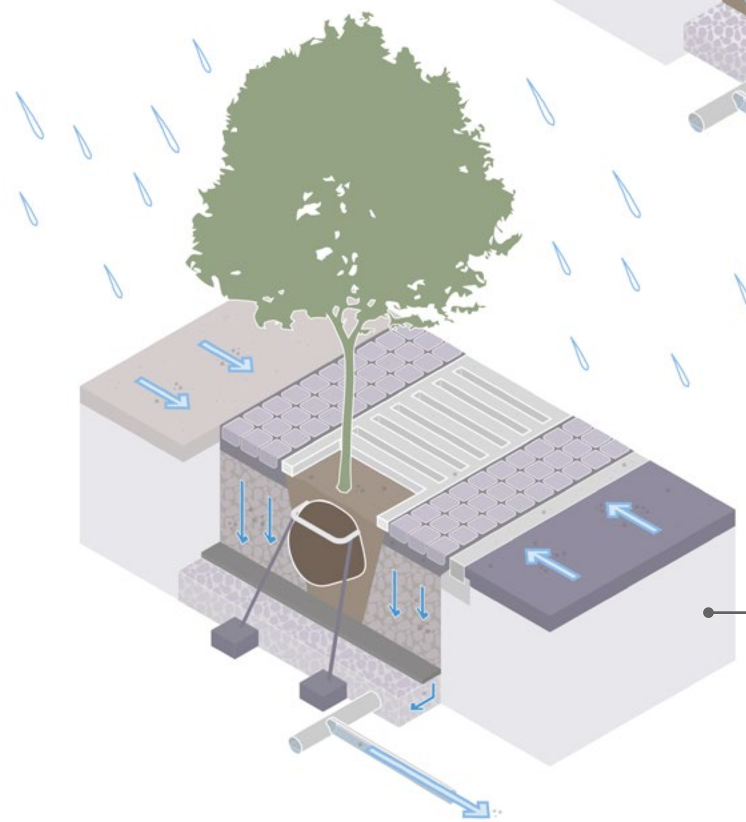


Diagram of a SuDS tree pit

7.5.3 SuDS as part of public open space

SDCC development Plan states that:

"proposed SuDS measures are only accepted as an element of public open space where they are natural in form and integrate well into the open space landscape supporting a wider amenity and biodiversity value". (Policy COS5 Objective 12)

SuDS basin used for informal play by children. Basin has a low flow channel and majority of the basin remains dry for vast majority of the time.

7.6 Local Area Plans & Masterplanning

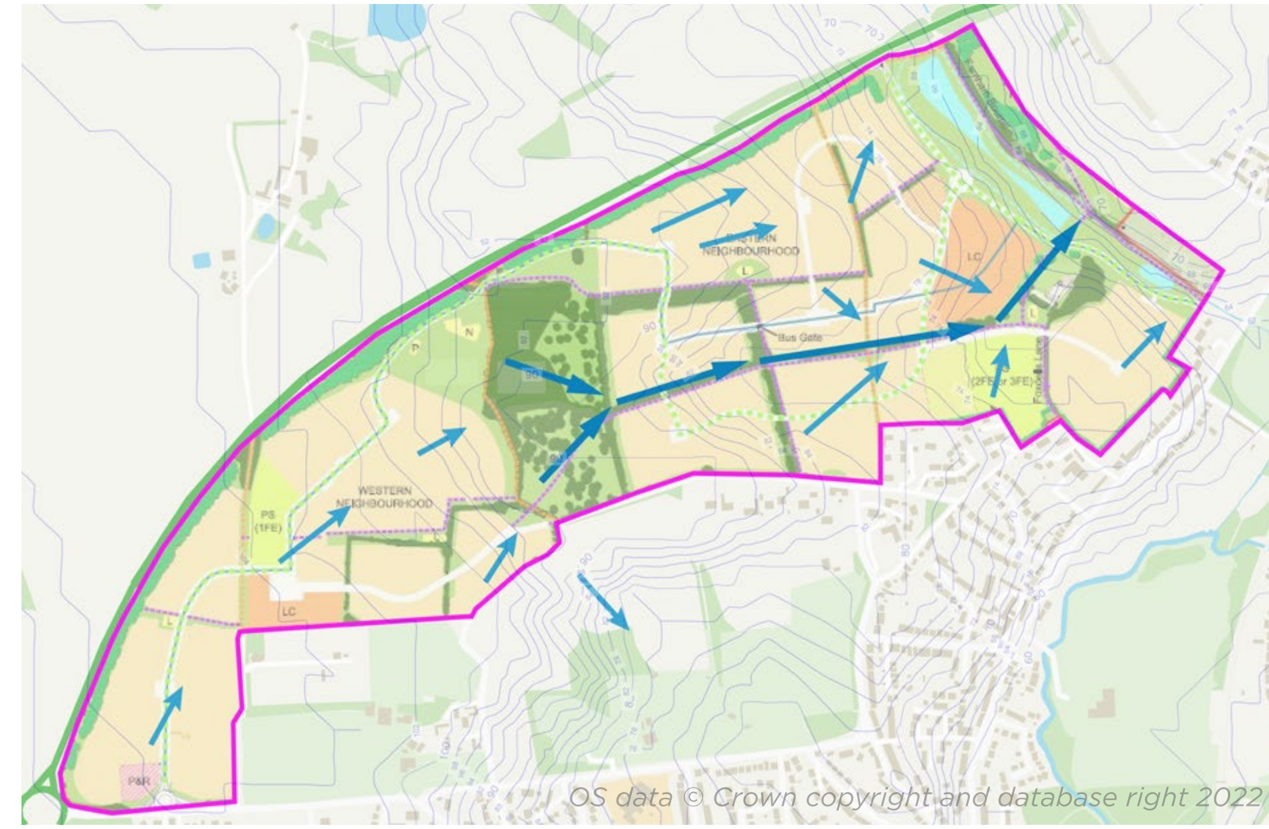
The development of surface water management strategies for LAPs and masterplans will follow the SuDS concept design process.

The natural hydrology and existing site characteristics should be assessed through flow route analysis to determine how the Plan Area behaves naturally before development. The SuDS design will have to consider how flows along these flow paths will be managed.

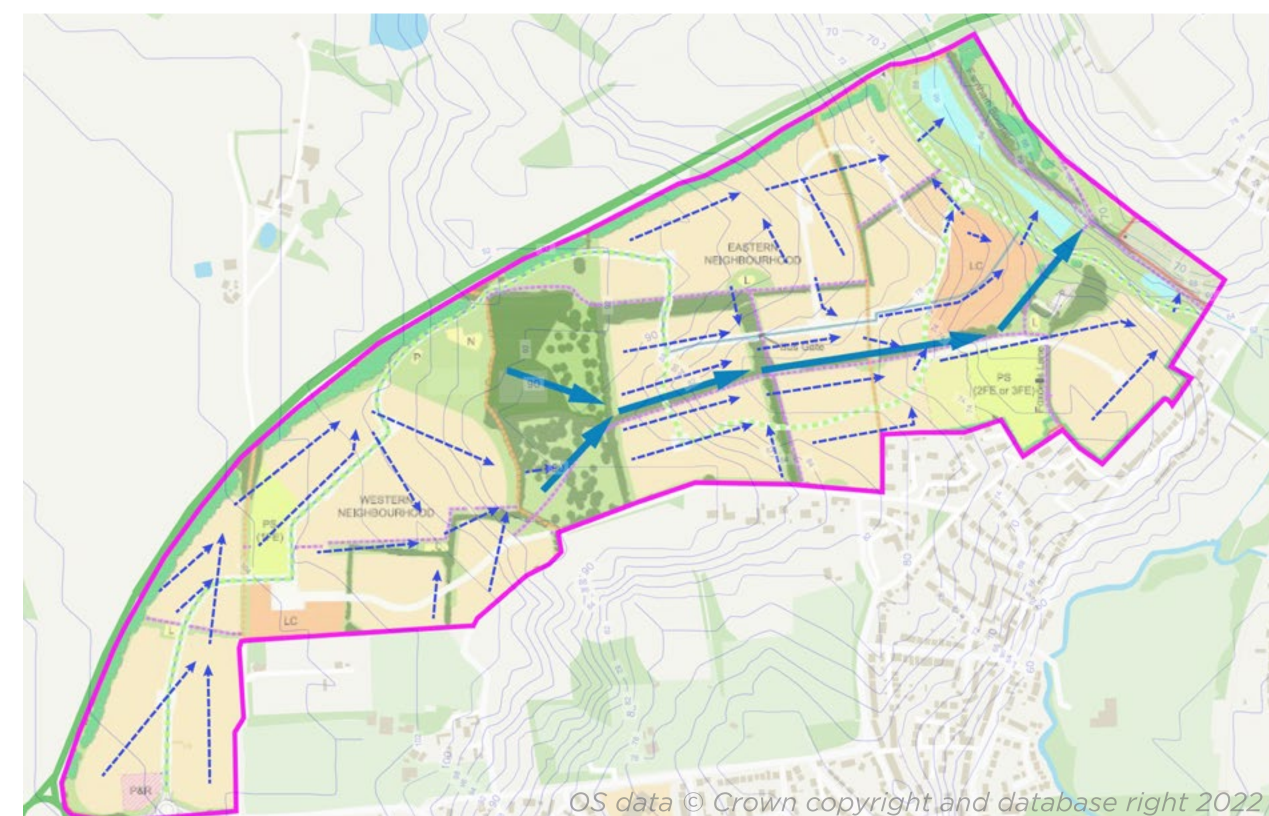
The modified flow route analysis is the basis for low flow conveyance, overflow arrangements and exceedance routes when design criteria are exceeded. The modified flow routes have been assessed in conjunction with the preliminary Plan Area layout and inform the concept SuDS design by suggesting a preferential flow path through the Plan Area.

Amenity and biodiversity site specific considerations should be identified which may further influence the modified flow routes.

Existing flow route analysis



Modified flow route analysis

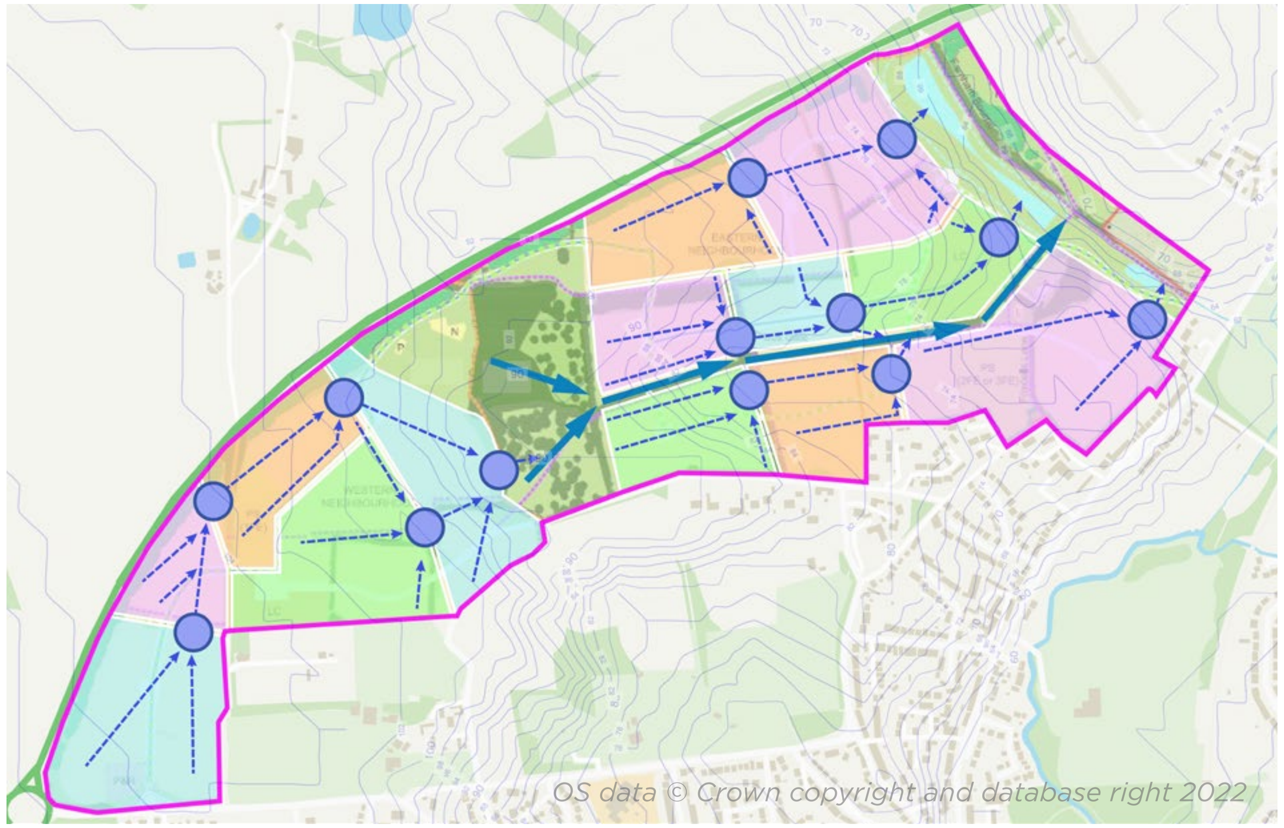


Runoff from the Plan Area should be managed within subcatchments using natural overland conveyance. Flows will be conveyed from one subcatchment to the next along one or more management trains, following the modified flow routes. A comprehensive review of potential SuDS components relative to Plan Area characteristics should be undertaken to identify appropriate SuDS techniques at an early stage to be taken through the design process.

The Plan should identify any specific requirements pertinent to the future development and development of a SuDS design. Considerations should cover;

- Criteria or standards that the SuDS design should comply with
- Provisions for ownership and maintenance of the SuDS features
- Identification of any protected areas
- Identification of any site specific constraints (floodplains or presence of utilities etc.) known at this stage.

Identifying subcatchments and storage locations



7.7 Evaluating SuDS Concept Design

The information that the designer will collate at Concept Design stage will depend on the type and scope of the proposed development. The designer should check that all opportunities for SuDS have been explored and that the design will satisfy SDCC Development Plan policy requirements prior to developing the design to outline / detailed design status.

7.7.1 Preliminary water quantity considerations

At the Concept Design stage, it is necessary to show how runoff is collected and how it is stored within the development:

- The designer should determine how volumes of runoff will be managed to ensure no unmanageable flood risk on site and no increase in flood risk elsewhere.
- Approximate storage volumes should be identified for each location where flows are attenuated.
- Storage will be identified within sub-catchments and along the management train, with the location of flow controls confirmed.

Design note: Ideally runoff should be stored in shallow landscape features or within permeable surfaces. Where this is not possible, deeper tank or pipe storage must be robustly justified.

7.7.2 Preliminary water quality considerations

At Concept Design stage it is necessary to show how water quality is managed:

- A simple assessment of risk using the 'treatment stage' approach is acceptable on low and medium risk development. If the risk screening (SuDS Manual p571) demonstrates that the 'simple index approach' is appropriate, then the 'treatment stage' is acceptable.
- All sites should demonstrate source control to remove silt, heavy metals and hydrocarbon pollution at the beginning of the management train.
- Unless permeable pavement is used to collect runoff, where the pavement provides high water quality treatment, there will usually be a second feature to manage additional volumes and provide additional treatment.

The design will also consider:

- Sensitivity of the receiving watercourse or groundwater.
- Environmental and technical constraints such as contamination, protected landscapes, SSSI, SAC, nature reserves and existing biodiversity features.
- SDCC will not accept the gully pot as a method of treatment. Table 26.15 of the CIRIA SuDS Manual denotes that conventional gully and pipe drainage provide zero treatment.

7.7.3 Preliminary amenity considerations

Amenity relates both to the usefulness and the appearance of SuDS features. Ideally SuDS features should be integrated into the landscape, to minimise dedicated land take and management obligations.

Key amenity elements to consider when designing SuDS features include:

- **Legibility** – can the design be understood by users and managers? Information signs can be used to further enhance understanding, particularly where there is a lack of understanding of SuDS.
- **Accessibility** – can all parts of the SuDS scheme be easily reached, both for recreation and maintenance? All parts of the scheme must be safe by design. It is not usually appropriate to fence SuDS features for safety reasons (except toddler fences where young children may not be fully supervised).
- **Multi-functionality** – all parts of the SuDS landscape should be available for use by people when not performing a SuDS function.
- **Visual character** – all elements of the SuDS design should be attractive (or at least visually neutral, e.g. inlets, outlets and control structures) and safe.

Image shows swale (linear basin) with potential for storing rainfall runoff (Tandys Lane Park, Adamstown)

Image shows example of an inlet

Image shows example of an outlet

7.7.4 Preliminary biodiversity considerations

There are key biodiversity requirements that should be demonstrated at the Concept Design stage:

- **Clean water** – 'a controlled flow of clean water' is provided by the use of source control at the beginning of the management train. Subsequent surface conveyance and open SuDS features will ensure connectivity and habitat opportunities.
- **Connectivity** - habitat connections outside and within the development ensure that plants and animals can travel between habitat areas.
- **Topographical diversity** – variation in vertical and horizontal structure allows for complex habitat development. This is implicit in SuDS design, e.g. swales, basins, ponds and wetlands.
- **Ecological design** - the creation of habitats within the development.
- **Sympathetic management** – through considered management, a mosaic of habitat types can be created, ensuring maximum ecological value.

7.7.5 Management and maintenance

It is important to consider a realistic and appropriate level of ongoing maintenance at the Concept Design stage.

SuDS features that require specialist maintenance, hazardous waste removal or replacement of component parts should be avoided.

Most landscape-based SuDS treat organic pollutants passively through natural processes. This approach encourages the continual breakdown of organic pollutants throughout the design life of the SuDS.

Source control is critical to passive maintenance as silt, heavy metals and heavy oils are trapped at the beginning of the management train where they can easily be removed and will not contaminate SuDS features further down the train. This can enhance amenity and biodiversity potential.

Landscape-based SuDS techniques and surface conveyance ensures that ongoing care can be provided as part of everyday site maintenance by landscape contractors, grounds or park maintenance crews, caretakers or even by residents themselves.

Image showing potential landscape maintenance for SuDS raingarden

7.8 Pre-application discussion

Pre-application discussion with the SDCC is recommended for all LAPs and Masterplan sites.

The design team will provide a Concept Design for a pre-application meeting.

Pre-application meetings provide an opportunity for the designer to confirm the preliminary requirements for the SuDS design, and for SDCC to understand the objectives and character of the SuDS proposed for the development.

Constructive discussion between SDCC and the SuDS designer will save the developer time and the cost of potential re-design, providing planners with reassurance that the project that is delivered will meet local planning expectations.

7.9 Designers Checklist for Concept Design Stage

The following list serves as a useful guide to designers to ensure that the concept design has been properly developed to meet requirements of SDCC Development Plan prior to advancing to outline design stage.

Information required	Rationale
1. Data gathering	
Information to understand site parameters including geology, topography, flood risk, utilities, landscape context, community and wildlife	To understand site constraints that inform Concept Design
Planning requirements that influence SuDS design	To be aware of planning constraints that impact SuDS design
2. Flow route analysis	
Existing flow routes	To understand site hydrology
Modified flow routes	To understand the impact of development
3. General SuDS design elements	
Collection of rainfall runoff	Runoff retained at or near the surface
Source control	Primary treatment stage to protect the development
Conveyance	At or near the surface
Management train	SuDS components in series to manage quantity and quality
Sub-catchments	Dividing development into discreet parcels of land each with a SuDS component
Storage	Indicate extent and location where runoff is stored
Flow control	Location to demonstrate storage location
Outfall	Locations and method of discharge
4. Quantity	
Confirm interception losses will occur	Demonstrate the use of SuDS components that provide interception losses
Confirm how rate of flow from development will be reduced to Greenfield runoff rates	Demonstrate restricted flow rates are achievable. Increase in allowable discharge rates where direct discharge is made to estuary or sea will only be permitted in agreement with SDCC Drainage Department
Confirm how runoff will be managed to Greenfield runoff volumes	Demonstrate that scale of SuDS will be sufficient to deal with volumes generated
Confirm climate change allowance and whether urban creep is applied	Demonstrate additional volumes to be managed

Information required	Rationale
Confirm 'long term storage'	Demonstrate no increase in runoff from pre-development status
5. Quality	
Confirm 'treatment stage' requirements	Demonstrate SuDS components used in series to mitigate 'pollution hazard level'
Confirm source control is present	Demonstrate protection of development to enable amenity and biodiversity benefits
Confirm interception losses	Demonstrate everyday pollution retained on site
6. Amenity	
Legibility	An understanding of how the SuDS function by people using or managing the site
Accessibility	All parts of the SuDS easily reached and safe for recreation and maintenance. Safety by design.
Multi-functionality	All parts of the SuDS landscape usable whenever possible
Visual character	All elements of the SuDS design attractive (or at least visually neutral, e.g., inlets, outlets, and control structures) and safe
7. Biodiversity	
Clean water	'A controlled flow of clean water' within and outside the site using 'source control' and the 'management train'
Connectivity	Links to outside and within development to ensure plants and animals can travel between habitat areas
Topographical diversity	Variable vertical and horizontal structures for complex habitat development
Habitat creation	Exploit opportunities through ecological design
Sympathetic management	Create a mosaic of habitat types through maintenance

Bord Gais green roof, Dublin.
Denis Byrne Architects.

8.0 Stage 2 - Outline Design

Outline Design bridges the gap between Concept Design and Detailed Design and may require additional information from that considered at concept stage, to ensure that all aspects of the design are fully considered.

Outline design is the minimum level of detail required to assess drainage aspects within planning applications.

8.1 Objectives of SuDS Outline Design

SuDS Outline Design builds on the ideas introduced in Concept Design taking into account responses from stakeholders. Outline design provides sufficient detail to demonstrate that the scheme can be successfully delivered.

Outline SuDS Design should clearly demonstrate how the SuDS design adheres with SDCC Development Plan policies. The SuDS design should outline how requirements for quantity, quality, amenity and biodiversity have been met and how the SuDS scheme is integrated into the wider development.

Design note: Outline design is the minimum level of detail which would be expected to support a planning submission and will be requested as further information where it is not presented with the original application.

8.2 What Outline Design should demonstrate

Outline Design will confirm how the SuDS will function, the scale, depth, relative levels, appearance and character of the SuDS as well as the practicality of the design by demonstrating:

- appropriate response to site conditions, constraints and opportunities relating to SuDS
- the layout reflects the Modified Flow Route analysis
- the design will show the appearance of the site and how the site will function
- how runoff is collected, the use of source control and the integration of management train into site layout
- how SuDS design complies with GDSDS hydraulic criterion (see Section 5.3)
- the design will be developed to a stage that confirms it can be constructed practically and can be managed and maintained at reasonable cost.
- SuDS components are designed to SDCC taken in charge standards where SuDS are proposed in areas to be taken in charge

Case study: Dense housing development

This housing development, comprising predominantly 4-10 storey high apartment blocks, workshop and community space, and associated public realm.

The overall attenuation volume, managing the 1 in 10 (+20% CCA) rainfall event, for the 7300m² developed area is 585m³.

The attenuation of runoff from all roof areas is managed by blue-green roof areas which comprise the majority of roofs in the development. Collectively these provide 235m³ of attenuation volume dramatically relieving pressure on the ground level landscape to attenuate runoff and eliminating the need for geocellular tank storage. This has been estimated to have saved the project approximately €800,000.

The remaining attenuation is provided by permeable paving and raingardens within the soft landscape areas.

Designs should demonstrate that they deliver the Four Pillars Of SuDS - water quantity, water quality, amenity and biodiversity - and this scheme is an example of how this can be achieved in dense urban developments.

8.2.1 Developing an outline design

Limited information may be available at Concept Design Stage and must be augmented to provide a full understanding of the site at Outline Design. The additional information required at Outline Design stage will depend on whether a Concept Design has been undertaken and the level of information already collated. Where concept design has not been completed then designers should refer to the Concept Design section of this Guide to ensure that the SuDS design is approached correctly.

The following information should be collated to evaluate site constraints and inform SuDS design:

- Existing services, including location and depth. These can influence layout, depth and placement of SuDS features.
- Planning policy, for example SuDS in designated Architectural Conservation Area (ACA) and conservation areas, which may influence choice of SuDS components and the use of materials.
- Ownership and future management of SuDS will influence component selection, typically where the structure is taken in charge by SDCC.
- Consents affecting off-site and on-site elements of the SuDS (proposed way-leaves and land transfers).
- Confirmation of the method of discharge: infiltration or runoff to a watercourse or sewer and impact of runoff volumes on the site. Infiltration test results are required to demonstrate potential for infiltration where this is proposed. Any discharge should be agreed in principle with the relevant authority.
- Confirmation of ownership and maintenance arrangements would be subject to a planning condition.

8.3 Design criteria

Quantity

The designer should **confirm**:

- existing drainage patterns, natural and modified flow routes
- an appropriate means of discharge(s) following the discharge hierarchy as set out in Section 5.2
- how flow rates and volumes will be managed
- contributing area of impermeable hard surface
- sub-catchment extents
- flow control locations
- storage locations and volumes to appropriate flow rates and rainfall return periods
- overflow arrangements from each storage location
- exceedance routing when design volumes are exceeded, or flows are generated from outside the site
- allowances for climate change and urban creep.

Quality

The designer should **demonstrate**:

- there are sufficient SuDS surfaces to meet interception losses requirements (no runoff from site for rainfall depths up to 5mm for the majority of rainfall events)
- sufficient treatment is available to manage pollution risk along the management train
- how spillage could be managed
- how runoff could be managed during construction.

Amenity

The designer should **demonstrate**:

- the SuDS is understandable to people using the site and maintenance personnel – this can generally be achieved by having SuDS at or close to surface
- the site is generally accessible to people, safe by design and adopts the 'general principles of prevention'
- the visual character of the SuDS will enhance the development
- spaces and connecting routes are multi-functional and can be used when not providing a SuDS function for rainfall management.

Biodiversity

The designer should **demonstrate**:

- confirm that water is clean as soon as possible along the management train using the principle of source control
- demonstrate water is kept at or near the surface as it flows from the beginning to the end of the SuDS management train and then onwards to the wider landscape, to ensure habitat connectivity
- demonstrate ecological design and the creation of habitats within the SuDS corridor
- confirm 'management practices' to enhance habitat development during maintenance.

Outline Design

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8.4 Designing for hydraulic requirements

Development causes an increase in runoff which increases the risk of flooding on site and elsewhere. Where runoff is temporarily stored it allows for a controlled release either into the ground or into a watercourse or sewer.

The storage volume required can be estimated using information such as the local rainfall characteristics and the rate at which flow is controlled to leaving the site. Expressing calculation outputs in an understandable format allows for easy application within the design process as well as transparency for evaluation.

8.4.1 Objectives of hydraulic calculations

Hydraulic calculations can:

- inform and validate the SuDS design
- provide confidence that there is sufficient capacity to cater for the additional runoff generated by the development to desired design standards
- make allowance for unknown factors such as runoff from off-site
- provide confidence that SuDS will function hydraulically and will not be prone to erosion.

8.4.2 What calculations should demonstrate

Designers should demonstrate through the calculation process:

- how the rates and volumes of runoff generated from development will not pose a flood risk within site boundary or elsewhere
- that future impacts to runoff such as climate change and urban creep are accounted for
- that the correct calculation inputs and methods have been used
- where exceptional flows are experienced, such as; design exceedance, instances of blockage, or flows from offsite, they can be managed without causing unreasonable risk to humans or development.

8.4.3 Calculation processes

Calculations outputs should always be viewed as an estimate of what is experienced in reality. Outputs will vary depending upon how inputs are selected and the calculation process used.

The calculations for SuDS design are used to assess aspects outlined in the following table:

Calculation process	Purpose of calculation	Main calculation inputs
Greenfield runoff rate - site estimate	Used to define flow control rate	Local rainfall data; site area; soil characteristics.
Attenuation storage or infiltration storage estimate.	The runoff generated by the site is balanced against the controlled rate of outflow.	Local rainfall data; site area; proposed site impermeable area; climate and creep allowances; infiltration rates; soil characteristics; discharge rate(s).
Long term storage estimate	Determining the difference in the volume of runoff between pre-development and post development scenarios	Local rainfall data; site area; existing site impermeable area; proposed site impermeable area; infiltration rates; soil characteristics; rain harvest volume, losses provide by SuDS, proposed discharge rate(s).
Flow velocity check	Flow velocity calculated to ensure: Conveyance along vegetated channels do not cause erosion during peak rainfall events. Low flow velocities for 1-in-1 year rainfall to allow settlement of silt.	Component sectional geometry; component gradient; component surface type (roughness); estimated flow rates.

Outline Design

8.4.4 Calculating storage requirements

The additional rainfall runoff generated by development should be managed (in order of preference) by harvesting for later reuse, infiltration back to ground or controlled flow discharge to a watercourse or sewer.

Much of the region is underlain by Dublin boulder clay and is unlikely to provide suitable conditions for full infiltration. However, unlined storage may deliver partial infiltration and can contribute to long term losses.

Both infiltration and attenuation require storage within the development to hold water long enough to be discharged either into the ground or through flow-controlled discharge to a watercourse or sewer.

The storage required will be determined by calculation. Calculation outputs are influenced by a number of factors such as defining area drained, runoff coefficients, flow control method, climate change allowance and urban creep. These factors must be carefully considered as part of the calculation process.

Sections 7.4.8-7.4.15 cover the basics of infiltration and attenuation storage calculation and should be referred to prior to progressing with this section where calculation inputs are considered in more detail.

8.4.4.1 Defining runoff coefficients (Cv)

The percentage of rainfall that occurs as runoff from a surface is called the **'coefficient of volumetric runoff' (Cv)**. In extreme rainfall conditions the losses anticipated from hard development surfaces such as roofs or paved areas are anticipated to be minimal. Runoff coefficients of 0.95 for roofs and 0.9 for paved areas would be considered acceptable by SDCC where no more detailed assessment is undertaken.

The designer must evaluate the runoff coefficient (Cv) for the types of surfaces contributing runoff to the storage location.

Where there is permeable surface contribution to SuDS storage, then this should be considered within calculations. The 'UKSuDS' website allows input for permeable surface runoff contribution within attenuation calculations. A similar approach can be applied within hand calculations or through software. A Cv of 0.10 - 0.15 (free draining – clay soils) is suggested for permeable runoff areas that connect to the drainage system.

Design note: Designer should explain how rainfall will be lost where Cvs lower than those suggested by this Guide are used.

8.4.4.2 Demonstrating interception losses

The design should identify SuDS features which can generate interception losses.

Criterion 1 (Section 16.3 of the Greater Dublin Regional Code of Practice for Drainage Works) requires demonstration of no runoff from site for rainfall depths up to 5mm for the majority of rainfall events.

As an rule of thumb, where the total wetted area of SuDS equates to at least 25% of the total buildings and hard surface areas draining to SuDS then it is acceptable to make an allowance for interception losses.

For advice on more detailed analysis regarding interception losses - see 2015 SuDS Manual (CIRIA C753) Section 24.8.

8.4.5 Infiltration

When specifying the test procedure, it is critical that the specified infiltration parameters should be representative of the proposed design. The depth of water and depth of test trench below ground level should seek to replicate the configuration (stored water depth, invert level, location etc.) of the proposed infiltration system.

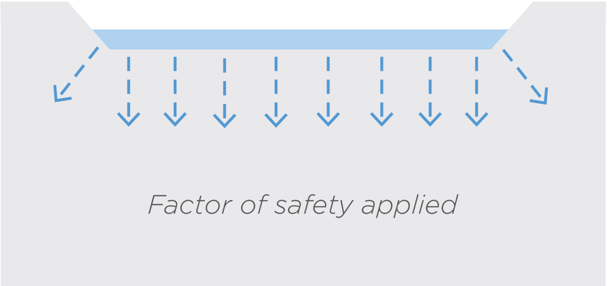
For example, tests should not be undertaken 1.5m below ground level when shallow infiltration is proposed from permeable pavement, rain gardens or basins which will be located close to ground surface.

There are two methods for calculating temporary storage for infiltration.

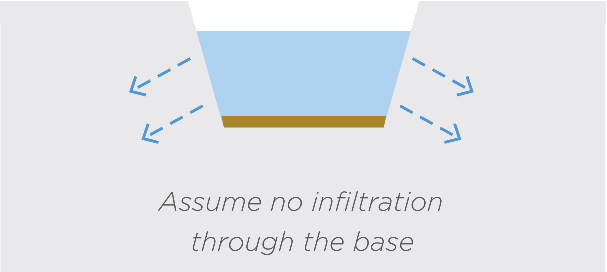
The CIRIA 156 method assumes that there will be infiltration through the base and sides of the structure on an ongoing basis. Factors of safety ranging between 1.5 and 10 depending on the consequence of failure, and the area draining to the infiltration structure (see C753 Table 25.2), are allocated to account for potentially reduced infiltration over time.

The BRE 365 method assumes that the base of the system, such as traditional soakaway, will silt up and therefore infiltration is only calculated through the vertical sides.

Various SuDS structures such as permeable pavement are resilient to ingress of silt.



CIRIA 156 method



BRE 365 method

Design note: Infiltration schemes are not straight-forward and sites which are free draining can quickly become compacted during the construction phase. Protecting infiltration zones during construction should be considered as part of a construction plan.

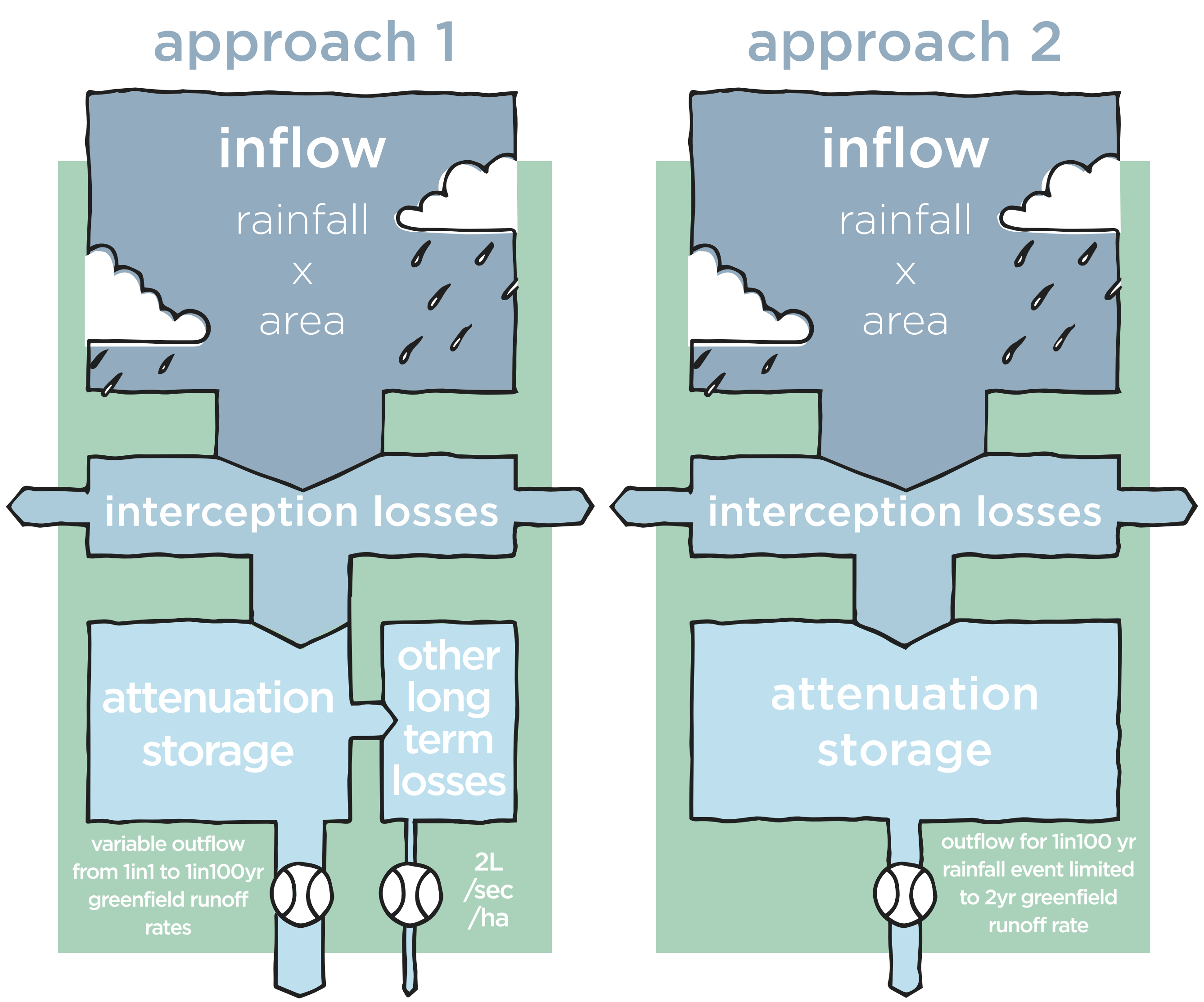
8.4.5.1 Calculating flow control rates and attenuation storage

SDCC requires that SuDS attenuate runoff from all sites to equivalent greenfield runoff rates.

This restricted rate applies to both green and brownfield (re)development.

As per the criterion previously set out in GDSDS and Section 16.3 of the Greater Dublin Regional Code of Practice for Drainage Works, there are two approaches for determining flow control rates (and resulting storage volumes).

Where discharge at Qbar rates has the potential to impact on property or infrastructure, or cause an environmental risk, flows discharged from site should be restricted to a maximum of 2l/s/ha. (See Section 5.3)



8.4.6 Establishing Greenfield (GF) Runoff Rates

The GF rate will be a function of the SAAR value which can vary significantly across the county and soil type with Soil types 2, 3 and 4 common across the South Dublin region.

The following Qbar rates can be used as a benchmark and are based upon a Standard Average Annual Rainfall (SAAR) of 750mm (as per page 71 of GDSDS Vol 3).

	SOIL type 2	SOIL type 3	SOIL type 4
Qbar (l/s/ha)	2.0	3.1	5.2

Design note: There is significant variation in annual rainfall across the South Dublin region and QBar should be calculated on a site specific location basis.

For site specific SAAR values visit:

https://www.met.ie/climate/services

1. Click Rainfall Returns periods
2. Scroll down and download the 1981-2010 Annual Average Rainfall Grid
3. Identify site coordinates.
4. Choose the SAAR value which is closest to site coordinates.

Where all GDSDS Criterion 2.1, 2.2, 4.1, 4.2 (Approach 1) is applied through the design process and flow is not restricted to 2l/s/ha, the rate of outflow can be controlled to the 1-in-1 year and 1-in-100 year greenfield runoff rate for the respective rainfall return period. To derive the outflow rate for the respective rainfall return period rate the Qbar flow rate is multiplied using the following growth factors. .

Return period (years)	Growth curve factor
1	0.85
Qbar	1.0
10	1.7
30	2.1
100	2.6
200	2.9

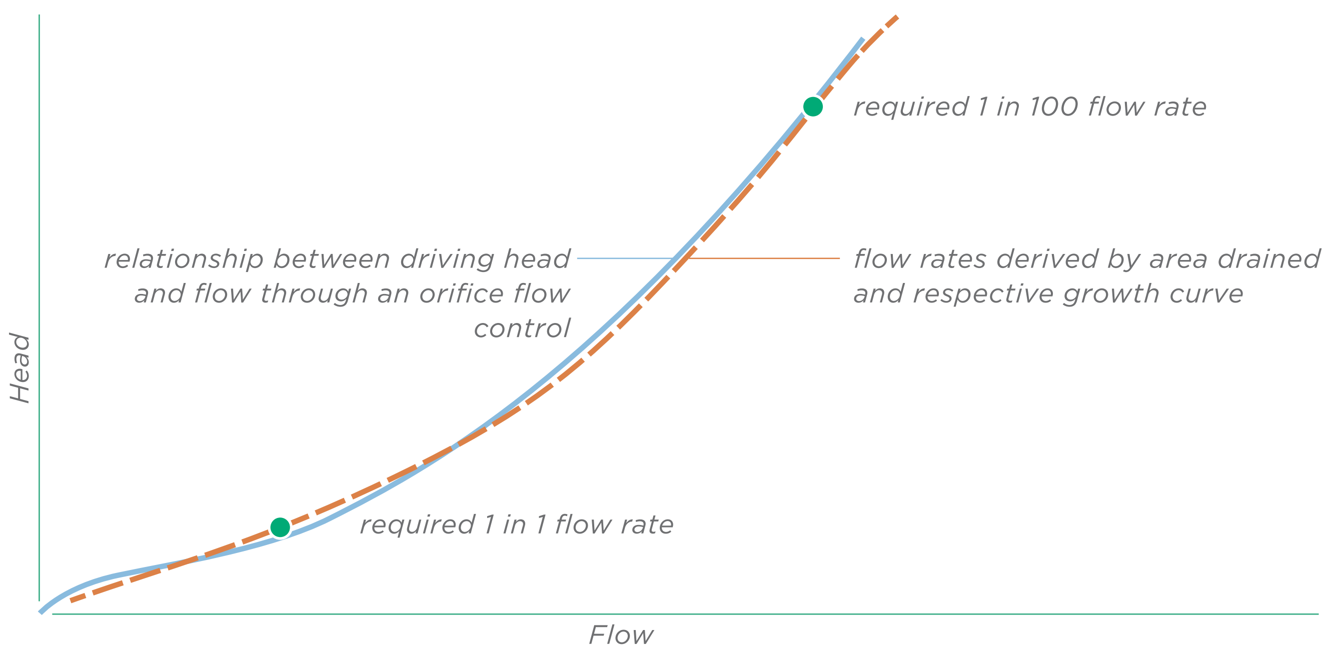
8.4.6.1 Sizing flow controls - Approach 1

This approach allows for varying the outflow rate for the 1 in 1 year and 1 in 100 year greenfield runoff rates for the respective rainfall events.

The following steps outline the process of calculating the opening size of an orifice flow control to meet the requirements of GDSDS Criterion 4:

1. Establish the controlled outflow (or greenfield runoff) rates for the 1 in 1 year and 1 in 100 year rainfall event.
2. Define the first, lower orifice invert. A reasonable starting point is to set the invert at the base (or slightly below the base) of storage.
3. Calculate the maximum storage depth for your SuDS component, based on its catchment, for the 1 in 100 year event and the 1 in 100 flow rate - for example this may be 350mm for a permeable pavement or up to 600mm for basins.
4. Make a note of the calculated opening size to achieve the 1 in 100 flow rate at the defined storage depth.
5. Based on the same storage component design and flow control opening, calculate how a 1 in 1 year rainfall event will behave – make a note of the maximum storage depth and maximum flow rate. Note that the volume and therefore driving head will be significantly smaller for the 1 in 1 year rainfall event and therefore the flow rate through the orifice will be significantly lower.
6. If the calculated maximum flow is less that the 1 in 1 year control rate then the opening does not need changing.
7. If the calculated maximum flow for the 1 in 1 event is larger than the 1 in 1 year control rate then reduce the opening size and recalculate based on the 1 in 1 event being mindful that the 1 in 100 year scenario will have to be reconsidered. Amend the opening size until the 1 in 1 year event is attenuated to the 1 in 1 discharge rate and make a note of the resulting maximum storage depth.
8. Re-run the calculations for the 1 in 100 year event based on the changed opening. The maximum flow rate will now be below the allowable discharge rate resulting in more storage than is necessary. To overcome this, a second opening may be placed above the 1 in 1 storage depth noted in step 7. Add a second opening so that it's lower most point (invert) is at or above the 1 in 1 storage depth and recalculate the storage behaviour in a 1 in 100 event. Adjust the opening size and height above the 1 in 100 storage depth until the 1 in 100 flow rate is achieved at the maximum storage depth for the 1 in 100 rainfall event.

Graph shows how a single flow control opening might be used to deliver variable outflow for different return periods.



Outline Design

Approach 1 - worked example calculation

For the example the following rates are assumed:

- 1 in 1 year 3.5 l/s
- 1-in-100 year 11.1 l/s

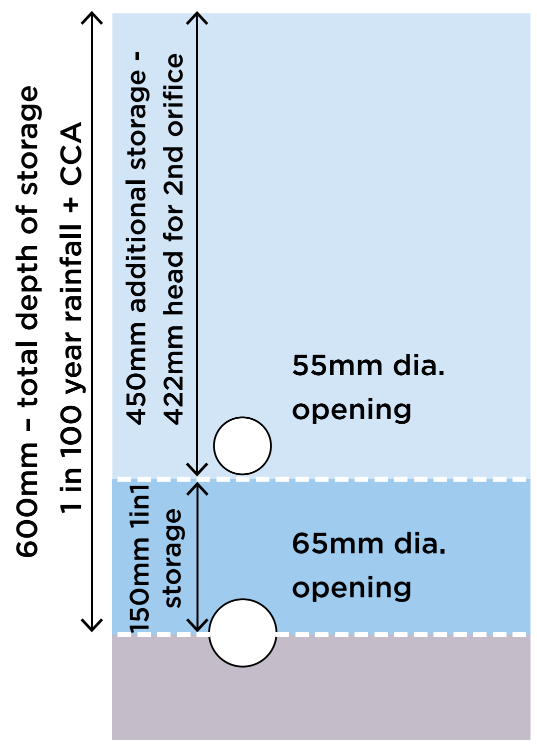
Depths of storage are assumed as 150mm and 600mm for 1 in 1 year and 1 in 100 year return periods respectively.

1 in 1 year

65mm opening with 150mm depth of storage for 1 in 1 year, which provides 3.5 l/s outflow.

1 in 100 year

65mm opening for 600mm depth of storage provides outflow rate of 6.9 l/s. Allowable discharge is 11.1l/s.



Therefore 11.1 – 6.9 = 4.2 l/s. The additional flow will be provided by an additional opening which will only operate once the 1 in 1 year storage is utilised.

Using an additional 55mm opening with invert 150mm above base invert of storage provides 4.2 l/s outflow.

8.4.6.2 Sizing flow controls - Approach 2

Where the design requirements for volume control cannot be achieved then all runoff from the site for the 1 in 100 year event including CCA should be discharged at a maximum of 2 l/sec/ha or Qbar (rural) rate (where permissible), for the development.

It is noted that for gravity-controlled systems the maximum permitted outflow Qbar rate / 2l/s/ha is only reached when the SuDS component is full, and the design head reached.

Approach 2 – worked example calculation

For the example the following flow control rate is assumed:

- 2 l/s

Depths of storage is assumed as 450mm for the 1 in 100 year rainfall return period (with allowance for climate change and urban creep).

35mm opening for 450mm depth of storage (design head at flow control) provides outflow rate of 2.0l/s. Allowable discharge is 2.0l/s.

8.4.6.3 Long term storage

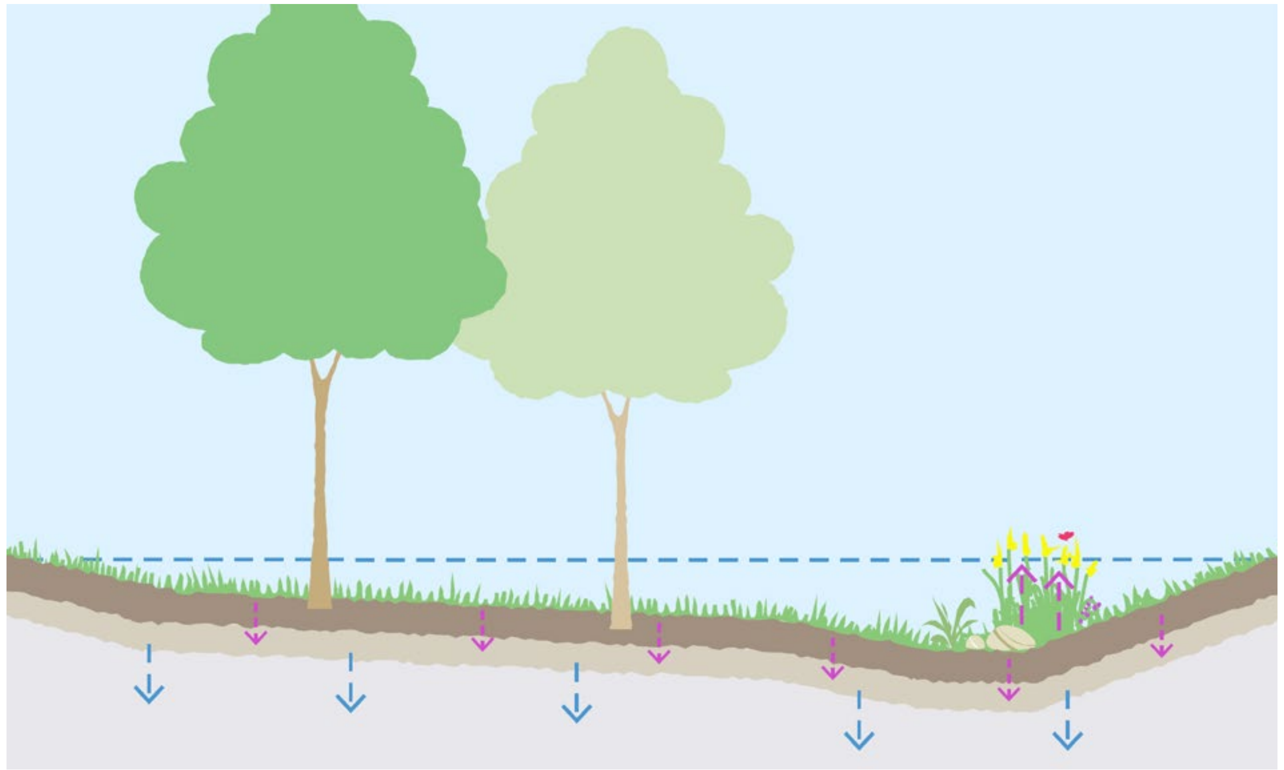
When designing the storage volumes for Approach 2 some runoff must be retained on site after attenuation storage has emptied to mitigate for flood risk caused by the increased runoff volume generated by the development.

Methods to reduce and manage the volume of runoff generated by development leaving the site:

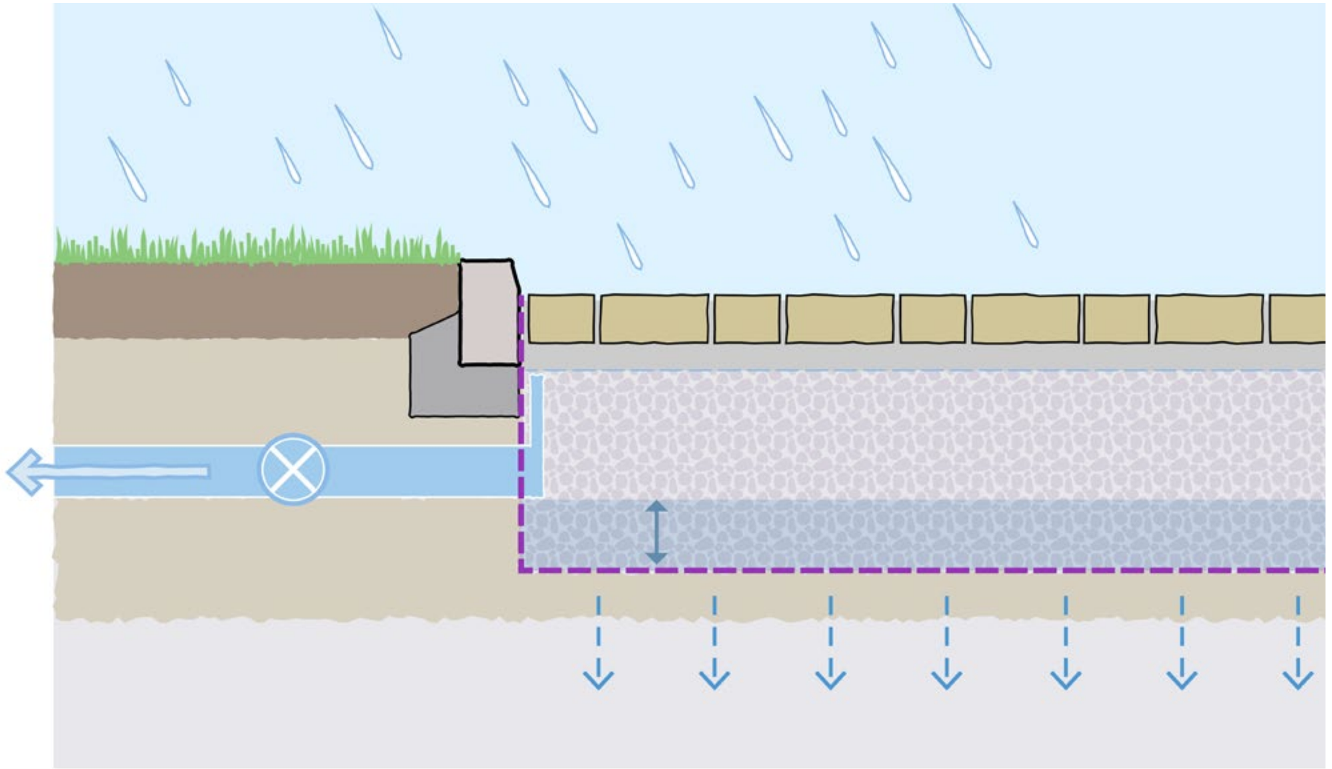
- **Rain harvesting** - Where it can be demonstrated that the harvesting system will be in use for the majority of time and demand exceeds supply, 50% of the rain harvesting volume can be offset against the long-term storage volume requirements. (BS 8515:2009)
- **Natural Losses** – For SuDS components which provide natural losses (interception) a 5mm reduction can be applied to rainfall depths to account for interception losses where the design demonstrates a ratio of 'SuDS space' to 'developed area' of 1:4.
- **Infiltration** - Where SuDS components are unlined, infiltration may occur even if rates are low. These additional losses can be offset against the long-term storage volume requirements. Infiltration rates should be demonstrated from infiltration tests (with suitable factor of safety applied to infiltration rate).
- **Separate area of storage** -A separate area of storage can be provided. It is prudent for areas which serve other purposes such as carparks or playing fields not to be inundated on a regular basis. The 1 in 30 year event is suggested as the point at which these areas would be first utilised for long term storage. Outflow from Long Term storage areas should be via infiltration or a controlled discharge rate of 2 l/s/ha.

Design note: Infiltration tests where low rates of infiltration are anticipated may have to be specified over a period greater than 24 hours. Where rates of infiltration are low there should always be gravity discharge (via flow control).

*This example shows a basin with a low flow channel and a sloped base. As rainfall runoff fills the basin, **interception losses** will occur. When runoff is held in an **unlined** basin over a period, further **infiltration losses** will occur (even on many clay soils). These losses contribute to **long term storage**.*



*This example shows a reservoir area within the permeable pavement subbase below the flow control level. There must be a sufficient infiltration rate to permit the permeable pavement to empty (a minimum infiltration rate of 5mm per hour is suggested). Using hydraulic modelling software, the volume infiltrated can be determined. As this volume of runoff is infiltrated it can be treated as '**long term losses**'.*



Outline Design

8.4.6.4 Accounting for Climate Change

Future predictions suggest that more extreme rainfall events will occur with greater regularity.

To make allowance for this within SuDS calculations rainfall intensities should be increased by a minimum of **20%** (Climate Change Allowance (CCA)).

Design note: Climate Change should be considered for both attenuation storage and conveyance calculations.

8.4.7 Accounting for Urban Creep

Urban Creep considers the potential impact on the drainage system from exempted development such as small extensions to houses and paving over front gardens to create driveways. Exempted development rights generally applies to residential development but can also apply to commercial development and schools.

The following table is taken from previously completed research and defines the anticipated percentage increase to impermeable area:

For housing developments, designers should determine the number of properties per hectare and apply the percentage increase to impermeable areas which are not taken in charge, for example roofs, pathways and driveways (but may exclude road areas which are taken in charge).

Urban creep allowance for commercial developments and schools should be agreed with the SDCC.

Paving front gardens is a common form of urban creep.

Residential development density (dwellings per hectare)	less than 25	30	35	45	more than 50	flats & apartments
Percentage area increase applied as percentage of proposed impermeable area within curtilage of private lands.	10%	8%	6%	4%	2%	0%

8.4.8 Drain down times

Storage volumes should ensure that **50% of the total attenuation volume is available within 24 hours** of a 1 in 30 year critical duration rainfall event occurring.

8.4.9 Critical Duration

A range of storm durations (**15 minutes – 48 hours**) should be assessed to determine maximum storage required.

8.4.10 Flow velocities

Peak flows should be retained to less than **1m/s** velocity to avoid risk of erosion of vegetated surfaces such as swale channels.

Where velocities are less than **0.3m/s** this will encourage silts to drop out of flow along the Management Train.

The Manning's Equation (SuDS Manual EQ.24.12) is used to estimate open channel flow velocities. The depth of flow will affect how much 'roughness' is applied by the channel. The SuDS Manual Figure 17.7 details the manning's roughness values which should be adopted for SuDS calculations.

8.4.11 Flow controls

Attenuation storage within sub-catchments and along the management train can require several flow controls. Flow controls come in many forms including orifice plates, slot or V-notch weirs and vortex controls. Any type of flow controls can be prone to blockage unless the opening is protected.

The rate of flow of water through SuDS components is slow as it is restricted to 'greenfield rates' of runoff through each flow control. There should always be an overflow arrangement to deal with blockage or exceedance of the design storm.

Silt is trapped at source in SuDS components and settles out along the management train. Where slow movement of flow is maintained throughout, floating debris that easily blocks outlets is not driven against openings; as is the case with conventional drainage. Simple design features such as sloping headwalls can direct floating debris past the outlet as the storage structure fills.

Images show a protected orifice plate within shallow chamber and weir made from recycled plastic planks.

8.4.11.1 The importance of protected openings

There are no minimum thresholds for attenuated flow rates in SuDS design. Previously the drainage industry has applied a minimum flow rate of 5 l/s, but this does not consider the need in SuDS for low flow rate controls and the design of **protected openings**.

Small sites and sub-catchments of larger sites may need to meet minimal outflow flow rates. Flows can be controlled down to 0.5 – 2 l/s using small openings (15-20mm diameter) with shallow depth of storage.

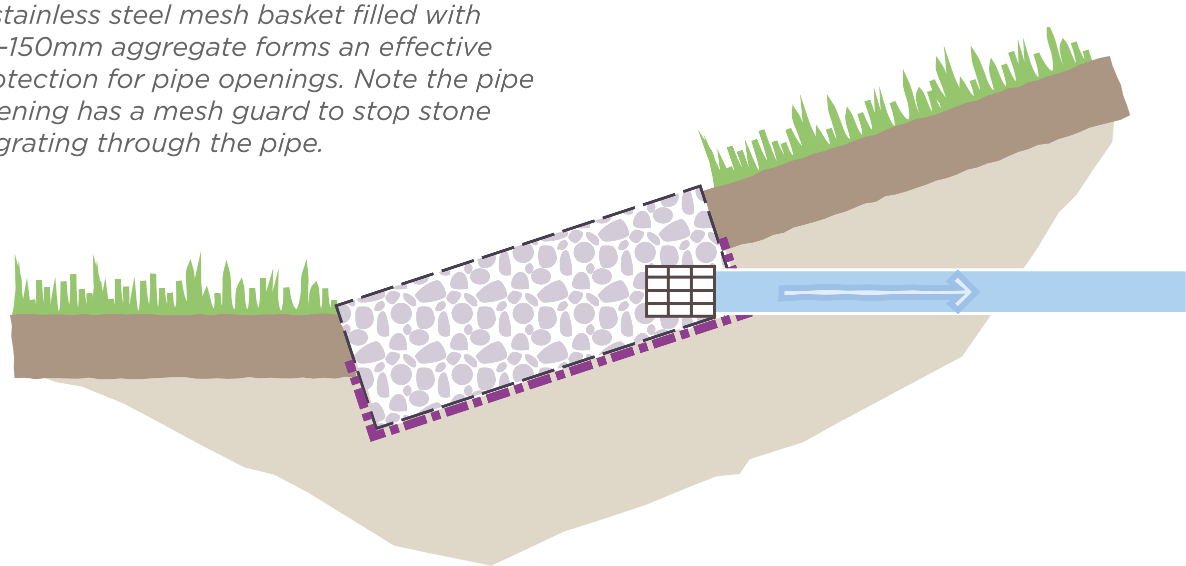
SuDS components such as permeable pavements, bioretention or filter drains are pre-filtered, and assuming collection through perforated pipes or similar, the flow control opening requires little additional protection.

Open SuDS components such as swales, ponds and basins, require additional protection. One way to provide this protection is to use a stainless steel basket filled with 80-150mm stone with the connecting pipe opening set within the stone to prevent floating debris reaching the flow control.

Key points to be considered when designing protected openings:

- Protection to the opening should be of a reasonable surface area to allow for accumulation of litter and vegetation across the surface of the protection.
- Outlets in open structures should be located on a slope to encourage debris to pass over the outlet as water rises in the SuDS component.
- Openings in the protective screen should be smaller than the orifice opening size, thus any residual silt passing through protective screen will pass through the orifice opening.
- Where the flow control is to be adopted a minimum protected opening size of 50mm will be acceptable. This increases to 100mm for unprotected openings.

A stainless steel mesh basket filled with 80-150mm aggregate forms an effective protection for pipe openings. Note the pipe opening has a mesh guard to stop stone migrating through the pipe.



8.4.12 SuDS Calculation checklist

Key calculation inputs and outputs should be presented in the SUDS design statement. The following checklist identifies calculation considerations:

Parameter	Guidance on design/calculation input	Information for assessment
Rainfall data	A range of rainfall durations must be considered when calculating attenuation storage.	Designer to demonstrate that sufficient rainfall durations have been considered to achieve maximum storage requirement
Areas generating runoff	All areas of contributing runoff should be represented within the storage calculation. Coefficients of runoff to be appropriately allocated	Provide a drawing clearly identifying the areas of surface runoff contribution within each subcatchment. Designer to state Cv's used and justify use of Cv less than 0.9.
Hierarchy of discharge	Discharge of rainfall runoff to the sewer network should be minimised.	Designer to demonstrate that they have considered discharge methods in the following order – rainwater reuse; infiltration; open channel watercourse; surface water sewer; combined sewer.
Maximum flow control rate	As per GDSDS. SDCC or Irish Water may place further restrictions on the outfall flow rates based on the available capacity of receiving infrastructure.	The flow control rate should be identified along with the approach used to calculate this rate.
Climate change allowance	CCA has been applied within calculations.	Designer to justify selection of CCA.
Urban creep	Urban creep allowance applied to impermeable areas on developments where permitted development is likely to occur (extensions, driveways etc).	Designer to justify selection of Urban Creep percentage

Parameter	Guidance on design/calculation input	Information for assessment
Initial interception losses	As a rule of thumb, where the area of development is no greater than 4 times the SuDS wetted area, a 5mm allowance may be made for interception losses for each m2 of development.	Designer to confirm whether 5mm interception losses have been applied in calculation.
Outfall design	Outfalls into receiving sewers or watercourses can be at risk of surcharge. This can result in additional storage being required. Free discharge should not be assumed. The risk of surcharge should be assessed and accounted for within calculations, as appropriate.	Designer is to indicate whether SuDS storage calculation is likely to be influenced by high water levels at the point of discharge.
Hydraulic Modelling of SuDS	Layout drawings should be clearly labelled with the numbering convention used by hydraulic model / calculation processes. Spreadsheet calculations can be prone to error and outputs should be benchmarked against a qualified source (e.g., UKSuDS.com)	Confirm details of calculation input parameters used e.g., Cv for various surface types, SAAR, and outputs (e.g., flow control rates, attenuation volumes). Confirm volumes as m3/m2, and total volume m3 required for the development.
Long section	Long sections will allow consideration of levels across the site.	Long section showing peak water levels.
Erosion check	Flows along swales (or other vegetated surfaces) are at risk from erosion. Peak flow velocities should be less than 1 l/s. Concentrated inlet points are also prone to erosion.	Designer to demonstrate that they have considered risk of erosion and taken measures to safeguard scheme. Peak flow velocity calculations to be provided as appropriate.

Parameter	Guidance on design/calculation input	Information for assessment
Designing for exceedance	The design should incorporate overflows at each SuDS component. Hydraulic calculations should demonstrate that overflows have sufficient capacity to deal with anticipated flow rates. SuDS layout drawing should identify the anticipated flow route for exceedance events.	Locations of overflows should be identified on the layout drawing along with proposed exceedance flow route.
Managing flows from off site	The SSFRA should identify the potential for flows from offsite. These flows can be unpredictable and difficult to quantify. Management of flows through the site should not increase flood risk elsewhere. Detailed modelling to establish the rates of flow anticipated would not be considered compulsory (but may be required on a case-by-case basis).	The designer should demonstrate how anticipated flows from off site will be managed through the site using the layout drawing and design statement.
Consistency of calculations and design	Detailed design of SuDS components should reflect hydraulic calculations / hydraulic models, considering slopes and low lying levels. SDCC will consider design drawings to ensure that flow control sizing and storage provision is as per calculations.	Drawings should clearly identify site levels, storage locations and flow controls with cross sections and long sections. The design statement should confirm that drawings deliver calculated volumes.

Outline Design

8.5 Design flexibility

Where a single storage volume is presented, it is the intuitive response of most designers to try and accommodate all flow at a single storage location. However, the opportunities for storage across the site are diverse and flexible.

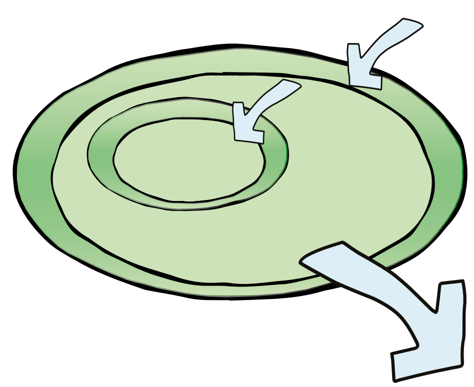
Appearance, functionality and character of a space can be influenced by how flows are stored and controlled within each SuDS component. Four approaches are explored by this guide. These approaches are intended to inspire the designer to think about the possibilities that exist for integrating storage as part of the development rather than defaulting to an underground storage structure prior to discharge from the site.

Single, tiered storage components

Store up to the 1 in 100 year rainfall in a single, tiered storage component, such as a smaller basin used on a regular basis within a more extensive basin for more extreme rainfall events and openings sized to achieve the variable outflow rates.

Source control should be in place where flows are taken to an amenity play basin. In this scenario, a tiered approach to storage is useful in order to maximize the usability of features for general amenity, play or sports. Biodiversity can be introduced in the smaller basin by creating wetland or any other desired habitat.

More frequent rainfall events which produced less runoff such as the 1 in 1 event, are prevented from covering the whole storage component by accommodating them in a smaller basin located within a more expansive basin which can accommodate further volumes of runoff up to the 1 in 100 event. As with other approaches the flow control can be designed to manage the desired variable outflows at various depths of storage.



Store up to the 1 in 100 year rainfall in a single, tiered storage component, such as a smaller basin used on a regular basis within a more extensive basin for more extreme rainfall events and openings, sized to achieve the variable outflow rates.

Detention basin with varying levels - The Way, Citywest Avenue

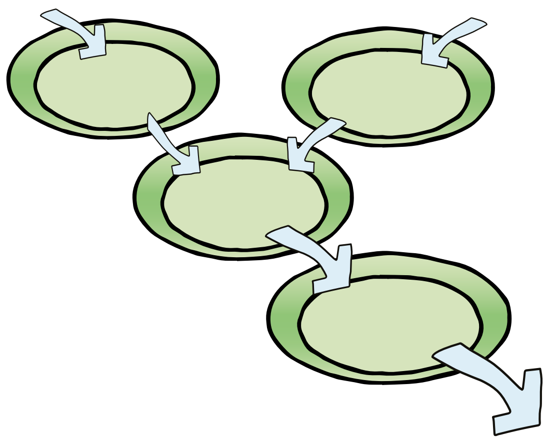
Distributed storage components

Distributed storage volumes into discreet storage components such as raingardens, swales, basins and permeable pavement with the potential for different rainfall depths being stored at each location.

This approach is useful for exploiting small parcels of available space within the development and results in features, such as rain gardens and small basins which can be located close to buildings. These small features are usually sized for between the 1 in 1 year and 1 in 10 year rainfall, with excess rainfall volumes conveyed along the management train to site control.

This approach keeps subsequent storage components from regular wetting as around 95% of rainfall events would be managed by the first component.

This can protect the functionality of downstream components as amenity spaces. The flow control opening for each component can be easily calculated and outflows from one storage component will passively move through subsequent storage components without the requirement for further storage.



Distributing storage volumes into discreet storage components such as raingardens, swales, basins and permeable pavement unlocks the potential for different rainfall depths being stored at each location.

Example of a raingarden managing day-to-day rainfall (e.g. up to the 1 in 10 rainfall event) with flows passing onto subsequent features.

Single, uniform storage components

Permeable pavements and blue-green roofs which have relatively flat formations can store all rainfall events up to the 1 in 100 year within their footprint. In this scenario the flow control would be designed to ensure that the depth of stored flow discharged at the respective 1 in 1 and 1 in 100 year greenfield runoff rates.

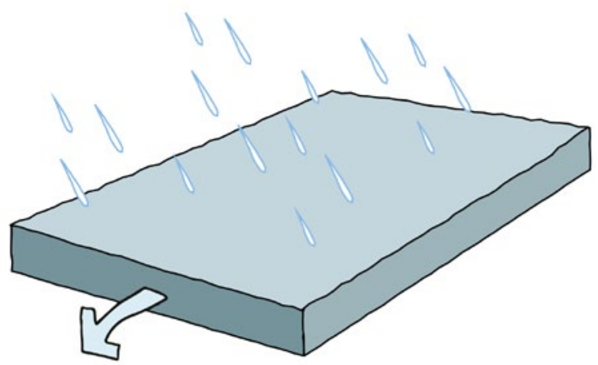
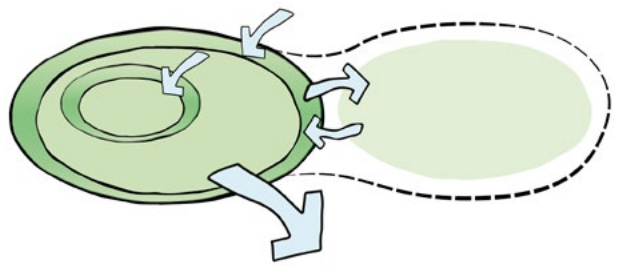


Image shows permeable paved on street carparking - Cuil Duin, Cooldown Commons

Site containment storage

On some sites, rainfall runoff from extreme rainfall could be stored in parts of the site such as overspill carparks or public open space, where the overall functioning of the site is not affected during these weather conditions. Storing water outside of the defined SuDS structures is referred to as site containment.

These areas should drain down within a short timeframe and should not come into operation until rainfall events above the 1 in 30 year rainfall. Depth of flowing within areas of site containment should be shallow (no greater than 150mm) and flow velocities should be less than 1m/s.



This play area provides site containment of flow which exceeds the capacity of the SuDS attenuation feature.

Design note: The onus is on the designer to demonstrate that site containment flows can be safely managed and do not pose a risk to site users.

8.5.1 Designing for exceedance

The designer must demonstrate that extreme flows, beyond design parameters, can be managed in a safe and predictable manner. Site levels should be designed to allow exceedance flows to flow from one storage location to the next along a defined management train/conveyance route.

The designer should evaluate likely flood volumes, depths and velocities to ensure there is no significant risk to development or people. Generally, depths less than 0.25m will not present a risk, but steep parts of sites may generate high velocities which may be unsuitable.

8.5.2 Managing off-site flows

Many sites are at risk of significant surface runoff from offsite with indicative flow routes identified by Surface Water flood maps.

SuDS design should demonstrate how offsite flows are intercepted and managed through the site without causing flood risk to the site or increasing flood risk elsewhere. Unless specifically required by SDCC, developers are not required to attenuate surface water flows which are generated from off site. This advice may be revised in exceptional circumstances which will be determined on a case-by-case basis.

Flood maps

SDCC Strategic Flood Risk Assessment

Exceedance routes are clearly visible in this housing development with dipped paths allowing exceedance flows to pass safely to the next part of the swale.

8.6 Water Quality

Rainfall picks up pollution from development surfaces. As runoff moves slowly through SuDS components most pollution is removed through sedimentation, filtration and bioremediation. Naturally occurring processes in many SuDS components break down organic pollution, meaning that there is no build up or need for removal of this pollution over time.

Using source control and the management train, SuDS provides a controlled flow of cleaned water through the development.

Open water features should not receive flows directly from development without sufficient treatment.

- Hydrocarbons remain in pond sediments for extended periods.
- Silts which carry heavy metals impact on the aquatic environment and add to maintenance problems due to the build-up of toxic sediments.

The amenity and biodiversity value of ponds and wetlands should be protected with pollutants removed at source and along the management train.

8.6.1 The objectives of designing for water quality

- Treat runoff to prevent negative impacts to the development's landscape and biodiversity as well as receiving watercourses and water bodies within the wider landscape.
- Treat runoff to prevent negative impacts on the receiving water quality. This may include onsite SuDS components which have amenity and biodiversity potential.
- Manage rainfall runoff at or close to source and at or near the surface where possible, to begin treatment quickly and maximise treatment through the system.

Design note: Where water quantity design adopts a SuDS management train approach, most designs will meet water quality requirements by default, due to the number of components already used in series.

8.6.2 Hazard and mitigation risk assessment

The 2015 CIRIA SuDS Manual adopts a 'Source-Pathway-Receptor' approach, with the extent of analysis required associated with the level of risk.

- On low to medium risk sites where discharge is to surface water – apply 'Hazard and Mitigation' Simple Indices Approach (SIA) to confirm that the proposed SuDS components required (CIRIA SuDS Manual Section 26.7.1).
- For medium risk sites where discharge is via infiltration, undertake risk screening to establish whether infiltration would have an undue risk to groundwater and apply the indicies approach to identify the number of SuDS components required prior to infiltration. (CIRIA SuDS Manual Section 26.7.2)
- Haulage yards, lorry parks, highly frequented lorry approaches to industrial estates and waste sites, sites where chemicals and fuels (other than domestic fuel oil) are to be delivered, handled, stored, used or manufactured and industrial sites. Discharges may require an environmental licence or permit. Designer should confirm with the appropriate licensing authority.

A level of understanding of the site's soil and underlying geology is required to undertake the **infiltration risk screening** assessment. The screening assessment will determine whether it will be permissible to infiltrate and the indices approach is applied to define the level of treatment required prior to the point of infiltration.

Table 26.2, 26.3 and 26.4 of the 2015 SuDS Manual identify the hazard indices and the treatment efficiency indices for a range of SuDS attenuation and infiltration features.

Milk spillages will bypass conventional drainage methods of spill containment

Design note: Table 26.15 of the 2015 SuDS Manual notes that conventional gully and pipe drainage provide zero treatment

8.6.3 Dealing with spillage

SuDS components are very effective at dealing with 'day to day' pollution. When a spillage occurs this can overload the treatment processes which occur within SuDS components. Where the spillage is an organic based pollutant a spill kit is used to take up the excess and the residual pollutants left in situ to breakdown naturally.

Designing SuDS to cater for spillage should demonstrate:

- Spillage is retained at or near the surface so that it is visible and accessible.
- Slow travel time along the management train allows time for reaction and initial clean-up to take place.
- Mechanical mechanisms such as shut off values should be avoided. An awareness of outlet locations which can be easily sealed off can provide simple and robust containment.

Item	What's being checked	Information presented for assessment
Treatment	Sufficient treatment in place protecting site biodiversity and amenity assets and the wider environment. Evidence of source control, subcatchments and management train.	Layout drawing clearly indicating SuDS components and management train. Details of Indices approach and infiltration screening assessment (as appropriate).
Spill management	Contingency measures in the event of a minor / major spillage.	Indicate on layout drawing potential for containment and where spill kits might be positioned.
Infiltration	Presence of contaminated land, depth to seasonal high groundwater table.	Coordinated constraints plan.
Construction phase	Demonstration of how site runoff could be managed during construction to minimise the risk of pollution to the wider environment due to silty construction runoff	Section of the drainage design statement outlining a potential approach for construction runoff management. Contractors will be responsible for developing and carrying out mitigation measures.
Operation and maintenance plan	Operation and maintenance should be simple to understand and easy to implement. Where available, SuDS design should deploy natural treatment process to breakdown organic pollutants passively. Contingency measures in the event of a minor / major spillage	Concise operation and maintenance plan. Description of tasks and detailing of where personnel are required to visit site to remove hydrocarbon based pollutants (i.e. organic pollutants have not been fully broken down passively as part of SuDS treatment process). Plan indicating potential for containment and positioning of spill kits (as appropriate)

8.7 Amenity

Amenity is one of the four pillars of SuDS design and perhaps open to the most interpretation and judgement.

Amenity focuses on the usefulness and aesthetic elements of SuDS design associated with features 'at or near the surface', and considers both multifunctionality and visual quality.

The amenity value of SuDS will have been considered at both Concept and Outline design stages but some finer aspects of value will be enhanced by detail design at stage.

An evaluation of the successful integration of amenity uses the design criteria set out in Concept Design.

Informal play, through integrated design.

Design note: When integrating SuDS in open space, the quality of the open space for the end user must always be considered as the central requirement during the design process.

8.7.1 Legibility

Understanding how the SuDS design functions is important both to everyday users of the SuDS environment and those who look after it.

An exercise in following each management train from source to outfall and imagining how the scheme presents itself to the visitor should highlight any problems with legibility.

Considerations will include:

- How is rainfall collected?
- What 'source control' techniques have been used and how they can be accessed and maintained?
- How does runoff travel from where it has been collected onwards through 'source control' components, to each part of the site?
- Where is runoff stored and cleaned along the management train in 'site controls' recognising that these functions may occur within permeable construction?
- Where are flow controls located?
- Are overflow and exceedance routes clear and easily understood?
- Is the outfall obvious, accessible and easily understood?

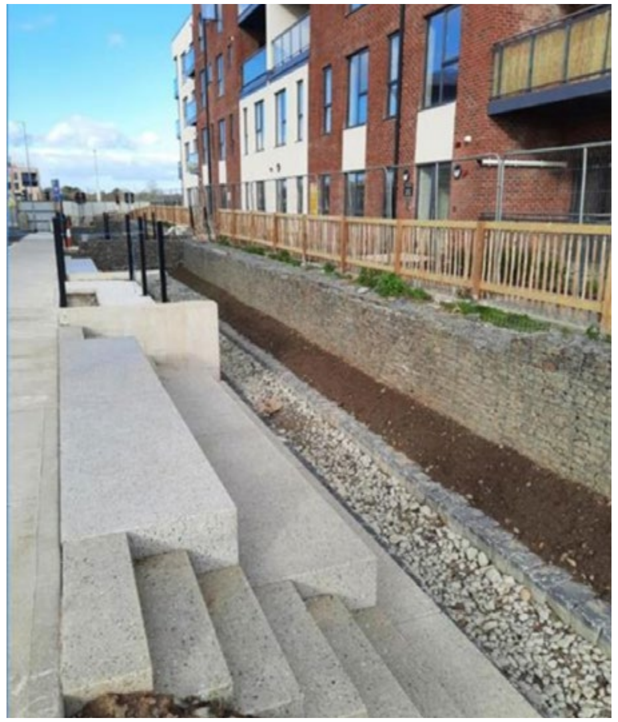
8.7.2 Accessibility

All parts of the SuDS landscape should be accessible to both everyday users and site managers.

Full accessibility requires 'safety by design' for every element of design including:

- Open water
- Changes of level
- Design detailing e.g., headwalls, inlets and outlets
- Clear visibility of the system
- Physical accessibility to all with an understanding of the limitations of level changes and open water

Water feature (in construction) adding to public amenity value in the area - Adamstown Strategic Development Zone



8.7.3 Multifunctionality

Many parts of the SuDS landscape can be useful in ways not associated with managing rainfall.

Permeable pavement is an example of full multi-functionality in that the surface is always available for managing rainfall and also allows vehicle access, parking and pedestrian use.

Reasonably level green space can be used for sports and other social activity most of the time but not when inundated. Everyday rainfall (1-2 year return period events) can be designed to be managed elsewhere in the landscape

Other functionality can include:

- Play opportunity throughout the SuDS landscape
- Informal leisure like jogging, picnics, dog-walking etc
- Community activities such as gardening, growing vegetables etc
- Wildlife habitat, pollinator areas
- Educational opportunities.

Usability of swales and basins can be enhanced by under-draining into filter trenches below the ground to keep grass surfaces dry most of the time. For instance, within housing where grass surfaces are valuable for play.

8.7.4 Visual quality

The overall character of the SuDS landscape and surrounding areas will have been considered during Concept and Outline Design stages.

Design detailing of SuDS components, particularly inlets, outlets, control structures, channels and basins with their edges and profiles remain to be confirmed during Detailed Design Stage.

Firstly, the collection and conveyance of runoff can add visual interest to development, spouts, rills surface channels, for instance, should be considered as part of the landscape character of a development.

Secondly, it is important to clean runoff as soon as possible so that water that flows through development is as clean as possible for both Amenity and Biodiversity benefits. This requires 'source control' at the beginning of the SuDS to remove silt and gross pollution..

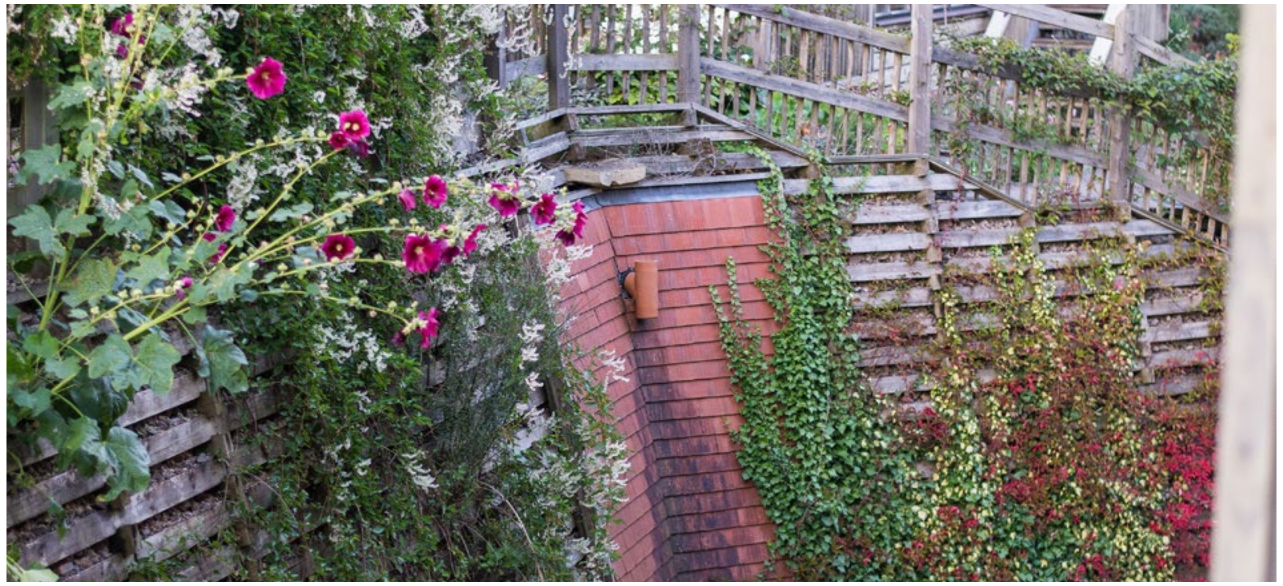
Source control components such as permeable surfaces, filter strips, green/ blue roofs, bioretention and in some cases swales and basins can all provide early cleaning and flow reduction at the beginning of the management train.

Community use and wildlife interest are both compatible with SuDS design. SuDS should integrate with both designated public open space, where both everyday rainfall and occasional heavy storms can be managed, and public pedestrian routes where conveyance of water and biodiversity can be combined.

The integration of SuDS with Amenity, Biodiversity and site layout provides additional benefits including:

- Efficient use of space through multi-functionality
- Usability through integrated use of landscape space
- Visual and biodiversity interest as part of integrated site design

Water flow is kept visible and used to dramatic effect in this housing development.

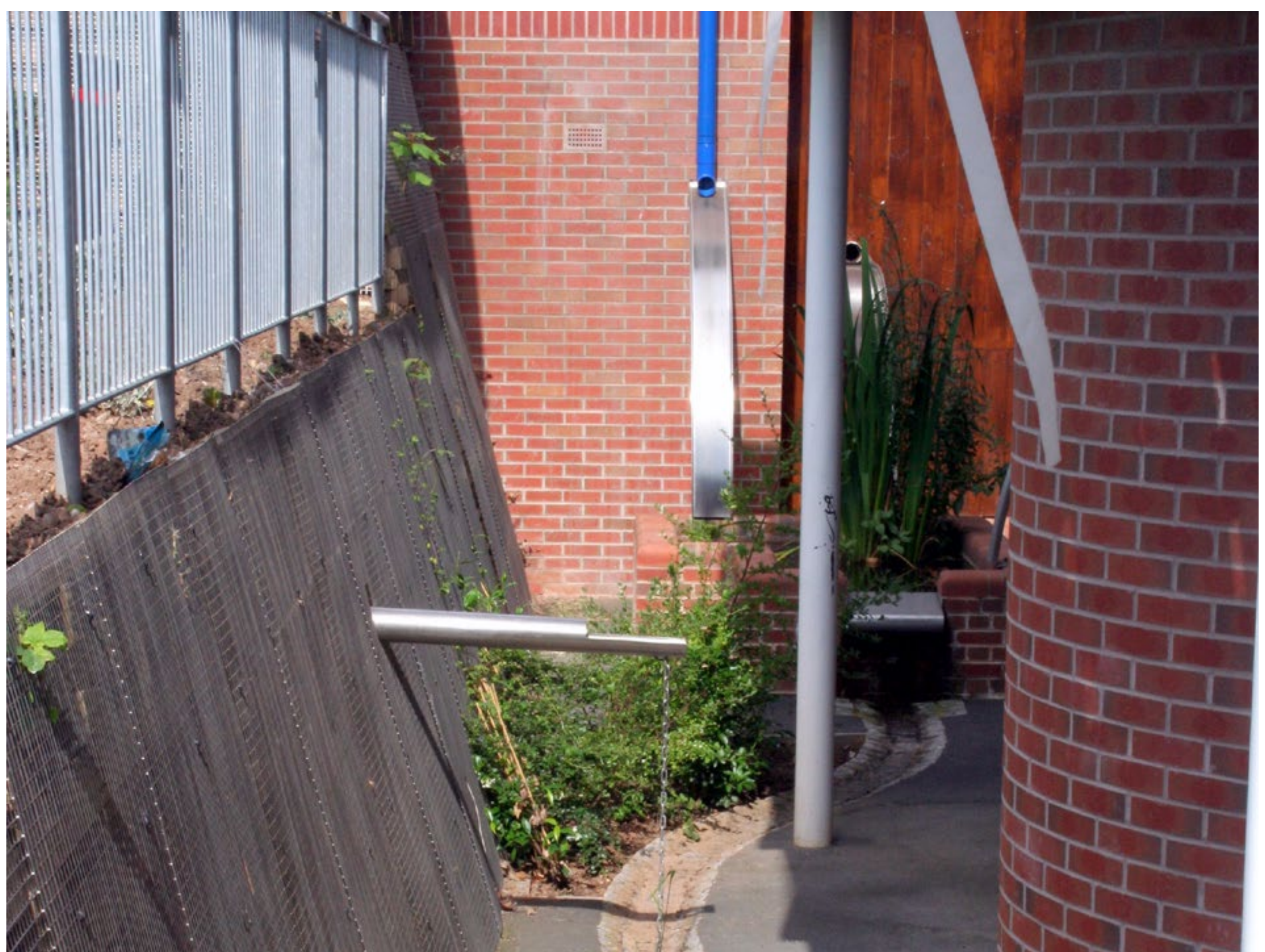


8.7.5 The integration of amenity and SuDS

Early SuDS design tended to create dedicated SuDS corridors with a series of basins, swales and wetlands which were in many cases fenced off, that were separate from the development they served. They were therefore thought to be land hungry, expensive and required additional site maintenance.

To maximize the value of SuDS it is important to understand the principle of integrated SuDS design. SuDS design should integrate the requirements of rainfall management with the use of development by people.

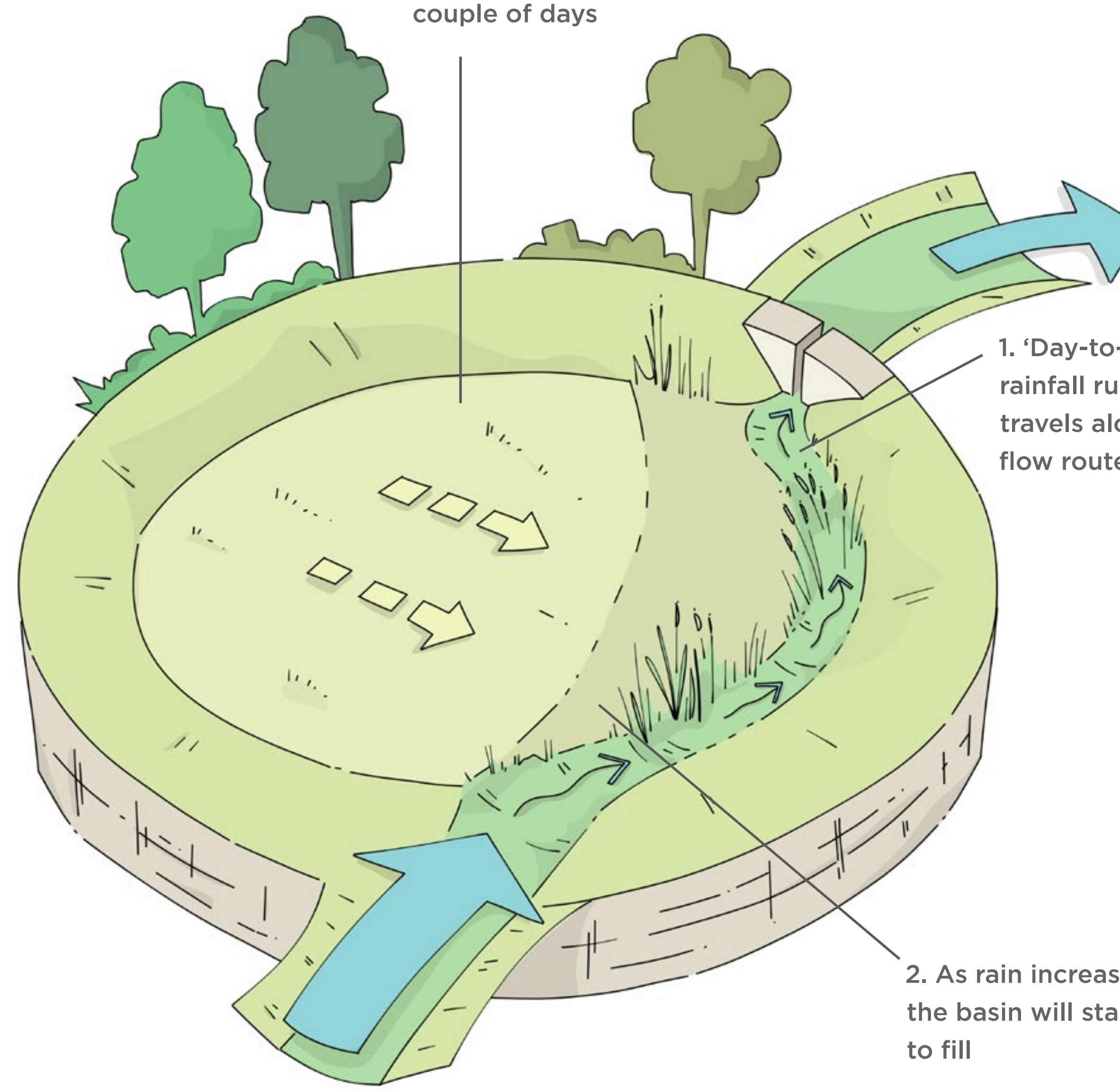
The flow of water in this school sensory garden can be touched, seen and heard.



8.7.6 SuDS in public open space

The following graphic demonstrates how levels within a basin can be adapted to ensure that most of the basin is available for play during the majority of rainfall events. As further surface runoff is stored water will encroach gradually up the slope, until the full storage capacity of the basin is utilised.

Note: Careful landscaping of levels will mean that most of the basin area will be available for amenity use nearly all of the time



8.8 Safety by design

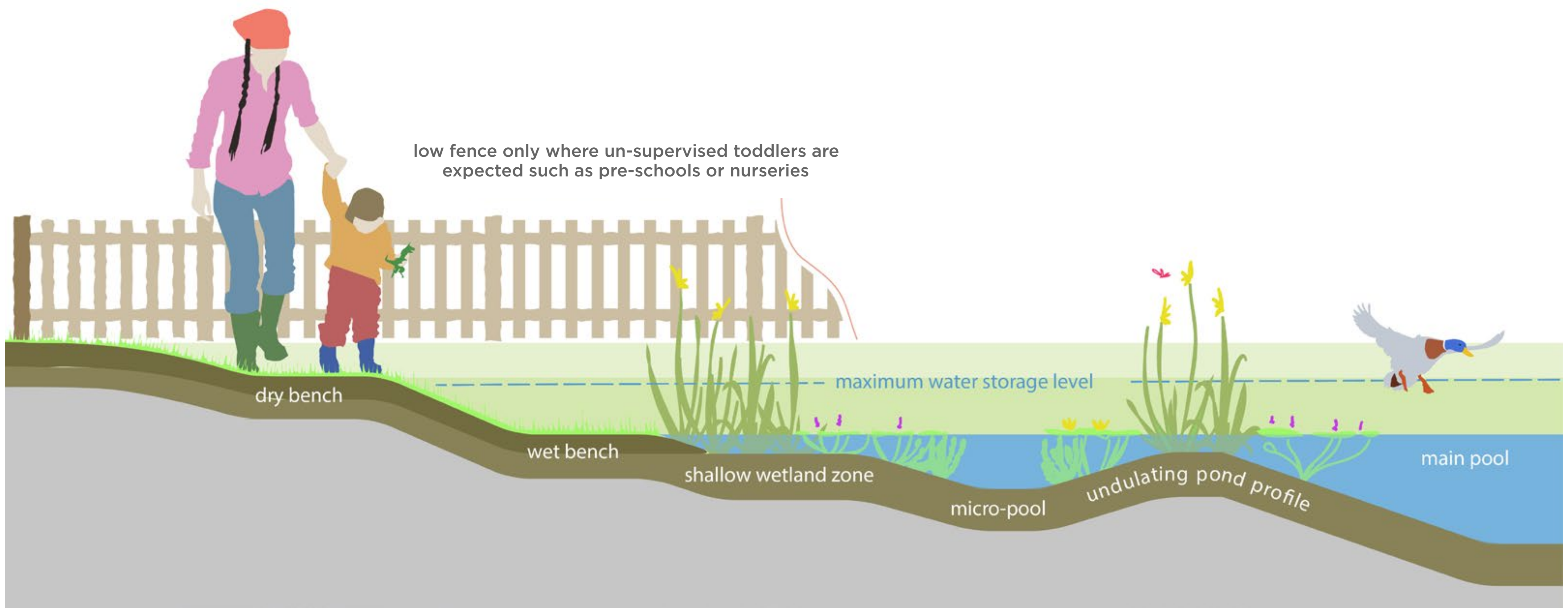
8.8.1 The place of water in the landscape

Although there are a number of risks associated with SuDS features, as there are with any landscape design, it is usually the presence of open water that is a concern.

It is important to consider the place water occupies in our everyday lives and its cultural importance. Water plays an integral part of the South Dublin urban landscape with presence of the Rivers Poddle, Camac, Griffeen and Whitechurch Stream. Water has increasingly become appreciated for its visual, recreational and wildlife value and most people like to see and experience water in the landscape.

Canal tow paths and ponds in parks have proved to be popular gathering places.

The issue of Health and Safety is therefore not one of risk elimination but of developing a design approach that celebrates water whilst managing any real or perceived risk in a way that is acceptable to the community and maintenance team.



8.8.2 Aspects of Safety in SuDS

A number of risks associated with SuDS can be identified:

- The risk of drowning
- Slip and trip hazard
- Risk of disease
- Risk of toxicity
- Infrastructure issues – aircraft (bird strikes), highways, sewers etc.

The general approach to 'Principles of Prevention' for SuDS is that all parts of a SuDS design should be fully accessible to people, with each element of the design considered from the health and safety perspective.

The design of the water edge to ponds, wetlands and basins is a good example of where the design allows a person to walk into and out of the feature safely in the design sequence.

A flat dry bench at the edge of the structure: a gentle slope, max 1:3 down to the water: a wet bench at permanent water level: another gentle slope into the water and another underwater level bench before deeper water.

See page 119 for further safety considerations.

Design note: The appointment of a PSDP is required when:

- **Construction work is expected to take longer than 30 working days**
- **If the work involves more than one contractor (or sub-contractor)**
- **If there is a particular risk present on the project**
- **If work will exceed 500 person days**

Health and safety principles for SuDS

Project Supervisor Design Process (PSDP)

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8.9 Biodiversity

8.9.1 Principles of design for biodiversity

Geology and climate are fundamental influences on the natural character of the landscape and determine the basic habitat types likely to evolve over time.

Local topography, aspect, soils, landscape design and habitat management all affect biodiversity in a developed landscape and can be influenced by SuDS design.

Biodiversity must be considered at the larger catchment scale to create a sympathetic green / blue infrastructure and also at a local scale to provide habitat and connectivity linkages within and around development.

8.9.2 Biodiversity at development scale

There is usually a host landscape that provides an enclosing envelope to the SuDS 'management train'. This term describes the landscape not directly affected by SuDS

features and the impact of rainfall management.

This surrounding 'host landscape' may include natural habitat or reflect more ornamental planting, particularly where it is close to buildings.

The wider host landscape should reflect the ecological character of surrounding natural habitat wherever this is possible but careful design can still enhance wildlife value in ornamental planting by following specific guidance.

Where SuDS installations are more isolated, for instance in urban retrofit and redevelopment, then SuDS spaces can act as biodiverse islands, sometimes likened to 'service stations', that act as staging posts and feeding sites for mobile species like birds, insects and other wildlife in an otherwise hostile environment.

A micropool within a flowering meadow raingarden creates structural and habitat diversity.

Outline Design

8.9.3 Key design criteria for biodiversity in the developed landscape

8.9.3.1 Clean water

Clean water is critical as soon as possible for all open water features in the landscape. Clean water is delivered using initial pollution prevention measures to prevent contaminants reaching water, source control features and further site controls along the management train.

8.9.3.2 Structural diversity

Structural diversity both horizontally and vertically within water features, the landscape and in vegetation generally provides habitat variety for wildlife. Structural diversity is inherent in many SuDS features particularly swales, basins, wetlands and ponds that can easily be enhanced for habitat creation. Ornamental planting should mimic natural vegetation by developing a complex vertical structure of trees, shrubs and herbaceous cover.

8.9.3.3 Connectivity

Connectivity between wetland habitat areas both within and outside the site encourages colonisation into and throughout the development landscape. These connections are particularly important both for animals on the ground but animals like bats use individual trees and woodland edges to travel from one place to the next and use SuDS wetlands to feed.

Connectivity is inherent in the management train principle but must be considered carefully where one feature links to the next. Surface conveyance and overflow routes, with a minimum use of pipework and inspection chambers, is helpful in retaining wildlife links.

There should be a direct connection between the SuDS landscape and the blue-green infrastructure that receives the 'controlled flow of clean water' from the development.

8.9.3.4 Prevent pollution to habitat

Permanent vegetation should cover all soil surfaces to prevent silt runoff and planting should be designed to avoid the use of fertilizer, pesticides and herbicides.

8.9.3.5 Maintenance for wildlife

Sympathetic maintenance enhances biodiversity but should be compatible with the aspirations of the local community to ensure acceptance of a more natural landscape character.

Outline Design

8.10 Affordability

The design of SuDS is influenced by the type of development and how important each component is to the appearance and functionality of the scheme.

An urban renewal project in highly urbanised areas of South Dublin will require a different approach to the visual quality than a simple SuDS design for a suburban layout.

SuDS components are cost effective when compared to conventional drainage but cost savings are only realised through good SuDS design.

A good example of cost-effective SuDS design in new build situations is the use of permeable pavement as a replacement for impermeable surfaces. The cost of the profile construction is marginally more expensive but avoids extensive pipe work, gullies, manhole, dedicated SuDS storage and in some situations oil interceptors. The open graded sub-base provides 30% void storage which is confirmed by a flow control and a low level of maintenance into the future.

Completing a cost comparison for permeable pavement demonstrates the wider considerations of drainage, surfacing and engineering profiles that have to be considered.

Comparative cost analysis for SuDS and conventional drainage

8.11 Management of SuDS features

The future maintenance of SuDS is influenced by design. Wherever possible the idea of 'passive maintenance' should be considered with SuDS components integrated into the everyday management.

Wherever possible maintenance should be allocated to site care (landscape management and cosmetic sweeping or hard surfaces) rather than SuDS management.

This reduced dedicated maintenance obligation can sometimes be reduced to just checking inlets, outlets and control structures. These structures must be easily accessible and able to be maintained by landscape care personnel.

Design note: Well designed SuDS are not 'land hungry' in that they can be integrated into both hard and soft landscape spaces which are available within development. Making SuDS cost effective reinforces the requirement to consider SuDS layout at Concept Design stage.

Where SuDS is not taken in charge the developer must confirm who will be responsible for this maintenance (along with specifying any legal agreements which confirm that the maintenance will be carried out).

8.11.1 Replacement

Where the design life of the SuDS component does not exceed the design life of the scheme, then engineering implications of replacement should be considered. This includes:

- A methodology for how the item will be replaced whilst maintaining drainage functionality of the site.
- Identification of how replacement will be financed (where not taken in charge by SDCC).

It is noted that some SuDS components may need some degree of rehabilitation / dedicated SuDS maintenance, for example, re-gritting of the joints in a permeable pavement. This is not the same as replacement, which may be required for geocellular or 'arch tunnel' tanks for example or other items with a defined or finite design life.

8.12 Submitting SuDS design as part of a planning application

The design information should be provided in plan form, confirming site layout and SuDS infrastructure together with a SuDS Design Statement presenting all information that cannot be conveyed on plan.

8.12.1 SuDS Design Drawings

The SuDS drawings will normally include plans, typical sections and typical details. Sufficient information should be presented within the drawing package to confirm / identify the following:

- Type of runoff collection to ensure runoff is at, or near, the surface
- Source control type(s) and location
- Management train (SuDS components in series) – extent and expected critical levels
- Sub-catchment boundaries with flow control locations
- Storage locations, extent and critical levels
- Conveyance – ideally at, or near, the surface
- Landscape character – the nature of the development and how SuDS is integrated into site design
- Biodiversity – opportunities for wildlife, clean water, connectivity and habitat design

Outline Design

8.12.2 SuDS Design Statement

The SuDS Design Statement should cover SuDS provisions on quantity, quality, amenity and biodiversity and how opportunities provided by the site have been maximised along with addressing the following:

- Confirm drainage design criteria stated by policy / SuDS requirements or agreed with SDCC. For example, rainfall return periods, discharge allowance, traffic loading requirements etc.
- Summarise the findings of the SSFRA (where one is required) and highlight any other significant site constraints
- Outline how requirements of South Dublin Development Plan SuDS related policies and objectives, requirements for multi-functional use of SuDS space and local objectives for sustainability including climate resilience are dealt with
- Explain how SuDS will function passively in terms of treatment and management
- Outline details of any off-site works required, together with any necessary consents.
- Details of any proposed wayleaves or land transfers in relation to surface water drainage

8.12.3 SuDS Design Calculations

Calculations are required to demonstrate the hydraulic performance of the scheme.

Structural / geotechnical assessments are also required for SuDS structures where loading is exerted. As a minimum an assessment of the following will be required;

- Strength of the soil supporting the SuDS structure
- Loading from vehicles etc. that the structure will be required to take
- Structural capacity of the SuDS structure

8.12.4 Design Evaluation Checklist

The following table provides a list of key considerations for design and evaluation.

The CIRIA SuDS Manual Table B.3 provides other aspects for checking which may be incorporated on a case by case basis.

Deliverable	Key design points	Key evaluation points
Design standards	Designers should confirm how all policies and standards have been achieved for quantity, quality, amenity and biodiversity.	Confirm discharge rates. Confirm that sufficient treatment is in place. Confirm amenity and biodiversity requirements.
Site surveys and investigations	Confirmation of existing utility locations, assessment of presence of contaminated ground, confirmation of infiltration rates Infiltration tests should be done prior to submitting planning application as this will determine to an extent what type of SuDS can be incorporated into the site	Infiltration tests undertaken in accordance with relevant standard (test repeated 3 times etc.)
Confirm method & locations of discharge	Where positive discharge is made to a watercourse / sewer, consider likelihood of surcharge on storage from the receiving sewer / watercourse. Infiltration – outline how ground will be protected from compaction during construction.	Review the level at which water is stored relative to receiving flood plain levels/sewer invert. Infiltration – review how groundwater table level has been confirmed and how ground will be protected from compaction during construction. Review risk of infiltrating close to buildings. Review how infiltration on brownfield sites has been assessed.
Hydraulic calculations	Detailed checklist is contained Section 8.5.2 GDSDS Criterion 1-4	Calculation inputs - review areas, run off coefficients, SAAR, soil value(s). The level of analysis required should reflect the risk of failure, scale of development and complexity of drainage.
Detailed consideration of site and drainage design levels	Levels are crucial – check that there are no locations where low points might compromise design. Designer to present drawing showing detailed levels across the site	Sensibility check to be performed for each subcatchment, comparing top level of storage, and lowest level of contributing areas.

Deliverable	Key design points	Key evaluation points
Drainage details	Minimise risk of blockage by designing protected outlets and flow controls	Review of inlets, outlets, flow controls, storage, edge details, connection details to receiving watercourse / sewers
Hydraulic calculations & drawings match	Drawings should confirm volumes from calculations. Drawing's references / annotations should clearly relate to calculations.	Sensibility check to be performed to ensure that sufficient storage is provided to meet hydraulic calculations.
Designers hazard & risk assessment.	To consider construction, maintenance / operation by personnel and day to day site use by public.	Demonstrate safe design for users and operatives of the scheme.
Long sections and cross sections	Cross sections should not use exaggerated vertical scales to allow proper understanding of how scheme will appear	Review in general, side slopes and depths shown.
Planting design & schedule	Outline any SuDS specific planting requirements.	Ensure plants from accredited source to minimise risk of invasive species.
Consents & permits	Vary and can include: discharge consents; offsite works & 3rd party access consent.	Check that relevant consents are in place or can be obtained in principle. Where applicant proposes to connect to a combined sewer they will need agreement in writing from Irish Water when submitting their planning application.
Maintenance	Key plan (1 side of A4) detailing the maintenance regime and identifying key maintenance locations such as outlets and flow control locations.	Maintenance is appropriate & proportionate and features are easily accessible. Design achieves passive maintenance where possible.
'Taking in charge' arrangements	Confirmation of commitment to take in charge aspects of the scheme agreed with SDCC. Confirmation of ownership and maintenance responsibilities for all parts of the SuDS scheme which are not being taken in charge.	Review that sufficient safeguards are in place for the long term maintenance and operation of the drainage. Review that SuDS are designed to SDCC taken in charge standards

9.0 Stage 3 - Detailed Design

The development of the SuDS design to Detailed Design stage will ensure that delivery against SuDS requirements and related policies within the Development Plan are upheld post planning approval through to construction stage.

Provision of detailed design for SuDS to SDCC may be conditioned as part of the planning approval. Further detail may also be required by DCC where SuDS structures are proposed to be taken in charge.

Changes can arise during construction, which may affect the design such as the presence of unknown utilities or ground condition variations. Further detail may also be required by SDCC where SuDS structures are proposed to be taken in charge from that presented during the planning approval phase.

A detailed design will enable a contractor to build the scheme to the correct specification and will confirm the specific detailing associated with the SuDS structures (where not confirmed at outline design stage).

9.1 Objectives of Detailed Design

Detailed Design should develop and refine the agreed SuDS strategy from the Outline design stages (agreed through the planning process). Outputs from the detailed design should:

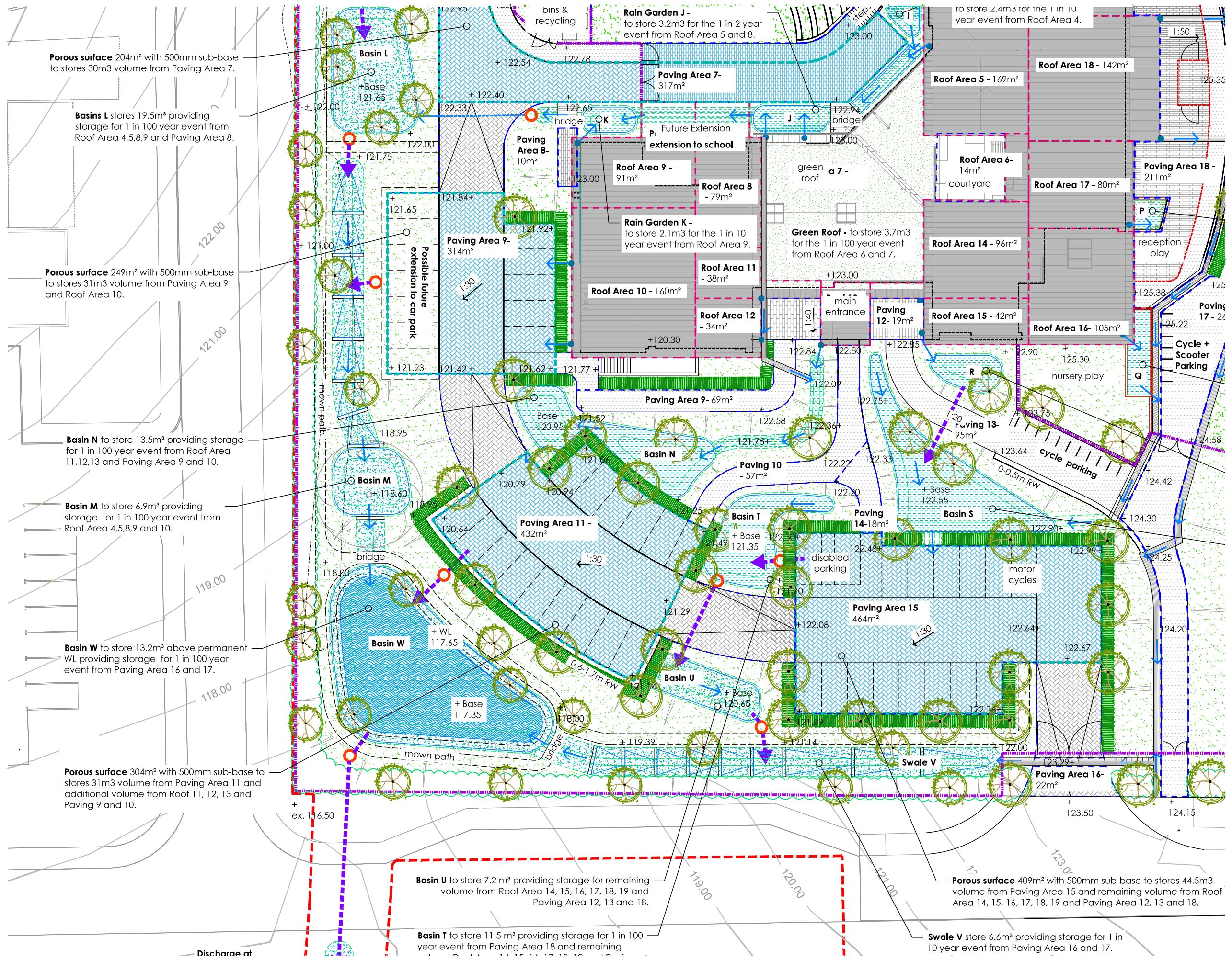
- Be based upon further detailed testing and site investigation results as may be appropriate to the scheme or arise as part of the construction phase.
- Provide sufficient information for full understanding of how the scheme will appear and operate.
- Provide sufficient materials and performance specification to allow a contractor to successfully build the scheme as per the design.

9.2 What Detailed Design should demonstrate

The SuDS Detailed Design considers in detail all the influencing factors on the scheme with over-arching requirements as follows:

- The use of Source Control techniques provides a controlled flow of clean water through the site
- Demonstrate that the modified flow route(s) provides for extreme flows and where possible connectivity corridors for biodiversity through the site
- Careful consideration of all site levels to ensure that the system will function as intended in 'day-to-day' and extreme conditions
- Demonstration that individual SuDS components meet respective design criteria
- Proportionate analysis to confirm attenuation volumes with allowances for climate change and urban creep, and controlled flow rates for each sub-catchment and final site discharge rates
- Materials and plant varieties specified in accord with local landscape character
- Demonstration of safe design for contractors, operatives and general users of the site
- That SuDS which are being 'taken in charge' meet the standards of SDCC.

Design note: Unforeseen information such as presence of previously unknown utilities can result in material changes to the design consented at planning stage. SDCC Planners should be consulted in such instances.



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Detailed Design

9.3 Typical Detailed Design package

The Detailed Design package will generally encompass a design statement with accompanying drawings, design calculations, maintenance plan and risk assessment.

9.3.1 Drawing package

The SuDS drawing package should include the following:

Design information drawings	Topographical survey of the site Coordinated constraints map identifying all potential design constraints including areas of flood risk (fluvial, pluvial and ground water), contaminated land, archaeological significance, poor ground conditions, presence of invasive species, protected habitats, Tree Preservation Orders (TPO) and root protection zones (RPZ), presence of existing basements or other underground structures. [note : list is not exhaustive] Existing utility services drawing. Details of existing site surface water drainage infrastructure and ownership established. Plan of site detailing flow routes including exceedance flow routes, subcatchment boundaries, flow control locations, storage locations, contributing impermeable area, and phasing where appropriate. Drawing of site drainage catchment areas showing permeable and impermeable areas within defined subcatcatchments.
Design drawings	Detailed site layout at an identified scale (1:200 or 1:500 or as appropriate or any other scale agreed) including a North direction arrow. Long sections and cross sections for the proposed drainage system, including surrounding site level and proposed finished floor levels (where appropriate) Construction Details – inlets, outlets, flow controls, storage, edge details, connection details to receiving watercourse / sewers / public surface water sewers; Planting arrangement and surface treatment / materials drawings where detailed not included on other drawings. Critical design levels should be identified on all relevant drawings.

9.3.2 Supporting information

Depending on the nature of the scheme, various investigations, tests and calculations may need to be performed along with obtaining necessary consents:

- Ground investigation, including infiltration test results, soil testing and groundwater monitoring as appropriate. Note that infiltration tests should be completed prior to submitting planning application as this will help determine what type of SuDS can be incorporated into the site and the method of discharge.
- Design calculations which demonstrate compliance with the design criteria for the site including all hydraulic and structural calculations for permeable pavements and underground storage structures as appropriate.
- Details of any offsite works required, together with any necessary consents in place (or can be obtained).
- Confirmation that discharge consents are in place (or can be obtained): Section 50 Consent (OPW) may be required for works in, under, over or near a main river, works on or near a flood defence or for works in the flood plain of a main river; or road drain (SDCC). Discussions should be held with EPA for infiltration within Source Protection Zone areas.
- Where applicant proposes to connect to a combined sewer they will need agreement in writing from Irish Water when submitting their planning application.
- Proposed maintenance schedule and confirmed management arrangements for all drainage which is not taken in charge. Identify any proposed split of the SuDS between private (curtilage) and public (open space or road) land.
- Designer's hazard and risk assessment- to consider construction, maintenance and operation by personnel and day to day site use by public.
- Details of any informative signage proposed for SuDS.

Detailed Design

9.4 Critical levels

Levels are important in any drainage system and especially so for surface based SuDS. The proposed surface levels should align with the modified flow route analysis in providing a flow path across the site and storage volumes can be significantly affected by inaccurate levels.

The following levels should be evaluated when developing or reviewing a design:

- The flow control invert level relative to storage - the flow control should not be situated above the base level of the storage component unless there is a requirement for permanent or semi-permanent water.
- The overflow level should demonstrate that the required volume of storage is contained between the flow control invert level and the overflow level.
- Areas contributing to a storage component should not be situated below the top level of storage as they may flood prior to the storage being filled.
- For storage components that are sloping, such as permeable pavements or linear basins, the 'effective' storage should be determined rather than the entire volume of the structure.
- A review of site levels should not identify any obvious obstructions along exceedance flow paths.

9.5 Importance of detailing

Poorly detailed aspects of SuDS structures will degrade the appearance of the development. Failure of individual detailed elements of the design can:

- invalidate expected storage volumes and flow rates
- prevent adequate treatment
- negatively impact or miss opportunities to contribute to amenity use
- create hazards to wildlife or miss opportunities to support biodiversity
- cause local ponding, flooding and inconvenience to the public
- increase maintenance difficulty and cost.

Competent design details ensure that runoff is collected, conveyed, cleaned, stored, controlled and discharged from site in an effective manner that provides wider benefits.

A dropped kerb inlet allows road runoff to enter a planted raingarden.

10.0 SuDS Components

Competent design and detailing of SuDS components ensures that runoff is collected, conveyed, cleaned, stored, controlled and discharged from site in an effective manner.

The general principles of SuDS component design are considered in the SuDS Manual 2015 Sections 11-23. The purpose of this section is to outline some of the key considerations, experiences and practical detail solutions of commonly used SuDS components.

The following classifications are not rigid, for example a permeable pavement can be considered as both source control and site control where it provides the required site storage:

A retrofit downpipe shoe and brick channel into a raingarden

Source Controls providing storage

Providing storage throughout the site (distributed storage components), means that every opportunity for storage across the site is exploited, greatly reducing the overall volume and size of site controls.

Source controls remove most silt, heavy metals and heavy oils from runoff, allowing basins, wetland and ponds to be designed as site assets.

- green/ blue roofs
- raingardens
- bioretention
- permeable pavements

Collection and connection

Where runoff is collected from roofs, conveyance to the SuDS component may be required. Historic urban design shows us a number of surface collection methods including spouts, surface channels and rills.

How runoff is collected and conveyed under crossing points such as footpaths and roads is a primary consideration of any SuDS design. Design details such as road gullies can artificially increase the depth and cost of SuDS.

- channels & rills
- filter strips
- pipe connections

Source Controls providing collection & conveyance

Water must either be kept at or near the surface to allow runoff to flow into SuDS structures, or it must be collected through permeable surfaces.

The simplest method of collection of runoff from an impermeable surface is to intercept it as sheet flow from a hard surface. Where runoff flows directly from hard surfaces to filter strips or swales then runoff must leave the hard surface effectively without the risk of ponding.

- swales
- under-drained swales
- filter drains

Site Controls

Where runoff is collected at the surface, a depression in the ground, mimicing hollows in the natural landscape, is the easiest and most cost effective way to manage large volumes of water in the landscape.

Where landscape is limited, storage opportunities within pavements and on roofs should be explored.

Careful design can maximize opportunities with different design volumes in different places providing maximum opportunities for multi-functional use and biodiversity.

- basins
- wetlands
- ponds
- storage structures

Detention Basin in public open space - The Way, Citywest Avenue

SuDS Components

Using SuDS structures for attenuating rainfall

The following table is intended to provide an initial guide of the potential storage available within various types of SuDS structures. Effective use should be made of available storage within SuDS structures throughout the management train, which will result in a more cost effective design.

SuDS structure	Indicative Attenuation storage (m^3 of storage per m^2 of SuDS structure)
Blue roofs	0.05-0.1
Rain water harvesting	0
Swales	0.15-0.4
Permeable pavements	0.05-0.15
Filter Drains	0.15-0.5
Rain Gardens	0.3
Tree pits	0.4
Detention basins	0.6
Ponds	0.6-1.2
Wetland	0.3-0.9
Underground storage	0.4-2.0

Designers should be mindful of:

- how site factors will influence the design and the storage.
- SuDS structures often have to be designed for structural performance (eg. Permeable pavement) which may require greater depths that what is required hydraulically.
- SuDS structures can be increased in size to meet hydraulic requirements. Safety considerations and designing as part of a multi-functional landscapes will factor into the consideration of maximum depths of open SuDS structures such as swales, basins, ponds and wetlands.

Designing ancillary structures

Inlets and outlets structures from an integral part of SuDS features. These structures should be at or near the surface and designed to be easily maintained and integrate with the host landscape.

Inlets are designed to reduce the risk of erosion and collect polluted silts washed off the adjacent surfaces. Small slabs or small concrete aprons are commonly used at concentrated inflow points.

Flow controls will be required to demonstrate that flow is being retained within the SuDS structure and should be designed to ensure that they are protected from blockage (See Section 8.5). In most situations 10-20mm can be used where there is a method of filtering debris and silt from flow in advance of the flow control.

SuDS Components

Confirming drain down mechanism

SuDS components always have a way of emptying, either through a free release outlet, a flow control or infiltration. The ability to fully drain down SuDS treepits and bioretention areas ensures that road salt does not become an issue as the salt will dissolve during rainfall and be washed through the structure and exit via the outlet.

Connecting SuDS to the combined sewer

Where connection is to the combined sewer an **odour trap** should be located between the SUDS feature and the point of connection to the sewer.

Non-return values will not normally be required. Where there is a risk of surcharge from the combined sewer, the flow control will protect the SuDS structure from debris within combined sewerage. Any polluted flow which enters the SuDS feature should therefore be free from debris and the treatment processes present within nature-based SuDS features will naturally break down with any residual organic pollution which remains.

Designing for maximum benefit

Each SuDS component has been assessed for their potential to contribute benefits against each of the four pillars of SuDS design.

The extent of benefit is defined by the shading for each of the icons associated with the individual SuDS components on the following pages of this guide.

0 - unlikely benefit
1 – maximum benefit could be achieved in some cases with good design
2 – likely benefit

	Green and Blue Roofs	Rain harvesting	Rain gardens	Bioretention rain gardens	SuDS tree pits	Permeable surfaces	Swale	Filter drains	Channels and rills	Filter strips	Basins	Wetlands and ponds	Storage structures
Quantity	1	1	1	1	1	2	2	2	1	0	2	2	2
Quality	2	0	1	2	2	2	2	2	1	1	2	2	0
Amenity	1	2	2	2	2	2	1	0	1	1	2	2	0
Biodiversity	2	0	2	2	2	0	2	0	1	1	1	2	0

Green & blue roofs

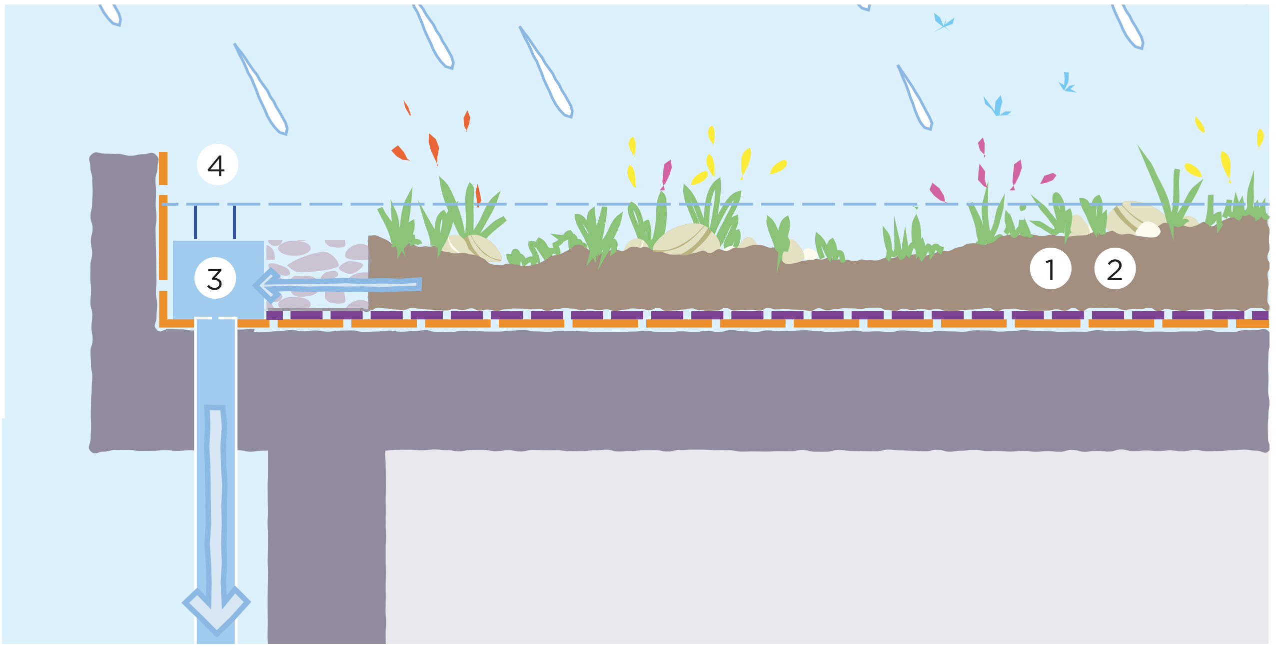
A green roof is a roof or podium deck onto which vegetation is grown, or habitats for wildlife are established. There are various types of green roofs including: extensive and intensive roofs, semi-intensive, roof gardens, biodiverse roofs and brown roofs. Green roofs can also serve an amenity function where designed for this purpose.

Blue roofs hold rainwater runoff on roofs and podium decks and release rainfall slowly through a 'flow control'. Blue roofs do not have to be vegetated. Flow can be stored within open or closed hard landscape structures on roofs and podium decks. Storing rainwater that falls on the roof provides the potential to reduce or remove the requirement for attenuation storage elsewhere on a development

1. A minimum 100mm soil depth is recommended for drought resilience and this design is particularly suitable for a natural dry grassland vegetation.
2. Most green and blue roof substrates have a water storage capacity of between 30-40% void ratio.
3. A simple orifice control together with overflow arrangements provides an ideal opportunity to retain water on the roof meaning that it does not have to be stored again at or below ground level. This arrangement is particularly important for urban redevelopment where the building footprint may take up all the site. This would be referred to as a blue roof.
4. Provide a suitably sized overflow / exceedance route

Design note: All green blue roofs shall be designed in consideration of current fire safety requirements.

All green blue roofs shall be designed in consideration of current fire safety requirements.



Rain harvesting

Rain harvesting systems come in a variety of forms, ranging from simple water butts, to larger more complex systems (with underground tank collection systems, filters, throttles, vales and pump). Rainwater from roofs and hard surfaces can be stored and used, although runoff from roofs is normally targeted due to reduced pollution risk.

Suitable used for harvested rainwater include:

- Garden watering
- Irrigation of larger amenity areas such as playing fields or gold courses
- Toilet flushing
- Car washing
- Fire suppression or emergency use water

Some aspects to consider:

- Potential for pollution in runoff being collected
- Sizing of rain harvesting facility and the likely demand by users
- Regularity of demand - will demand fluctuate and how does this compare with local rainfall patterns
- Provisions for ongoing maintenance.

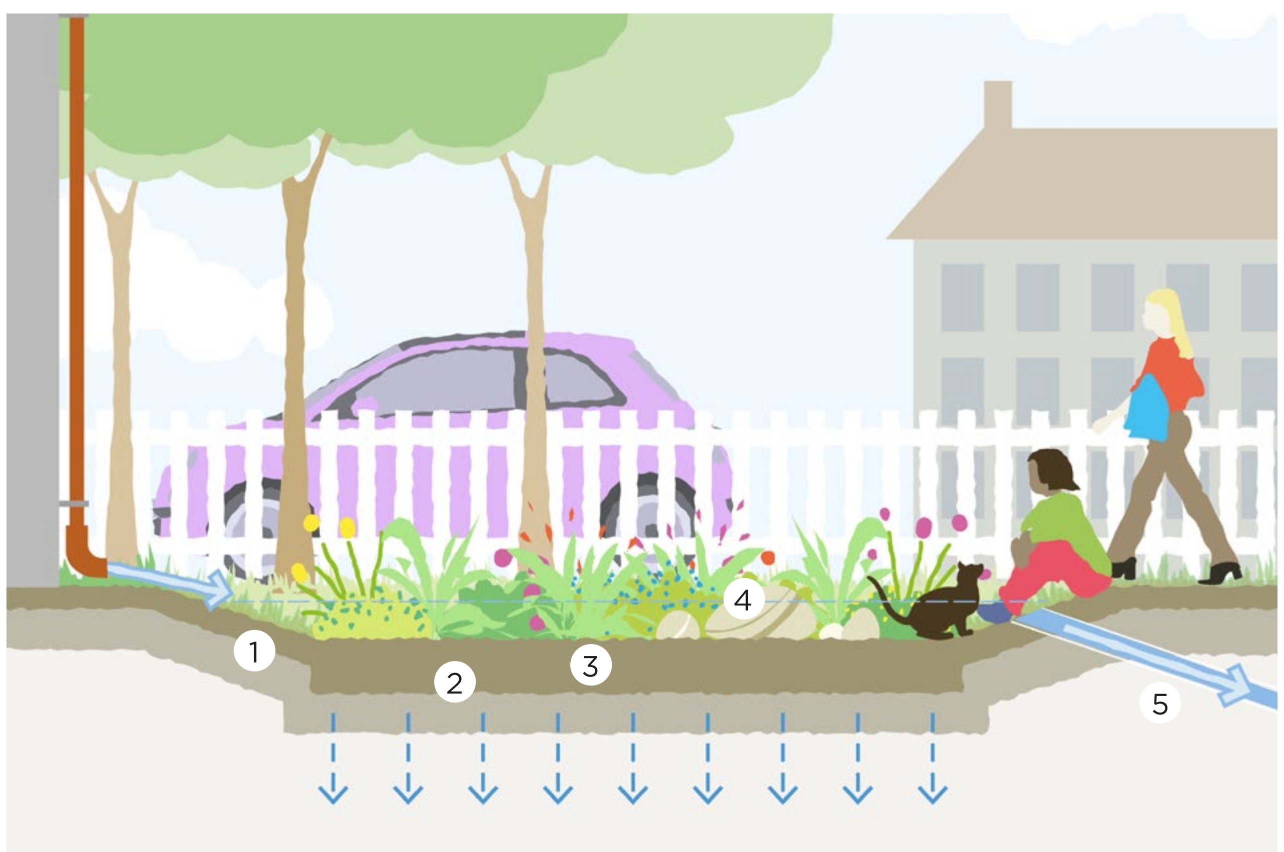
See 2015 CIRIA SuDS Manual (C753) Chapter 11 for further information.

Raingardens

Raingardens are designed to collect and manage reasonably clean water from roofs and low pollution risk drives and pathways. They are generally installed where community or private maintenance is available to upkeep these attractive features.

Key aspects of raingarden design include:

1. gentle side slopes with water collected at the surface
2. a free-draining soil, sometimes with an underdrain to avoid permanent wetness
3. a minimum of 450mm improved topsoil with up to 20% coarse compost
4. garden plants that can tolerate occasional submersion and wet soil – this includes most garden plants other than those particularly adapted to dry conditions
5. an overflow in case of heavy rain or impeded drainage.



Bioretention Raingardens

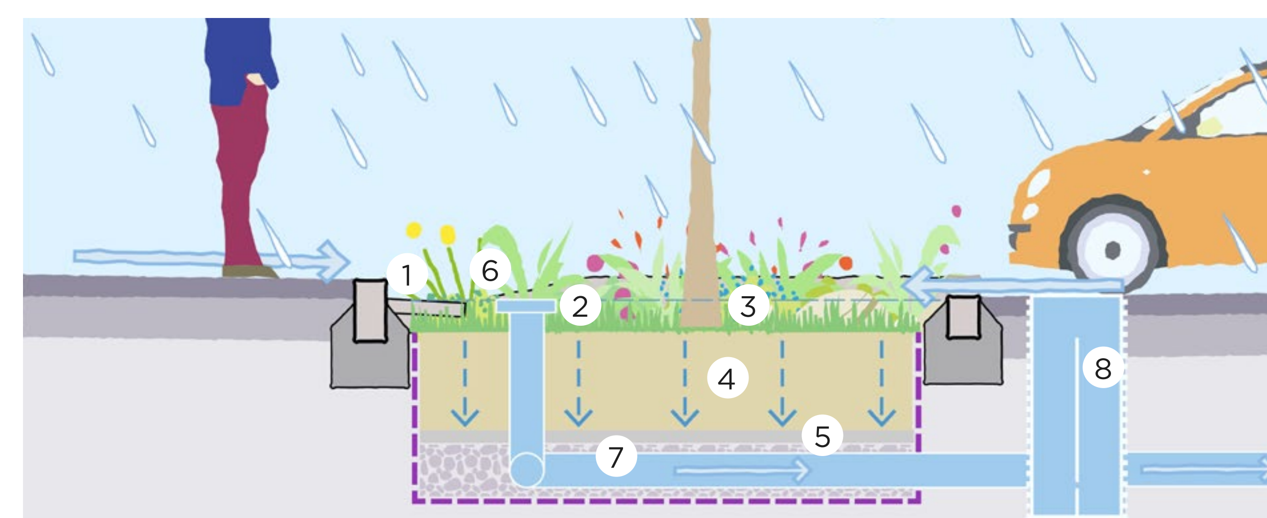
A bioretention structure differs from a raingarden in that it employs an engineered topsoil and is used to manage polluted urban rainfall runoff in street locations and carparks. These features can contribute significantly to the urban scene so should be designed to meet urban design standards.

The runoff entering bioretention features will normally carry silt and pollution from vehicles and urban street use. Therefore, some maintenance should be expected to remove the build-up of inorganic silt.

The free-draining nature of engineered soils leads to the washing away of nutrients from the soil. The proportion of organic matter should be relatively high and replenished yearly by the application of a mulch layer of well composted green waste or shredded plant matter arising from maintenance.

Key design aspects for bioretention raingardens include:

1. silt collection in forebays – using a small apron or slab to allow for easy removal of silt
2. space above the soil profile for water collection and stilling before infiltration through the engineered soil
3. a surface mulch of organic matter, grit or gravel protects the infiltration capacity of the soil
4. a free draining soil, 450 -600mm deep, with 20-30% organic matter cleans, stores and conveys runoff to a drainage layer
5. a transition layer of grit and/or sand protects the under-drained drainage layer
6. a surface overflow for heavy rain or in the event of blockage.
7. perforated land drain to allow for full drain down
8. flow control to ensure that storage is utilised (particularly on larger bioretention areas)



SuDS Tree pits

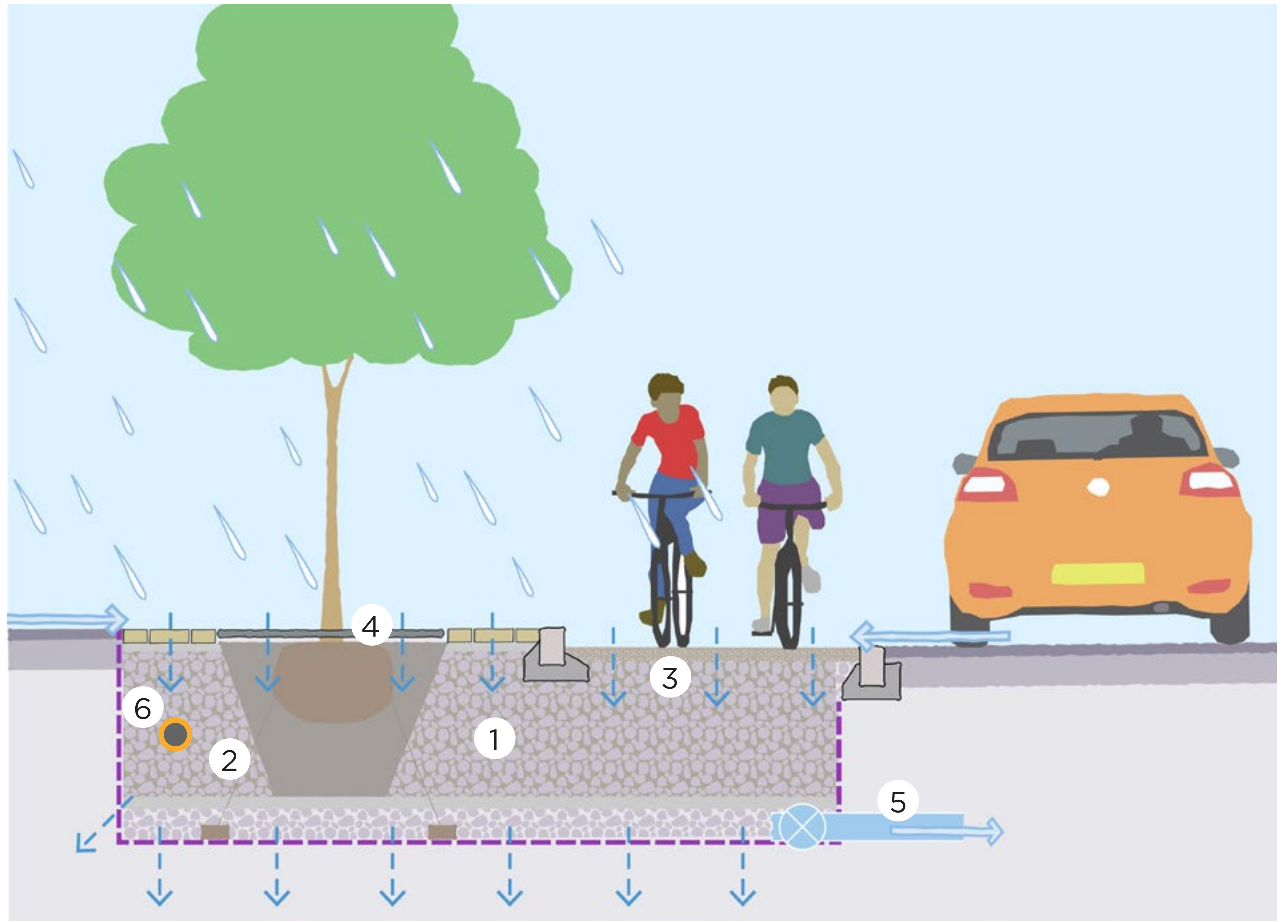
SuDS tree pits are designed to collect runoff from the surrounding landscape. They can be integrated into both new development and urban renewal enabling large trees to thrive by being watered every time it rains. Healthy trees also need sufficient soil to grow, and this growing medium can also be used to store water before being released slowly to the next part of the drainage system. SuDS trees can contribute significantly to the Climate Action Plan and the size of the proposed tree canopy should be carefully considered to achieve maximum benefits.

The runoff entering bioretention features will normally carry silt and pollution from vehicles and urban street use. Therefore, design will have to carefully consider how this can be intercepted and some maintenance should be expected to remove the build-up of inorganic silt.

SuDS tree pits managing runoff conveyed through kerb inlets. These two trees share a connected structural soil zone beneath the surface.

Key design aspects for SuDS tree pits include:

1. Trees should have a growing medium of between 10-30m3 depending upon the tree species.
2. A number of tree pits can be linked along a trench to optimize the volume available to each tree.
3. Robust silt removal must be incorporated within the tree pit design to allow runoff from roads to be permitted into the SuDS tree pit.
4. Positioning and specification of trees to be in accordance with Design Manual for Urban Roads and Streets
5. Drain down pipe must be provided to ensure there is no prolonged waterlogging of roots and no build-up of road salt within the SuDS tree pit.
6. Service trenches can be provided through the tree pit (in agreement with SDCC). Suitable services include most water, gas and drainage systems. Consider requirement for replacement if the utility is old. Electrical supply or telecoms with a joint box located in the SuDS feature are not recommended.

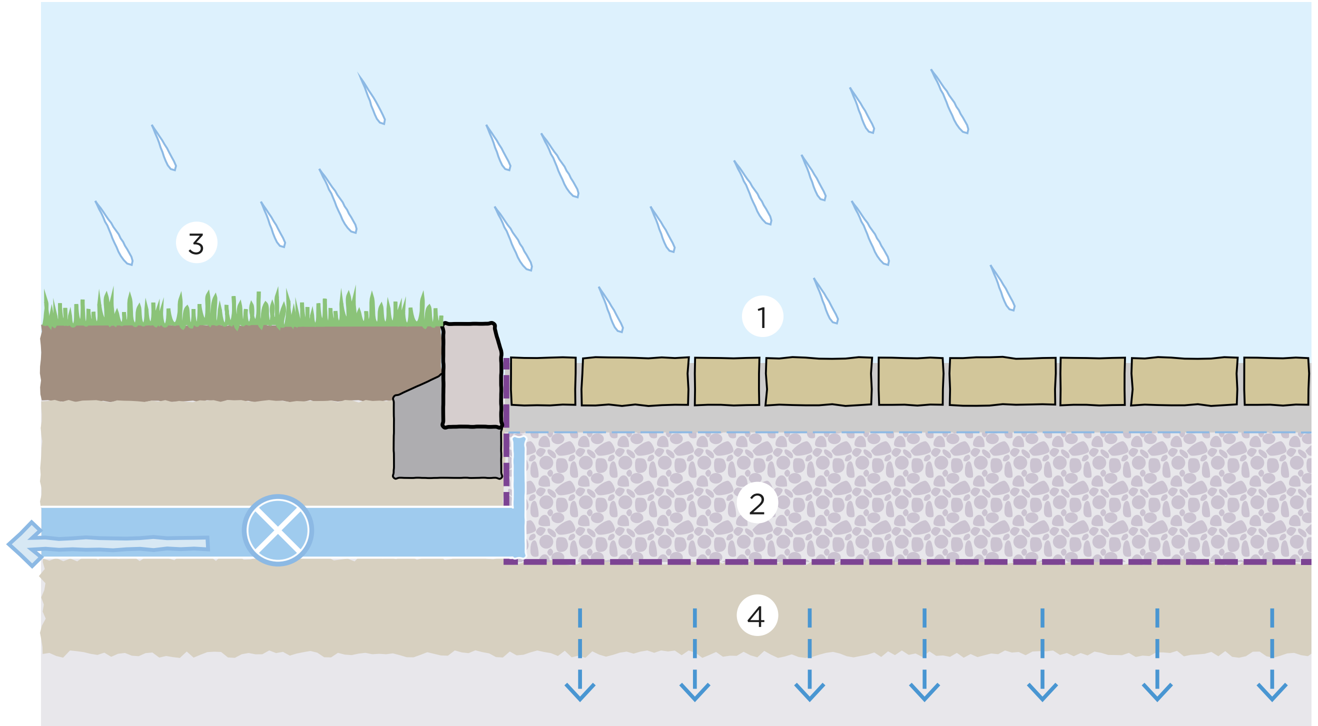


Permeable surfaces

Permeable surfaces enable SuDS designers to direct rainfall straight into a SuDS structure for cleaning and storage or infiltration into the ground.

There are several permeable surfaces available. All should have in common:

1. a pervious surface to allow water through the pavement surface
2. an open-graded sub-base layer that provides structural strength to the pavement with about 30% by volume available for water storage. The sub-base needs to be designed structurally and hydraulically.
3. Silt washed off adjacent landscape areas can lead to localised surface clogging. This risk can be managed through design detailing as follows:
    - slope adjacent landscape areas away
    - use paved or turfed surfaces to adjacent areas
    - soil in adjacent planting beds should be min. 50mm below the top of kerb and planting should include dense ground cover to bind the soil.
4. Infiltration test to be undertaken at formation level (where system is proposed to infiltrate). Design to be based on saturated CBR values.



The design and construction of pervious pavements are covered by guidance in the 2015 SuDS Manual (Section 20) and the Interpave website www.paving.org.uk

There are no reported issues with surface clogging under normal use. Maintenance may be required after 10 to 20 years of use comprising a brush and suction removal of grit joints and joint replacement.

Design manual for Concrete Block Permeable Paving

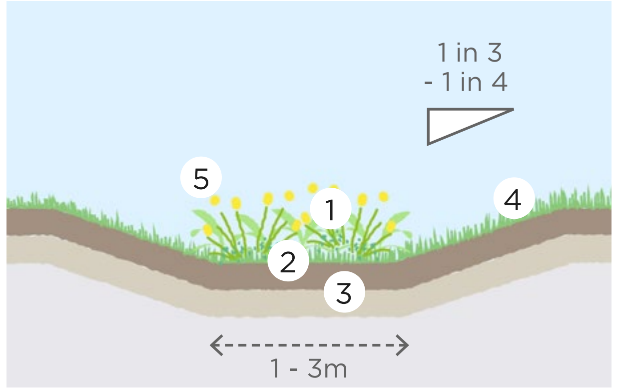
Reinforced grass paving area
Dodder Valley Park Sports Pavilion (credit AOCA)

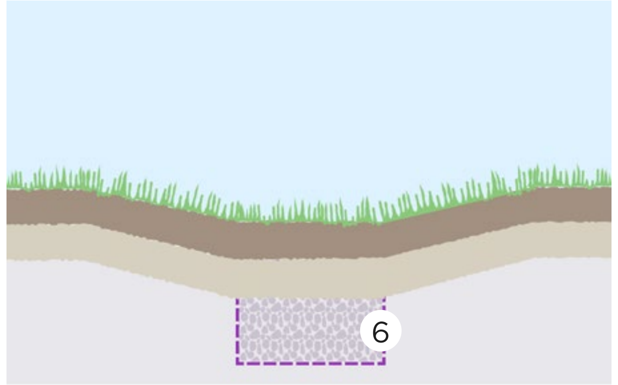
Soft landscape areas are set below kerb level at this permeable paving installation.
Almac Car Park, Limerick, Ireland.

Swale

Swales are shallow, flat bottomed vegetated channels which can collect, treat, convey and store runoff.

1. The basic profile is a 1 in 3 or 1 in 4 side slopes to a flat base falling at no more than 1 in 50 to prevent erosion. Checkdams or terraced swales can be used to mitigate risk of erosion where 1 in 50 falls cannot be achieved.
2. Base width less than 1m wide will increase the risk of erosion and ditch forming, conversely, base width wider than 3m a meandering channel can develop.
3. 150mm clean topsoil over subsoil. Ripping or light harrowing will improve establishment of the swale by providing a key for the topsoil, encourage deep rooting and assist infiltration.
4. Where swale vegetation is kept less than 100mm, the shoulders at the top of the swale can be 'scalped' leaving bare soil. The shoulders should therefore be rounded to prevent this happening.
5. Swale can be vegetated with more biodiverse plants to attract pollinators etc.
6. Swale can be under-drained using a filter drain to create a dry swale.





Performance criteria

Max. velocity at peak capacity – 1m/s

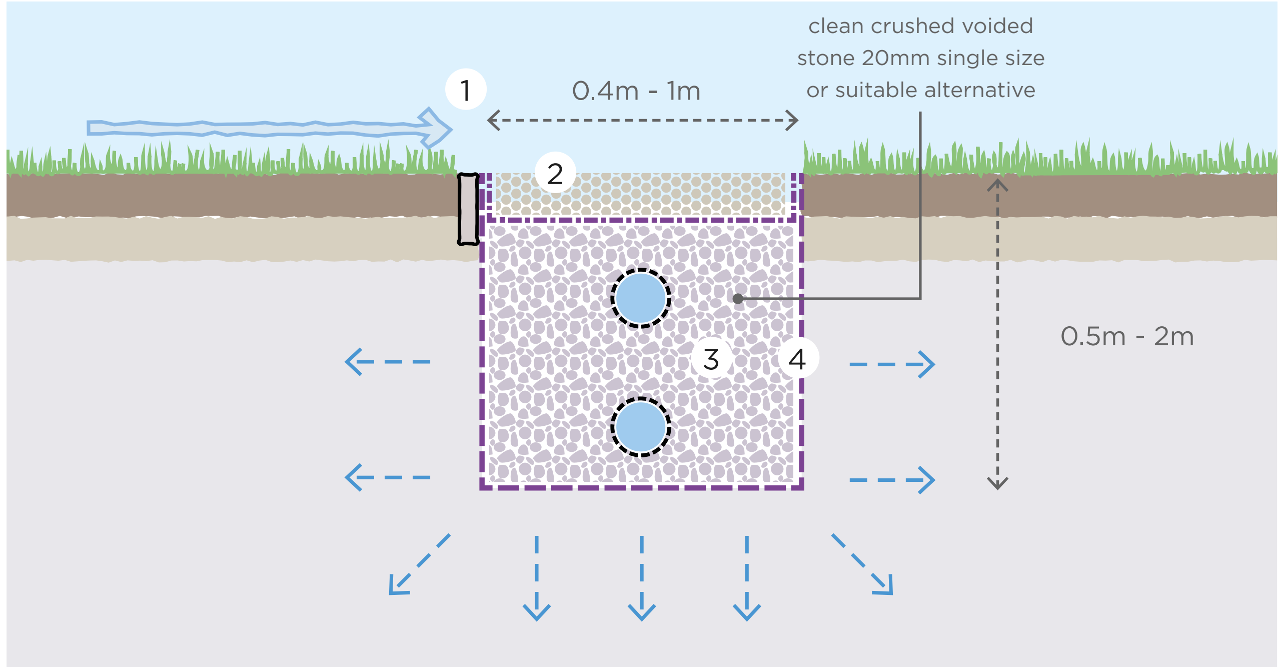
Max. velocity at low flow – 0.3m/s

Travel time (low flow) – 9 minutes

Filter drains

Filter drains, sometimes called a French drain, is an open stone filled trench. Sizing of filter drains will depend on several factors and capacity can be considered for both conveyance and temporary storage requirements.

1. Runoff should ideally cross the long edge of the trench as a sheet. This may require a temporary level timber board along the leading edge to prevent erosion of unconsolidated soil.
2. A sacrificial top layer may be considered at the top of the drain to trap any silt for simple removal. Alternatively, a grass filter strip placed in front of the filter drain will reduce potential for clogging.
3. A lower perforated pipe will assist discharge and an upper perforated pipe can act as an overflow. However, neither may be necessary depending on the design and location.
4. Most filter drains are designed with geotextile lining. Many geotextiles are susceptible to blinding from fine materials in soils and specialist advice should be sought for specification. Alternatively consider hessian liner which will biodegrade over time by the time soils around the filter drain will have stabilised.



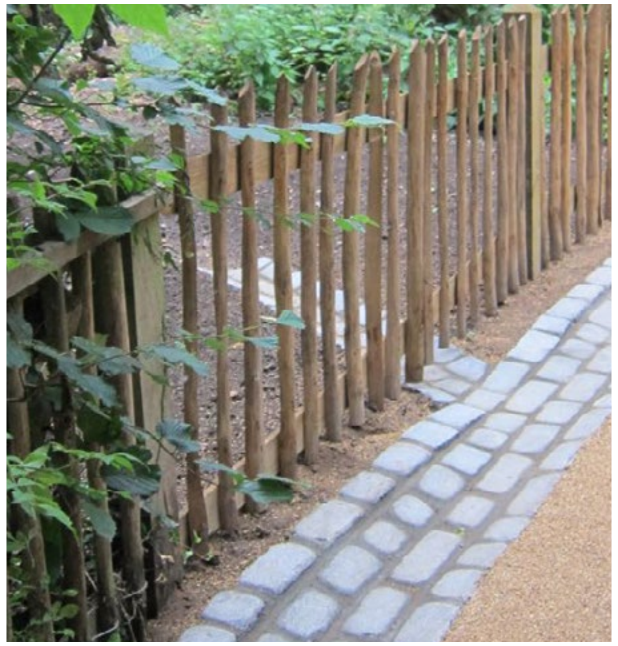
Channels and rills

Sett Channels and rills keep rainwater at or near the surface. This is important as it allows water to flow directly into SuDS features reducing cost, trip hazards and the inconvenience of deep structures in the landscape.

In some places a grated surface channel may be more appropriate, but the mesh size should not be too small, or the grating will be prone to blockage.

Collecting runoff from a road can be more difficult where there is a path present, and a flush kerb inlet or chute gully may be needed.

A granite sett channel collecting and conveying runoff.



Use of pipes

Although SuDS are delivered without the requirement for extensive piped networks, short lengths of pipe can still be very useful in providing connections under roads, footpaths and other crossing points. Key points to consider are as follows:

- Short lengths of pipework should allow direct rodding from one end of the pipe to the other without the need for internal chambers.
- Inlets and outlets should be designed so that they are not prone to blockage.
- An exceedance flow path should be integrated into the development surface above pipework to ensure that unpredictable flows are directed SuDS immediately after the crossing.
- The depth of the downstream component should not be artificially increased due to a requirement for structural cover over pipework. Different pipe materials or concrete surround can be considered to minimise cover - as used for driveway crossings at the Devonshire Hill project above.

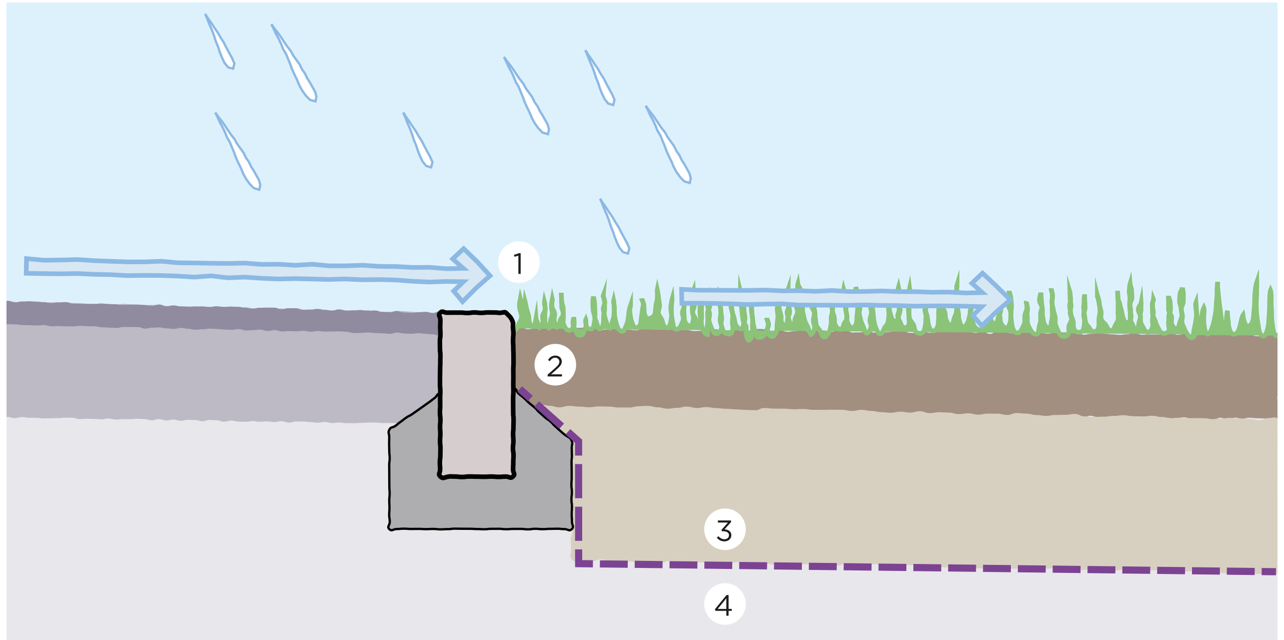
A planted rill - School Science Block.

Filter strips

The hard edge from a pavement to a filter strip is generally defined by a kerb. Filter strips are effective at removing silt at source and will connect to SuDS feature such as a swale after a short distance. Where runoff is introduced as sheet-flow noticeable silt build up is only likely after a prolonged period (10 years +).

Image shows topsoil washout. The haunching is set near the top of kerb allowing for minimal topsoil to be placed, therefore prone to erosion over time.

1. Provision of a small drop across the edge of the kerb (circa 25mm) allows runoff to move freely off the pavement.
2. The concrete haunch should be finished at minimum of 100mm below the surface to ensure good grass growth up to the edge of the pavement.
3. Free draining soils - a protective liner should be situated at least 300mm below clean sub-soil for an agreed distance offset from the pavement to prevent pollution migrating through subsoils to groundwater. The liner should extend laterally until the risk of contamination is suitably mitigated (circa 2-3m is suggested)
4. Clay soils - runoff will flow across the surface with limited potential for infiltration negating the requirement for a liner.



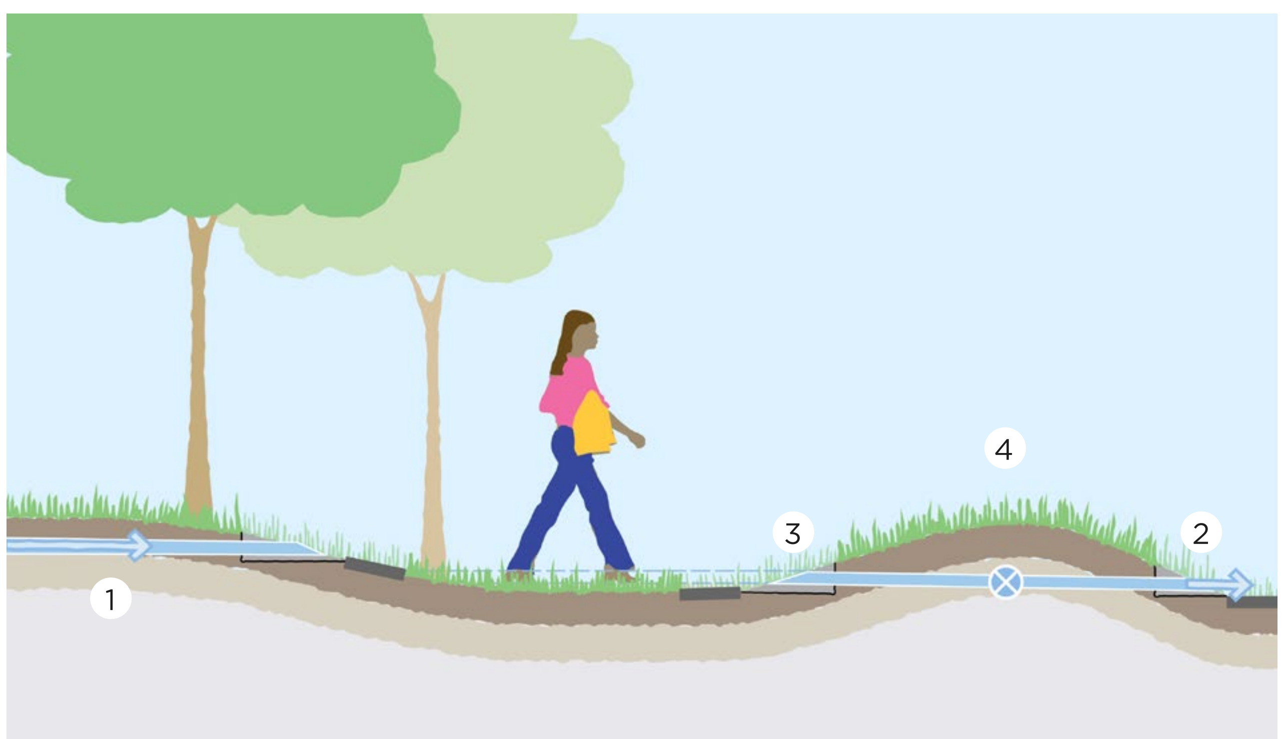
Basins, wetlands and ponds

1. Reasonably clean water, through use of source control, should flow into site control components at or near the surface in a channel or swale.
2. Where a pipe connection is unavoidable they should flow through a safe and visually neutral headwall, such as a mitred concrete headwall or stainless steel gabion basket inlet.
3. Small aprons (slab or similar) at points of entry and exit for collection of silt.
4. Suitably sized overflow

Avoid using riprap as a form of erosion control, as loose stones easily move around and cause a nuisance for maintenance teams.

This basin can be used throughout the year.

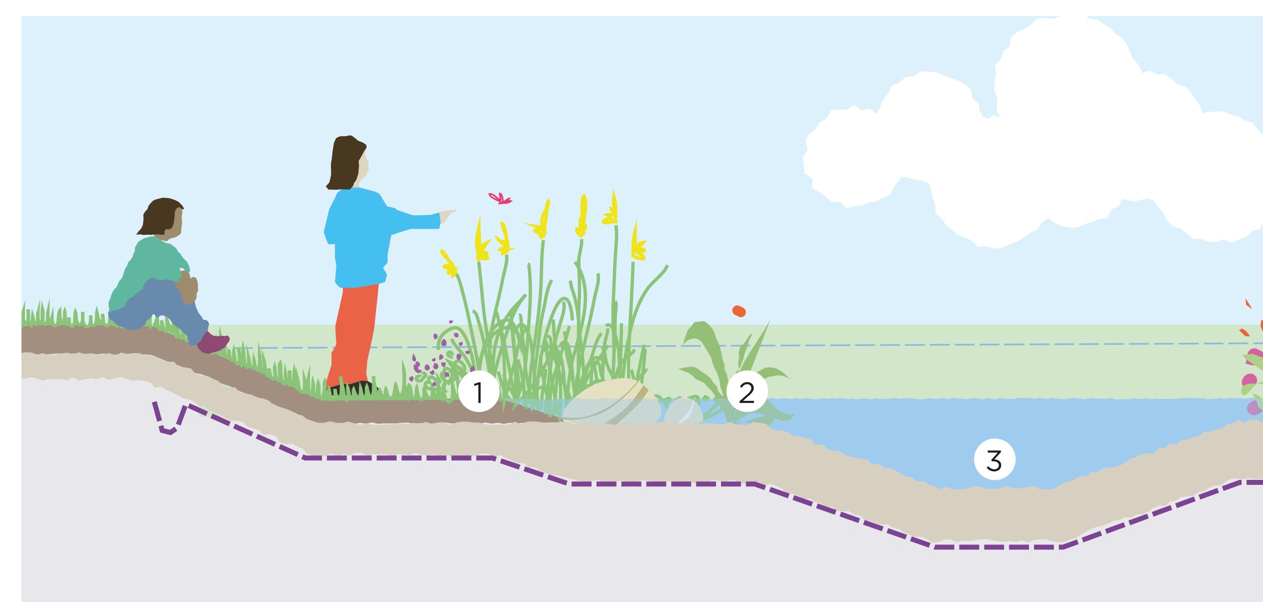
An example of 'safety be design': these children are doing a dance and movement class in a SuDS storage area at a School.



1. The profile of the structure should allow easy and safe access for people and maintenance machinery. Slopes should not exceed 1 in 3 or 1 in 4 and in larger basins access ramps with a gentler slope should be considered. The idea of a series of slopes and level benches is now accepted as an appropriate detailing for SuDS basins and ponds.
2. The overall depth of temporary storage should not normally exceed 600mm as this depth is critical for a feeling of safety in water. The bottom of the temporary storage dry basin should slope gently so that most of the time the base is firm and dry. Shallow micropools and wetland habitat should be integrated carefully into the basin as they will not be visible when the basin is full of water.
3. Permanent pond depth need not exceed 600mm as this is a common depth of natural ponds and where most biological activity occurs. However, a depth 600mm without regular maintenance means that vegetation will cover the pond in time. Most wetland edge plants cannot colonise beyond 1.2m depth of permanent water. Therefore, a deeper area in the centre of the pond, with surrounding shallower benches can be considered if open water is desired. Effective storage of 600mm over permanent water depth of 1.2m provides a total potential stored depth of 1.8m and the design must take this into account.

The safety considerations in basin, wetland and pond design should be considered carefully.

Further safety considerations are outlined on the following page.



Further Safety Considerations

All hard engineered structures should be set back 1m from permanent water edge, which will prevent drowning in the event of concussion.

Protective fencing will not keep children out of ponds and merely acknowledges a dangerous condition. Well designed ponds should be easy to exit and accessible for rescue if this is required.

Pond depths and profiles should not be designed for ease of open water swimming. This can be achieved by varying the profile of the pond throughout.

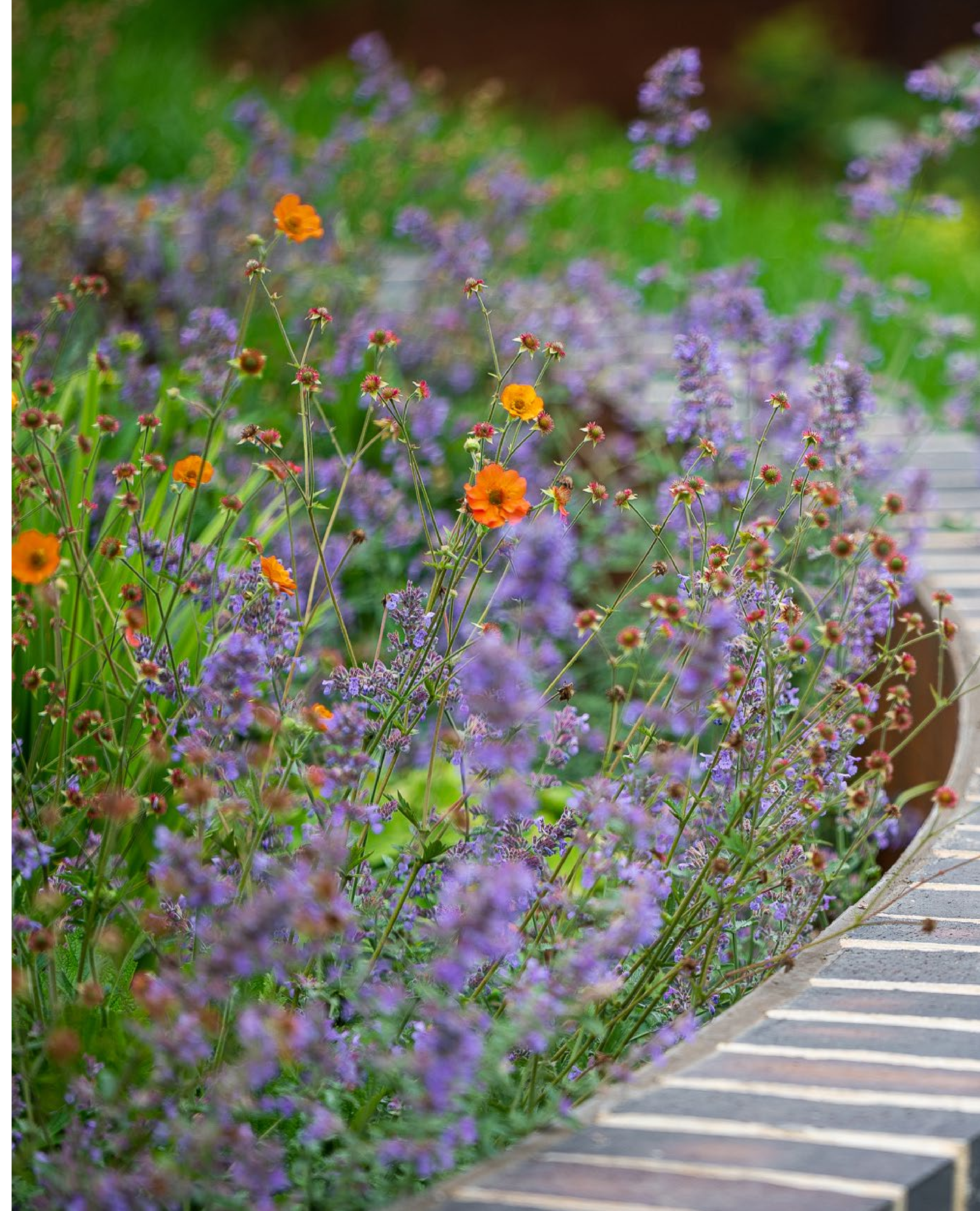
Where unsupervised toddlers may be expected (such as in proximity to play areas in preschool or nursery for example) a 600-700mm picket fence should be considered as this stops most toddlers and allows adults to easily step over the fence for rescue. A fence is not expected in normal public realm situations where toddlers would be expected to be supervised.

There must be an acceptance by the community that open water is part of a landscape character. It is useful to sensitively communicate health and safety messages identifying the presence of permanent and temporary water using well designed informative signage.

The use of 'danger – deep water' signs and lifebuoys should be avoided, as they imply that risks have not been sufficiently catered for by design.

This project failed to adequately consider safety when designing attenuation features into a residential pocket park. There is now no public access allowed. There should be no need for such measures if properly designed.

Colourful and seasonally changing planting within a raingarden provides visual amenity and food sources for pollinating insects.



Storage structures

Attenuation storage in underground structures is currently utilised throughout construction industry with may applications being in the form of geocellular or arched tanks. Simply providing underground tanks should not be confused with a full SuDS approach; however, they can form part of the SuDS management train.

The introduction of geocellular structures is still relatively recent in the construction industry and the long term implications of their use is still being understood. The 2015 SuDS manual (Section 21.1) clarifies that:

- *Where storage is in an underground tank, failures and blockages tend not to get noticed, which may mean that the consequences of failure can be catastrophic.*
- *Underground storage tanks do not have inherent treatment capacity and therefore require integration with a SuDS management train.*
- *Geocellular systems and plastic arches tend not to be easily accessible for inspection or cleaning, so effective upstream treatment is required to ensure adequate sediment removal.*
- *The structural design of geocellular systems tends to be more complex and there have been a number of collapses of these systems caused by inadequate design. (see Mallett et al, 2014, and O'Brien et al, in press) (see C737)*

In addition, to the statements from the SuDS Manual the following should also be considered:

- There are risks of structural failure due to construction loading, which may exceed design life loading that the designer may not be aware of.
- There are a wide range of attenuation products each with its own loading characteristics. Surety must be provided that a specified product is not swapped for one of inferior quality during the construction phase.
- Guarantees and warranties are dependent on the survival of product manufacturers.

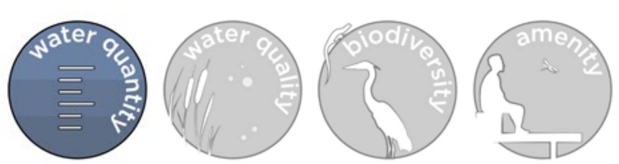
Structural and geotechnical design of modular geocellular drainage systems (C737)

Design note: Where the stated design life of the tank does not meet the design life of the development, the design should demonstrate how the structure will be replaced whist maintaining the functionality of the drainage system and the scheme. Consideration should also be given to funding mechanism for undertaking these replacement works.

SDCC Advice Note : underground storage systems should only be considered as a last resort.

Where underground storage is preferred after a full exploration of the available options the designer should demonstrate that:

- Robust silt removal has been provided through means of filtration (bioretention, permeable pavement) or other source control SuDS components. Catchpits will not be accepted as a demonstrable form of silt removal. The 2015 SuDS manual (Section 4.1) clarifies that sediments within catchpits can be remobilised and washed downstream. Equally, gully pots are suggested by Table 26.15 to provide negligible to zero treatment (Ellis et al, 2012).
- Underground structures require structural design consideration even if they are not receiving vehicular loading. CIRIA report C737 outlines the design requirements for geocellular tanks. The SuDS Manual (Table 21.1) provides a summary of the structural design requirements using a risk classification system (Scored between 0-3). Designers should demonstrate that the classification system has been followed and present the appropriate level of design information accordingly.



SuDS Components

11.0 Management of the SuDS landscape

11.1 The principles of SuDS management

All designed landscapes require some level of management. Where maintenance is not carried out development will evolve towards woodland or an urban wasteland.

This document introduces a '**passive maintenance**' approach for SuDS. This does not imply no maintenance but rather that much of the care for SuDS is site management rather than dedicated SuDS maintenance.

Hydrocarbons and other organic based pollution that washes off hard surfaces is broken down by natural processes (**passive treatment**), within many SuDS components meaning that there is no long term build-up of organic pollution. Heavy metals and inorganic pollutants are trapped within Source controls at low concentrations and therefore form no threat to amenity features or aquatic environments.

This is different to 'intervention' maintenance which is required for conventional drainage to remove toxic liquor from gully sumps or oil and grit from interceptors and separators which can be costly and in many cases not completed, rendering the treatment function redundant. Intervention maintenance can also be required for SuDS to remove silt, however using source controls this requirement will be minimised.

Importantly, where SuDS form part of a landscape (which would be present regardless of SuDS), this minimal attention should be considered as site care and not dedicated SuDS care. The cleaning of gullies and pipe work is not needed which reduces overall management costs.

Passive maintenance is therefore linked to integrated SuDS design.

Polluted silts collecting from a busy road at an inlet apron allows for easy removal

A light tracked excavator removes aquatic vegetation to de-water next to the wetland, before moving to a wildlife pile.

11.2 The SuDS Management Plan

A SuDS Management Plan is a document that describes the development, the place of SuDS in managing rainfall and can include landscape maintenance. It will describe the aspirations for the development and expected changes over time including any future expansion or redevelopment.

The plan will provide a brief explanation of SuDS, how the SuDS infrastructure on the site operates and the benefits of retaining functionality of SuDS.

SuDS management will be explained including anticipated changes over time.

The management plan will include a Schedule of Work covering the following:

- maintenance tasks identifying frequency of undertaking
- waste management requirements
- a pricing schedule for the maintenance contractor where appropriate with any specification notes required to explain technical details.

Site management usually requires an element of regular site attendance, often monthly, which corresponds with most SuDS maintenance. Occasional and potential remedial maintenance should also be covered by the plan.

- Regular maintenance – SuDS visits should be at a monthly frequency to match everyday site management visits.
- Occasional maintenance – covers tasks where the frequency cannot be predicted accurately or is infrequent.
- Remedial maintenance – covers work that cannot be anticipated or is a result of design failure. Damage may include, for instance, rutting where unexpected vehicle access has occurred on wet ground. Replacement of items which have a defined lifespan, such as geocellular tanks should be covered here or provisions made elsewhere.

Information in the management plan should be conveyed in a manner that is understandable to Site Operatives. Use of technical terms and unnecessary information should be avoided.

The Maintenance Schedule and key plan identifying locations of key features should not exceed a double sided A4 which can be laminated and retained in the operatives work van.

11.3 Example of SuDS and Site Maintenance

Type	Activity	Normal site care (Site) or SuDS-specific maintenance (SuDS)	Suggested frequency
Regular Maintenance			
Litter	Pick up all litter in SUDS Landscape areas along with remainder of the site – remove from site	Site	1 visit monthly
Grass	Mow all grass verges, paths and amenity grass at 35-50mm with 75mm max. Leaving cuttings in situ	Site	As required or 1 visit monthly
Grass	Mow all dry swales, dry SUDS basins and margins to low flow channels and other SUDS features at 100mm with 150mm max. Cut wet swales or basins annually as wildflower areas – 1st and last cuts to be collected	Site	4-8 visits per year or as required
Grass	Wildflower areas strimmed to 100mm in Sept or at end of school holidays – all cuttings removed Or Wildflower areas strimmed to 100mm on 3 year rotation – 30% each year – all cuttings removed	Site	1 visit annually 1 visit annually
Inlets & outlets	Inspect monthly, remove silt from slab aprons and debris. Strim 1m round for access	SuDS	1 visit monthly
Permeable paving	Sweep all paving regularly to keep surface tidy	Site	1 visit annually or as required

Occasional Tasks			
Permeable paving	Sweep and suction brush permeable paving when ponding occurs	SuDS	As required - estimate 10-15 year intervals
Flow controls	Annual inspection of control chambers - remove silt and check free flow	SuDS	1 visit annually
Wetland & pond	Wetland vegetation to be cut at 100mm on 3 – 5 year rotation or 30% each year. All cuttings to be removed to wildlife piles or from site.	Site	As required
Silt management	Inspect swales, ponds, wetlands annually for silt accumulation	Site & SuDS	1 visit annually
Silt	Excavate silt, stack and dry within 10m of the SUDS feature, but outside the design profile where water flows. Spread, rake and overseed.	Site & SuDS	As required
Native planting	Remove lower branches where necessary to ensure good ground cover to protect soil profile from erosion.	SuDS	1 visit annually
Remedial Work			
General SuDS	Inspect SuDS system to check for damage or failure when carrying out other tasks. Undertake remedial work as required.	SuDS	Monthly As required

11.4 Silt and waste management

Silt and sediment removal is often considered a major element of SuDS management. In most cases where SuDS features are located at the surface silt accumulates slowly and can be removed easily. Management of silt becomes more difficult and costly at the end of the management train, particularly in ponds and wetlands.

Where silt has accumulated in SuDS components downstream or the design has specifically included a silt collection feature, it is important to monitor silt accumulation visually and remove on a periodic basis before it impacts drainage capacity.

Silt removed from most low to medium risk sites can be de-watered and land applied within the site but outside the SuDS component profile.

Silt management and removal from site should follow the protocols set out in the 2015 SuDS Manual Chapter 32 p699

SuDS vegetation green waste can be managed in the same way as site green waste, either on site in wildlife piles, compost arrangements or taken off site.

The use of composted green waste or chipped woody material should be considered for raingardens, bioretention or any other planted feature on site.

Any waste considered to be contaminated should be evaluated as set out in the SUDS Manual Chapter 33 – Waste management p709

The gradual silt build-up at this kerb inlet into a swale was easily removed with a shovel.

12.0 Glossary & Acronyms

Glossary

Amenity	The quality of place; being pleasant, useful or attractive. A feature that increases attractiveness or value.
Attenuation	Reduction of peak flow and increased duration of a flow event.
Attenuation storage	Volume used to store runoff during extreme rainfall events attenuating flows by limiting flow rates out of it. Comes into use once the inflow is greater than the controlled outflow.
Biodiversity	The diversity of plant and animal life in a particular habitat.
Climate change	Climate change refers to any significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period (decades or longer).
Conventional drainage	The traditional method of draining surface water using gully pots and subsurface pipes.
Conveyance	Movement of water from one location to another.
Diffuse pollution	Pollution arising from land-use activities (urban and rural) that are dispersed across a catchment, and do not arise as a 'point' pollution load at a single identifiable location
Evapotranspiration	Evapotranspiration is the sum of evaporation and plant transpiration from the surface to the atmosphere.
First flush	The initial runoff from a site or catchment following the start of a rainfall event. As runoff travels over a surface it will pick up or dissolve pollutants and the "first flush" portion of the flow is usually the most contaminated as a result.
Greenfield runoff	The runoff that would occur from the site it its undeveloped and undisturbed state.
Infiltration (to the ground)	The passage of rainfall runoff into the ground.
Interception storage / losses	The capture of the first 5mm of rainfall from the majority of rainfall events which is prevented from leaving the site as runoff.
Long term storage / losses	A means of managing the volume of development runoff to greenfield volume.
Percentage runoff	The proportion of rainfall that runs off a surface.
Porosity	The percentage of a material, substance or structure that is occupied by voids, whether isolated or connected.
Return period	An estimate of the likelihood of an event. For example a 1 in 100 year return period has a 1% likelihood of occurrence within any particular year. Also referred to as Annual Exceedance Probability (AEP)
Site control	Final SuDS component in the SuDS management train which is used to ensure runoff from a site, up to the 1 in 100 year rainfall return period with climate change allowance does not exceed the permitted discharge rate.
Source control	The control of rainfall runoff at or near its source.
SuDS management train	The management of runoff in various SuDS components linked in series as it drains from a site. A range of SuDS components can be used to maximise the hydraulic, water quality management, amenity and biodiversity benefits.
Sub-catchment	A division of a catchment, to allow runoff to be managed as near to the source as is reasonable.

Glossary & Acronyms

Acronyms

AEP	Annual Exceedance Probability
BRE	Building Research Establishment
CCA	Climate Change Allowance
CIRIA	Construction Industry Research and Information Association
Cv	Coefficient of Volumetric Runoff
DHLGH	Department of Housing, Local Government and Heritage
DMURS	Design Manual for Urban Roads and Streets
EPA	Environmental Protection Agency
FRA	Flood Risk Assessment
FSR	Flood Studies Report
FSU	Flood Studies Update
GBI	Green and Blue Infrastructure
GDSDS	Greater Dublin Strategic Drainage Study
GF	Greenfield (runoff)
HSA	Health and Safety Authority
l/s/ha	Litres per second per hectare
m/s	Metre per second
m3/m2	Cubic metre per square metre
NbS	Nature-based Solutions
NWRM	Natural Water Retention Measures
OPW	Office of Public Works
PSDP	Project Supervisor Design Process
Qbar	Mean / Average Flow (Q)
Qmed	Median Flow (Q)
RoSPA	Royal Society for the Prevention of Accidents
RPZ	Root Protection Zone
SAAR	Standard Average Annual Rainfall
SAC	Special Area of Conservation
SDCC	South Dublin County Council
SFRA	Strategic Flood Risk Assessment
SIA	Simple Index Approach
SSFRA	Site-Specific Flood Risk Assessment
SSSI	Site of Special Scientific Interest

SuDS	Sustainable Drainage Systems
SWMP	Surface Water Management Plan
TPO	Tree Preservation Orders
WFD	Water Framework Directive
WRAP	Winter Rain Acceptance Potential

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Átha Cliath Theas
South Dublin County Council