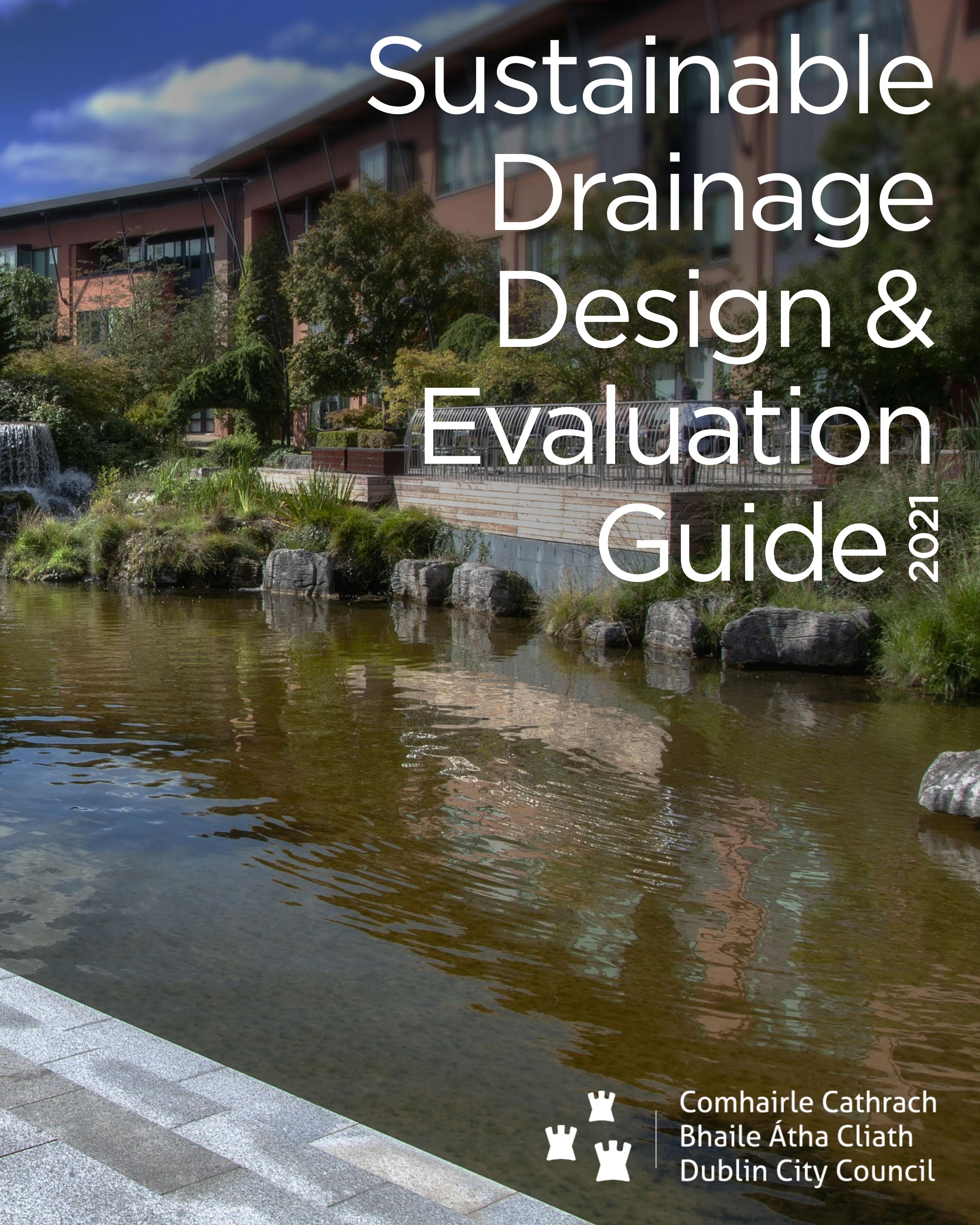

Sustainable Drainage Design & Evaluation Guide 2021

Comhairle Cathrach
Bhaile Átha Cliath
Dublin City 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. This contributes to increased risk of flooding, increased likelihood of contaminated rainfall runoff polluting our watercourses and the loss of our relationship with water and the benefits it can bring to us all. Dublin City Centre 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 so that it mimics the drainage processes found in nature and addresses the issues with conventional drainage. Dublin City Council (DCC) supports SuDS techniques that are nature-based. 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 DCC region. The Guide will also support the evaluation of planning applications, where SuDS schemes are assessed by DCC against the Policies and Standards set out in the Dublin City Development Plan 2022-2028.

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.

This guide begins by giving a background context for SuDS design. Next, the three accepted design stages are described: Concept Design, Outline Design and Detail Design. Subsequent chapters offer supporting information. This guide sets out how SuDS designs should be presented as part of the planning application proposal.

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

Authors

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

Anthony McCloy
Director McCloy Consulting

Anthony McCloy is a Chartered Engineer working exclusively in the water sector since 1998. Since 2003 he has focused on SuDS design, hydraulic modelling for SuDS and flood risk. He has co-authored SuDS Guidance documents for Planning Authorities and is a key tutor for the (CIRIA) National SuDS training workshops since 2006.

Kevin Barton
Director Robert Bray Associates

Kevin Barton has been working as a Landscape Architect for over 25 years and designing SuDS landscapes exclusively since 2011. In addition to project work, Kevin has also contributed to SuDS Guidance documents for Planning Authorities and water companies; presented on SuDS topics at domestic and international conferences; provided expert SuDS training through CIRIA and directly to local authorities.

Bob Bray
Director Robert Bray Associates

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.

Acknowledgements

We would like to thank the members of the Dublin City Council SuDS Working Group who provided their valuable time and input in the development of this Guide:

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Also:

- Erika Casey and Emma Gosnell

Contents

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 several 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'.

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

1.3 Why SuDS are required in Dublin City?

The Dublin City Council (DCC) Development Plan (2022-2028) has identified SuDS as the preferred way of managing rainfall from new development.

SuDS, if well designed, will make a valuable contribution to Dublin City, 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 affecting local weather systems and the introduction of additional hard landscape connected to the drainage system.

It is projected that by 2028, up to 640,000 people could be living in Dublin City and its suburbs. This additional demand means that the way that we deal with rainfall runoff will have to evolve and adapt (as the sewer network serving Dublin is already at capacity in many areas), whilst also tackling the effects of climate change and improving water quality in Dublin's network of rivers.

1.4 Background to this document

New development is expected to integrate the principles of Sustainable Drainage Systems (SuDS) with all other environmental aspects of new development, using best practice solutions to develop a high standard of sustainable development

DCC will require a softer engineered or '**nature-based approach**' to be used to manage rainfall runoff at source as it is a more environmentally sustainable approach for managing surface-water on development lands.

The main objectives of this Design and Evaluation guide are:

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

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, to successfully integrate SuDS into development.

This guide supports the delivery of the Dublin City Development Plan (2022-2028), the Dublin City Strategic Flood Risk Assessment and is complementary to the CIRIA 2015 SuDS Manual (C753).

2.0 Understanding Rainfall

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

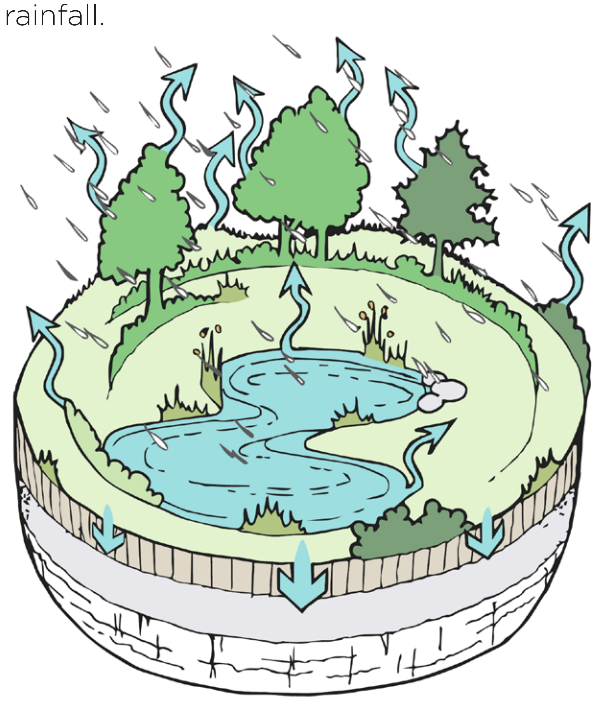
2.1 It begins to rain

In forests, flushes, and wetlands, when it rains, water can be lost in a few 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.

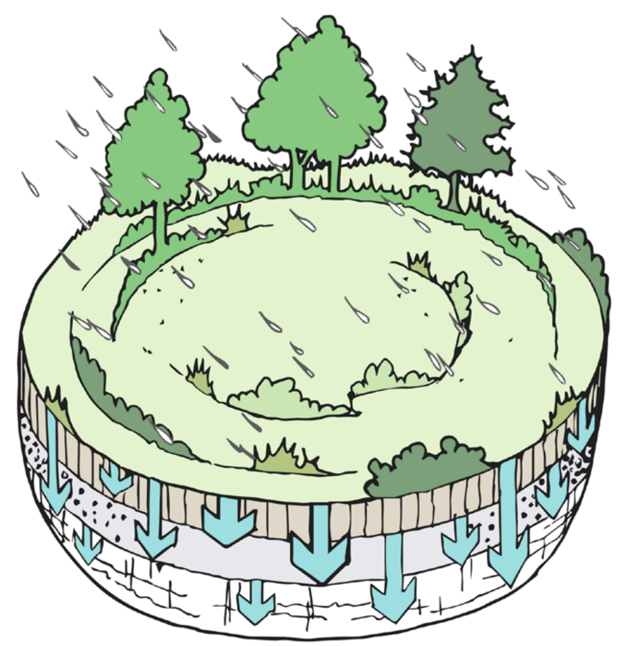
2.2 The ground becomes saturated

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.



Interception losses in the natural landscape



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**.

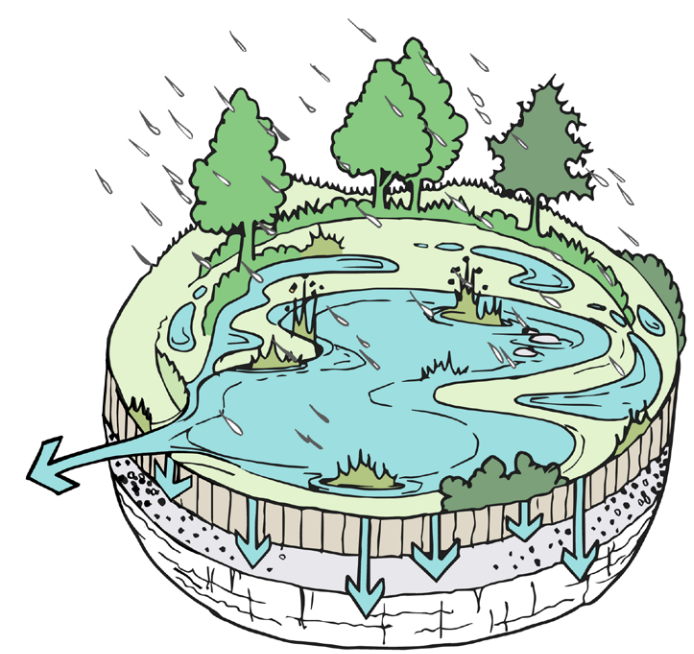
2.3 Natural losses continue during heavy rain

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

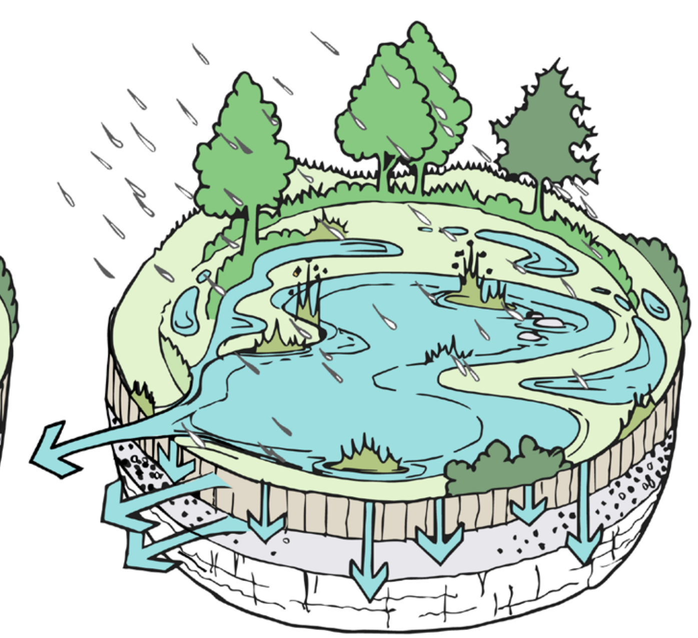
Once the ground is saturated there are ongoing natural losses that occur during rainfall, particularly where the ground has some permeability.

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.



*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.*



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. Over the last couple of centuries, the scale of urbanisation and our attitudes toward rainwater have caused serious problems to both the people of Dublin City 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**.

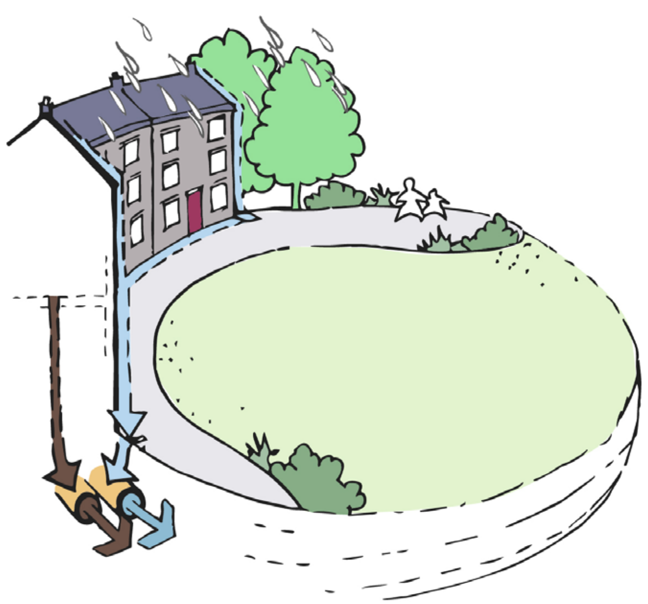
A combined sewer network serves much of the Dublin City region and is known to be at capacity. Even small amounts of 'day to day' rainfall (4-5mm depth) can cause combined sewer overflows to discharge untreated foul sewage into receiving watercourses.

The Combined Sewer.

3.2 Separating rainwater from foul sewage

In the mid-twentieth century it was realised that foul sewage and rainfall runoff should be separated. A separate sewer arrangement was introduced with the **foul sewer** for human waste and the **surface water sewe**r for rainfall.

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.



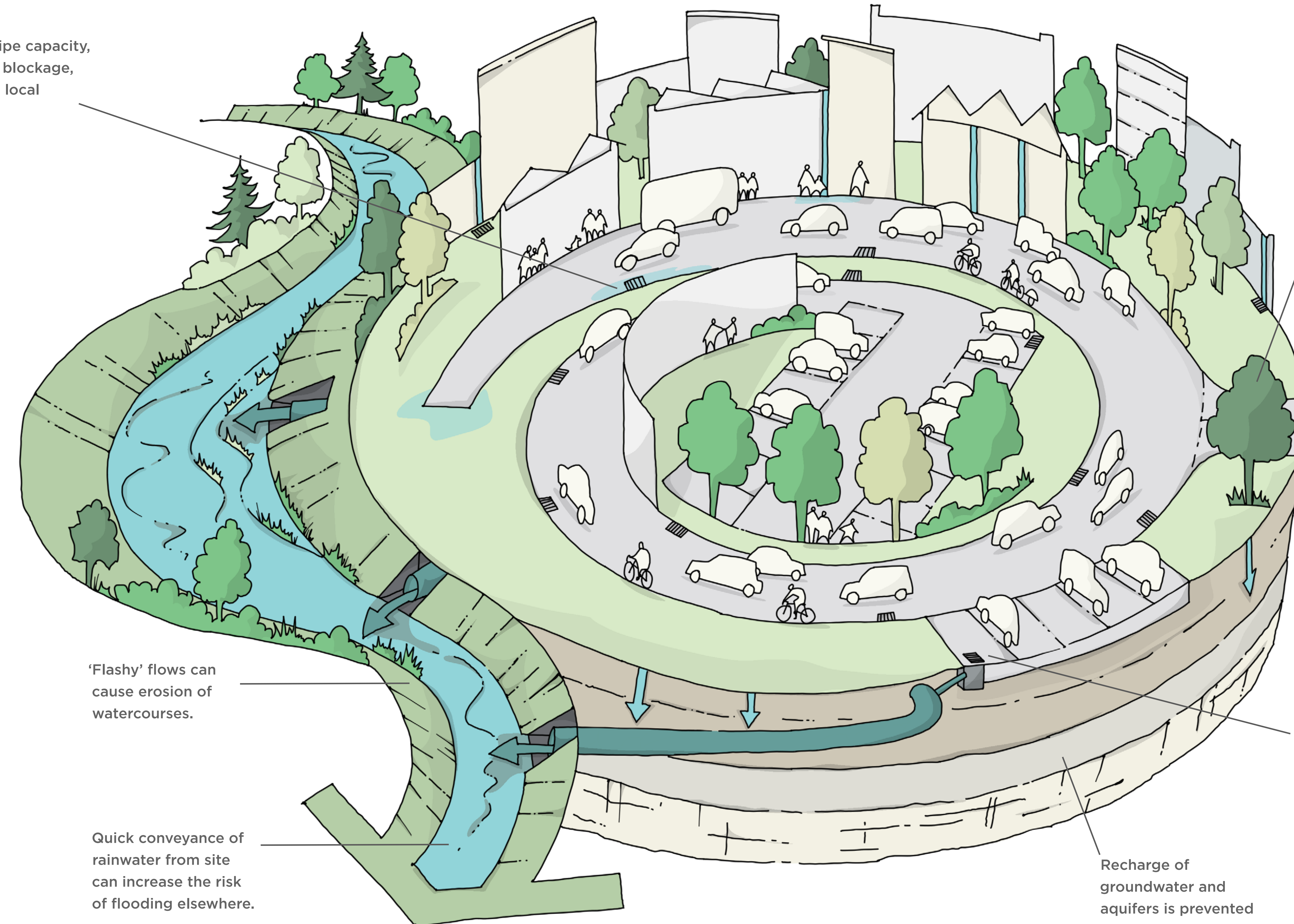
Separate pipes for foul sewage and surface water were introduced in the mid-twentieth century

3.3 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.



The Impact of Development

4.0 The Role of SuDS in 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 rainfall runoff from development as quickly as possible. In contrast, SuDS slow the flow and store rainfall runoff 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 rainfall runoff at or near the surface, can bring significant community benefits, adapting their function to the weather.

The loss of habitat can be reversed when using SuDS techniques which are nature-based. This allows fauna and flora to flourish, and to connect with existing habitats.

Image: Tolka Valley

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 environment. They are also able to rehabilitate the hydrology of the urban environment through sustainable re-development and SuDS retrofit.

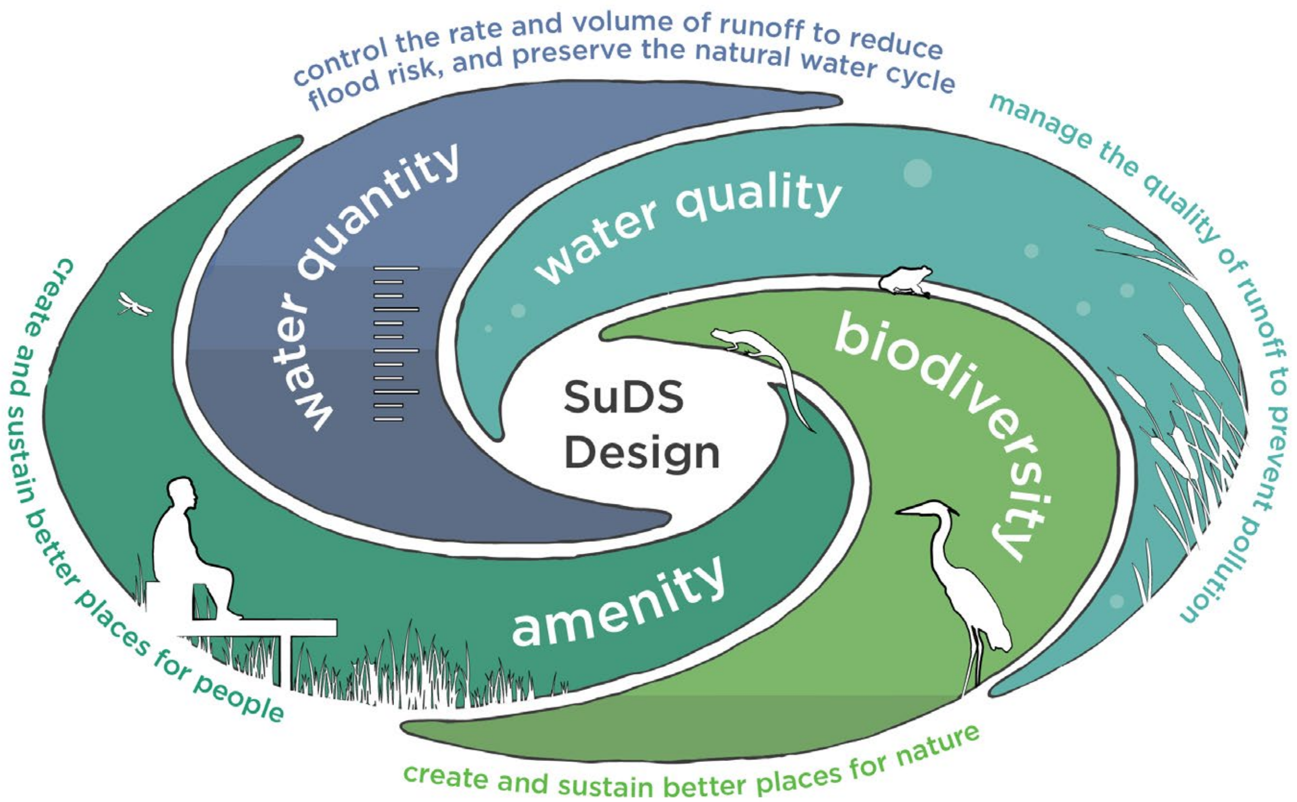
There are four critical objectives that SuDS seek to meet:

Quantity: managing flows and volumes to match the rainfall characteristics before development. This helps 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.



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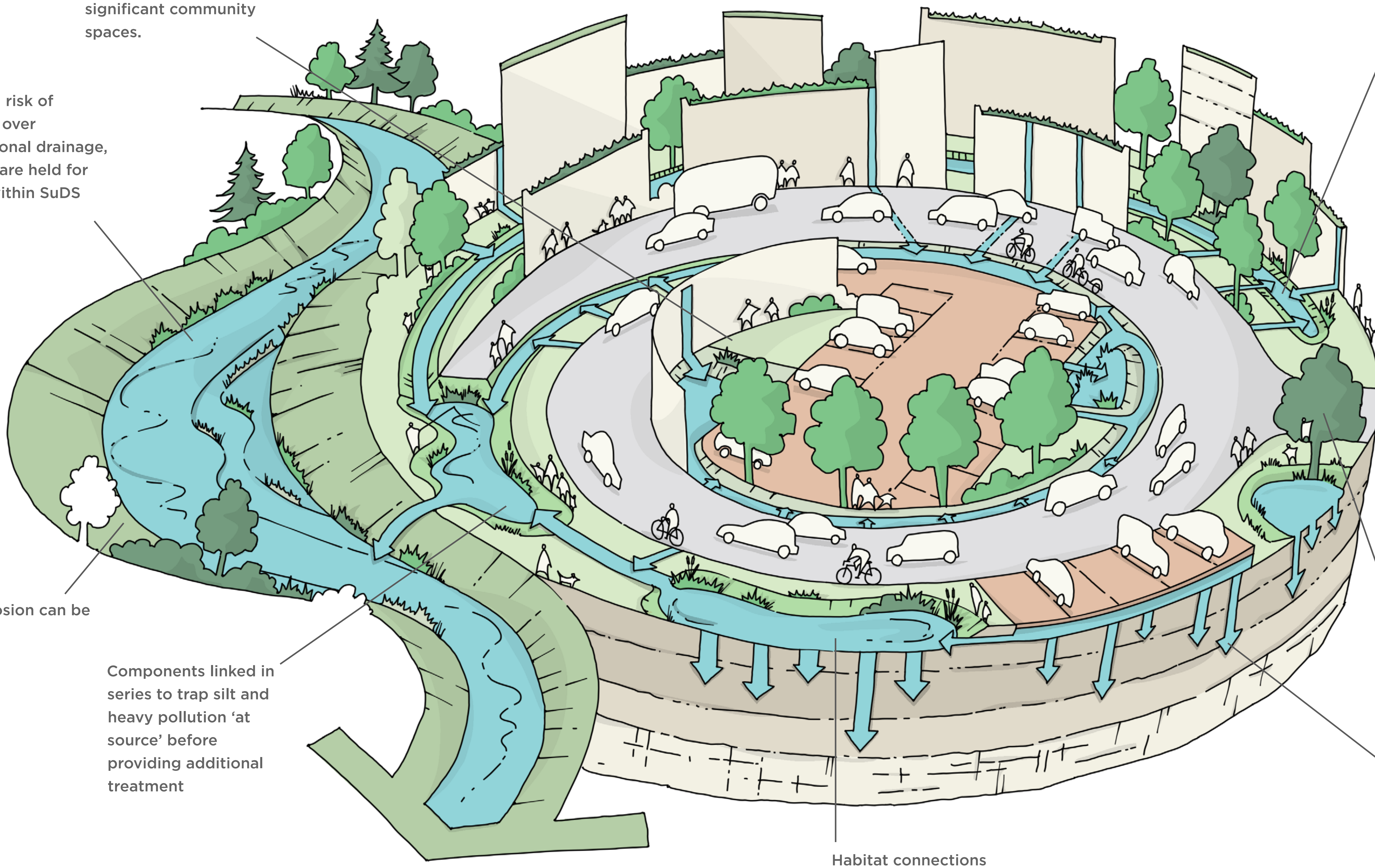
The Role of SuDS in Dublin


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.

4.3 Linkages between Nature based Solutions, Natural Water retention Measures, Green & Blue infrastructure and Sustainable Drainage

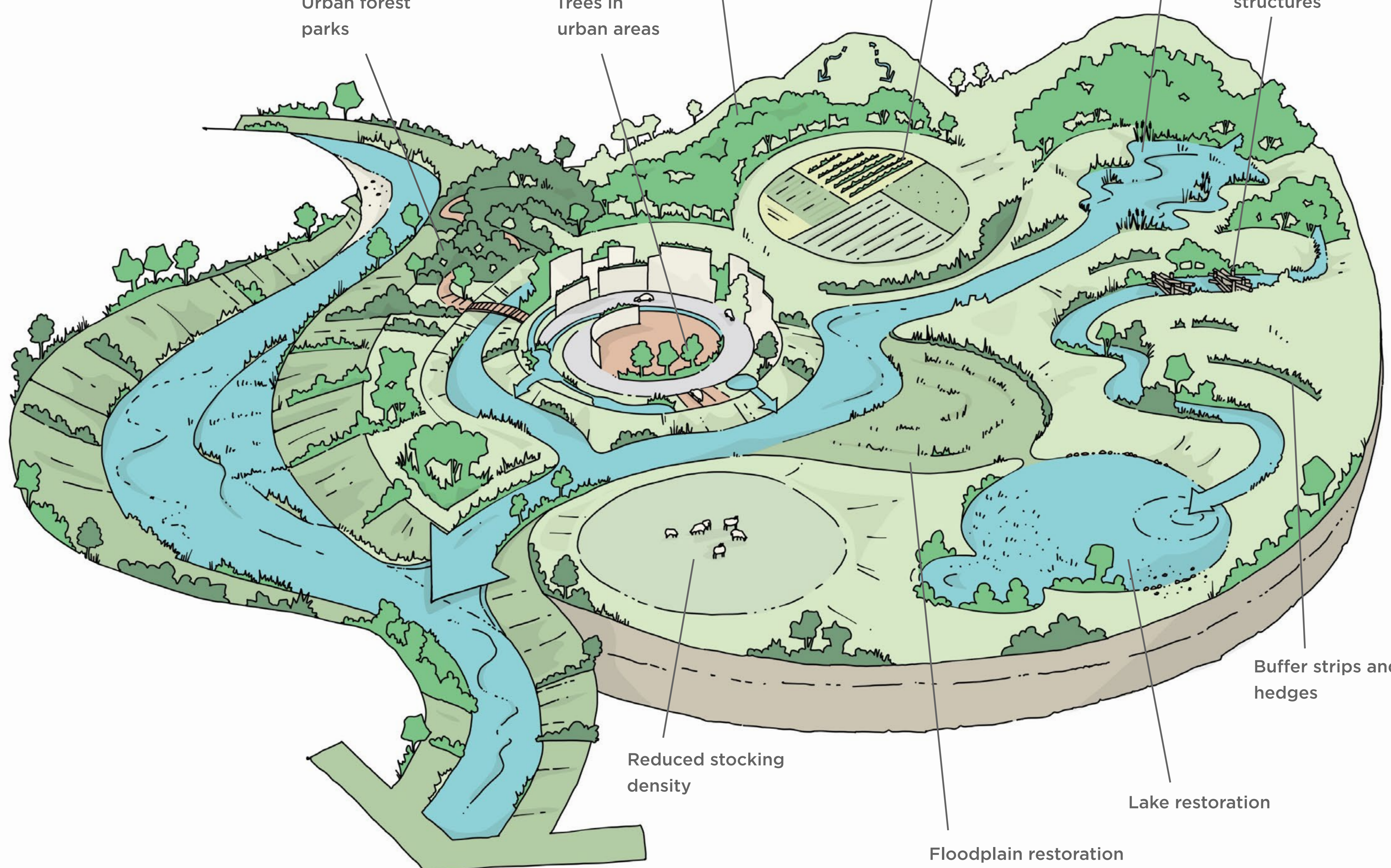
Over the last 20 years several industry terms have come to the fore including Sustainable Drainage (SuDS), Nature-based Solutions (NbS), Green & Blue Infrastructure (GBI) and Natural Water Retention Measures (NWRM).

These approaches have a common goal to improve the environment using processes, systems and structures which are inspired by nature or have a strong natural component.

NbS, GBI and NWRM can be described as umbrella terms as they cover a wide range of approaches including SuDS, river and floodplain restoration, sustainable land management, which also offer many co-benefits including; making provision for biodiversity, combating effects of climate change, promoting active travel along with other health and wellbeing benefits.

This Guide is planning led and focuses on delivery of well designed SuDS within the urban and peri-urban environments. It is useful to understand how SuDS integrates with wider catchment management strategies.

Draft Dublin City Development Plan 2022-2028



SuDS integrated with wider catchment management strategies

The Role of SuDS in Dublin

5.0 Misconceptions about SuDS

Since SuDS was first introduced as a new way of managing runoff it has been met with scepticism and resistance to change. Numerous misunderstandings and doubts have evolved over the years, which generally go unchallenged despite having little or no supporting evidence. This has led to designers being wary of nature-based SuDS approaches to managing surface runoff.

This section explores a number of the commonly raised 'SuDS misconceptions' and provides the DCC position which is based on evidence, case studies and experience.

Misconception 1: Nature-based SuDS require a lot of space and are land hungry. This is an issue in Dublin City where development land is at a premium.

Response: Well designed SuDS are integrated as part of the scheme design. On high density sites SuDS can form part of the building and surrounding hard landscape space using Blue roofs (see DCC Green Blue Roof Policy, Appendix11 Technical Summary and Dublin City Council Green Blue Roof Guide (2021)), permeable pavement and raised planters. These spaces can form part of the development footprint, therefore using them for a SuDS application ensures no requirement for additional 'SuDS dedicated' space.

Case Study: The Water Gardens

Case Study: RBG Pocket Parks

Misconception 2: What about contaminated sites - can you deliver nature-based SuDS on a site that is contaminated / partially remediated?

Response: SuDS mimic natural catchment drainage conditions. Where the geology is not suitable for infiltration, then SuDS will mimic how non-draining soils and water would move across the surface, be held in SuDS storage structures and released slowly at 'greenfield runoff rates'. Most SuDS components can be used as attenuation storage and are not reliant upon infiltration. Water is held within structures such as permeable pavements, green roofs, swales, basins, and wetlands and conveyed laterally to a watercourse or sewer.

Misconception 3: Are SuDS safe – is there a risk of drowning?

Response: Research on SuDS undertaken by Health and Safety Authority (RoSPA) demonstrates that with good design, the risks associated with SuDS will be extremely low. SuDS are not designed for swimming and side slopes should be shallow to allow for ease of entry and exit.

SuDS should be designed to ensure that they are not a danger to people, particularly those with mobility or visual impairments. SuDS should always be designed to be appropriate to their location. For example, it would be inappropriate to integrate informal play structures as part of SuDS features immediately beside a major road.

It is also worth noting that unprotected water bodies are already a common feature of Dublin's Parks along with the various open rivers and canals running through Dublin.

SuDS risk assessment checklist

Misconception 4: Are SuDS not more expensive than conventional drainage?

Response: There is a growing body of evidence that SuDS are less expensive than conventional drainage approaches that use pipes and underground storage structures. In contrast, no evidence exists to suggest that conventional drainage approaches are less expensive to construct than well designed SuDS schemes.

To undertake a comparison of costs all relevant elements of the scheme must be considered.

Example: Permeable paving can be used to convey, treat, and store rainfall runoff within its construction, removing the requirement for conventional below ground drainage features such as gullies, manholes interceptors and pipes. A full comparison of cost will also include the cost of the pavement for conventional drainage option.

The following research reports provide cost comparisons for SuDS which are transferable to a Dublin context.

Analysis of evidence including costs and benefits of SuDS construction and guidance (Welsh Government, 2017)

Comparative costing of surface water drainage (Defra/WSP, 2013)

Costs and benefits of Sustainable Drainage Systems (Committee on Climate Change, 2012)

Costs and benefits of Sustainable Drainage Systems (Scotland)

Misconception 5: Is maintenance an issue? Will permeable pavement quickly clog?

Response: Well designed SuDS are integrated into the development. This means that the SuDS will receive regular maintenance as part of the overall site care. Most maintenance will take the form of grass cutting or annual strimming of vegetation.

SuDS may also take the form of permeable surfaces / pavements. There are numerous examples of permeable pavement installed across Ireland and UK over the last 20 years with no noticeable loss of performance. The joints between the blocks are much larger than they need to be, even to deal with extreme rainfall. Simple periodic brushing of the surface with a longer term refreshing of the grit joint will prolong the performance of the permeable pavement.

Further research on the matter is contained in the following link.

Long-term in-situ infiltration performance of permeable concrete block pavement

Misconception 6: Can areas used for SuDS also be used for amenity purposes?

Response: There are plenty of examples where SuDS incorporate amenity use. SuDS basins can be designed using source control so that the main storage areas rarely receive rainwater and would only be in full use after significant rainfall. Simple design methods will ensure that most of the SuDS area is dry most of the time, if this is the desired outcome.

SuDS can be used to enhance public realm such as parks and have been shown to increase the recreational use of a public amenity space.

Case Study: Charter Square, Sheffield

Case Study: Crescent Gardens, Haringey

Appendix 12 of the Development Plan considers SuDS multifunctionality for recreation areas and public open space.

Misconception 7: SuDS may not be 'taken in charge'. This will make it more difficult to deliver a nature-based SuDS scheme.

Response: Drainage for commercial or industrial sites and developments with a single owner would not generally be 'taken in change'. Where SuDS are not 'taken in charge', suitable arrangements should be made to ensure that required maintenance is undertaken.

Nature-based SuDS can be designed to facilitate maintenance activities within the remit of normal site care maintenance regime.

Misconception 8: Do the requirements for SuDS conflict with other guidance documents such as the Design Manual for Urban Roads and Streets (DMURS)?

Response: The DMURS does not specifically consider SuDS. In terms of SuDS competing with the traditional uses of urban roads and streets, there can be a perception that city centre or commercial urban areas must consist almost exclusively of hard surfacing. This is specifically referred to in Chapter 4 of DMURS where "harder" landscape elements are seen to "define them as urban, allow greater freedom of movement and are able to withstand higher level of pedestrian traffic".

The Department of Housing, Local Government and Heritage (DHLGH) are considering updates to the DMURS to include SuDS.

Other cities across the world are seeking to redefine contemporary concepts of green infrastructure by extending this vision into the very heart of the city. The green infrastructure and ecological goals can be balanced against functionality and urban design aesthetics.

Case Study: Grey to Green, Sheffield

Summary

Mis-understandings and doubts surrounding SuDS are reducing over time as designers, developers and local communities get used to seeing SuDS as part of development. Designers and contractors are gaining experience on how SuDS schemes can be successfully delivered and communities are appreciating the wider benefits that they contribute.

In considering what type of SuDS would be appropriate for a site, the designer should explore the wide array of options available and ensure that proposals are not skewed by preconceptions but are instead based upon the extensive bank of case studies and research reports which support the introduction of SuDS in all types of development.

Image: Sheffield Grey To Green

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.

DCC expect the designer to consider SuDS at the earliest point in the scheme design. 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.

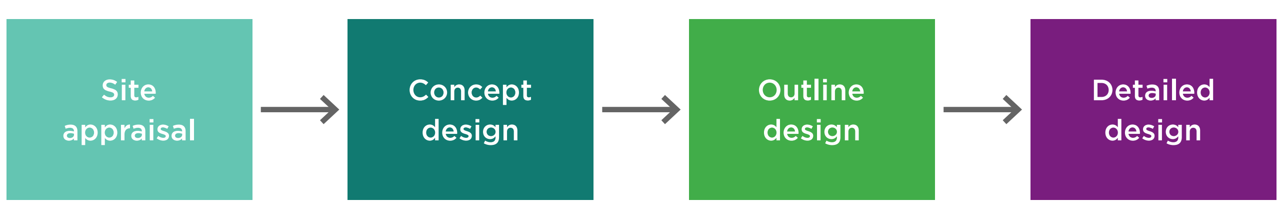
SuDS Concept Design ensures that SuDS can be properly considered as part of the layout of the development.

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.

DCC 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 to 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
- appropriately consider site topography and landscape character
- 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.
- where the scheme may 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
- 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
- consider safety at each design stage, with confirmation that this has been achieved through the 'safety by design' principle (see section 9.8).

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 of the scheme and sensitivity of the development site / receiving environment.

7.0 SuDS requirements

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

7.1 SuDS and Dublin City Development Plan 2022-2028

The Dublin City Development Plan requires SuDS to be incorporated into new development. DCC considers that SuDS is appropriate and reasonably practicable in all new developments.

S122

Sustainable Drainage Systems
To require the use of Sustainable Drainage Systems (SuDS) in all new developments, where appropriate, as set out in the Greater Dublin Strategic Drainage Study (Vol 2: New Development)/ Greater Dublin Regional Code of Practice for Drainage Works. Sustainable Drainage Systems (SuDS) should incorporate nature-based solutions and be designed in accordance with the Dublin City Council Sustainable Drainage Design and Evaluation Guide (2021) which is summarised in Appendix 12. SuDS should protect and enhance water quality through treatment at source while enhancing biodiversity and amenity.

Delivering high quality SuDS which are nature-based and integrated with the development, will support the delivery against policies, action plans and strategies, both at local and national level. SuDS designs should adhere to the requirements set out in DCC Development Plan, in particular:

- Chapter 3 - Climate Action
- Chapter 9 - Sustainable Environmental Infrastructure
- Chapter 10 - Green Infrastructure and Recreation
- Chapter 15 - Development Standards, Section 15.6 of the Development Plan
- Appendix 11 – Technical Summary of Dublin City Council Green Blue Roof Guidance Document (2021)
- Appendix 12 - Technical Summary of Dublin City Council SuDS Design and Evaluation Guidance Document (2021)
- Appendix 13 – Dublin City Council Surface Water Management Guidance

And:

- Draft Dublin City Biodiversity Action Plan 2021-2025
- Dublin City Parks Strategy 2019-2022
- Dublin City Climate Action Plan 2019-2024

7.2 Green Blue Roof requirements

Appendix 11 of the Development Plan outlines Green Blue Roof requirements covering the following:

- Applicable development types
- Areal coverage
- Hydraulic operation
- Use
- Access, operation and maintenance

The Dublin City Council Green Blue Roof Guidance Document should be referred to for further information on Green Blue Roof requirements.

7.3 SuDS requirements

Appendix 12 of the Development Plan identifies a series of ‘SuDS requirements’ which will be considered in the assessment of the planning application. These requirements (repeated below) will apply to all developments reviewed by Dublin City Council as part of the planning process:

SuDS Requirement 1 - Runoff Destination

The following methods of utilising or releasing rainfall run-off from development are set out in order of preference:

- Use surface water run-off as a resource.
- Provide interception of rainfall through the use of nature-based SuDS approaches.
- Where appropriate, infiltrate run-off into the ground.
- Discharge to an open surface water drainage system.
- Discharge to a piped surface water drainage system.
- Discharge to a combined sewer.

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

SuDS Requirements

SuDS Requirement 2 - Hydraulic Control

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

Surface run-off 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) 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 following 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 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.

SuDS Requirement 3 - Water Quality

SuDS designs will integrate a sufficient number of appropriately sized SuDS components to manage and remove pollution, to provide protection of groundwater, surface waters and sensitive coastal waters. The SuDS design will demonstrate that water is suitably cleansed prior to entry to SuDS components that are intended for amenity use and biodiversity benefit.

Preference should be given to SuDS techniques which generate interception losses.

SuDS Requirement 4 - Amenity

Designs should seek to generate amenity benefits using SuDS, through the creation of multi-functional places and landscapes.

SuDS Requirement 5 - Biodiversity

Designs should seek to generate biodiversity benefits using SuDS.

7.4 Surface Water Management Plan requirements

In compliance with Policy SI25, development proposals must be accompanied by a Surface Water Management Plan (SWMP) for all new development which impact on surface runoff. The extent of detail required for the SWMP will depend upon the scale of the development.

It is expected that SuDS design submitted as part of a SWMP will be 'outline design' status as a minimum.

A SWMP will be prepared as part of the plan-making / master planning process (statutory and non-statutory).

It is expected that Plan Making SWMPs will be developed to concept design status (as a minimum).

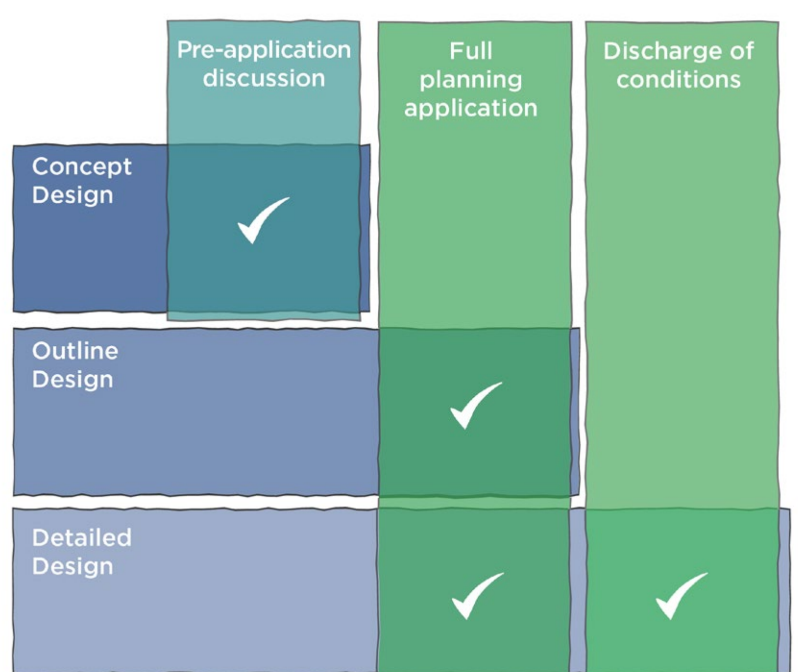
7.5 Other requirements

Surface water runoff from public areas should not be attenuated in private systems.

Consideration must also be given when designing SuDS to requirements set out within;

- Greater Dublin Regional Code of Practice for Drainage Works
- Design Manual for Urban Roads and Streets
- Construction Standards for Road and Street Works in Dublin City Council
- Building Regulations Technical Guidance - Document H

Draft DCC Development Plan 2022-2028 Technical Appendix 13



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

Facing: Pelletstown.

8.0 Stage 1 - Concept Design

SuDS Concept Design is used to express initial ideas for the management of rainfall within a development. The same process is also applied through development of Frameworks / Masterplans / Plans to ensure that sufficient consideration is made for the conveyance and storage of rainfall runoff.

8.1 Objectives of SuDS Concept Design

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

The Concept Design plan and Preliminary Design Statement are necessary where discussions with DCC are proposed at pre-planning application stage.

The development of surface water management strategies for Frameworks / Masterplans / Plans will follow the SuDS concept design process.

8.2 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.

8.3 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.

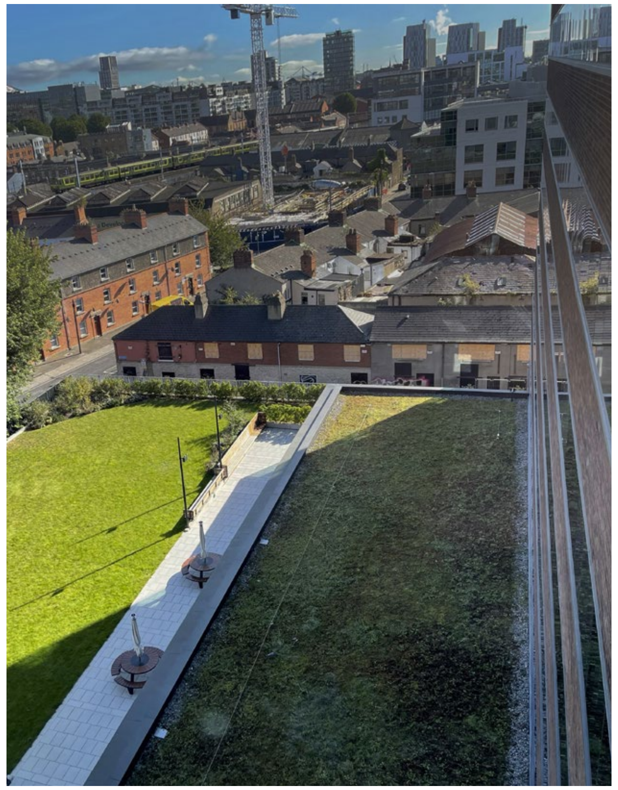
Evaluation will begin with:

- 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 do not manage water most of the time, avoid colouring them blue on plan. Blue shading is best used for denoting permanent water bodies, like ponds and wetlands.



Dublin biodiverse and amenity green roofs. Courtesy Dusty Gedge.

8.4 Concept Design process

8.4.1 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.

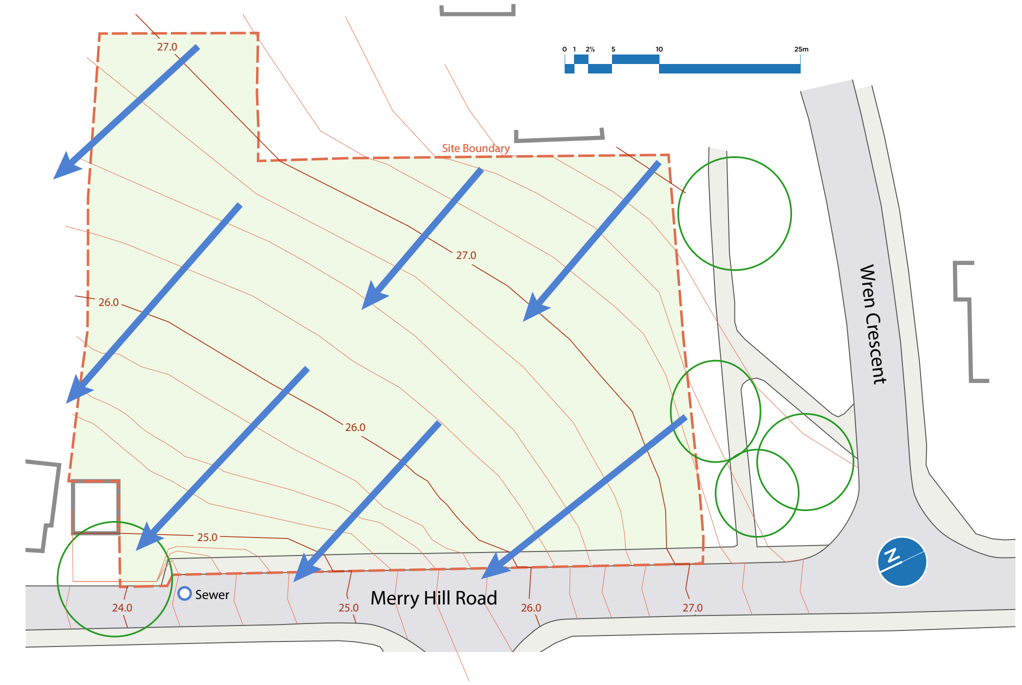
The first step in flow route analysis is to consider how a site behaves naturally before development. This analysis can be applied to re-development and retrofit sites and is informed by topography and geology. There may be a number of other factors influencing the analysis, including:

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

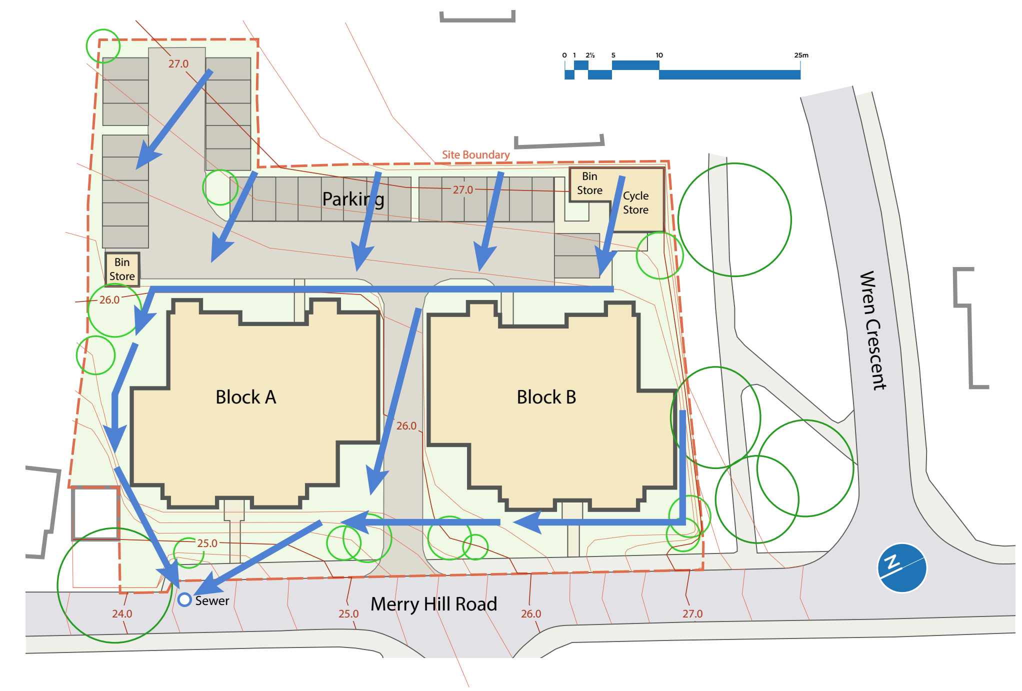
A topographical survey provides the basic template for determining existing and future flows. Geology indicates whether rainfall will flow from the site as runoff and / or infiltrate into the ground.

Designers should be mindful that a site that infiltrates naturally may not continue to infiltrate once it has been developed. Across many parts of the DCC region, sites will be underlain by Dublin boulder clay and potential for infiltration of all rainfall runoff up to the 1 in 100-year rainfall event is likely to be limited. Limited infiltration rates may be able to cater for smaller rainfall events and infiltration potential should not be discounted from design.

In Dublin City centre, the building often takes up the entire footprint of the site; a common approach to providing attenuation of site runoff is the placement of a storage tank below the basement level, which will then usually require a pump to ensure emptying of the tank. Consideration as part of the modified flow route analysis should be given to how flows can be managed at or above ground level to remove the requirement for the below basement tank and pumped outlet.



Existing flow route analysis



Modified flow route analysis

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8.4.2 Building the management train

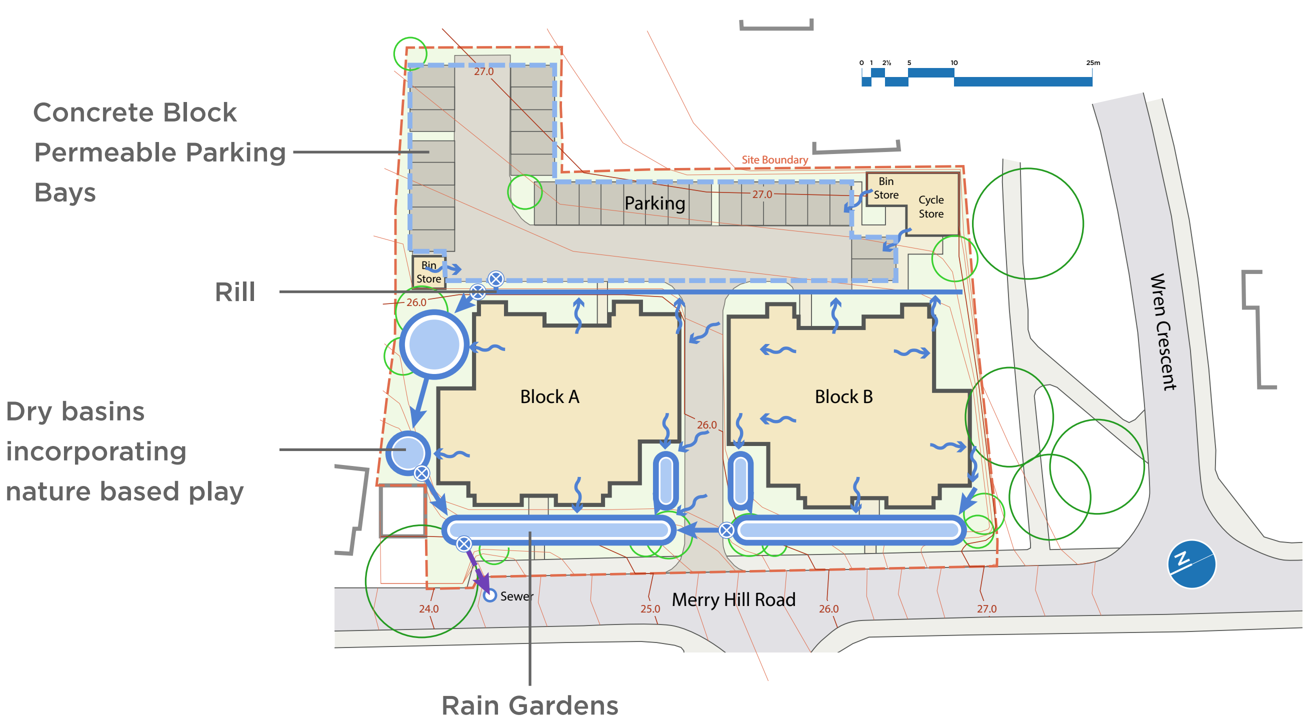
A management train begins with source control, and uses surface conveyance, wherever possible, to link subsequent SuDS components in series. Integration of the management train should be considered from the Concept Design stage and throughout the design process.

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 there 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



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

Collection of rainfall runoff using flush kerb and swale - Pelletstown

8.4.4 Source control – managing runoff at source

Source Control include features such as pervious surfaces, filter strips, green / blue roofs, SuDS 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 the 1-in-100 + Climate Change Allowance (CCA) storage, with the introduction of a simple flow control device.

Green Roof Lower Kilmacud Road DLR

8.4.5 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.

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.

8.4.6 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. All end of pipe solutions may fill with silt and generate management problems.

When designing SuDS to be integrated as part of 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.

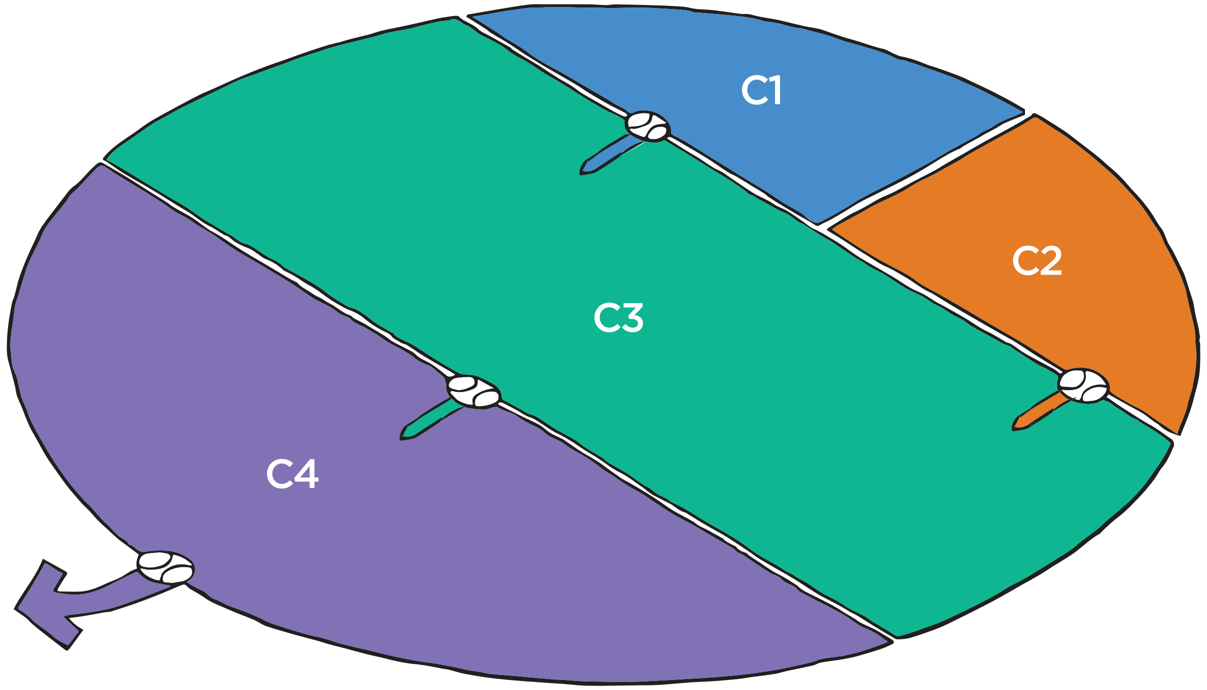
Flows are conveyed from one sub-catchment to the next along one or more management trains, following the modified flow routes determined early in the design process.

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

A flow control usually 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.



8.4.7 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.

Additional levels of treatment may be required where surface water discharges to protected waters or areas of environment sensitivity. Sensitive receptors that could be affected by runoff include North Dublin Bay and South Dublin Bay. Consideration is required where discharge is to a pipe or watercourse that carries flow onwards towards these areas.

Where potential exists, additional considerations for infiltrating soils

- More general discharge to groundwater (usually infiltrating soils) can be found 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 SuDS Manual

8.4.8 Method of discharge – how rainfall leaves the site

The way that rainfall runoff leaves a development should follow the preferred hierarchy as outlined in Section 7.3.

Depending on the site characteristics, drainage from different parts of the site can have different means of discharge. Equally, rainwater harvesting and infiltration may be able to deal with day-to-day rainfall, with other SuDS features catering for runoff from larger rainfall events with discharge to a watercourse or sewer.

8.4.9 Preliminary flow and volume calculations

It is essential 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.

In some circumstances, for example where development is speculative, it may be acceptable for the Concept Stage to omit flow and volume calculations (or base these on estimated development densities), but a Modified Flow Route analysis will be required to show that runoff can be effectively conveyed to a discharge location.

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.

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 the evaluation team to check that calculated storage volumes are as anticipated.

Example: A 10000m² development requires 600m³ of 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.

8.4.10 Infiltration

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 5 m 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

8.4.11 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**).

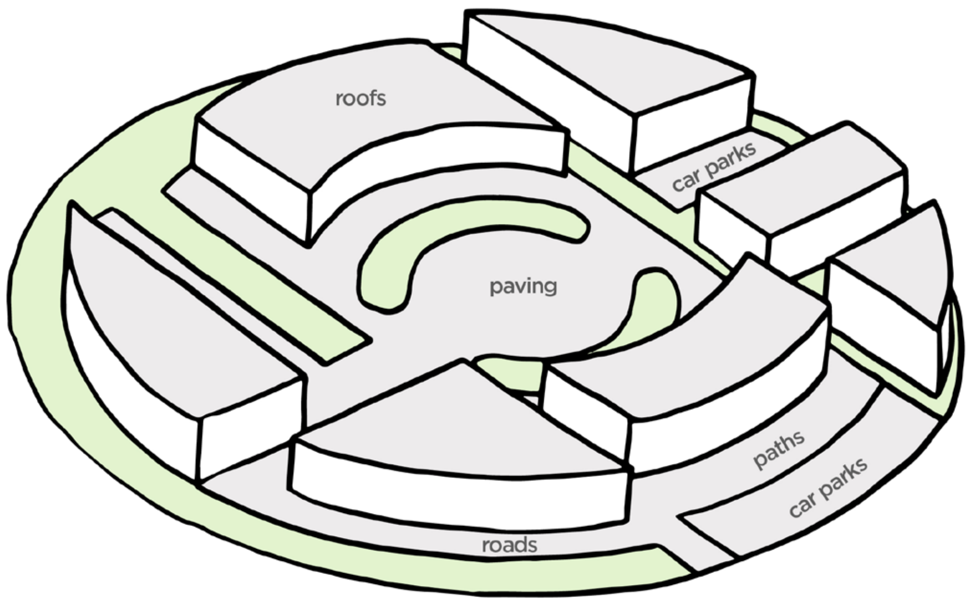
Design note:
The website www.uksuds.com provides estimation tools for the calculation of 'greenfield runoff rates', 'attenuation' volumes and 'long-term storage' volume losses.

8.4.12 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.



8.4.13 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 or drainage system with limited capacity). **Qbar** and **Qmed** are terms used to describe the average Greenfield runoff rate which equate to the 1-in-2 year flood return period.

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 generally takes the form of a restricted opening on the outlet of the SuDS storage feature and allows the stored runoff 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 or location where there is a known downstream capacity issues / flood risk	2 l/s/ha	2 l/s/ha	No
Discharge to a surface water sewer or watercourse (no known flood risk or capacity issues) Criterion 2.1, 2.2, 4.1, 4.2	1-in-1 year greenfield rate	1-in-100 year greenfield rate	Yes
Discharge to a surface water sewer or watercourse (no known flood risk or capacity issues) Criterion 4.3	Qbar/ Qmed	Qbar/ Qmed	No

8.4.14 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. The uksuds.com calculator is based on regional geological mapping which can be unrepresentative of actual site conditions. Inputs to the Greenfield runoff calculation should rely upon **actual soil types for the site** rather than regional geological maps.

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.

8.4.15 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 but 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.

8.5 Integrating SuDS as part of the development

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

8.5.1 Integrating SuDS as part of building fabric

On very high density developments particularly where the building takes up most or all of the foot print 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.

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

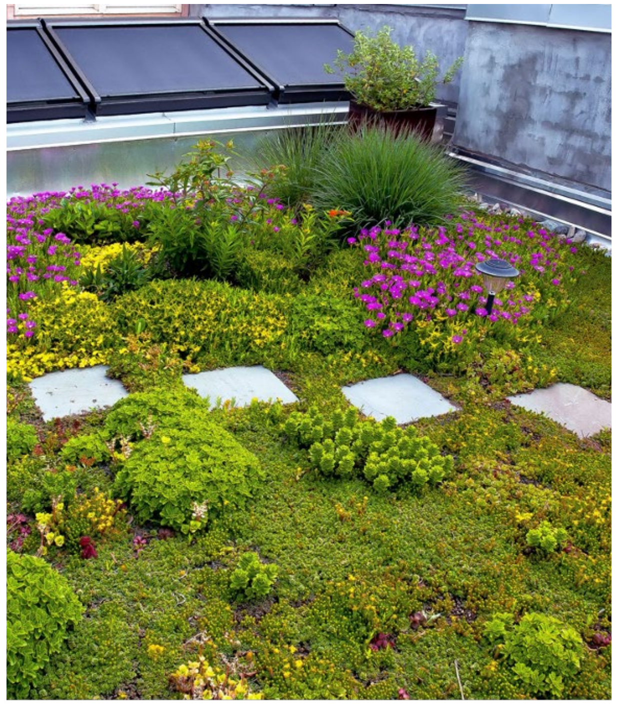
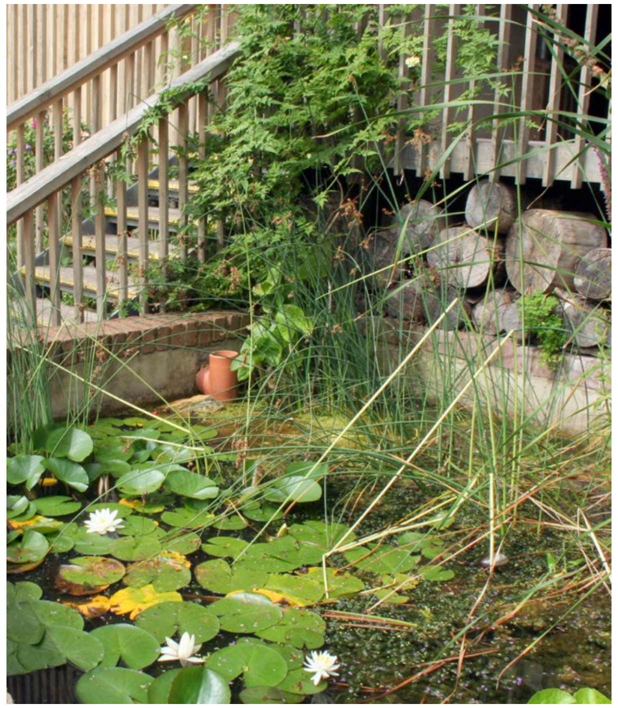


Image shows raised rain planter.

Image shows urban pond within high density residential development.



8.5.2 Designing SuDS in proximity to basements

There are no over-riding issues with locating SuDS over basements. Consideration should be made whether the SuDS structure should be lined and specialist geotechnical and (or) structural advice may be required on a case-by-case basis. There are two scenarios to be considered;

- Basement is being constructed (usually projecting into back garden) but may project from the frontage of the property into the road. DCC basement policy references SuDS and recommends that a thickness of at least 1m of soil on the roof of a basement is required to minimise surface water runoff.
- SuDS are being constructed over existing basement which may not be lined (e.g., SuDS retrofit along road or civic space). SuDS structures should be lined and under-drained and 1-2m beyond the basement footprint extents to remove risk of infiltration towards the existing basement.

Dublin City Development Plan 2022-2028 Appendix 9: Basement Development Guidance

8.5.3 SuDS as part of streetscape

The methods that are used to collect and treat runoff such as permeable pavement, SuDS 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.

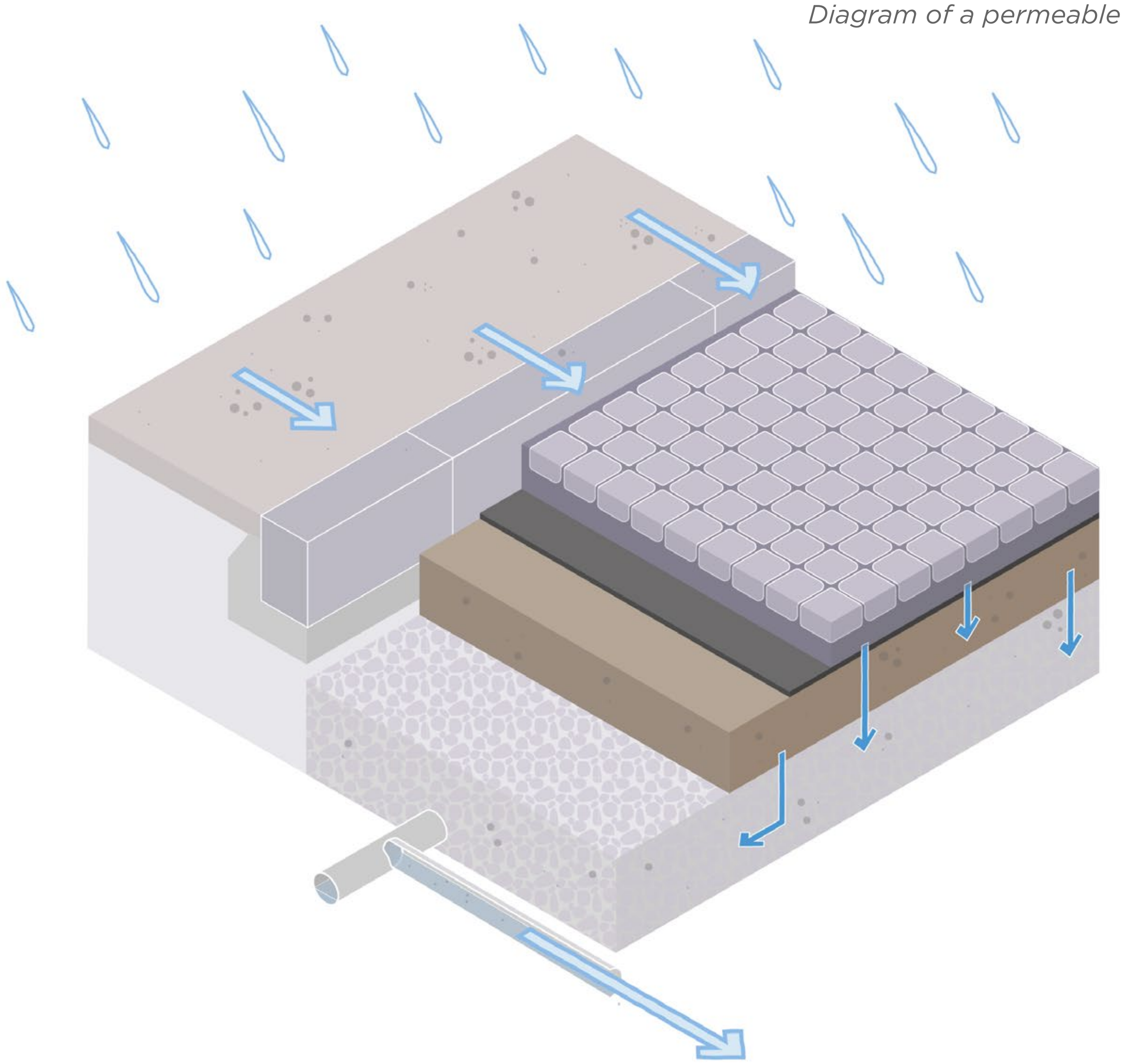


Diagram of a permeable paving

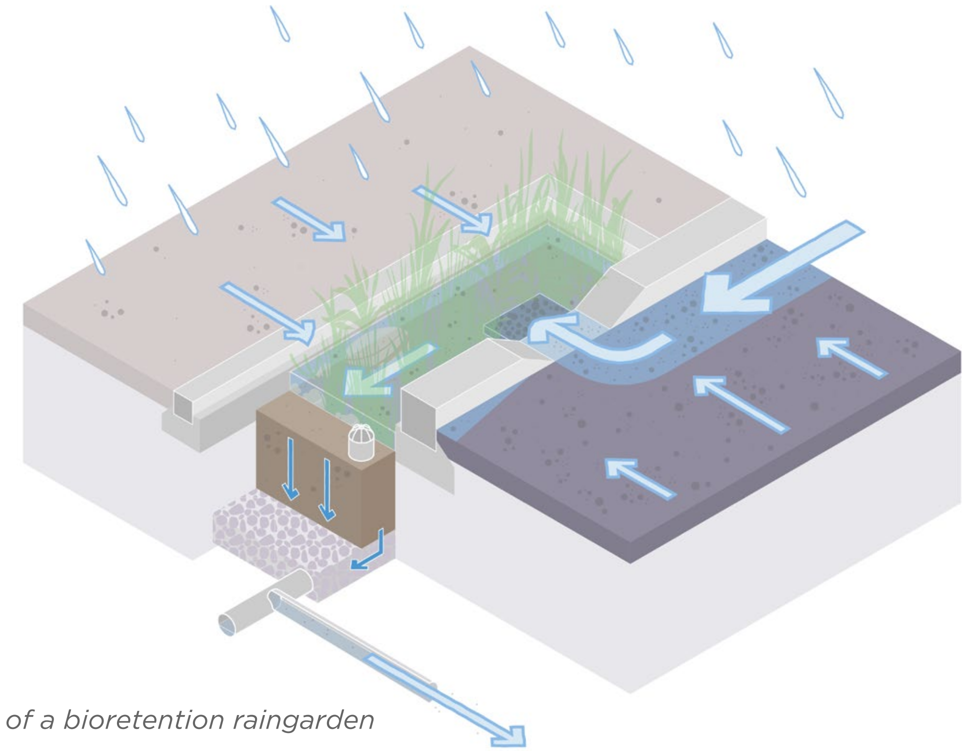


Diagram of a bioretention raingarden

Diagram of a SuDS tree pit

8.5.4 SuDS as part of public open space

One of the primary purposes of open space in the Dublin region is as a useable asset for urban communities. Considering how the space will be used and incorporation of nature-based play (as appropriate), will underpin the design of SuDS in public open space.

Areas that store surface water during regular rainfall events, except ponds or wetlands, shall not normally be included in the calculation of open space provision. However, where SuDS proposals enhance biodiversity and amenity value and would be readily available for use in most weather conditions, a portion of the SuDS area may be incorporated as part of the communal or public open space provision (subject to agreement with DCC). (see Section 9.7.6)

Dublin City Development Plan - Appendix 12 Section 2.0

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.

8.6 Frameworks / Masterplans / Plans

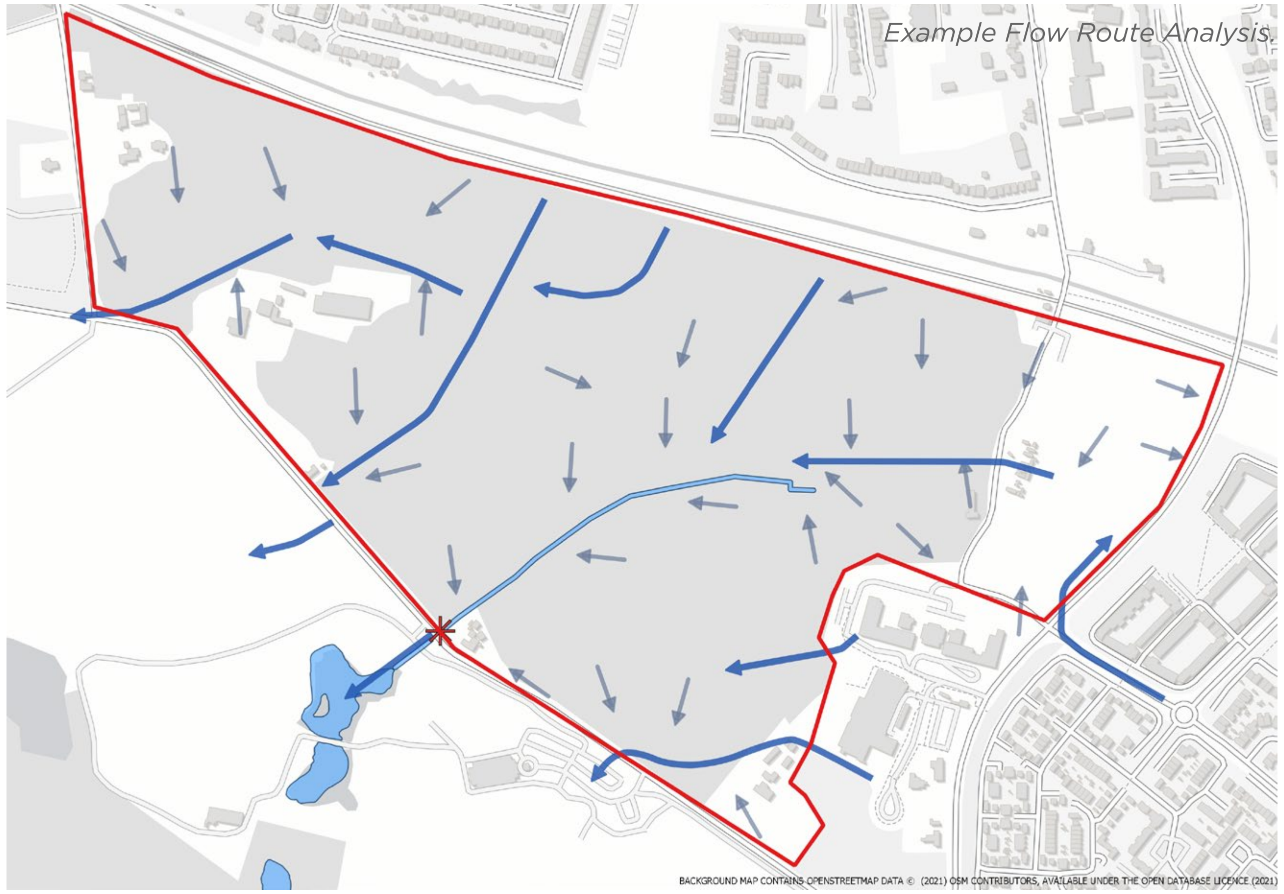
The development of surface water management strategies for Frameworks / Masterplans / Plans will follow the SuDS concept design process.

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 flow route analysis is the basis for understanding day-to-day runoff conveyance, exceedance routes when design criteria are exceeded. Modified flow routes are assessed in conjunction with the preliminary Plan Area layout and inform the concept SuDS design by suggesting preferential flow paths through the Plan Area.

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

Design note: Analysis of spatial arrangements at masterplan stage is essential to ensure clear legibility within the scheme including good visibility, clear hierarchy of space, appropriate location of open space, connectivity, permeability, appropriate scales, good orientation and microclimate.

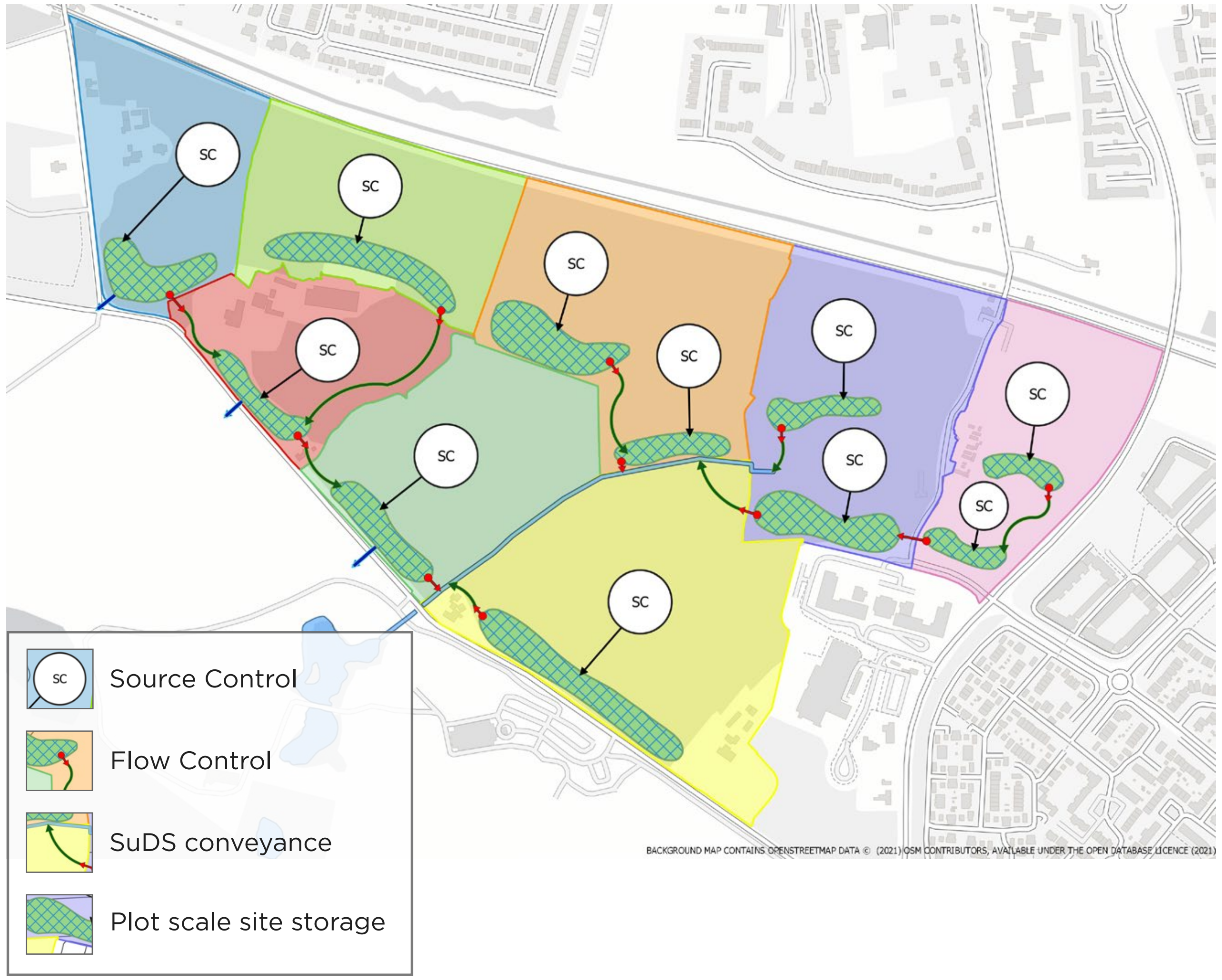


Example Flow Route Analysis

Rainfall runoff generated from development is managed within subcatchments. 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 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 SWMP for the Plan Area 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.



8.7 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 DCC Development Plan (2022-2028) policy requirements prior to developing the design to outline / detailed design status.

8.7.1 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 as a last resort.

8.7.2 Preliminary water quality considerations

At the 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 (CIRIA SuDS Manual C753 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, site of special scientific interest (SSSI), special area of conservation (SAC), nature reserves and existing biodiversity features.
- DCC will not accept the gully pot as a method of treatment. Table 26.15 of the CIRIA SuDS Manual details that conventional gully and pipe drainage provide zero treatment.

8.7.3 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.

The importance of usable open space in providing a high-quality living environment for all is well established. Dublin City Council Development Plan recognises this and the need to protect and enhance open spaces for both biodiversity and recreation. It also recognises the benefits this asset provides for the city's sustainability and attractiveness as a place to live, work and visit.

Reference should be made to the local context analysis to establish local and future requirements of users as well as identifying local amenity and biodiversity deficits. Consideration should be given to how SuDS design can be incorporated with amenity / open space design to address deficits.

Key amenity elements to consider when designing SuDS features include:

- Legibility – can the design be understood by users and managers? (Signage is not a substitute for legible design.)
- 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 must 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 (Pelletstown)

8.7.4 Preliminary biodiversity considerations

SuDS design should ensure that existing habitats and open spaces are considered for their biodiversity value, both locally and at a citywide scale, for their importance as corridors for wildlife across the city. This should influence SuDS design and technique selection.

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

- Clean water – 'a controlled flow of clean water' is provided using 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. Assess the site for existing biodiversity and consider how this can be retained / enhanced through SuDS design. The findings of any appropriate assessments and ecological surveys to inform design.
- Sympathetic management – through considered management, a mosaic of habitat types can be created, ensuring maximum ecological value.

8.7.5 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 structure.

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.

8.8 Pre-application discussion

Pre-application discussion with the DCC is recommended for all Plan / Framework / Masterplan sites. The relevant departments within DCC should be involved in these discussions.

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

Pre-application discussions with DCC planners and drainage departments provide an opportunity for the designer to confirm the preliminary requirements for the SuDS design, and for the evaluation team to understand the objectives and character of the SuDS proposed for the development.

Constructive discussion between DCC 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.

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 DCC 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

Information required	Rationale
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 DCC 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
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

Information required	Rationale
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.

9.0 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.

9.1 Objectives of SuDS Outline Design

SuDS Outline Design builds on the ideas introduced in Concept Design considering any pre-application discussion with DCC and other stakeholders and additional information gathered as part of the Outline Design process to confirm how the SuDS will be successfully integrated into the development.

The Outline SuDS Design should:

- Clearly demonstrate how the SuDS design adheres with relevant DCC Development Plan policies and Technical Appendices
- Meet the requirements for OPW document 'The Planning System and Flood Risk Management'
- Confirm how the SuDS scheme maximises opportunities for amenity and biodiversity
- Deliver schemes which are legible and function passively.

SWMP requirements - Draft DCC Development Plan (2022-2028) Technical Appendix 13

9.2 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 the following:

- 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
- The design will be developed to a stage that confirms it can be constructed practically and can be managed and maintained at reasonable cost.

The level of detail provided as part of the planning application will be representative of the scale of development being proposed.

Design note: Outline design is the minimum level of detail that would be expected to support the submission of a planning application for determination (as part of the SWMP) in compliance with DCC Policy SI25 & DCC Development Plan Appendix 13.

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 (+40% 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.

9.2.1 Developing an outline design

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

- Sufficiently detailed site topographical survey, geology assessment, risk assessment for presence of site contamination.
- Existing services, including location and depth. These can influence layout, depth and placement of SuDS features.
- Planning policy, for example SUDS features adjacent to protected structures, archaeological zones, in designated Architectural Conservation Area (ACA) and conservation areas, where conservation or heritage constraints might influence. Choice of SuDS components and the use of materials.
- Ecological constraints and opportunities. Well-designed SuDS can be used to enhance existing habitats and assist in the delivery of biodiversity net gain.
- Other competing site design considerations such as required building orientation, open space requirements and access/parking arrangements etc. (SuDS should assist in informing development layout using the flow route analysis).
- 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. Any discharge should be agreed in principle with the relevant authority.
- Confirmation of ownership and maintenance arrangements.

Design note: Where concept SuDS 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.

9.3 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 set out in SuDS requirements (see Section 7). Discharge to a closed pipe system is least preferred method of discharge.
- 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 of 5mm for the majority of rainfall events).
- Sufficient treatment is available to manage pollution risk along the management train. Evidence can be provided using the Simple Index Approach from the 2015 SuDS Manual (CIRIA C753).
- How spillage (oil spill or release of other pollutant) could be managed.
- How runoff could be managed during construction.

Amenity

The designer should demonstrate:

- That SuDS is easily understood 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' (https://www.hsa.ie/eng/Your_Industry/Construction/Designing_for_Safety/).
- The visual character of the SuDS will enhance the development.
- Spaces and connecting routes are multi-functional and can be used for recreation when not providing a SuDS function for management of rainfall runoff.

Biodiversity

The designer should demonstrate:

- That water is cleaned as soon as possible along the management train using the principle of source control.
- That 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.
- Ecological design and the creation of habitats within the SuDS corridor.
- 'Management practices' to enhance habitat development during maintenance.

9.4 Designing for hydraulic requirements

Development causes an increase in rainfall 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 leaving the site. Expressing calculation outputs in an logical format allows for easy application within the design process as well as transparency for evaluation.

Design note: The same hydraulic criteria will be applied to both brownfield sites and greenfield sites.

9.4.1 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 DCC SuDS standards
- Demonstrate how factors such as design exceedance and runoff from off-site coming into the development can be managed without causing unreasonable risk to humans or development
- Provide confidence that SuDS will function hydraulically and are not prone to erosion.

9.4.2 Calculation processes

The calculations for SuDS design are used to assess:

- Appropriate discharge rates via infiltration or controlled discharge rates to a watercourse or sewer
- The volume of runoff that requires storage to allow infiltration or attenuation to controlled discharge rates
- The long-term storage volume that needs to be managed
- Flow velocities.

Calculation process	Purpose of calculation	Main calculation inputs
Greenfield runoff rate - sites 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.

9.4.3 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 several 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 8.4.8 - 8.4.15 cover the basics of infiltration and attenuation storage calculations and should be referred to prior to progressing with this section where calculation inputs are considered in more detail.

9.4.3.1 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 DCC where no more detailed assessment is undertaken.

The designer must evaluate the Cv which will be informed by the types of surfaces contributing runoff to the storage location.

Where there is a 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 0.1-0.15 (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.

9.4.3.2 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 a

demonstration of no runoff from site for rainfall depths up to 5mm for the majority of rainfall events.

As a rule of thumb, where the total wetted area of SuDS equates to at least 25% of the buildings and hard surfaces 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.

9.4.3.3 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.

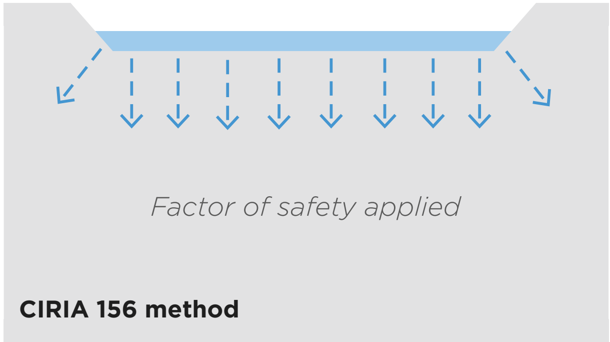
For example, tests should not be undertaken 1.5m below ground level when shallow infiltration is proposed from permeable pavement, rain gardens or basins which will be located close to ground surface.

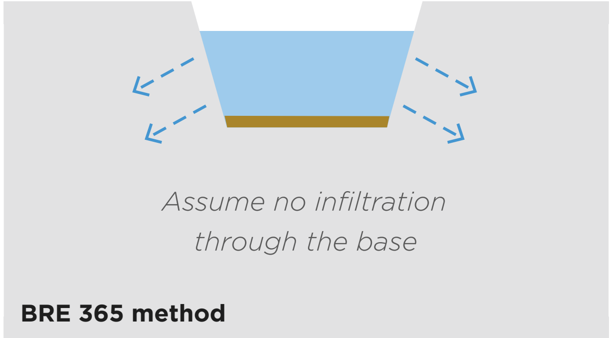
There are two methods for calculating temporary storage for infiltration.

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, may silt up over time and therefore infiltration is only calculated through the vertical sides.

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





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.

9.4.4 Calculating flow control rates and attenuation storage

DCC requires that runoff generated by development is attenuated from all sites to equivalent greenfield runoff rates.

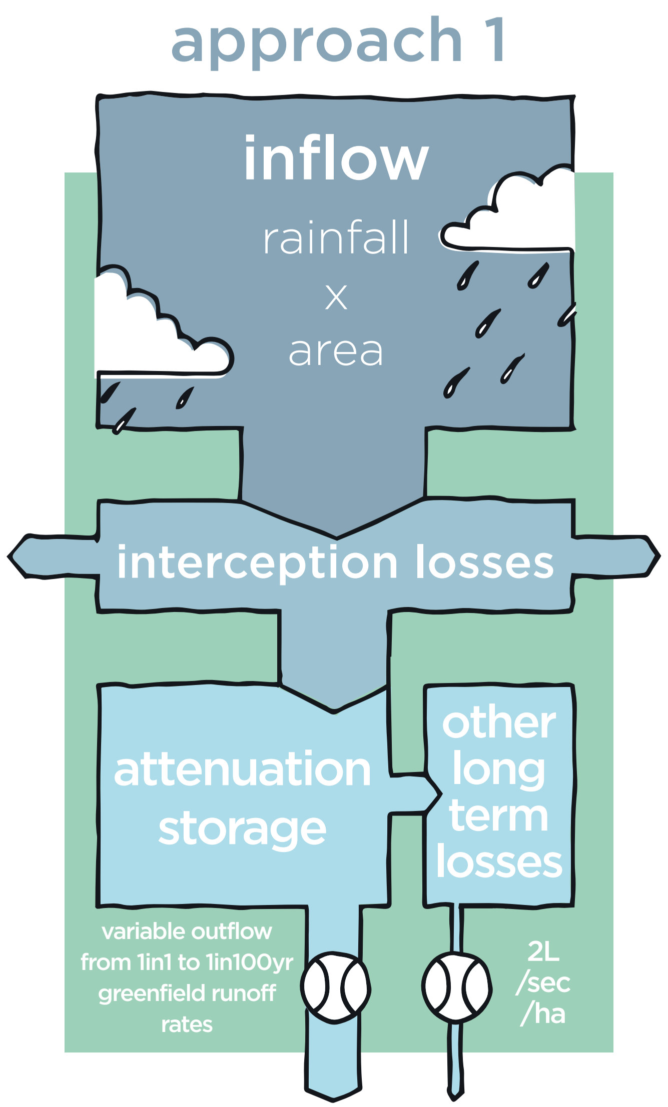
Restricted rates apply to both green and brownfield (re)development.

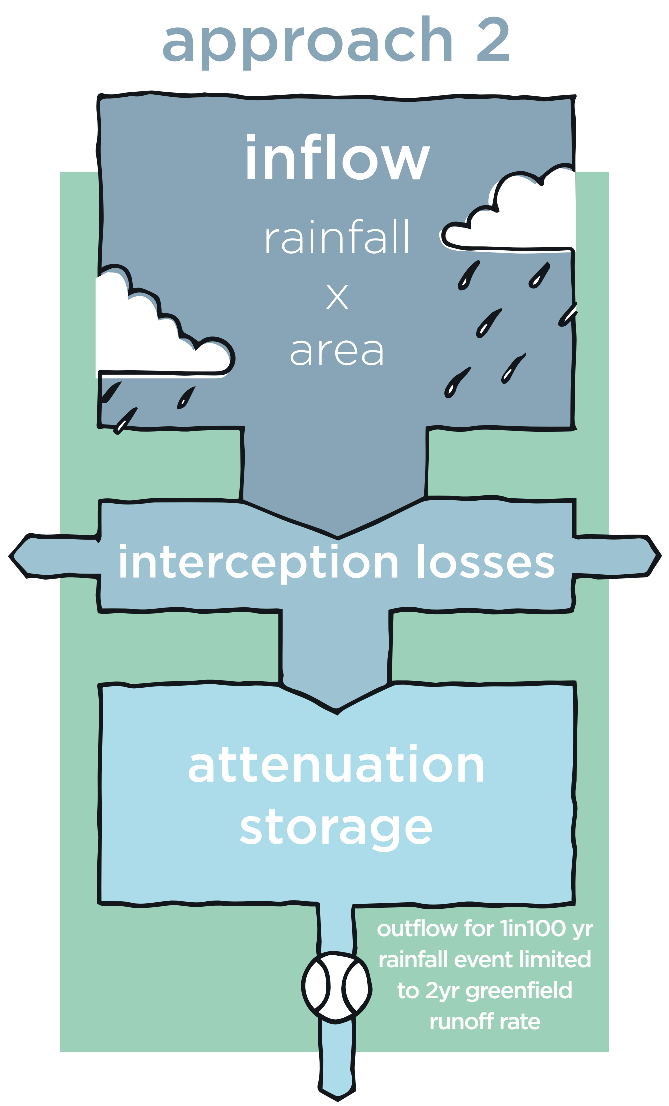
Where discharge from the site contributes to a combined sewer network or to an area of known flood risk / capacity issues

All flows to be restricted to 2l/s/ha for the 1-in-100 year rainfall with allowance for climate change.

Where discharge is to a surface water sewer or open watercourse channel with no known flood risk / capacity issues

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.





9.4.5 Establishing Greenfield (GF) Runoff Rates

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

The following Qbar rates are provided as a benchmark (to check calculations against) and are based upon a 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: Qbar should be calculated on a site location basis. In many cases across Dublin City the maximum permitted outflow will be 2l/s/ha due to connection to the combined sewer or limited capacity in the receiving storm sewer.

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

9.4.5.1 Sizing flow controls - Approach 1

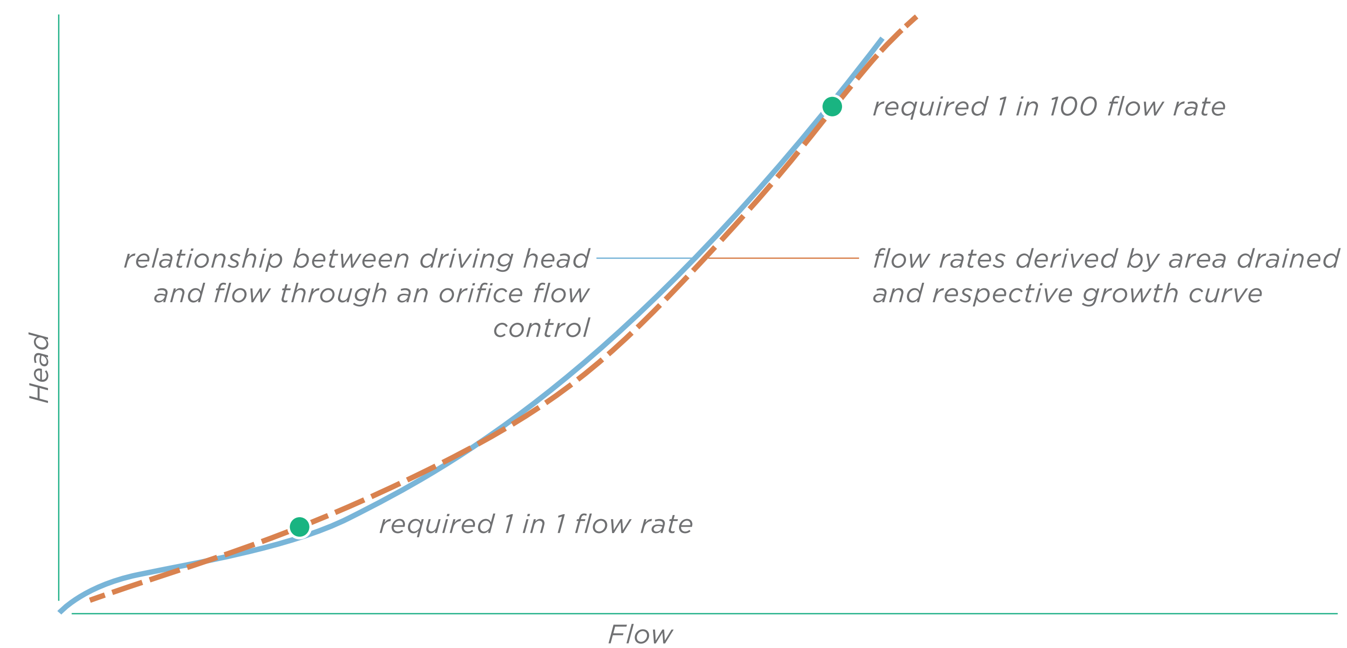
This approach allows for varying the outflow rate for the 1 in 1 year and 1 in 100 year greenfield runoff rates for the respective rainfall events.

Worked example - Sizing flow controls - Approach 1

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.



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

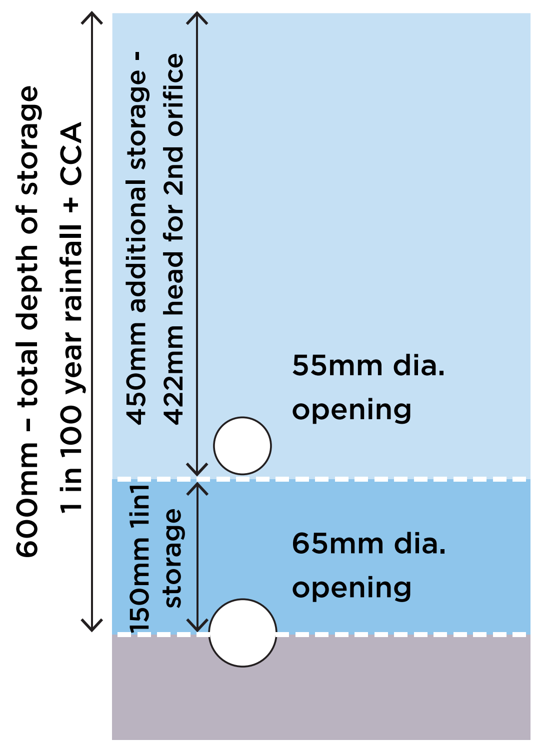
Depths of storage are assumed as 150mm and 600mm for 1 in 1 year and 1 in 100 year return periods respectively.

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.

9.4.5.2 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.

9.4.5.3 Long term storage

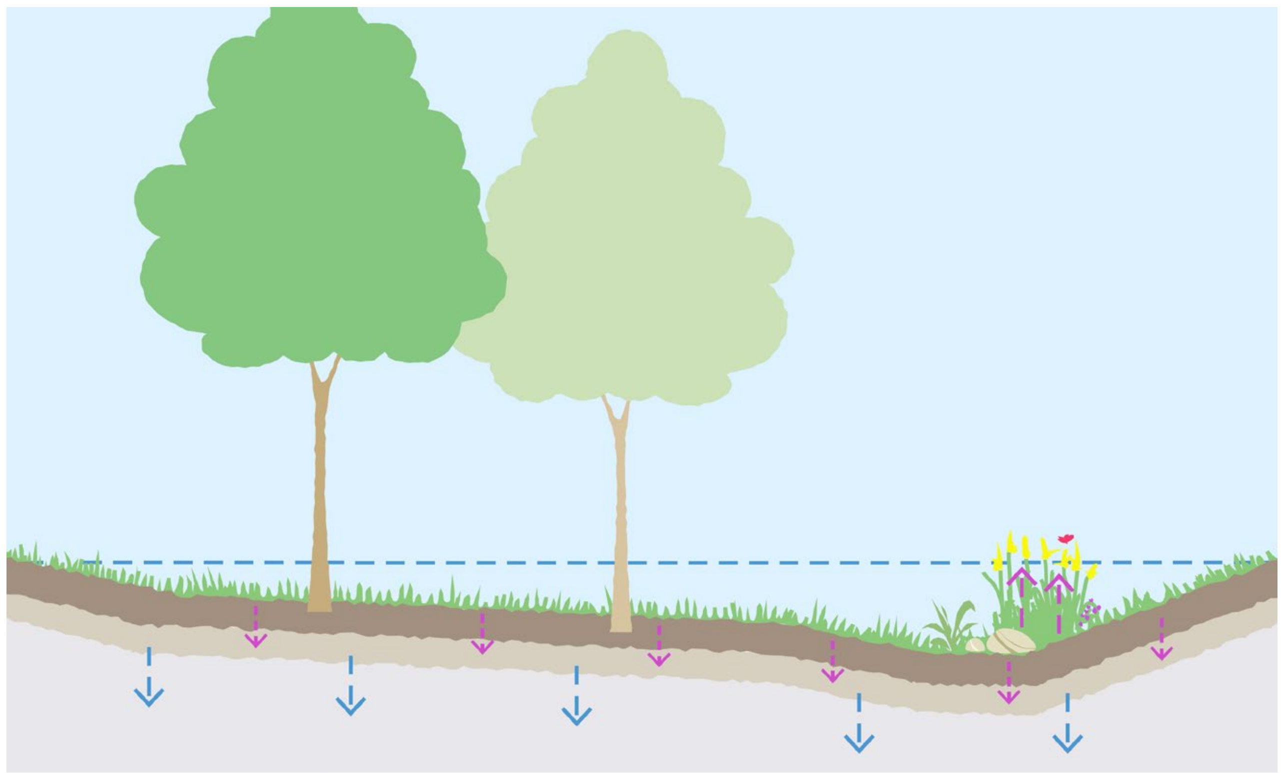
When designing the storage volumes for Approach 2 some runoff must be retained on site after attenuation storage has emptied to mitigate for flood risk caused by the increased runoff volume generated by the development.

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

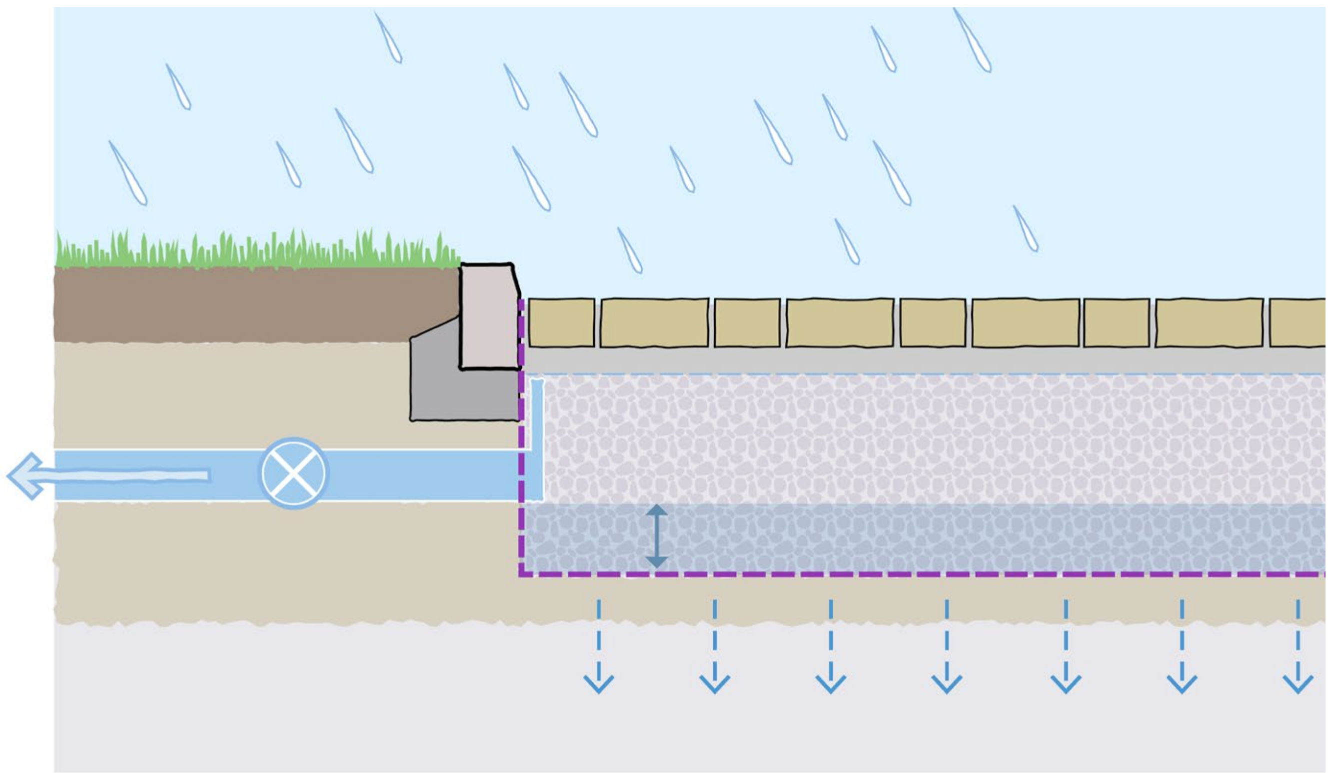
- **Rain harvesting** - Where it can be demonstrated that the harvesting system will be in use for most of the time and demand exceeds supply, 50% of the rain harvesting volume can be offset against the long-term storage volume requirements. (BS 8515:2009)
- **Natural Losses** – For SuDS components which 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 car parks or amenity open space should 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

9.4.5.4 Accounting for Climate Change

SuDS design must demonstrate site containment or surface runoff for design rainfall intensities with additional 20% uplift for Climate Change Allowance (CCA).

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

9.4.6 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 DCC drainage department.

DCC Development Plan SI24 - Control of Paving of Private Driveways / Vehicular Entrances / Grassed Areas

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%

9.4.7 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. Shorter drain down times may be required to allow area accommodated by SuDS to be treated as open space/ amenity land.

9.4.8 Critical Duration

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

9.4.9 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.

9.4.10 Design flexibility

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

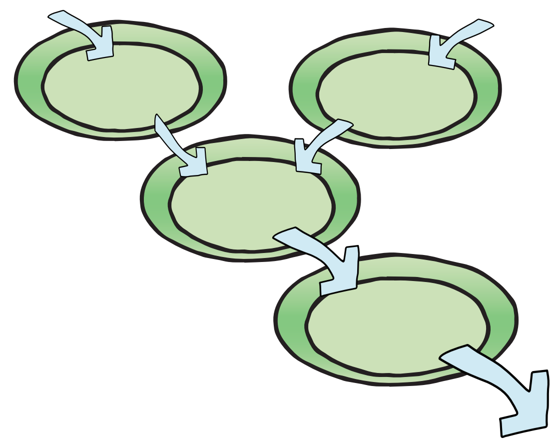
Appearance, functionality and character of a space can be influenced by how flows are stored and controlled within each SuDS component. Four approaches are explored by this guide. These approaches are intended to inspire the designer to think about the possibilities that exist for integrating storage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

9.4.10.1 Distributed storage components

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.

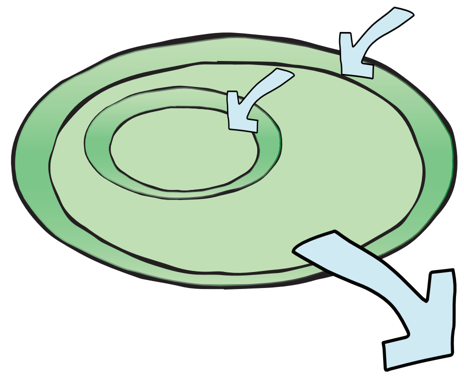
Example of a raingarden managing day-to-day rainfall (e.g. up to the 1 in 10 rainfall event) with flows passing onto subsequent features.

Outline Design

9.4.10.2 Single, tiered storage components

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 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.

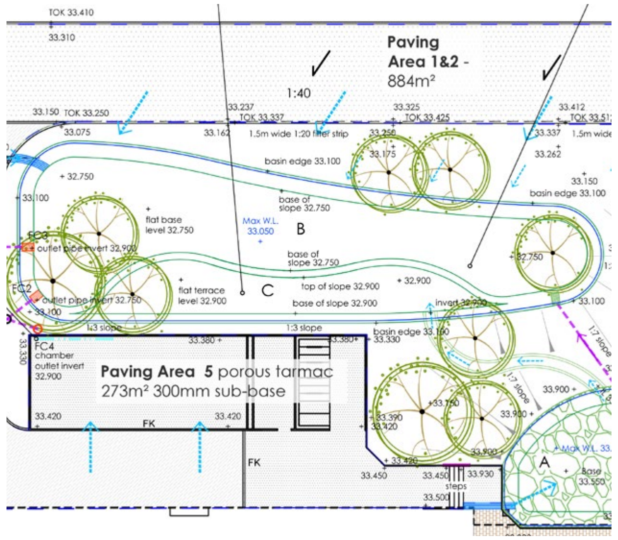
More frequent rainfall events which produce less runoff such as the 1 in 1 year rainfall event, are prevented from covering the whole storage component by accommodating them in a smaller basin. The small basin is located within a more expansive basin which can accommodate further volumes of runoff up to the 1 in 100 year rainfall 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.

Example of a small wetland (with attenuation capacity over the permanent water level) located within a larger bunded grass attenuation basin.

A project drawing showing a large tiered storage basin.



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9.4.10.3 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.

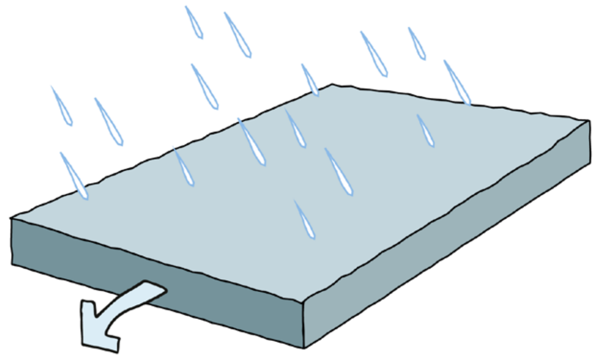
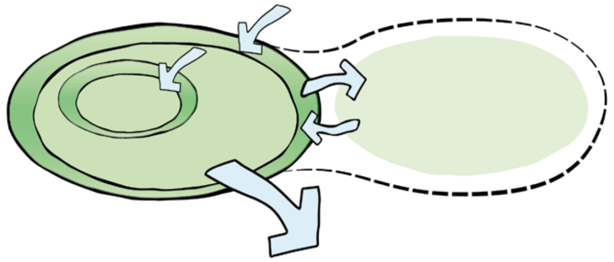


Image shows permeable pavement which stores slows within the sub-base using a flow control

9.4.10.4 Site containment storage

On some sites, rainfall runoff from extreme rainfall events could be stored in parts of the site such as overspill car parks 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. Flow depth where site containment is provided should be shallow (no greater than 150mm) and flow velocities should be less than 1m/s.



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

9.4.10.5 Designing for exceedance

The designer must demonstrate that extreme rainfall events, beyond standard design parameters (1 in 100 year rainfall event + CCA), 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.

Flows greater than the storage capacity of SuDS components should be directed along modified flow routes. Where there is potential for flows across the surface, 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.

9.4.10.6 Managing off-site flows

Many sites are at risk of significant surface runoff from offsite with indicative flow routes identified by pluvial 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 DCC, developers are not required to attenuate rainfall runoff flows which are generated from offsite. This advice may be revised in exceptional circumstances which will be determined on a case-by-case basis.

Flood maps

DCC 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.

9.5 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 through a filtering or screening process.

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 which directs flow into the modified flow route and onto the next part of the SuDS management train.

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.

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 (10-20mm diameter) with shallow depth of storage.

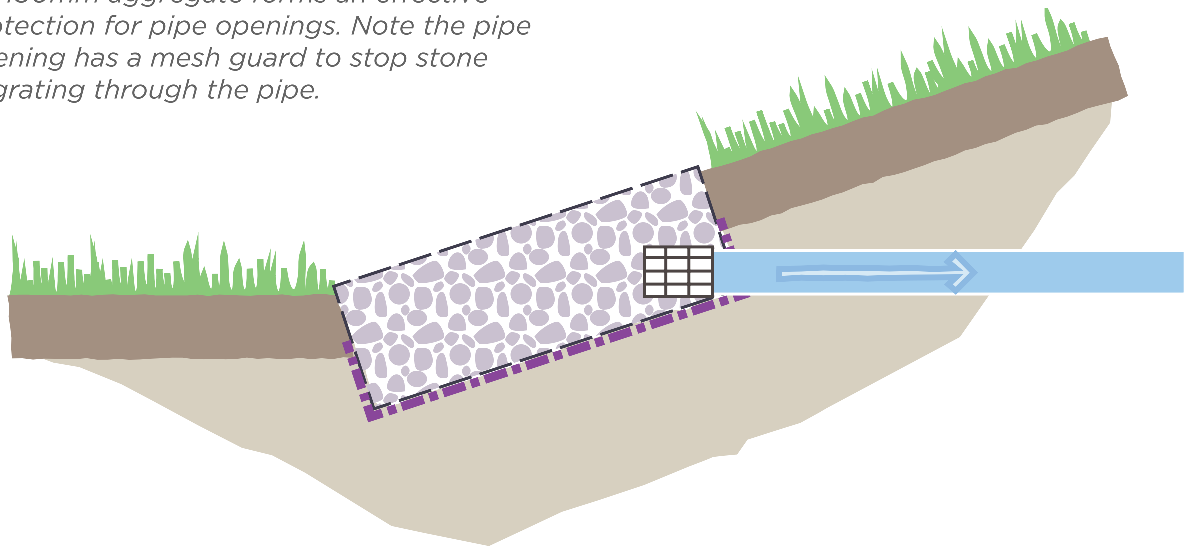
SuDS components such as permeable pavements, bioretention or filter drains are pre-filtered, and assuming collection through perforated pipes or similar, the flow control opening requires little additional protection.

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.

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.



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. DCC 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. DCC 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.

9.6 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.

9.6.1 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.

9.6.2 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 body – 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 indices 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.

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

Outline Design

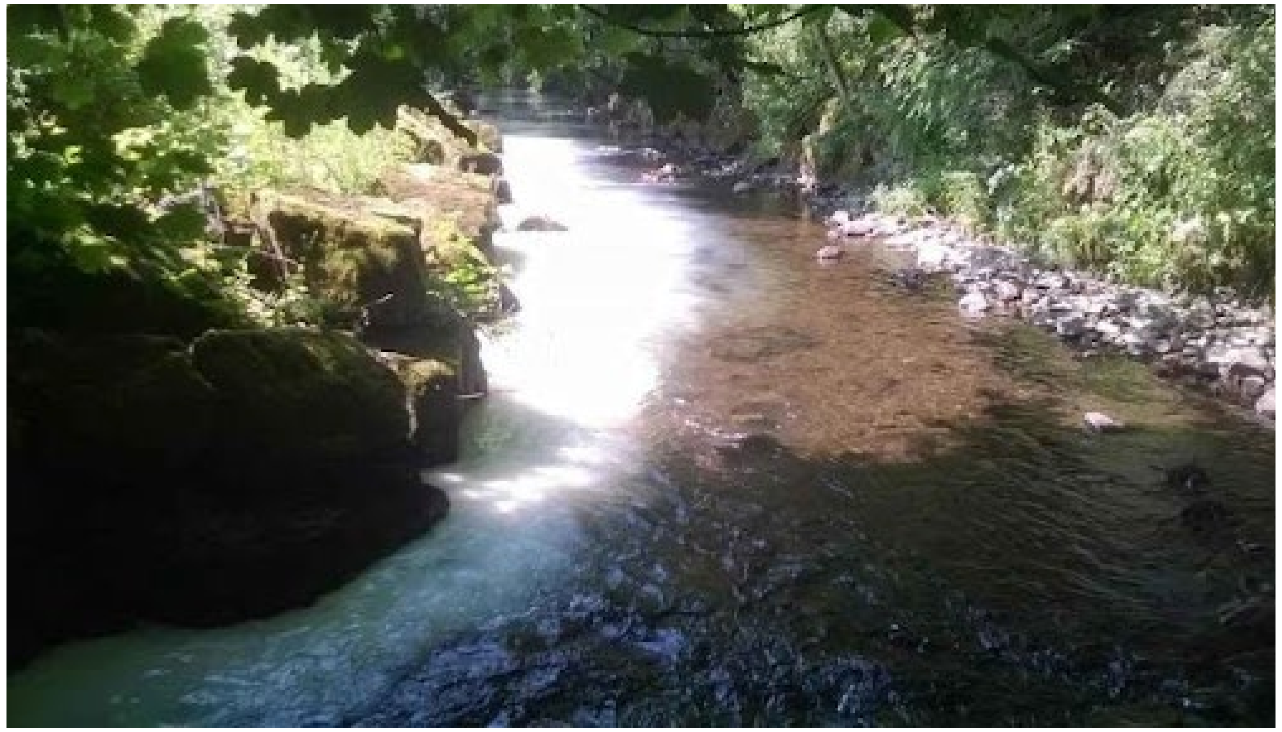
9.6.3 Dealing with spillage

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.

Milk spillages will bypass conventional drainage methods of spill containment



9.6.4 Water quality design checklist

Item	What's being checked	Information presented for assessment
Method of discharge	Sensitivity of receptor and level of treatment required	Design statement to specify method to discharge and sensitivity of receptor
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.

9.7 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 at Detailed Design 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.

9.7.1 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 are located?
- Are overflow and exceedance routes clear and easily understood?
- Is the outfall obvious, accessible and easily understood?

9.7.2 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

Hopwood Park Motorway Service Area, M42. Wooden terrace and balustrade with wet bench and planted aquatic bench protection to open water

9.7.3 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 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.

9.7.4 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 associated edges and profiles, remain to be confirmed during Detailed Design Stage.

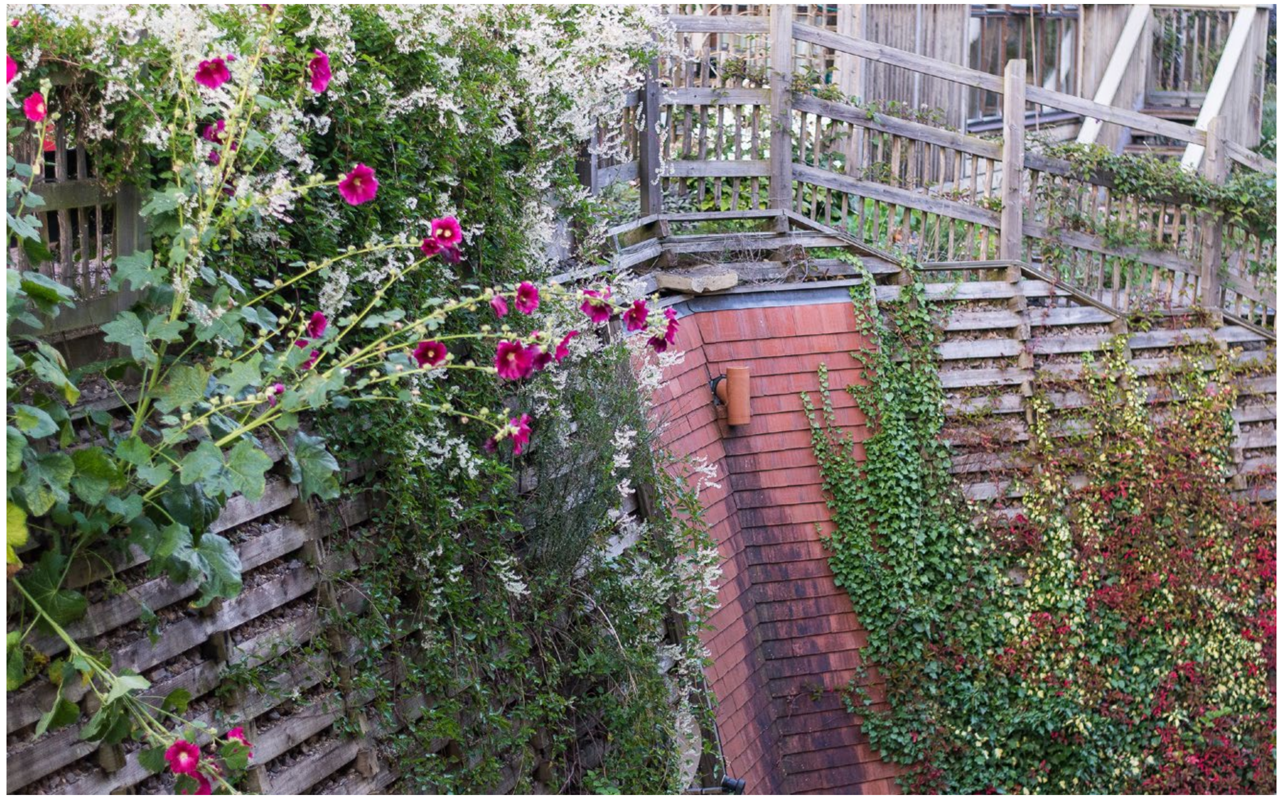
Firstly, the collection and conveyance of runoff can add visual interest to development, spouts, rills surface channels, for instance, should be considered as part of the landscape character of a development.

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 spaces, where both everyday rainfall and occasional heavy storms can be managed, and public pedestrian routes where conveyance of water and biodiversity can be combined.

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



Outline Design

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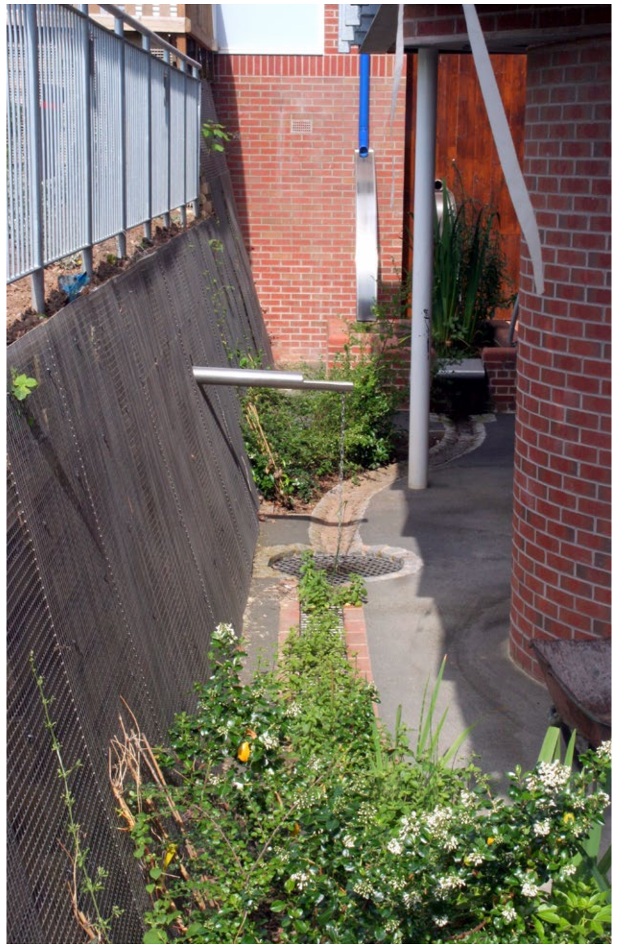
The integration of SuDS with amenity, biodiversity and site layout provides additional benefits including:

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

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



9.7.5 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 and 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 design. SuDS design should integrate the requirements of rainfall management with the use of development by people.

- Accessibility analysis to and from amenity space to ensure access for all abilities is a key requirement, in this regard level differences within SuDS components or ones which may create barriers should be carefully considered.
- The SUDS design should refer to the local context analysis to establish local and future requirements of users, as well as identifying local amenity and biodiversity deficits.

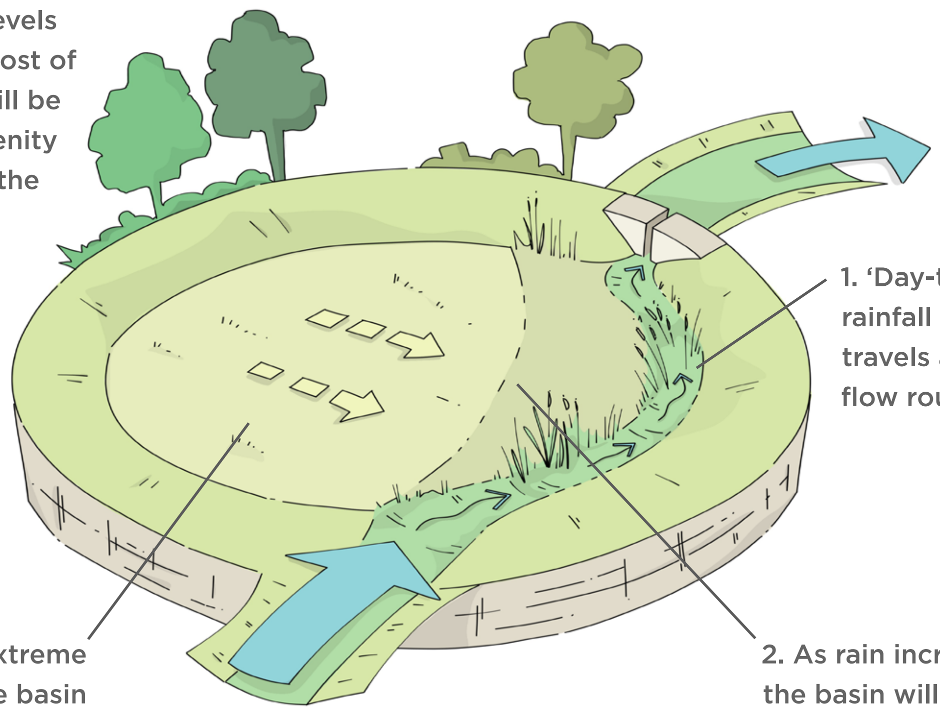
Design note: Well-designed SuDS schemes will be designed for 'people first'

9.7.6 SuDS in public open space

The following points will be considered in determining the areal extent of SuDS which serve as multifunctional space and/ or contribute to the public open space allocation:

- That sufficient open space remains available (except in response to extreme rainfall events) to allow for passive and active recreation including organised sport, informal play or active recreational use.
- How often a particular feature would hold surface water.
- The duration that features would hold surface water.
- Period between rainfall ending and the area being available for use.
- Whether the SuDS features could be deemed to be providing an open space benefit even when holding surface water (for example, ponds and wetlands).

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.



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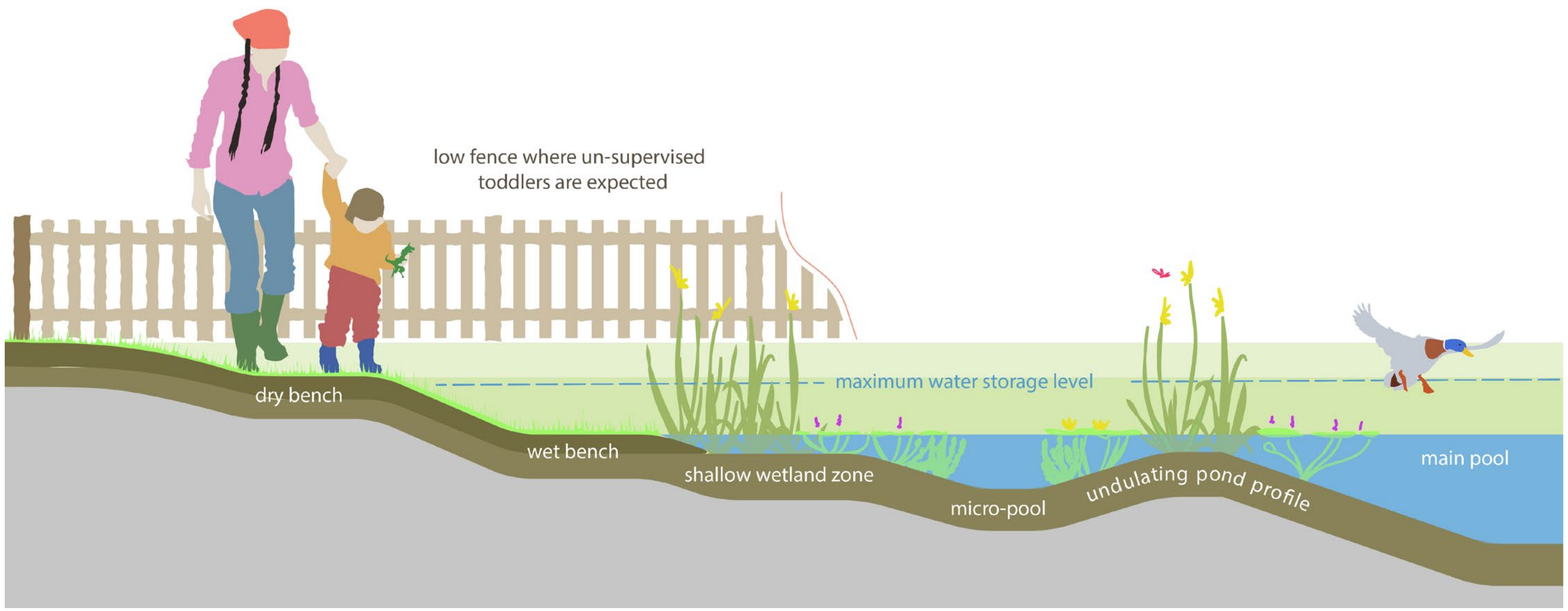
9.8 Safety by design

9.8.1 The place of water in the landscape

Although there are a few 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 Dublin urban landscape with presence of the Liffey, the Dodder, the Santry River and the Tolka which remain open in places, along with the Royal Canal and Grand Canal. 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 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.



9.8.2 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 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 125 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**

Project Supervisor Design Process (PSDP)

9.9 Biodiversity

9.9.1 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 at a local scale to provide habitat and connectivity linkages within and around development.

9.9.2 Biodiversity at development scale

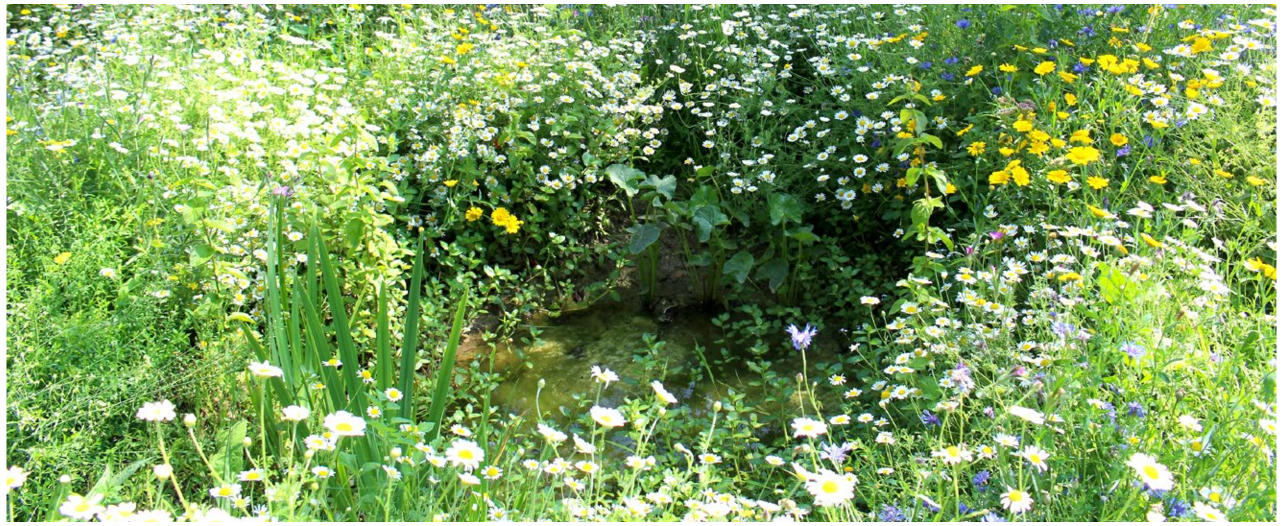
There is usually a host landscape that provides an enclosing envelope to the SuDS 'management train'. This term describes the landscape not directly affected by SuDS features and the impact of rainfall management.

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.



9.9.3 Key design criteria for biodiversity in the developed landscape

9.9.3.1 Clean water

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

9.9.3.2 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.

9.9.3.3 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 also animals like bats which 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.

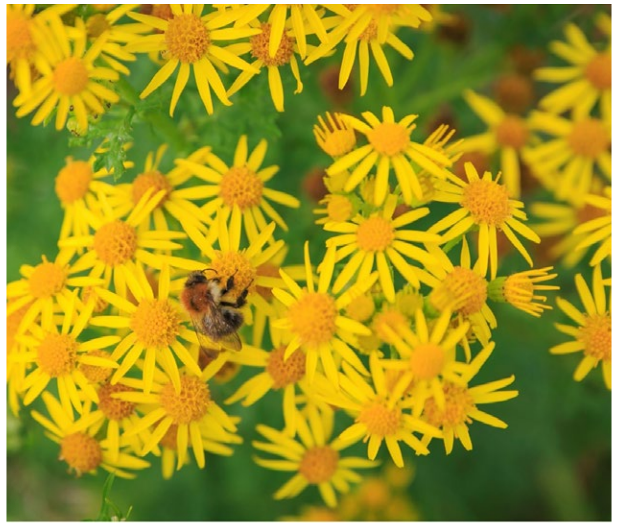
There should be a direct connection between the SuDS landscape and the blue-green infrastructure that receives the 'controlled flow of clean water' from the development.

9.9.3.4 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.

9.9.3.5 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.



9.10 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.

Any requirements for maintenance arrangements should be confirmed as part of the SWMP submission.

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).

9.10.1 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 DCC)

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 tanks for example or other items with a defined or finite design life.

9.11 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.

9.11.1 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

9.11.2 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 DCC. 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 Dublin City 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

9.11.3 Detailed 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.
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 9.5.2	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 checks 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 checks 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.
Landscape design drawings	Integrate SuDS within the wider landscape design	Check that the SuDS network is accessible, multifunctional and contributes to the overall landscape quality.
Consents & permits	Various and can include discharge consents; offsite works & 3rd party access consent.	Check that relevant consents are in place or can be obtained in principle.
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'	Confirmation of commitment to 'take in charge' aspects of the scheme agreed with DCC. 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.

10.0 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 DCC 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. 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).

10.1 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.

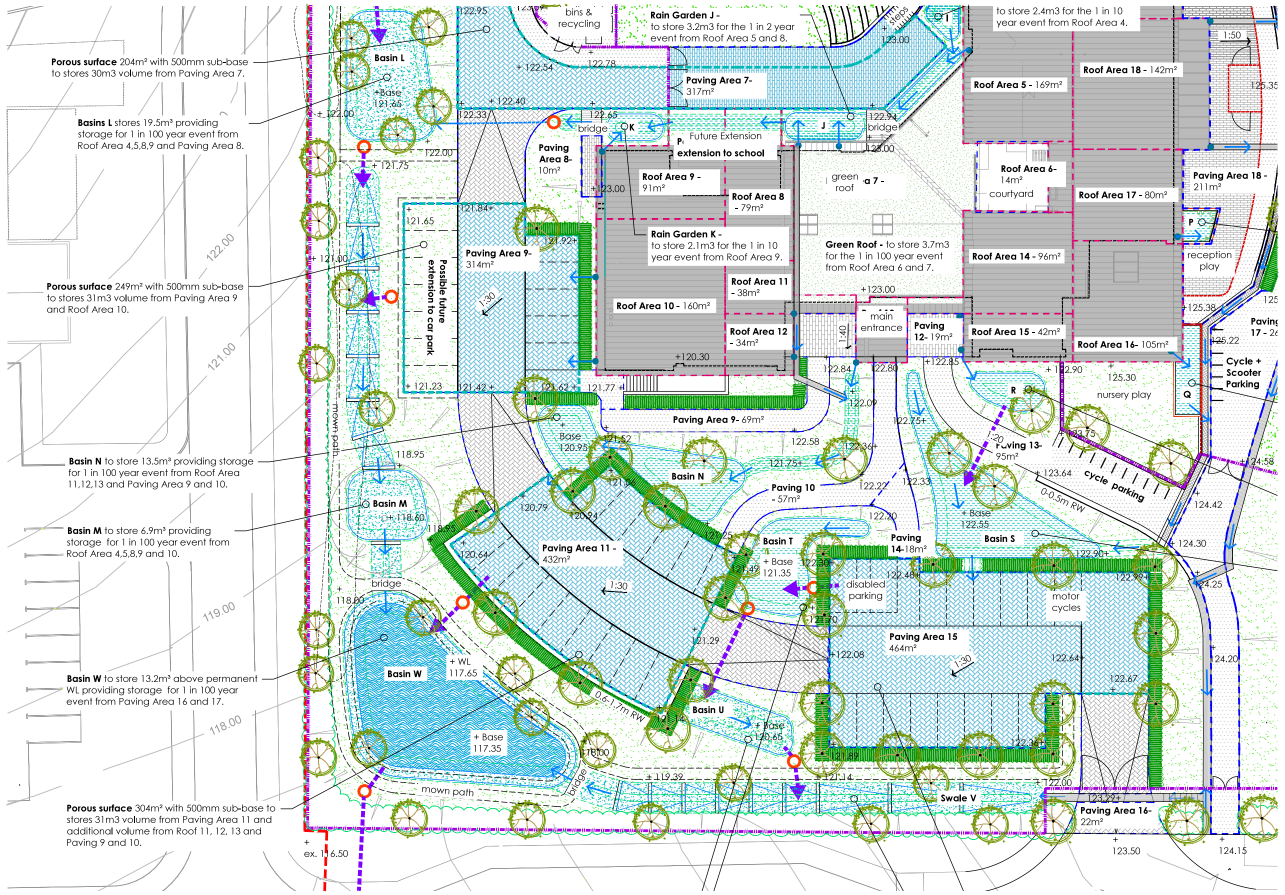
10.2 What Detailed Design should demonstrate

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
- Demonstration 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 DCC.

Design note: Unforeseen information such as presence of previously unknown utilities, archaeology, etc. can result in material changes to the design consented at planning stage. Relevant DCC departments should be consulted in such instances.



10.3 Typical Detailed Design package

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

10.3.1 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, sub-catchment 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 sub-catcatchments.
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.

10.3.2 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 highway drain (DCC). Discussions should be held with EPA for infiltration within Source Protection Zone areas.
- Irish Water consent to discharge where a connection to a combined sewer is required.
- 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.

10.4 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.

10.5 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.

11.0 SuDS Components

Competent design and detailing of SuDS components ensure 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 assets to the development.

- 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 several 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 rainfall runoff to flow into SuDS structures, or it must be collected through permeable surfaces.

The simplest method of collection of rainfall runoff from an impermeable surface is to intercept it as sheet flow from a hard surface. Where rainfall 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

Low risk access road with sheet flow over a flush kerb and shallow conveyance swale. (Pelletstown)

Site Controls

Where rainfall runoff is collected at the surface, a depression in the ground, mimicking 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

Vegetated basin . (High density residential development Pellestown).

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 9.5.1). 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.

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.

Green & blue roofs

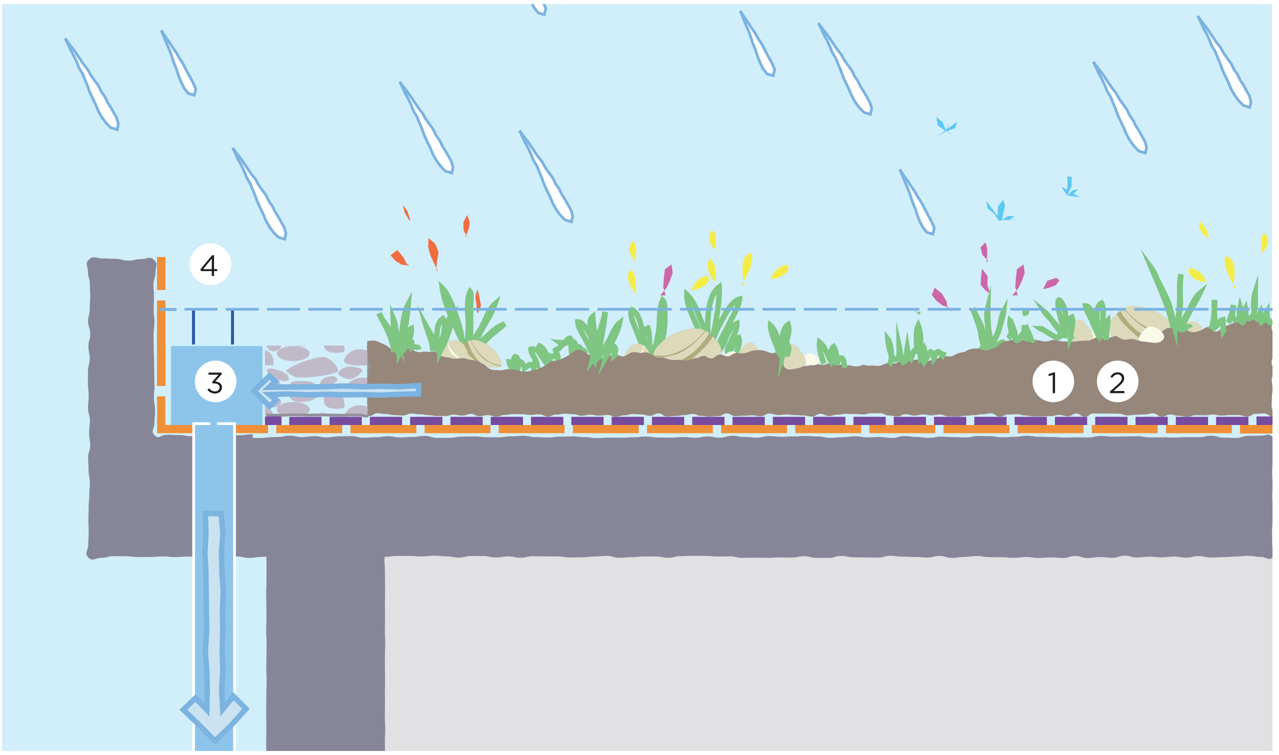
All development types are considered appropriate for green blue roof application.

Roof areas that are not considered for green roof due to the presence of solar panels should still be considered for blue roof.

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

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

DCC Green Blue Roof Guidance, DCC Development Plan Appendix 11

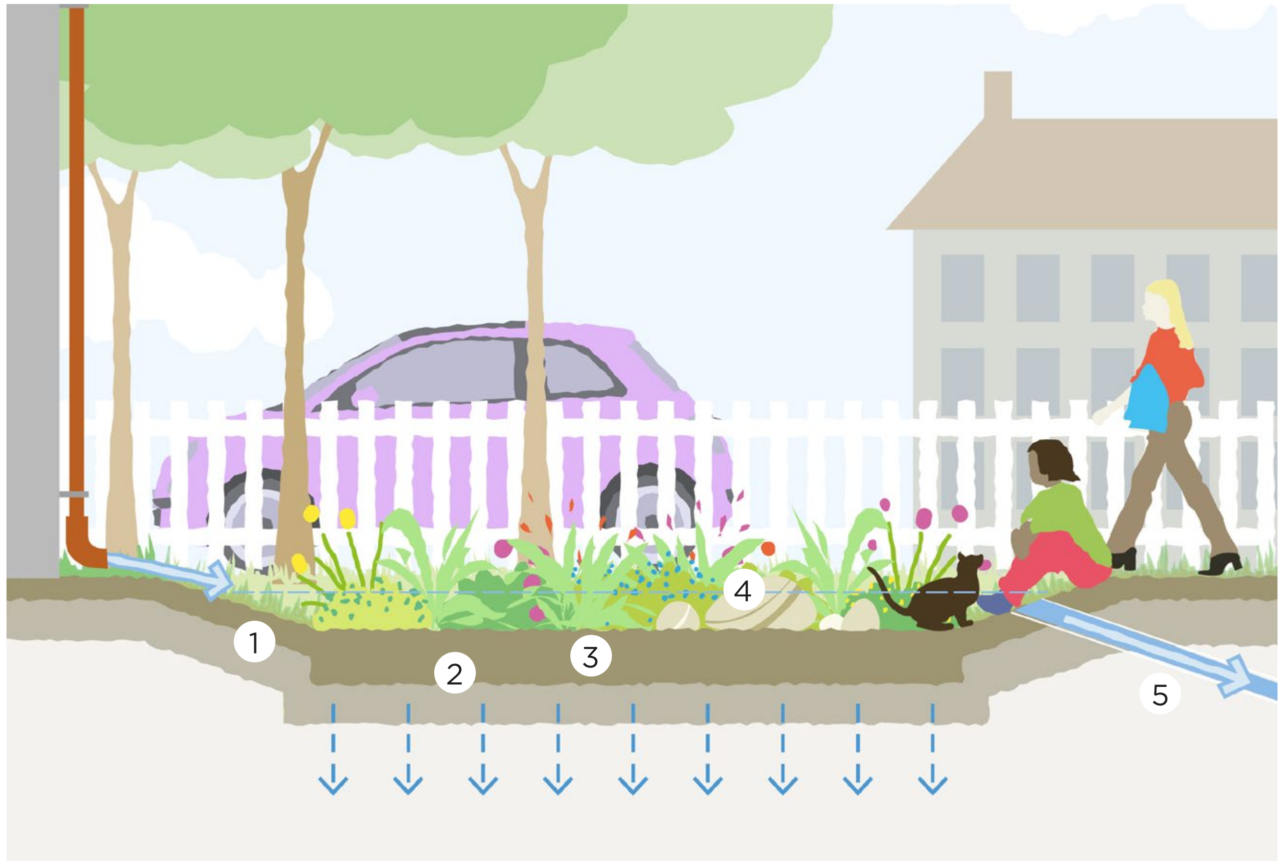


Raingardens

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 under-drain 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

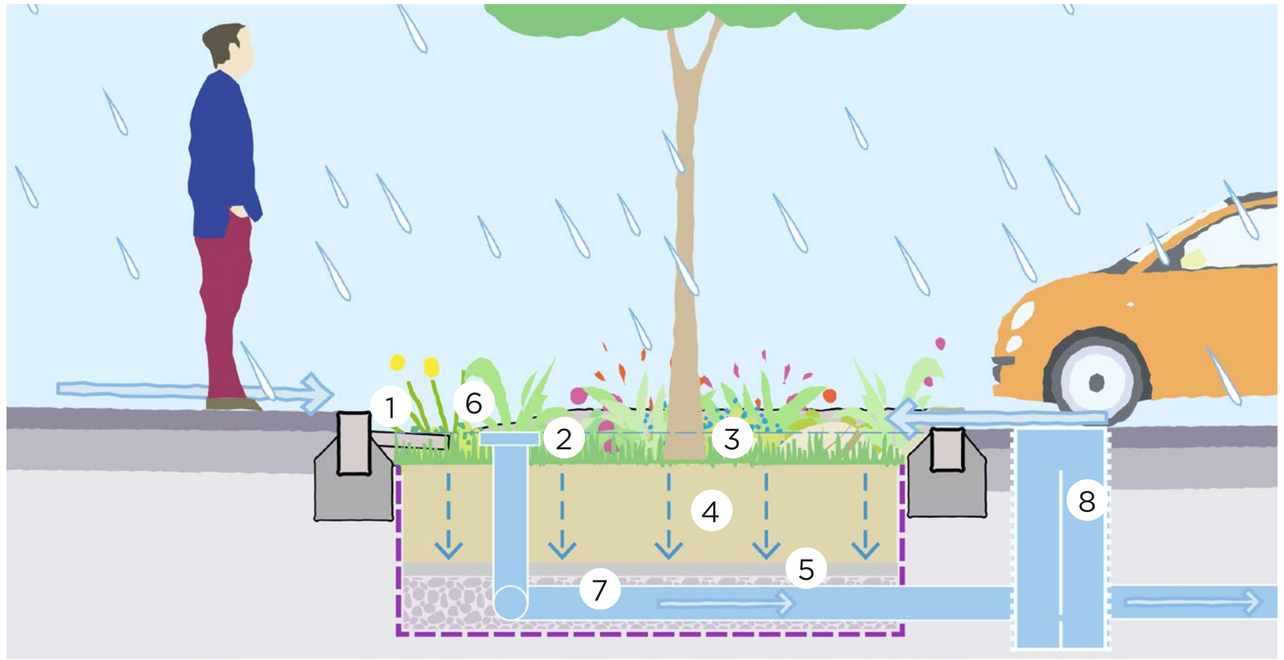
A bioretention structure differs from a raingarden in that it employs an engineered topsoil and is used to manage polluted urban rainfall runoff in street locations and carparks. These features can contribute significantly to the urban scene so should be designed to meet urban design standards.

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)

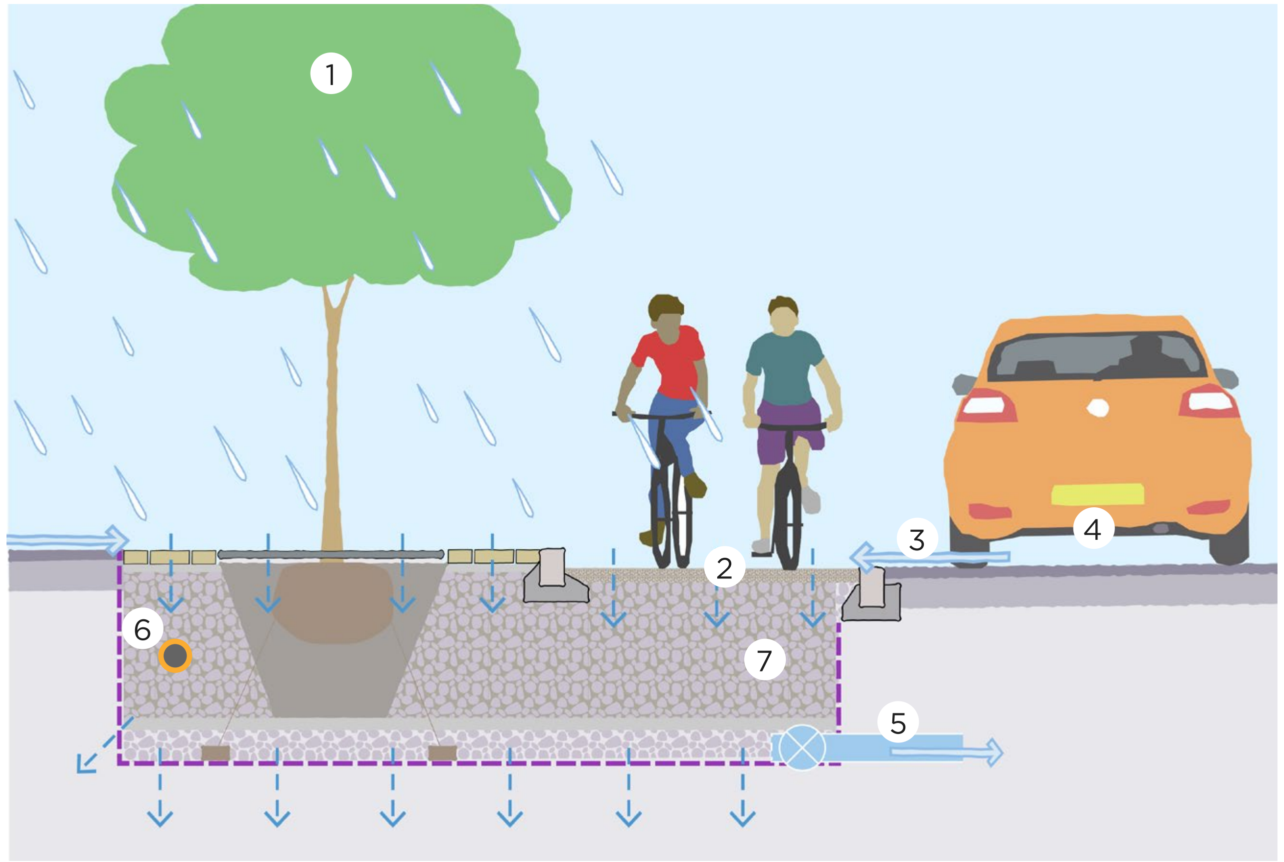


SuDS Tree pits

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.

A free draining soil will allow water to pass through to an under drain. Recent research indicates that where air space is provided deeper in the construction profile roots grow naturally in that direction. Tree roots are attracted to the underside of impermeable pavement because of the water trapped under the paving surface (also affected by tree choice) and the lack of air (oxygen) in lower soil layers.

[Dublin City Tree Strategy 2016-2020]



Key design aspects for SuDS tree pits include:

1. The choice of tree species is dependent on suitability to the planting location, local landscape character and application of the 10.20.30 diversity rule.
2. Soil specification:
    - Sufficient growing medium (soil) - for forest trees that will have a significant effect on the urban landscape and meet the impacts of climate change, like heat island effects etc., a volume of between 20- 30 cu m is necessary.
    - The soil must allow air to penetrate the soil profile to enable tree growth and reduce the lifting effect on urban pavements. This may require structural support to avoid long term compaction of the soil.
    - Tree trenches/pits must be designed to accommodate drain down rates that avoid root zones being inundated with water for more than 24 hours.
3. The runoff entering SuDS 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 using source control and silt removal mechanisms and some periodic maintenance should be expected to remove the build-up of inorganic silt.
4. Robust silt removal must be incorporated within the treepit design to allow runoff from roads to be permitted into the SuDS tree pit.
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. In new development sites, routing of utilities through the tree pit should be avoided.
7. The soil must receive enough water to enable the tree to grow - either supplied naturally or artificially. Artificial watering will not be permissible after the first 24 months.

If these basic conditions are met, then a range of trees can be facilitated. Some trees are more suitable than others for urban situations and the advice of an arboriculturist should be sought.

Where possible SuDS tree pits should remain open and preferably will not be paved over.

The impact of salt on urban trees has long been a concern. SuDS tree pits differ from traditional tree pit as they have a free draining soil and a way of draining down entirely within a reasonably short time frame. This allows the melt water after snow or ice, along with rain to flush the soluble salt through the soil and to the drain. This does require avoidance of piling salt around trees.

Design note: Several tree pits can be linked along a trench to optimize the volume available to each tree.

The widest selection of trees should be considered both to provide species diversity, disease resistance and visual interest.

To improve resilience Dublin City has adopted a best practice rule developed by the US National Arboretum 'Trees for Urban Planting: Diversity, Uniformity, and Common Sense', to plant no more than 10% of same tree species, no more than 20% from the same genus and no more than 30% from the same family. The ongoing tree inventory (Street trees and open spaces) has demonstrated that we rely too much on 4 trees species (Platanus x hispanica, Tilia x europeae, Acer pseudoplatanus and Acer platanoides) which represent 50% of our tree population.

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

DCC's current planting strategy encourages the use of new tree species to have a more resilient urban forests which contribute to a more sustainable, resilient Dublin.

Trees can also be located in other SuDS feature. Any tree planting associated with other SuDS features (such as basins and bioretention areas) should demonstrate:

1. Sufficient soil mass
2. Sufficiently permeable tree soil to drain
3. Effective drain down and outfall discharge of water.

Local tree canopy context must be considered as part of a SuDS integration strategy, and where planting targets for deficit areas have been identified these should be considered in tree selection (trees must be suitable for SuDS features).

Design note: Runoff from roads should not be directed towards existing trees. Traditional tree pits do not have the soil specification and drain down mechanisms provided for SuDS tree pits.

Permeable surfaces

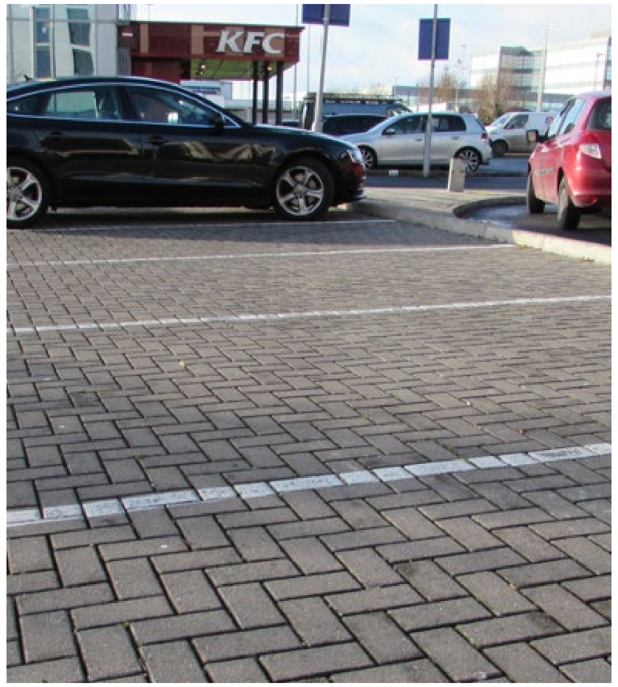
Permeable surfaces enable SuDS designers to direct rainfall straight into a SuDS structure for cleaning and storage or infiltration into the ground.

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.

[**Design manual for Concrete Block Permeable Paving**]

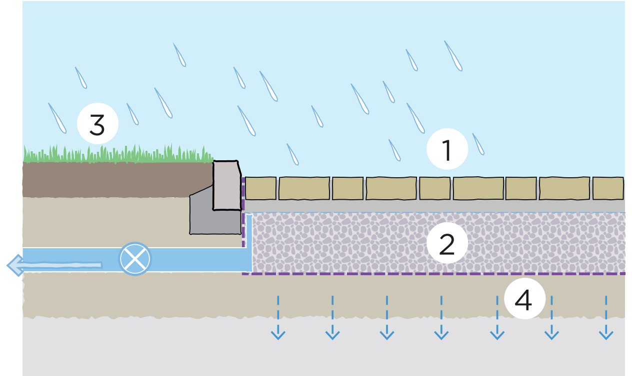
Permeable pavement (installed 2008) Finglas



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 SuDS Manual (Section 20) and the Interpave website www.paving.org.uk

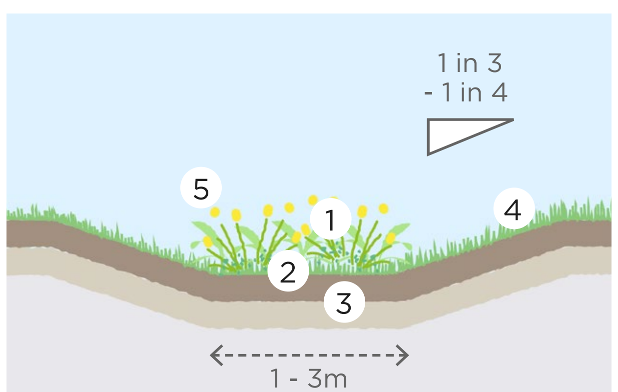
There are no reported issues with surface clogging under normal use. Maintenance may be required after 10 to 20 years of use comprising a brush and suction removal of grit joints and joint replacement.



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

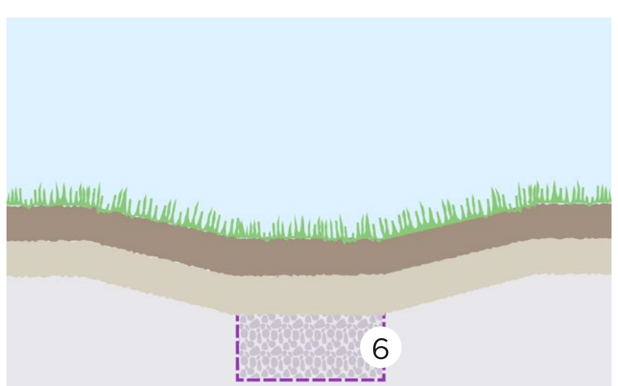


Performance criteria

Max. velocity at peak capacity – 1m/s

Max. velocity at low flow – 0.3m/s

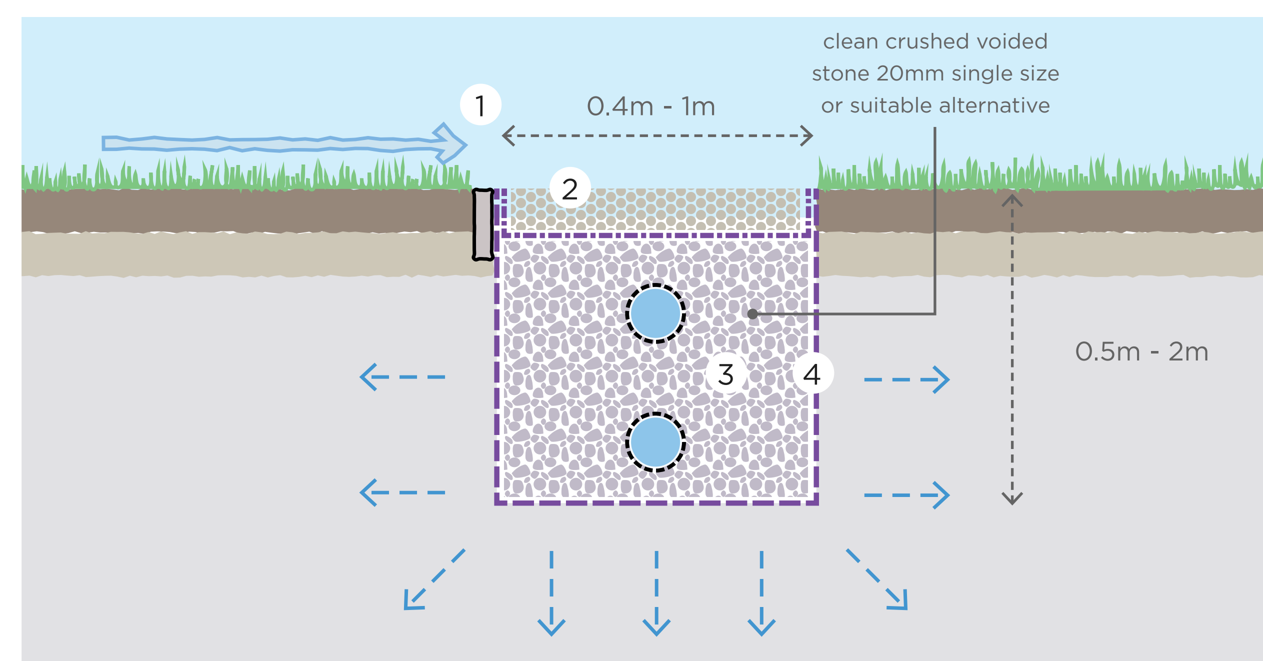
Travel time (low flow) – 9 minutes



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.

Concrete pipe surround has been used here to provide minimal cover for a driveway crossing.

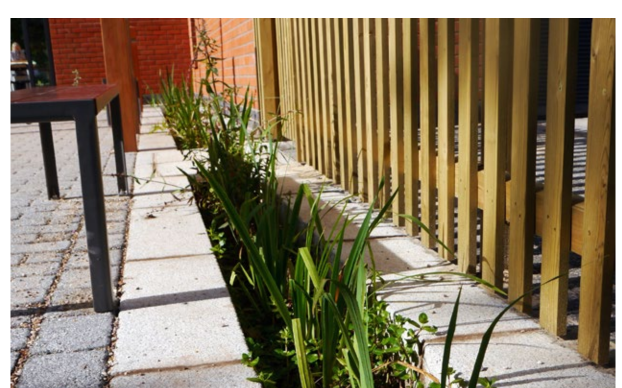
A granite sett channel collecting and conveying runoff.

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.

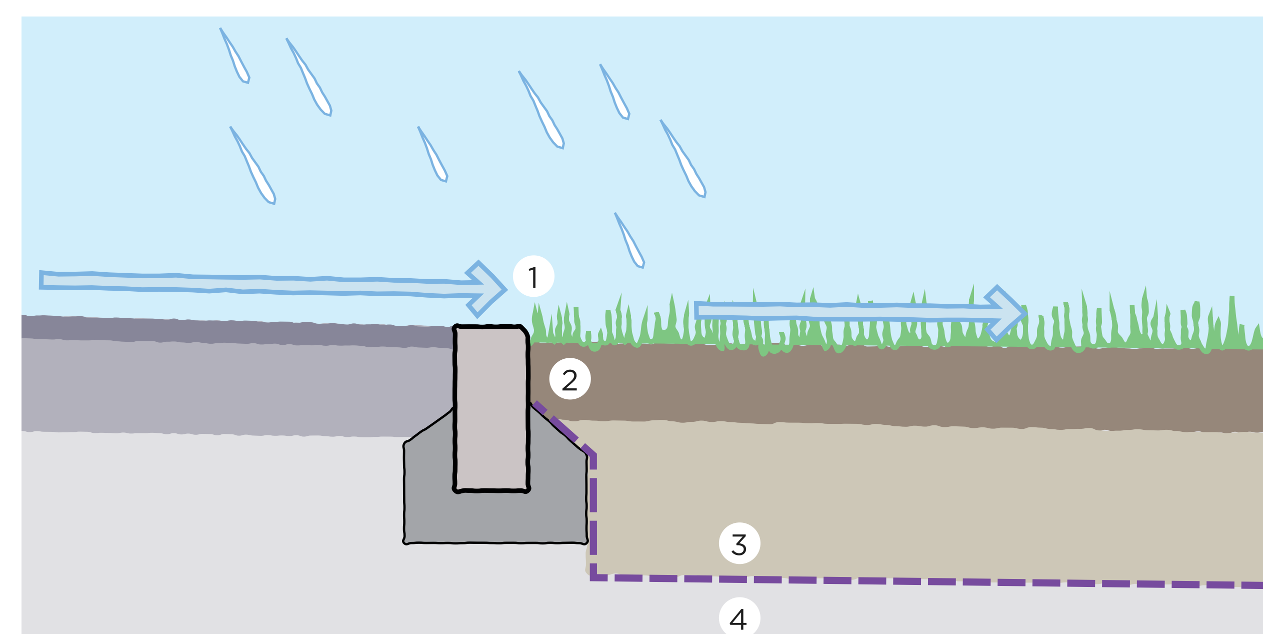


Filter strips

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.



SuDS Components

Basins, wetlands and ponds

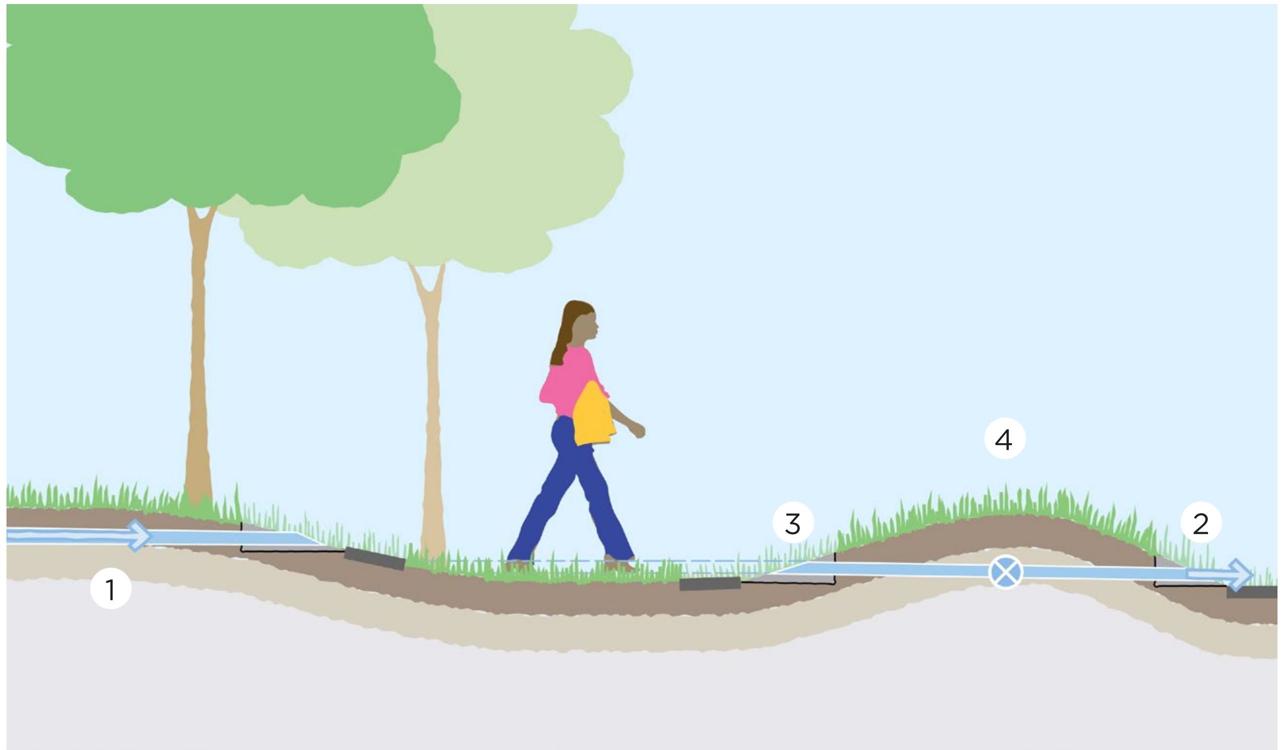
1. Reasonably clean water, through use of source control, should flow into site control components at or near the surface in a channel or swale.
2. Where a pipe connection is unavoidable they should flow through a safe and visually neutral headwall, such as a mitred concrete headwall or stainless steel 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.

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

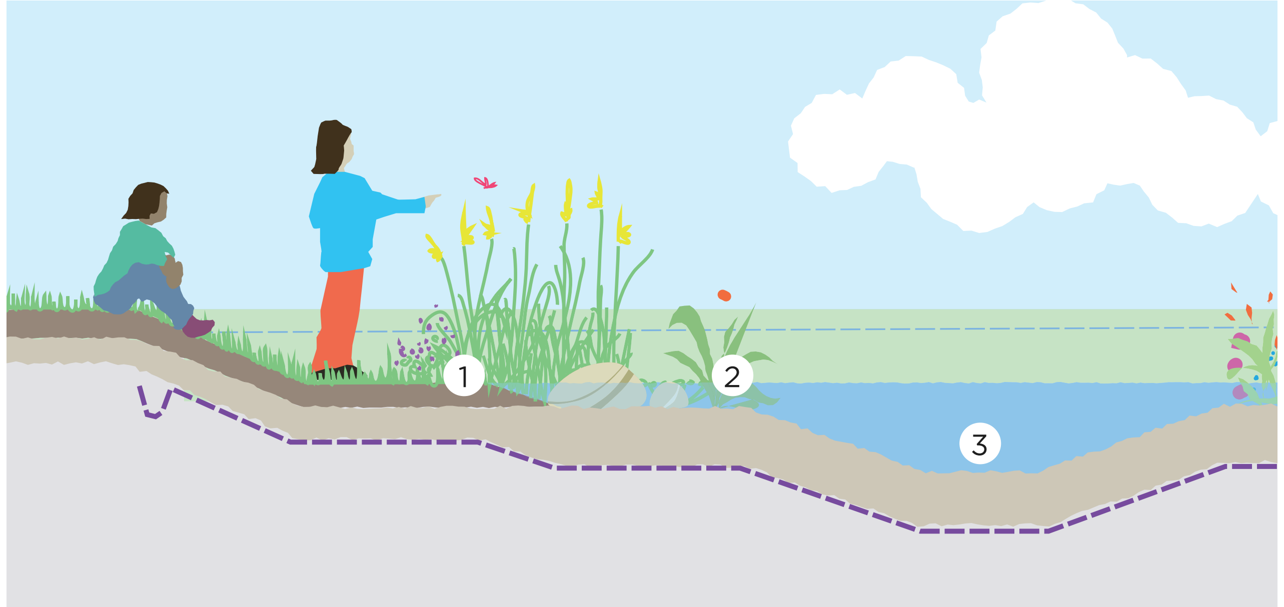
This basin can be used throughout the year.

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.

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



Further Safety Considerations

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 a 600-700mm picket fence should be considered as this stops most toddlers and allows adults to easily step over the fence for rescue.

There must be an acceptance by the community that open water is part of a landscape character. It is useful to sensitively communicate 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.

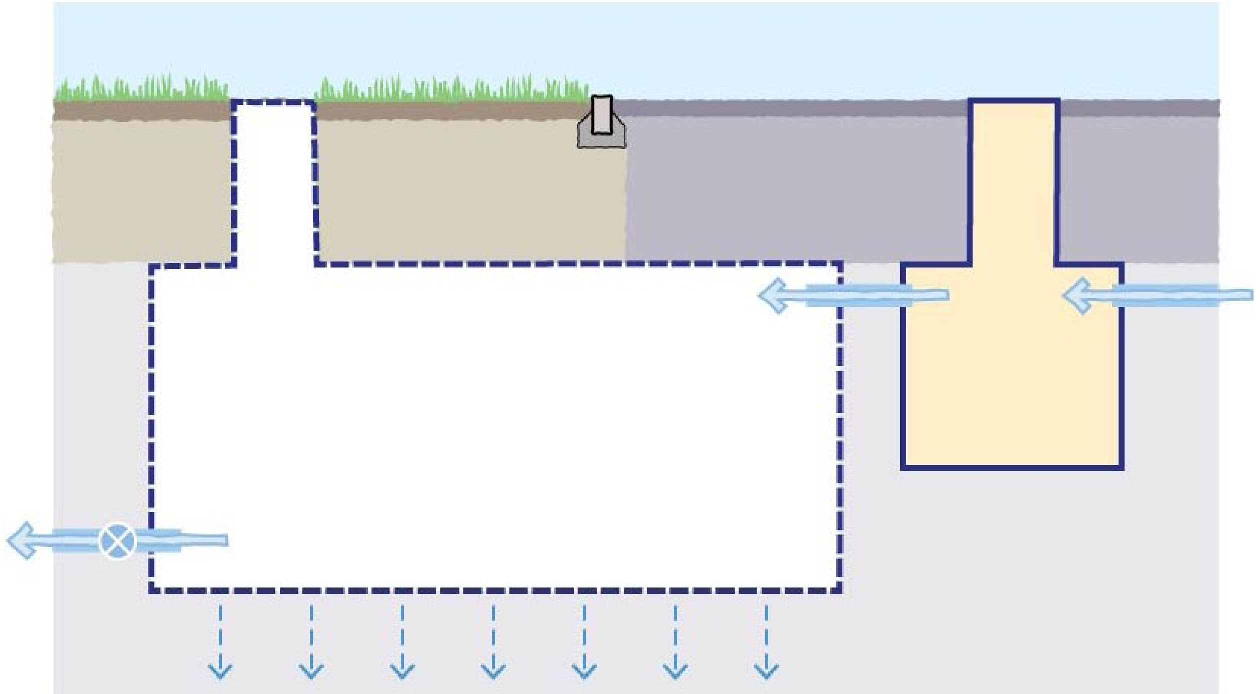
This project failed to adequately consider safety when designing attenuation features into a residential pocket park. There is now no public access allowed. There should be no need for such measures if properly designed.

Storage structures

Attenuation storage in underground structures is currently utilised throughout construction industry with may applications being in the form of geocellular 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 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:

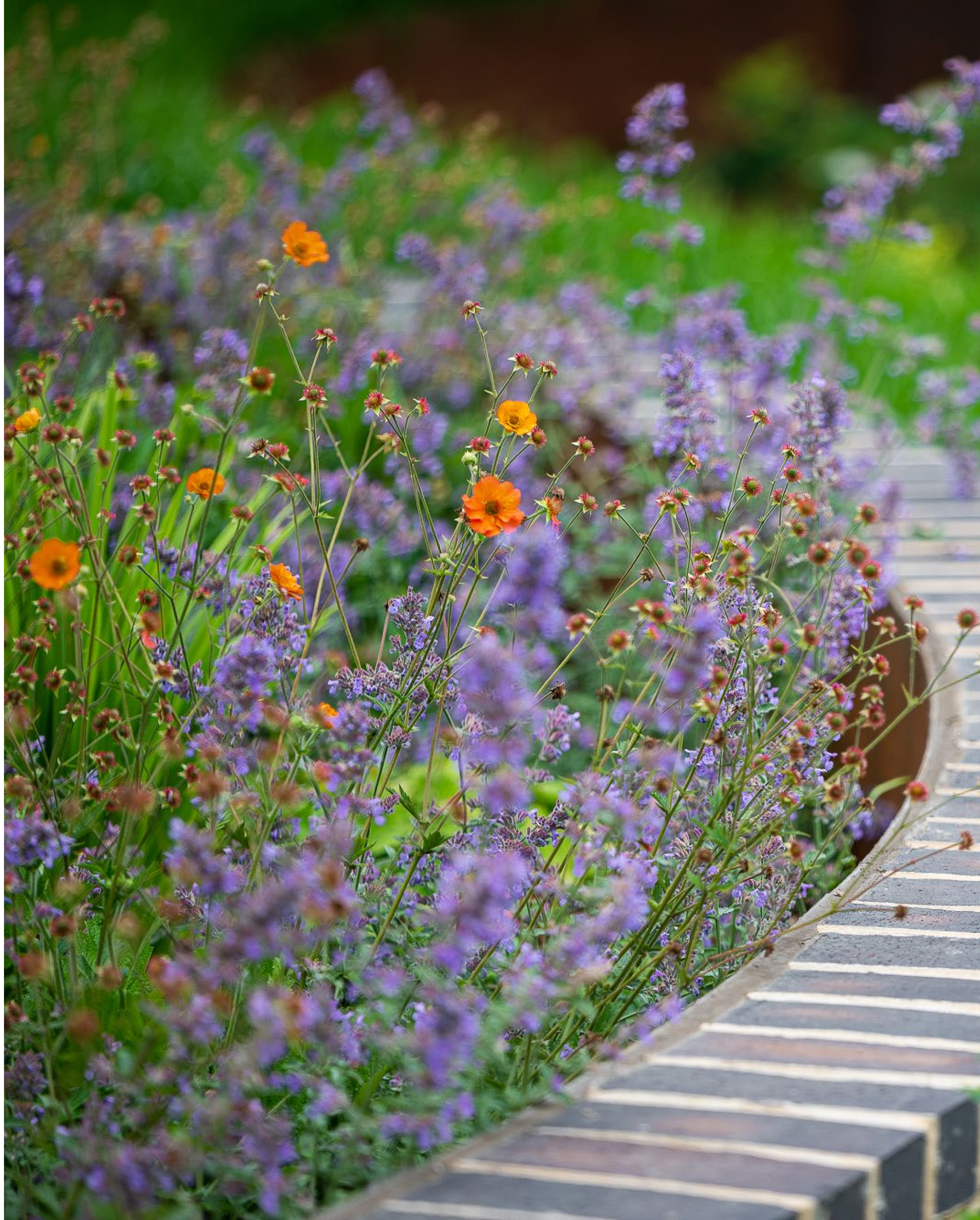
- There are risks of structural failure due to construction loading, which may exceed design life loading that the designer may not be aware of.
- There are a wide range of attenuation products each with its own loading characteristics. Surety must be provided that a specified product is not swapped 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.

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 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.



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

12.0 Management of the SuDS landscape

12.1 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.

12.2 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. Site inspection should also be undertaken before and after major storm events.
- 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.

Design note: 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.

12.3 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

Management Of The SuDS Landscape

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	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

12.4 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.

13.0 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.

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
DCC	Dublin City Council
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
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

Comhairle Cathrach
Bhaile Átha Cliath
Dublin City Council