Carlow Rain Gardens,
Carlow County Council

Implementation of Urban Nature-based Solutions

Guidance Document for Planners, Developers and Developer Agents

January 2025
Version 2.0

Local Authority Waters Programme
vibrant communities | catchment assessment | healthy waters
Comhairle Chontae Chill Chainnigh Kilkenny County Council
Comhairle Contae Thiobraid Árann Tipperary County Council
Uisce Éireann Irish Water
OPR Oifig an Rialaitheora Pleanála Office of the Planning Regulator
Engineers Ireland
Irish Planning Institute Institiúid Pleanála Na hÉireann
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Image on front and back cover provided courtesy of :
Ciaran Brennan, Carlow County Council

Contents

Chapter 4 contains worked examples and case studies of Traditional and NbS Urban Drainage Designs across different development typologies at a variety of scales. These should be read in conjunction with the Nature-based Solutions Toolbox (Chapter 3, p13-22)

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Guidance Context Document List

- **Advice Note 5 Road and Street Drainage using Nature-based Solutions - Design Manual for Urban Roads & Streets (DMURS)**, July 2023
- **National Transport Authority (NTA) Greening and Nature-based SuDS for Active Travel Schemes**, September 2024
- **CIRIA report C753 The SuDS Manual**, December 2015
- **Dublin City Council Sustainable Design & Evaluation Guide**, 2021 - Guide to designing SuDS up to an agreed standard ensuring that they are maintainable now and into the future. *Supports the delivery of the Dublin City Development Plan (2022-2028), the Dublin City Strategic Flood Risk Assessment and is complimentary to the CIRIA 2015 SuDS Manual*
- **Dublin City Council Green & Blue Roof Guide**, 2021 - Confirms Dublin City Council specific requirements in relation to green and blue roofs and expands on how schemes should deliver in accordance with Development Plan Policy S123
- **Southern Regional Assembly Blue Green Infrastructure & Nature-based Solutions Framework**, 2022 - A high-level framework for developing Blue Green Infrastructure (BGI) and Nature-based Solutions (NbS) in the Southern Region of Ireland.
- **Nature Based Management of Urban Rainwater and Urban Surface Water Discharges, A National Strategy**, May 2024 - A strategy document, sitting alongside the Water Action Plan addressing how to implement the NbS approach to urban design and move away from the current hard surfaces approach.
- **Water Action Plan 2024**, September 2024 - A plan setting out the measures that are necessary to protect and restore water quality in Ireland. It lays out the environmental improvements to be delivered during a river basin planning cycle up to 2027.
- **Sustainable Residential Development and Compact Settlements Guidelines for Planning Authorities**, January 2024 - Guidelines setting out the policy and guidance in relation to the planning and development of urban and rural settlements with a focus on sustainable residential development and the creation of compact settlements.

This millennium has witnessed a series of unprecedented climatic, cultural, medical and technological advances. These have fundamentally changed our life expectations and what we understood as our destiny.

The fact that the world's population and the planet belong to a single integrated system is finally a mainstream view. The majority in developed nations recognise that the natural world is a single ecosystem, where actions in one part of the world affect all of the planet.

From a technological perspective, we have at our fingertips the ability to access news and information in real time from across the globe while sat at our kitchen table. Markets and investors make commercial decisions and take action on political, natural disasters or competitor events that have real-world consequences on our legal requirements and our everyday lived experience.

The catalytic impact of COVID-19 has fundamentally reordered our lives. The mainstreaming of working from home, has had a profound impact on how and where we choose to spend our time. We now better understand and appreciate the benefits of wellbeing and personal health provided by living in Compact Neighbourhoods.

Compact Neighbourhoods consist of clustering amenities, services and facilities in close proximity to where we live, greatly increasing the likelihood of walking, cycling, or using public transport to make these shorter journeys. This shift in urban design reduces the need for vehicle space, enabling vibrant, accessible, and social streetscapes. These new infrastructure designs and the reallocation of space offer the opportunity to meaningfully incorporate Sustainable Drainage Systems (SuDS) and Nature-based Solutions (NbS) into our neighbourhoods, working in harmony with the natural environment.

These changes require adapting training, supply chains, and narratives around benefits, balancing new and existing risks. Embracing SuDS and NbS fosters health, resilience, and biodiversity, helping reverse climate impacts. This guidance provides practical steps, reimagining approved projects with NbS to inspire sustainable transformation.

This guidance sets the policy scene in outline, with an overview of the advantages. It then goes on to demonstrate the process of converting current planning approved schemes into Nature-based Solution versions, accepting the general layouts and designs of each.

This guidance aims to inspire and demystify, it is intended as a companion piece to the plethora of policies that already exist, one that tells the story step by step with projects and schemes that are familiar, applying the Nature-based Solutions lens and laying down the straightforward interventions that positively shifts the dial towards healthier and more sustainable choices.

We hope that you find the guidance practical, helpful and inspiring.

Local Authority Waters Programme
(LAWPRO)

Figure 1: Dry Swale - Min Ryan Park, Wexford

Safe routes to school
Belgooly National School
Cork

1. Introduction

Wetland
Wexford County Council

1.1 Purpose & context of the Nature-based Solutions (NbS) guidance document

The Water Action Plan 2024 for Ireland – A River Basin Management Plan published 3rd September 2024 identifies urban runoff as a significant contributory factor to waterbody quality and quantity pressures in Ireland. There is a growing recognition amongst industry professionals to move toward Blue & Green Nature-based spaces and biodiversity in urban areas to better serve this Water Action Plan agenda.

An important development in the pursuit of climate-adapted sustainable design was the production of the CIRIA SuDS manual in 2015. This, alongside other guidance and documentation referred to throughout the document, has led to Sustainable Urban Drainage objectives which are evident across the majority of City and County development plans. However, as highlighted by the Water Action Plan, the resultant current outcomes are focused upon engineering solutions rather than on NbS which have a multitude of benefits for the environment.

Refer to the Reference section at the beginning of this document for the: **Guidance Context Document List**. Further resources and references can be found in Appendix A

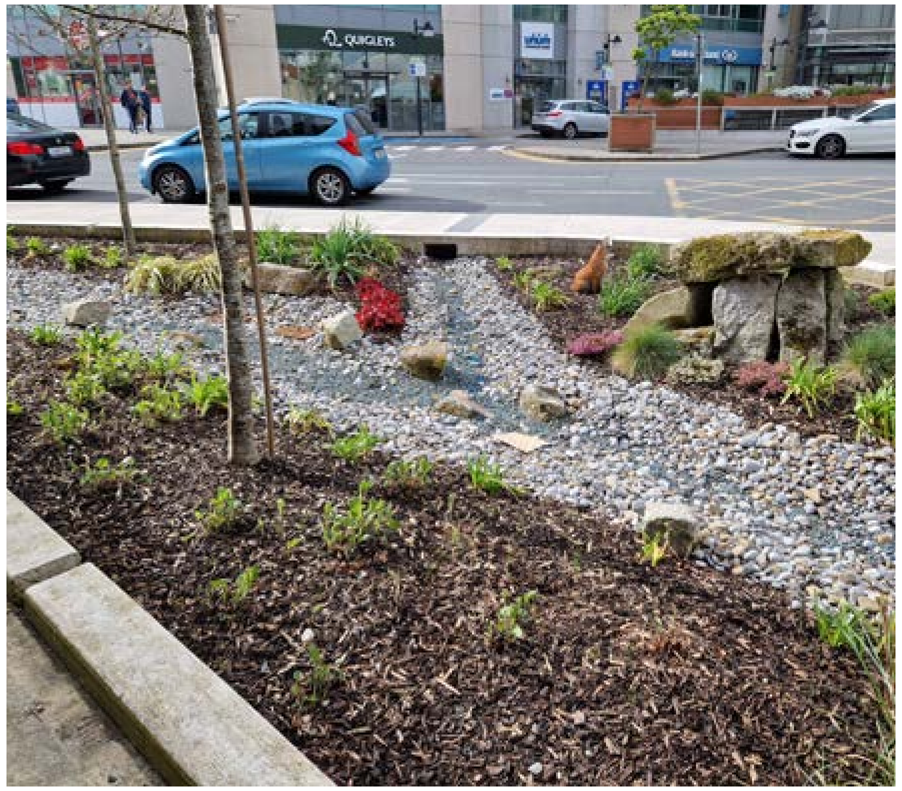


Figure 2: Rain Gardens - Pollerton Road, Carlow

The need for NbS guidance for planners and developers was highlighted from feedback between Local Authorities and LAWPRO throughout 2023-2024 (preceding the issue of this document). This guidance document aims to apply NbS principles and design to address the following:

- Issues of volumetric control in terms of surface water management in urban areas
- Changing weather and rainfall patterns driven by Climate Change, which are impacting on our ability to cope with rainfall and rainfall events
- A growing recognition to move towards Blue & Green Nature-based spaces and biodiversity in urban areas
- The move from car-based design to one focused on Sustainable transport and increasing use of outdoor areas
- The need to identify alternatives to the use of heavy engineering features for drainage systems such as underground storage tanks
- Treating rainwater runoff as close to its sources as possible through localised solutions as part of a wider catchment rainwater management plan

The guidance document comprises the following:

- **Introduction** – covering the purposes of the guidance document and the contexts in which it has been brought about. Introduction to the concept of NbS, their key principles and benefits.
- **Design of NbS** – outlining the steps taken to integrate NbS into development proposals from the earliest stage and the headline parameters that should be considered as part of robust and best-practice NbS design.
- **NbS Toolbox** – covering identified NbS features, their considerations and benefits, and precedents and typical details of each.
- **Case Study Examples for Various Development Types** – providing examples of standard site locations and development types where traditional hard drainage options have been contrasted against an NbS approach with due regard to existing site conditions. The development types considered in this document are as follows:
  - Small Edge of Town Development
  - Urban Residential Development
  - Large Urban Mixed Residential Development
  - Urban Educational Development
  - Urban Infill Commercial Development
  - Urban Public Realm Development
  - Small Urban Residential Infill Development
  - Urban Link Road Development
- **Management of NbS –** ongoing maintenance and management of NbS during the Operational Phase (short, medium and long term). Guidance on the conditioning of planning applications for the ongoing maintenance of NbS.
- **Health & Safety Risk Assessment –** Discussion of risk in relation to NbS.
- **Appendices** – appendices covering the guidance referenced throughout the document (Appendix A), information on water quality (Appendix B), information on ground water protection requirements (Appendix C), a worked case study example of high-level NbS design (Appendix D), example of typical maintenance strategies for each NbS feature (Appendix E), and, an NbS proforma (Appendix F).

1.2 Climate Change, the Water Framework Directive (WFD) & the United Nations Sustainable Development Goals (UN SDGs)

Climate change

The average temperature of the Earth's surface is now approximately 1.2°C warmer than pre-industrial levels and the global mean sea level has risen approximately 20cm since the beginning of the 20th century (between 1901 and 2018) rising at a current rate of around 3mm per year according to satellite observations since the 1990s[i]. This change in temperature, weather patterns and sea level results in an increase in the intensity and frequency of storm events with wetter autumns and winters, and more intense dry spells in summers.

As defined by the UN, climate change refers to 'long-term shifts in temperatures and weather patterns which has been exacerbated by human activity since the 1800s primarily due to the burning of fossil fuels.

Nature-based Solutions (NbS) have a multifaceted approach in helping to combat and adapt to the ongoing and future effects of climate change. They reduce carbon emissions by minimising the need for traditional drainage infrastructure and follow the principles of Nature-based stormwater management – that being that the best way to drain the land is the one that already exists (on a greenfield site) through surface and groundwater runoff routes and that new sites should adapt to and use this natural drainage toolbox.

The National Policy Position of Ireland is that policy development is to be guided by a long-term vision based on an aggregate reduction in CO^2 emissions of at least 80% (compared to 1990 levels) by 2050 across the electricity generation, environment and transport sections[ii].

i www.climateireland.ie/impact-on-ireland/future-climate-of-ireland/sea-level-rise
ii www.gov.ie/en/publication/6f393-national-climate-policy-position/

The Water Framework Directive (WFD)

The EU Water Framework Directive (2000/70/EC) requires all Member States to protect and improve water quality in all waters in order to achieve good ecological status by 2027 at the latest. The directive applies to rivers, lakes, groundwater, and transitional coastal waters and requires that management plans be prepared on a river basin basis and specifies a structured method for developing these plans.

Given legal effect in Ireland by the European Communities (Water Policy) Regulations 2003 (S.I. No.722 of 2003)

NbS manage water quality through a number of treatment process which are strongly linked to the hydraulic control of the surface water runoff, and which are heavily dependent on the characteristics of any media through which runoff filters. Hydraulic control measures are divided into two main types:

» **Velocity Control for** sediment deposition and filtration at low flow velocities during rainfall
» **Runoff Retention** for contaminant removal via settling and adsorption within NbS treatment media or permanent water storage volumes

United Nations Sustainable Development Goal's (UN SDGs)

The UN SDGs were adopted by all United Nations members in 2015 as part of the 2030 Agenda for Sustainable Development with the intention of being a shared blueprint for peace and prosperity. They should shape decision making through all projects and policy decisions in future growth and progress and in the fight against climate change.

NbS have the direct possibility of contributing to the following SDGs, whilst having a holistic impact across achieving the rest of the goals.

Urban Wastewater Treatment Directive (UWWTD)

'A revised version of the directive was adopted by the European Council in November 2024. This includes requirements for measures to address pollution generated by urban runoff. Member States shall ensure that **"an integrated urban wastewater management plan is established for drainage areas of all agglomerations of >100,000 population equivalent (PE), and also for agglomerations between 10,000-100,000PE where pollution from urban runoff and storm water overflows is considered to be a risk"**

Measures must meet **pollution reduction requirements of the directive**, including at a minimum, the measures as set out in Annex V to UWWTD. Pollution mitigation measures should include **"the creation of new infrastructures with a priority to green and blue infrastructure, such as vegetated ditches, treatment wetlands and storage ponds designed in order to support biodiversity."**

1.3 Policy & Legislative Context

Broader Context

The design of any water management system needs to be considered in parallel with all aspects of built environment design due to the interconnected nature of all decision making.

The design of NbS should be a key factor in the development of any urban proposal and should be incorporated at the earliest possible stage. The design parameters for NbS and site layout are heavily impacted by the geography in which the site sits – best highlighted by the compact growth guidance referenced below:

Sustainable Residential Development and Compact Settlements Guidelines for Planning Authorities (adopted January 2024):

"The NPF priorities for compact growth include an emphasis on the renewal of existing settlements, rather than continued sprawl. This priority recognises the impacts that our dispersed settlement pattern (including the dispersal of residential, commercial and employment uses within settlements) is having on people, the economy and the environment. In particular, there is a recognition that dispersed settlements patterns are contributing to the social, economic and physical decline of the central parts of many of our cities and towns, as population and activities move out."

"Dispersed settlement patterns create a demand for travel and embed a reliance on carbon intensive private car travel and long commutes that affect quality of life for many citizens. Dispersed growth is also accelerating environmental degradation through loss of farmland and habitat and impacts on water quality. It creates a higher demand for new infrastructure and services in new communities that places a heavy financial burden on the State and results in a constant cycle of infrastructure catch up."

Figure 3: 15-Minute City (Source: Georgia Pozoukidou and Zoi Chatziyiannaki, in 15-minute City: Decomposing the New Planning Eutopia, 2021)

The compact settlements guidance makes reference to integrated networks of well-designed and mixed-use neighbourhoods which offer the following within a short walk of all homes:

- Improved access to services and amenities
- Better integration with existing infrastructure and public transport
- More efficient use of land
- Facilitate and support the transition to lower carbon living.

The '15-minute' city described in the document is a term which describes: ***compact neighbourhoods with a range of local services and amenities and access to public transport all within a short walk or cycle of homes.*** This urban design concept should be the overarching objective for the design of sustainable residential development and compact settlements.

Water Management Context

The Project Ireland 2040 National Planning Framework (NPF), adopted February 2018, lays out two National Policy Objectives in the way of water management and water quality, those being:

National Policy Objective 57

"Enhance water quality and resource management by: Ensuring flood risk management informs place-making by avoiding inappropriate development in areas at risk of flooding in accordance with The Planning System and Flood Risk Management Guidelines for Planning Authorities. Ensuring that River Basin Management Plan objectives are fully considered throughout the physical planning process. Integrating sustainable water management solutions, such as Sustainable Urban Drainage (SUDS), non-porous surfacing and green roofs, to create safe places."

National Policy Objective 63

"Ensure the efficient and sustainable use and development of water resources and water services infrastructure in order to manage and conserve water resources in a manner that supports a healthy society, economic development requirements and a cleaner environment."

The National Planning Framework also identifies a raft of guidance documents which lay out the best-practice for NbS as a method of surface water runoff management.

Refer to the Reference section at the beginning of this document for the: **Guidance Context Document List**. Further resources and references can be found in Appendix A

Historically, the Greater Dublin Strategic Drainage Study (GDSDS), 2005 by the four Dublin Local Authorities, was used as the standard approach for SuDS design across Ireland, with a focus on volumetric management. The policies in the GDSDS[i] were adopted by most other local authorities and incorporated into their local plans. The guidance within the document reflects a diversion from the GDSDS towards NbS design that considers rainwater management at a catchment level, in line with the **Nature Based Management of Urban Rainwater and Urban Surface Water Discharges - A National Strategy** (2024)[ii].

i https://www.sdcc.ie/en/download-it/publications/gdsds-new-development.pdf
ii https://www.gov.ie/en/publication/d9a24-nature-based-management-of-urban-rainwater-and-urban-surface-water-discharges-a-national-strategy/

1.4 What are Nature-based Solutions (NbS)?

Nature-based Solutions, as defined by the EU commission, are 'solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and streetscapes, through locally adapted, resource-efficient and systemic interventions.' In the context of urban drainage design they are methods which use nature to replicate natural processes of drainage, providing a solution that is more sustainable, and not based on hard engineering.

The difference between NbS & SuDS

SuDS design is guided by the management of surface water runoff such that it achieves maximal benefits. The main types of benefits offered by SuDS are categorised by the four pillars of SuDS: Water Quantity; Water Quality; Amenity; and Biodiversity (see Figure 4). For a feature to be categorised as SuDS it does not need to achieve all four pillars. A combination of SuDS components may be used to achieve all the design objectives.

NbS are categorised by the use of nature and the required adherence to all four pillars of SuDS. Each component feature must provide water quantity, water quality, amenity and biodiversity benefits. As such, components which might be considered as SuDS (when used as part of a SuDS management train) – Attenuation Storage Tanks and Permeable Paving – do not meet the criteria of NbS in their most common hard format and should not be the first port of call for any sustainable urban drainage design.

The suite of NbS tools can be found in Chapter 3 (p13-22).

An **NbS Management Train** promotes division of the area to be drained into sub-catchments with different drainage characteristics and land uses. The NbS features are used in series to change the flow and quality characteristics of the runoff in stages, allowing runoff to pass through several different NbS features before reaching the receiving discharge point.

Key Principles & Benefits of NbS

The key principles of NbS are:

- Low-tech solutions dispersed across the whole site, that keep water on the surface
- Localised solutions treating rainwater falling on urban areas as close to its source as possible, using NbS features to store and treat runoff before it is released from the site in line with the hierarchy of surface water discharges
- Management of overland flows and overland flow routes by direction to suitable surfaces, NbS or retention area to manage flood and pollution risks before release from the site in line with the hierarchy of surface water discharges
- Maximising the ancillary benefits that occur as a result of the implementation of NbS including biodiversity, placemaking, health and wellbeing
- The use of NbS management trains; the sequencing of NbS components to collectively control runoff frequency, flow rates, and volumes; and to provide the necessary treatment of contaminants

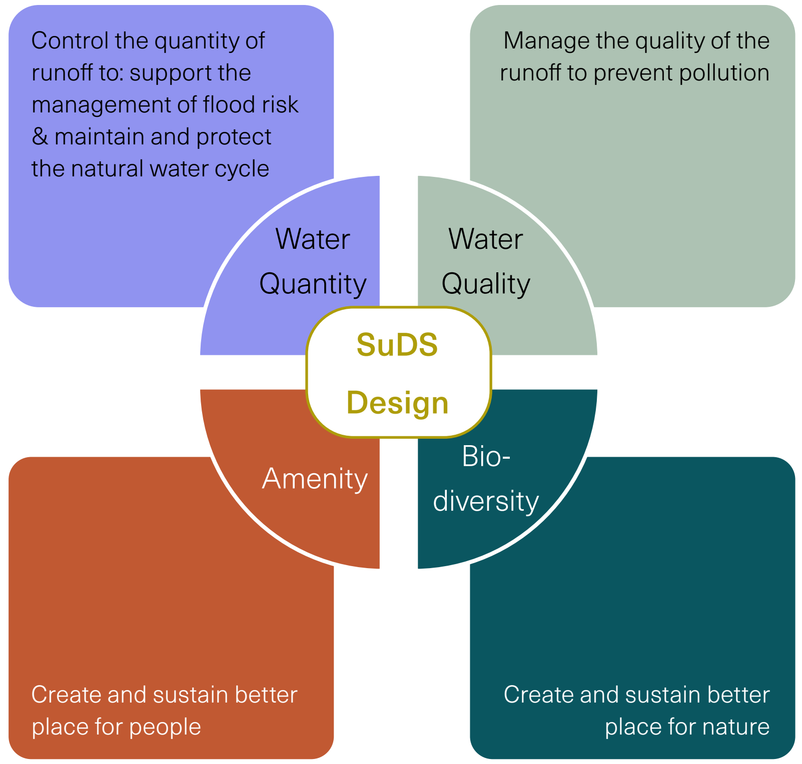


Figure 4: Four Pillars of SuDS Diagram

Ecologists are integral to maximising ecological value and where feasible should provide input into the NbS at an early stage

The key benefits of NbS are:

All Categories:
- Climate change Adaptation and resilience
- Climate change mitigation
- Transition to a circular economy

Water Quantity:
- Resilience against flooding and reduction in flood risk
- Control of water runoff
- Sewerage systems and sewage treatment works available capacity (including reduced sewer overflow spills)

Water Quality:
- Water quality
- Sustainable use and protection of water and marine resources
- Pollution prevention and control
- Groundwater and soil moisture recharge

Amenity:
- Amenity and placemaking
- Education opportunities
- Health and wellbeing
- Noise reduction
- Recreation
- Visual character
- Air quality improvements
- Carbon emission reduction and sequestration
- Economic growth and inward investment
- Air and building temperature regulation

Biodiversity:
- Protect and restore biodiversity and ecosystems

Riparian flowers along river bank
County Kerry

2. Design of Nature-based Solutions

Wet Swale. City West, Dublin

2.1 Integrating NbS into development proposals

Nature-based Solutions should be considered in development proposals from the earliest possible stage. The designer should consider NbS at the earliest possible point in any scheme design. Any NbS design should reflect the natural geological, topographical and drainage characteristics of the site:

The following diagram shows the considerations to be taken at each stage of a project to best integrate NbS. The considerations are broken down into analysis and design tasks.

Strategic Management Objectives

Local Area Plan & Strategic Flood Risk Assessment
- Identification of appropriate potential sites for development

Local Rainwater Management Plan
- Identifies preferred Nature-based Solutions for managing rainwater and surface water runoff
- Inform future urban planning and decision making as well as considering both the existing settlement and proposed future expansion of settlements.
- Emphasise managing rainwater on the surface using Nature-based Solutions to minimise harm from flooding and pollution while enhancing the urban environment through improved provision for amenity and biodiversity.

Site Desk Survey

- Analysis of the Flood Zones to identify early constraints and required mitigations

- Sequential Approach undertaken in accordance with '**The Planning System and Flood Risk Management - Guidelines for Planning Authorities**' (2009)

Hydraulic & Geological Analysis

- Existing catchment analysis
- Assessment of existing water quality

- Review of site topography and existing overland flow routes
- Calculation of Greenfield Runoff Rates (using FSU 7-variable method) and analysis of existing flow routes
- Review of ground conditions and the potential for infiltration with high-level estimation of any infiltration rates for full/partial infiltration solution

Concept Design

- Assessment of water quality

- Architectural layout designed to work around overland flow routes
- Proposed catchments of site determined
- Surface water storage estimate undertaken
- Determination of m^3/m^2 value in order to allow for allocation of runoff storage as close to source as possible or at the next most available catchment
- Identification of possible NbS features and locations with an NbS management train methodology

Outline Design

Refer to Case Study examples, Chapter 4 (p23-37) showing the NbS Toolbox in use

- Proposed scheme design with full details on flow of runoff through system, including discharge rates and associated flow controls, infiltration components and associated infiltration rates, storage volumes, exceedance design, planting, ecological design and water quality assessment(s)

- Drainage strategy document, which describes the design rationale and highlights how proposals will deliver the design criteria
- A Flood Risk Assessment (FRA), where required as part of planning
- A 'Justification Test', where required as part of planning
- Preliminary health and safety risk assessments
- Outline operation and maintenance plan
- Records of stakeholder consultations and community engagement

Detailed Design

- Detailed design drawings (including general arrangements, detail drawings, cross sections, planting information and schedules) and specification documents.
- Hydraulic model simulation results/ hydraulic calculations for both overall scheme and individual NbS components.
- Final maintenance plans and health and safety risk assessments.
- Construction method statements

Pre-planning engagement should be undertaken. This can occur at any point from Site Desk Survey to Outline Design to best suit the needs of the project

2.2 NbS Design Parameters

For further discussion of the application of the design parameters and the high-level NbS design methodology undertaken please refer to Appendix B

Hierarchy of Discharge

Runoff discharges should follow the hierarchy of surface water discharge, as detailed below. Each method of discharge should be considered to its fullest, prior to the consideration of the next sequential option. It should be noted that discharging runoff from a site may use one or more means of discharge.

Refer to Water Services Policy Statement 2024-2030, DHLGH which states: "The integrated drainage plans should promote the adoption of Nature-based Sustainable Urban Drainage (green infrastructure) as a climate adaptation measure."

1. Use surface water runoff as a resource

Can be through the use of low tech solutions such as rainwater butts and planters or through rainwater harvesting systems to store runoff for use on site.

2. Provide interception of rainfall through the use of nature-based SuDS approaches

Interception design is defined as the capture and storage of the first 5mm for the majority of rainfall events. This is delivered through a combination of infiltration and evapotranspiration from attenuated runoff. All NbS features referred to in the toolkit (Chapter 3, p13-22), provide a level of interception storage.

3. Where appropriate, infiltrate runoff to the ground

Subject to ground conditions, confirmed by on-site infiltration testing (see p11 for further information).

4. Discharge to an open surface water drainage system

Discharge of surface water runoff to a surface water drainage system should be restricted to greenfegld runoff rate, as determined through the use of the FSU 7-variable equation (see Appendix D, p51).

5. Discharge to a piped surface water drainage system (requires a connection agreement with Local Authority)

Discharge of surface water runoff to a piped surface water drainage system should be restricted to greenfield runoff rate, as determined through the use of the FSU 7-variable equation.

6. Discharge to a combined sewer (requires a connection agreement with Uisce Éireann)

Discharge of surface water runoff to a combined sewer should be restricted to greenfield runoff rate, as determined through the use of the FSU 7-variable equation. It is only in the most extreme cases that a connection into a combined sewer from a non-NbS feature (eg an attenuation tank) should be allowed.

Topography and Site Catchments

Refer to CIRIA Fact Sheet: **Assessing attenuation storage volumes for SuDS** (2014)

The topography of the site is intertwined with the overland flow routes. A clear understanding of the site topography allows for an understanding of where the water is likely to go, how best to design an architectural solution to the site such that it works with the existing contours and where water should be locally managed. Site catchment areas, based on the topography, should be derived to allow for drainage design to consider control of runoff as close to the source as possible. Derived catchments should have a required storage expressed in terms of 'm³' for each 'm²' of developed area. This allows for the dispersal of NbS features across each sub-catchment as opposed to the allocation of storage in a single location (such as through the use of a tank). This maximises opportunites for NbS across the whole site and integrates the NbS thinking at an earlier stage (see Figure 5). The m^3/m^2 value refers to the calculated attenuation volume/developed (impermeable) site area. Expressed in full this means that for every Xm^2 of site area Ym^3 of attenuation storage is required.

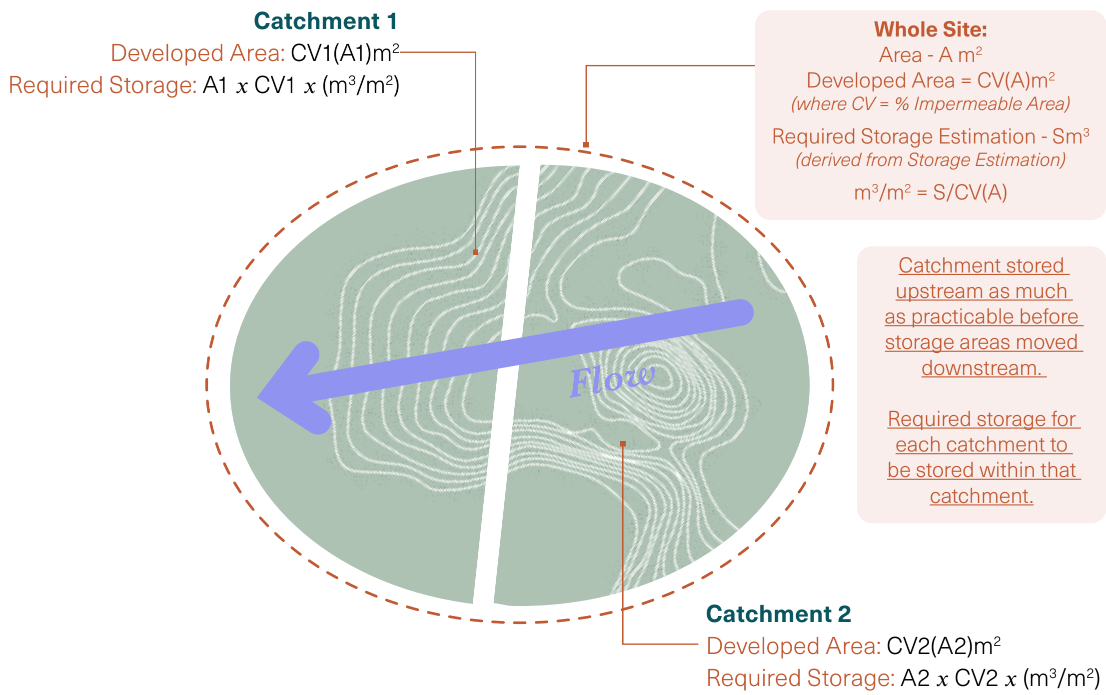


Figure 5: Catchment Area Diagram

Private vs Public Control

In addition to working with the site topography and placing NbS features to capture runoff as close to source as possible, there is an additional element of design in relation to land ownership. Typically, NbS features should be proposed within the highway boundary and areas that are expected to be taken in charge. Within this guidance document, proposed features do not rely on the use of private domain. Where NbS features are to be placed in the private domain, there must be some form of guarantee that these features will be maintained into the future and not replaced without prior consent.

Urban Creep

Consideration should be given to urban creep, especially where landscaped features (such as gardens) proposed are within the private domain.

Urban creep refers to the increase in impermeable area of a site (as a result of patio additions, extensions or other hardstanding), which increases the area required to be drained. An appropriate design factor should be applied to the development, based on its type. In the absence of any guidance, a figure of 10% may be applied as conservative estimate to the impermeable area to be drained in any calculations.

Climate Change

All designs should account for an appropriate estimation of the effects of climate change, in accordance with the National Adaptation Framework (NAF).

Table 1 (below) shows the climate change allowances from the Flood Risk Management Climate Change Sectoral Adaptation Plan which represent the climate change factors to be applied to any storm event based on the modelling available at time of publication.

The Mid-Range Future Scenario (MRFS) is to be considered for most development scenarios whilst the High-End Future Scenario (HEFS) is to be considered for high value, high vulnerability development which cannot be relocated. In practice, this means that a design should account for the 1 in 100yr + [Extreme Rainfall Depth] % if it is being designed for no flooding in that time period.

Parameters	Mid-Range Future Scenario (MRFS)	High-End Future Scenario (HEFS)
Extreme Rainfall Depths	+20%	+30%
Peak Flood Flows	+20%	+30%
Mean Sea Level Rise	+500mm	+1000mm

Table 1: Climate Change Allowances (Source: Flood Risk Management Climate Change Sectoral Adaptation Plan)

Water Quality

One of the key components of NbS is the dual focus on water quality as well as water quantity. Best practice for treatment design is listed as follows:

- **Manage surface water runoff close to source**
- **Treat surface water runoff on the surface**
- **Treat surface water runoff to remove a range of contaminants**
- **Minimise risk of sediment remobilisation**
- **Minimise impact from accidental spills**

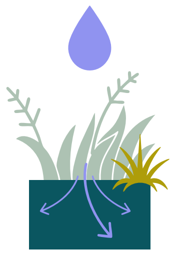
For further information governing the use of the CIRIA Simple Index Approach please see the CIRIA SuDS Manual Section 26

For most design cases the CIRIA Simple Index Approach is appropriate for determining the pollution hazard level of the land use and resultant pollution hazard indices: Total Suspended Solids (TSS), Metals & Hydrocarbons. The approach further provides mitigation indices for each NbS feature (see Appendix B, p49) Designs should demonstrate that the site delivers appropriate water quality treatment by showing the total NbS mitigation index is greater than the incoming pollution hazard index. Where pollution risk is greater, such as for trunk roads, motorways and sites with heavy pollution risk, guidance and risk assessment process from the EPA, Irish legislation and EU Directives should be followed.

Discharges to receiving surface waters and groundwater may require environmental licences and permits and it is recommended that pre-permitting advice is sought from the environmental regulator.

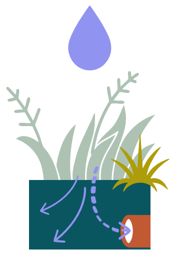
Means of Discharge

Means of discharge, in contrast to the hierarchy of discharge presented previously (see p9), refers to the location of discharge, covers three principal systems of water management:



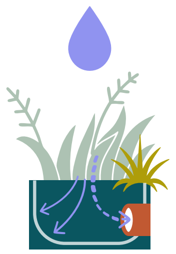
Type A, Total Infiltration

Systems in which all rainfall is infiltrated into the ground



Type B, Partial Infiltration

Systems which manage low level storms through infiltration with only the proportion of rainfall which exceeds the infiltration capacity of the subsoils overflowing into the receiving drainage network



Type C, No Infiltration

Systems in which no infiltration is permitted where the NbS would be wrapped in an impermeable membrane. Runoff here is conveyed to the outfall location through the drainage network

Definition: Systems which promote infiltration of surface water runoff into the ground where the capacity and permeability of soils and the depth of groundwater allows

Designing for Infiltration

Site suitability for infiltration can be obtained at an early stage through existing geological and hydrogeological studies, contamination record, borehole and groundwater records, aquifer designations and geohazard mapping. This information must be verified through Ground Investigations.

Infiltration is especially suitable for the management of lower storm events. Where infiltration rates are not sufficient to drain a site on their own, a (Type B) partial infiltration solution can be sought in which infiltration manages lower storm events and overflow piped connections assist with the higher volume storm events.

Key benefits:

» Provision of interception storage
» Leads to a reduction in the required attenuation storage and volume of runoff
» Infiltrating area can be multi-functional and provide recreational or other amenity facilities
» Significantly reduces pollutant load discharged to the receiving body
» Easy to incorporate into site landscaping
» Aids in replenishing local aquifers and supports river base flows and wetland systems
» Supports local soil moisture levels and vegetation, reduces the adverse effects that trees can have on foundations by reducing the potential for shrinkage of soils

Where existing in-situ soils / topsoil is considered to have suitable infiltration or permeability properties following on-site testing to confirm the design requirements, this material may be utilised as the planting medium for any proposed NbS.

Key considerations:

Refer to TII Publication Design DN-DNG-03065-03065 Road drainage and the water environment (2015), The CIRIA SuDS Manual (2015) Section 13 and standard industry practice

» Ensure that there is adequate pre-treatment of any runoff before infiltration into the ground such that the groundwater is not at risk of contamination. There should be a minimum of 1m distance between the base of the infiltration system and maximum likely groundwater levels. Pre-treatment is required to remove sediment and silt in order to prevent long-term clogging and system failure
» An Aquifer Vulnerability Assessment should be undertaken on a site by site basis to determine if infiltration is appropriate. Infiltration systems should not be proposed above vulnerable groundwater
» Due to uncertainty surrounding the infiltration coefficient in the design of infiltration systems a factor of safety (refer to Table 2 below), should be applied to the infiltration coefficient based on the consequence of system failure. The worked example in Appendix D (p51) shows the application of the FoS. Appropriate FoS should be determined by a competent engineer based on the context of a project

	Consequences of failure		
Size of area to be drained	No Damage / Inconvenience	Minor Damage to external areas / Minor Inconveniences	Major Damage to structures / Major inconveniences
< 100 m²	1.5	2	10
100 - 1000 m²	1.5	3	10
> 1000 m²	1.5	5	10

Table 2: Suggested factors of safety, F, for use in hydraulic design of infiltration systems, designed using Bettess (1996) (Source: CIRIA SuDS Manual Table 25.2)

Risks/Constraints:

- Urban areas usually include large areas of made ground with variable materials and large numbers of underground services, which can, themselves act as conduits for runoff directing rainwater into areas that may cause problems. Where flow of groundwater could be problematic this should be addressed. Ground investigations and further hydrogeological consultation will provide further information on the likely direction of infiltrated groundwater
- Risk of ground instability, ground sinking (subsidence) or raising (heave) and of slope instability or the movement of mass as a result of freeze-thawing activities (solifluction) due to infiltration
- Pollution and flooding risks of groundwater with a risk of groundwater leakage into sewers, basements, tunnels or other structures

The European Environment Agency **definition of an aquifer:** 'a subsurface layer or layer of rock or other geological strata of sufficient porosity and permeability to allow either a significant flow of groundwater or the abstraction of significant quantities of groundwater

Infiltration Coefficients:

Table 3 (top right) illustrates typical infiltration coefficients (the rate of runoff infiltration into the ground) for soil types and provides an initial estimate of expected infiltration rates based on high-level understandings of the soil conditions on site. All estimates are subject to detailed on-site infiltration testing.

Design Sources:
BRE (2016) Soakaway Design, BRE Digest 365, Building Research Establishment, Bracknell, UK (ISBN: 0-85125-502-7)
CIRIA SuDS Manual 2015 – Chapter 13
CIRIA Guidance on the construction of SuDS (C768) – Chapter 26
Bettess, R (1996) Infiltration drainage – manual for good practice (R156)
Volume 4 Section 2 Part 1 of the National Roads Authority Design Manual for Roads & Bridges
Groundwater Protection Schemes (1999)

Groundwater Protection

Groundwater Risk is based on three categories. The relevant categorisation can be found using **Geological Survey Ireland's Groundwater Data Viewer**.

- **Aquifer**: Where there is a gravel aquifer present, the protection requirements for the gravel aquifer supersede those required for the underlying bedrock aquifer
- **Groundwater vulnerability**: The groundwater vulnerability refers to the contamination risk and is based on the thickness and permeability of the overburden on the aquifer in question. The invert level of the discharge should be used as the criteria to determine the groundwater vulnerability
- **Source protection areas**: areas that contribute to public groundwater supply and identify important resource locations such as public and group water supply sources

Table 4 (bottom right) presents the Groundwater Protection Response Matrix for use where infiltration presents a groundwater contamination risk.

There are four levels of response to the risk of a potentially polluting activity:

- **R1** – Acceptable subject to normal good practice
- **R2** – Acceptable in principle, subject to conditions
- **R3** – Not acceptable in principle, some exceptions may be allowed subject to conditions
- **R4** – Not acceptable

Where there is a condition attached to the response to the groundwater risk (indicated by R(x) where x is 1,2 or 3), the condition can be found within the Groundwater Protection Schemes report (see Appendix C, p50)

	Soil Type / Texture	ISO 14688-1 Description (after Blake, 2010)	Typical infiltration coefficient (m/s) Low Value	Typical infiltration coefficient (m/s) High Value
Good Infiltration Media	Gravel	Sandy GRAVEL	3×10^{-4}	3×10^{-2}
	Sand	Slightly silty slightly clayey SAND	1×10^{-5}	5×10^{-5}
	Loamy Sand	Silty slightly clayey SAND	1×10^{-4}	3×10^{-5}
	Sandy Loam	Silty clayey SAND	1×10^{-7}	1×10^{-5}
Poor Infiltration Media	Loam	Very silty clayey SAND	1×10^{-7}	5×10^{-6}
	Silt Loam	Very sandy clayey SILT	1×10^{-7}	1×10^{-5}
	Chalk (structureless)	n/a	3×10^{-8}	3×10^{-6}
	Sandy Clay Loam	Very clayey silty SAND	3×10^{-10}	3×10^{-7}
Very Poor Infiltration Media	Silt Clay Loam	-	1×10^{-8}	1×10^{-6}
	Clay	-	-	$<3 \times 10^{-8}$
	Till	Can be any texture of soil described above	3×10^{-9}	3×10^{-6}
Other	Rock	n/a	3×10^{-9}	3×10^{-5}

Table 3: Typical infiltration coefficients based on soil texture (after Bettess, 1996) (Source: CIRIA SuDS Manual Table 25.1)

Vulnerability Rating	Source Protection Area	Resource Protection Area (Aquifer Category): Regionally Important Aquifer Rk*	Rf	Rg	Locally Important Aquifer Lg	Lm	Ll	Poor Aquifer Ll	Pl
Extreme: Rock near surafce or Karst (X)	R4	R4	R4	R3(2)	R3(2)	R3(1)	R3(1)	R3(1)	R3(1)
Extreme (E)	R4	R2(3)	R2(2)	R3(2)	R3(2)	R2(2)	R2(2)	R2(1)	R2(1)
High (H)	R3(2)	R2(2)	R2(2)	R2(2)	R2(2)	R2(2)	R2(2)	R2(1)	R2(1)
Moderate (M)	R3(2)	R2(1)	R2(1)			R2(1)	R2(1)	R1	R1
Low (L)	R3(2)	R1	R1			R1	R1	R1	R1

Table 4: Groundwater Protection Response Matrix (Source: Groundwater Protection Schemes, Deportment of the Environment and Local Government, Environmental Protection Agency, and Geological Survey of Ireland, 1999)

3. Nature-based Solutions Toolbox

Examples of how the NbS Toolbox can be applied to development proposals at a range of scales and differing typologies can be found in Chapter 4, pages 23-37

Proprietary Reinforced Grass
Mount Congreve Gardens,
Kilmeaden, County Waterford

3.1 Filter Drains

Definition: Linear drains consisting of a trench filled with a permeable filter medium material, often with a perforated pipe in the base of the trench to assist drainage

Design Sources:
BRE (2016) Soakaway Design, BRE Digest 365, Building Research Establishment, Bracknell, UK (ISBN: 0-85125-502-7)
CIRIA RP992 Design Assessment Checklist: Filter Drain
CIRIA SuDS Manual 2015 – Chapter 16
Higgins, N, Johnston, P, Gill, L, Bruen, M & Desta, M (2008) 'Highway runoff in Ireland and management with a 'French Drain' system.
CIRIA Guidance on the construction of SuDS (C768) – Chapter 29

Filter Drains can replace conventional pipework as a conveyance system, their use can remove the need for kerbs and gullies when placed adjacent to a highway. They should be incorporated as part of an NbS train and used in conjunction with other features presented in this section. The drains can be protected with geotextile covered with topsoil and planted with grass, as opposed to the use of a permeable aggregate. In this case it is important to ensure that maintenance of the Filter Drain is not overlooked.

Key benefits:

» Can be designed creatively to provide attractive boundary lines or edging
» Possible replacement for standard kerbs and gullies
» Provide connection between NbS features as part of a wider NbS management train
» Often used in highway scenarios, instead of traditional highway drainage, providing water treatment benefit which would not otherwise be included in the design

Key considerations:

» Depth of a Filter Drain should generally be around 1-2m, with the minimum depth of the filter medium below any pipework being 0.5m to ensure that there is a reasonable level of pollutant removal
» Pre-treatment of runoff arriving at the Filter Drain should be considered, this can be managed by having the runoff flow over a small filter strip between the drained area and the Filter Drain
» Granular fill/filter material should have a void ratio and permeability of a suitable level to ensure that there is sufficient movement of fluid through the porous material (percolation) and to minimise the potential risk of blockages
» Considerations should be taken regarding whether the Filter Drain will need to be able to withstand surface load, such as that from vehicular traffic, be that intended or from incidental runover

Risks/Constraints:

» Filter Drains require relatively flat areas and, as such, their use is restricted to sites without significant slopes unless there is an opportunity to place the drains parallel to the contours of the site
» Consideration as to whether the filter drain needs to be lined or unlined is based on its geographical context
» To ensure pollutant removal and stable conveyance through the filter medium, longitudinal slopes should not exceed 2%
» Where there is a continuous flow from groundwater or other sources, Filter Drains should not be used. Their design is based on intermittent flow and requires the ability to drain and re-aerate in between subsequent rainfall events
» Build-up of blockages can be difficult to see, especially where covered with topsoil
» Limited to draining relatively small catchments (6m width of drained area to every 1m width of Filter Drain as per CIRIA RP992), when used in isolation. Catchments are typically linear features such as roads[i]

i Refer to CIRIA RP992 The SuDS Manual Update: Paper RP992/26 Design Assessment Checklist: Filter Strip

Figure 6: Filter Drain - Climate Innovation District, Leeds

#1: Filter Drains
See Chapter 4 (p23-37) for case studies showing the NbS Toolbox used across different typologies of development at a variety of scales

Impermeable / permeable membrane subject to site conditions, site investigation and location of Filter Drain

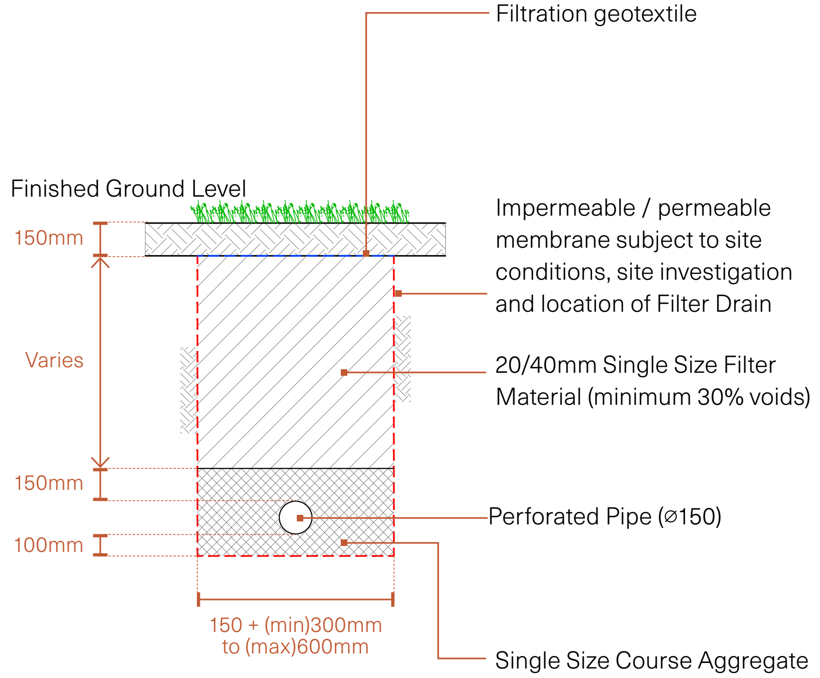


Figure 7: Typical Grassed Filter Drain Detail

3.2 Swales

Definition: Shallow vegetated channels designed principally to convey and treat runoff

Design Sources:
CIRIA SuDS Manual 2015 – Chapter 17
CIRIA Guidance on the construction of SuDS (C768) – Chapter 30
Advice Note 5 Road and Street Drainage using Nature-based Solutions – Design Manual for Urban Roads and Streets

There are three major swale variations - the Conveyance & Attenuation Swale, the Dry Swale and the Wet Swale. A **Conveyance & Attenuation Swale** is a shallow vegetated channel. A **Dry Swale** is a Conveyance Swale that has the addition of a filter medium and underdrain system. A **Wet Swale** is a Conveyance Swale, designed to deliver wet and/or marshy conditions at the base.

Key benefits:

- Well suited to managing pavement runoff as a result of their linear design
- Provides interception storage volumes
- Used to integrate attractive vegetated corridors into streetscapes
- Can be adapted to natural overland flow paths to provide direction for runoff
- Pollution and blockages are visible at the surface and are easily dealt with
- Minimal difference between maintenance requirements for a swale and a general landscape feature and, as such, maintenance can be incorporated into existing general landscape maintenance regimes. Where a Dry Swale is used it requires no additional maintenance over the case where a separate landscape and drainage maintenance strategy is in place. Maintenance requirements for a Wet Swale are lesser than those for a Dry Swale.
- Reduce the urban heat island effect by providing cooling via the return of moisture to the air through evapotranspiration from vegetation.

Key considerations:

- The shape of the swale has an impact on its function, typical design practice is to provide a trapezoidal or parabolic cross-section as these offer good hydraulic performance and are the easiest form to construct and maintain
- The longitudinal slope of any swale should be constrained to between 0.5-3%, where slopes are greater than 3% check dams should be incorporated to ensure efficient use of storage space and to slow runoff velocities. Where runoff velocities are greater than recommended standards, permanent reinforcement matting ground protection should be considered
- Swale depths need to be considered against side slopes to ensure the NbS feature doesn't pose a hazard. The normal maximum swale depth is 400-600mm
- The bottom width of a swale should generally be between 0.5-2m. Where widths are greater than 2m, the use of flow dividers (separates out flow) and flow spreaders (uniformly disperse flow) should be considered to prevent flow channelling (constraining flow to a concentrated area)

Risks/Constraints:

- Difficult to incorporate into dense urban landscapes where space is limited
- Requires check dams when on a steep site. Generally, not suitable where longitudinal slopes are greater than 10% even with the addition of check dam

Figure 8: Dry Swale - Min Ryan Park, Wexford

#2: Swales

See Chapter 4 (p23-37) for case studies showing the NbS Toolbox used across different typologies of development at a variety of scales

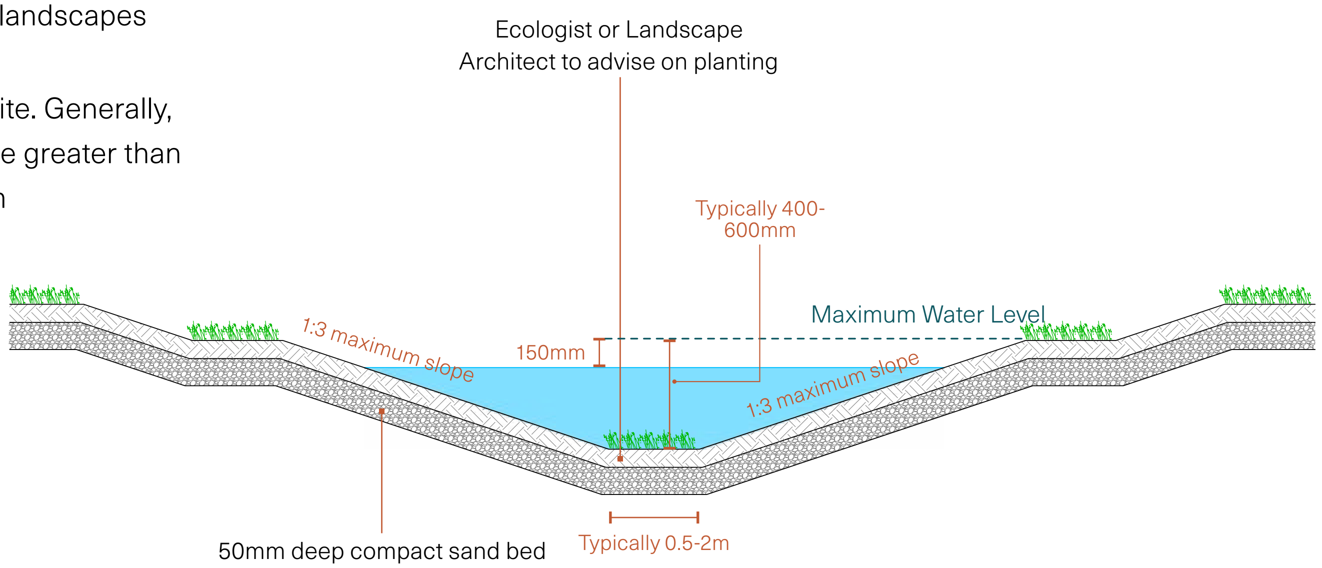


Figure 9: Typical Wet Swale Detail

3.3 Bioretention Systems

Definition: Planted, soft landscaped areas, positioned to collect, store, filter and reduce surface runoff from frequent rainfall

Design Sources:
CIRIA SuDS Manual 2015 – Chapter 19
CIRIA Guidance on the construction of SuDS (C768) – Chapter 30
Advice Note 5 Road and Street Drainage using Nature-based Solutions – Design Manual for Urban Roads and Streets

There are a number of NbS features that fall into the remit of bioretention systems – these include, but are not limited to, raingardens, raised planters, bioretention tree pits, swales and/or trenches.

Key benefits:

- Effective in delivering interception and providing for interception storage
- Landscaped pockets provide visual amenity, habitat and biodiversity
- Reduce the urban heat island effect by providing cooling via the return of moisture to the air through evapotranspiration from vegetation
- Flexible component able to be adapted to the needs of an NbS train, and suitable for installation in areas that are highly impervious
- Retrofit capability

Key considerations:

- The maximum size of freeboard, in the design of a bioretention system, is typically between 150-300mm
- The depth of filter medium normally lies between 750mm and 1000mm with a typical minimum recommended value of 400mm. An absolute minimum of 300mm depth of filter medium should be provided for shrubs and 200mm depth for wildflower or grasses[i]
- The permeability of the generic soil filter media should be between 100 - 300mm/hr
- A 50mm depth of inorganic mulch should sit atop the filter medium set a minimum of 50mm below the level the water enters the raingarden
- The width of a bioretention system should lie between 600mm and < 20m (depending on excavator access arrangements)
- The inflow should not scour the bioretention surface and should be uniformly distributed over the surface area. Inflow velocities should be less than 0.5l/s, or 1.5l/s for a 1-in-100-year storm event
- In a bioretention system, vegetation choices impact performance by directly affecting pollutant levels and enhancing soil processes that remove nutrients. Vegetation selection should be site specific, considering factors such as shade tolerance, height, and maintenance needs. Advice should be sought from a horticulturalist in determining soil-mix and appropriate planting. Dense planting (6-10 plants/m^2) is recommended to boost root density and maintain surface permeability. As plants have an impact on the long-term hydraulic conductivity (ease of which fluid can pass through) of the filter medium and any erosion, they should fulfil the following criteria:
  - characteristics of the landscape
  - appropriateness of species
  - drought tolerance
  - tolerance of free-draining sandy soil
  - tolerance of inundation (flooding)
  - expected pollution loads
  - propensity of fibrous root structure, and
  - propensity to spread growth
- Where the filter medium sitting above the sub-base is specified as a bioretention soil it can have 30% voids or greater[ii]

Risks/Constraints:

- Not suitable for areas with steep slopes
- Systems are susceptible to clogging if the surrounding landscape is not maintained

i NTA Greening and Nature-based SuDS for Active Travel Schemes (2023) and CIRIA SuDS Manual (C753) Chapter 19 (2015)

ii Further information should be sought from the soil manufacturer and can be found in BS 3882: 2015 Specification for topsoil

Figure 10: Linear Raingarden - Cashel Road Active Travel Scheme, Clonmel, County Tipperary

#3: Bioretention Systems

See Chapter 4 (p23-37) for case studies showing the NbS Toolbox used across different typologies of development at a variety of scales

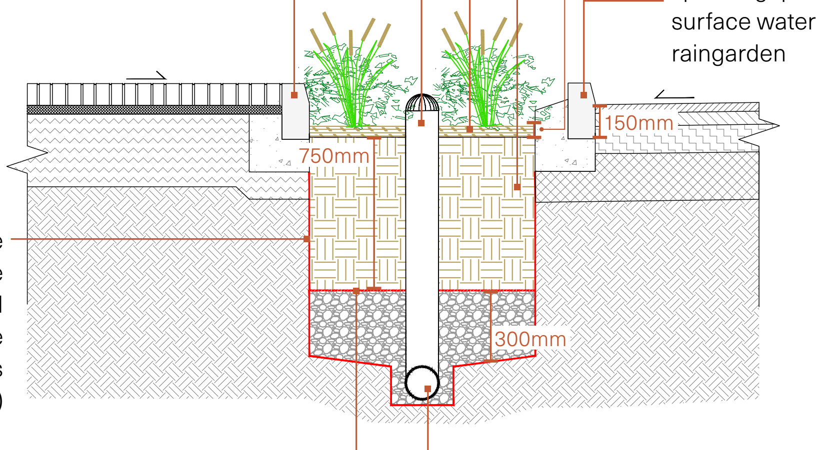


Figure 11: Typical Bioretention Raingarden Detail

3.4 Tree Pits

Definition: Constructed underground structures used to create voided space to contain a soil and/or storage volume and protect the root space of one or more trees when located within a paved area

Design Sources:
CIRIA SuDS Manual 2015 – Chapter 19
CIRIA Guidance on the construction of SuDS (C768) – Chapter 32
Trees in Hard Landscape: A Guide for Delivery, Tree Design Action Group (TDAG)
Advice Note 5 Road and Street Drainage using Nature-based Solutions – Design Manual for Urban Roads and Streets

Whilst Tree Pits can be considered as a standalone NbS feature, it should be noted that Tree Pits (or trees) **can be incorporated into a wide number of NbS features** (bioretention systems, swales) **and that Tree Pits function best within an NbS management train.**

Types of Tree Pit:

Structural soil – A structural soil is a stone-based growing medium that can support pedestrian and vehicular traffic and, as such, allows the Tree Pit to be extended beneath hard surfacing. This provides additional space for roots to grow, allowing the tree to mature, and provides attenuation storage much in the same way as sub-base. The three main types of structural soil are sand-based substrates, medium-sized aggregate substrates and large-stone skeleton substrates. Further information on structural soil can be found in the TDAG: Trees in Hard Landscape guide.

Soil cells/crates – Crate systems rely on proprietary products and are made out of modular plastic or concrete and provide load-bearing capacity. The space created under the surface can be filled with loose soil to support tree growth. The advantage of the cell system is that greater soil volumes can be provided in the same space as a traditional tree planting which provides a better growing environment for the tree.

Key benefits:

- Contribute to the surface water management through transpiration, interception, increased infiltration and treatment of contaminants
- Health and psychological benefits of urban trees
- Increase in property values, local air quality and filtering harmful pollutants from the air
- Reduce the urban heat island effect by providing cooling via the return of moisture to the air through evapotranspiration from vegetation
- Add beauty and character to the urban landscape
- Provides a barrier to noise pollution, the greater the density of vegetation and planting – such as through a multiple Tree Pit system – the greater the tree cover the greater the reduction in noise
- Enables local biodiversity to thrive through the creation of new habitats[i]
- Placement, as part of a wider public realm scheme, can lead to speed reduction
- Carbon sequestration

Key considerations:

- Requirements include space, soil types, oxygenation, water supply and drainage. The soil properties and volume are key to the growth of the tree. The larger the size of tree and tree planting zone the larger the capacity of the tree and tree system to manage runoff
- Consideration to the location of tree roots. Typically, the majority of the tree's total length of roots occur within the upper 1m of soil
- Consideration to: the width and density of tree canopy; life expectancies and tree growing rates; tolerance to drought and saturated soils; pollutant resistances; extent of root systems; bark roughness and, vertical branching structures
- Tree Pit sizes depend on the tree type and its soil requirements. Typically, 1.5–2m should be provided around the tree to allow for roots to take hold with the depth dependent on the soil volume. The typical recommended minimum volume for a medium mature tree (of 10-15m height) is 26m^3[ii]

Risks/Constraints:

- Disruption to planting resulting from soil compaction by vehicles
- Limitations to access of air and water to the roots
- Location of a Tree Pit in relation to buried utility services should be considered

i The planting of trees in suitable locations outside of formalised Tree Pit Systems or NbS elements will also serve to slow the flow and promote the evaporation and take up of rainwater.
ii NTA Greening and Nature-based SuDS for Active Travel Schemes (2023) document

Figure 12: Tree Pit - Altrincham, Manchester

#4: Tree Pits
See Chapter 4 (p23-37) for case studies showing the NbS Toolbox used across different typologies of development at a variety of scales

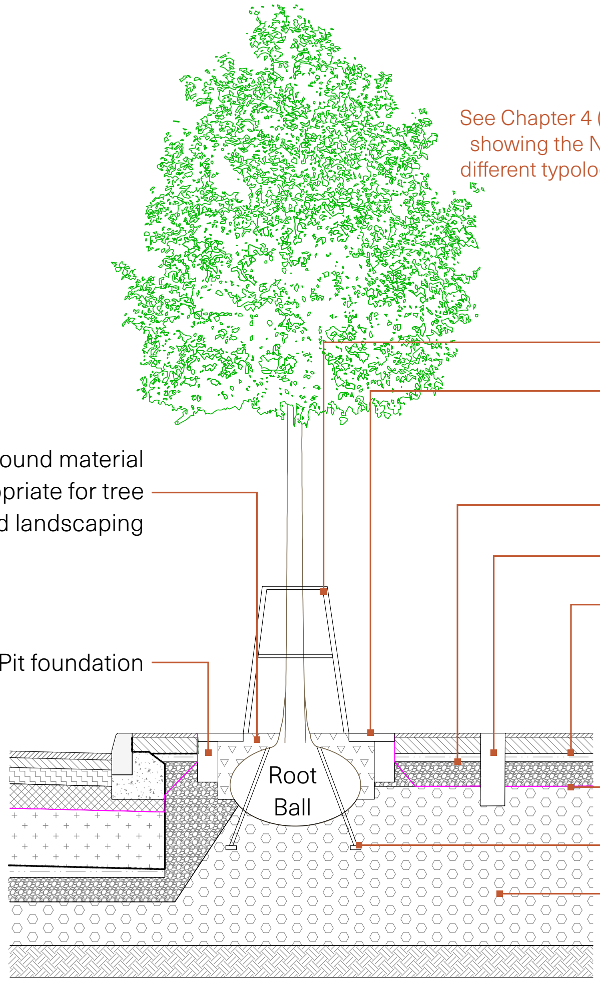


Figure 13: Typical Tree Pit Detail

3.5 Detention Basins

Definition: Landscaped depressions that are normally dry except during and following rainfall events, designed to attenuate runoff and, where vegetated, provide treatment

Design Sources:
CIRIA SuDS Manual 2015 – Chapter 22
CIRIA Guidance on the construction of SuDS (C768) – Chapter 35
CIRIA Small Embankment Reservoirs, Report R 161 (1996)

Detention Basins are typically dry and can provide multi-functionality by acting as a recreational facility.

Key benefits:

- Size allows for the basin to cater to a wide range of differing rainfall events
- When lined can be used in circumstances with vulnerable groundwater
- Provide opportunity for dual amenity and drainage land use and are relatively simple to design, construct and maintain
- Design allows for safe and visible capture of incidental spillages
- Widely flexible and applicable to the majority of development types, appropriate for use in retrofit scenarios[i]

Key considerations:

- The water depth in a basin should not exceed 2m under extreme conditions. Typically, lower water depths will be required and should be agreed with the local authority
- The bottom of the basin should be relatively flat with a gentle slope (max 1:100) towards the outlet to enhance runoff vegetation contact and prevent standing water. Areas above the high water mark should also slope towards the basin for effective drainage
- For on-line (those being where regular surface water flows through the basin) vegetated detention basins, the length-to-width ratio should be between 3:1 and 5:1. Side slopes should typically not exceed 1:3, unless site-specific conditions allow for steeper slopes, particularly in very shallow basins. For areas requiring mowing, slopes should be no steeper than 1:3 to minimize maintenance risks

i Whilst widely flexible it should be noted that not all locations will be suitable

Risks/Constraints:

- Detention basins provide little reduction in runoff volume and therefore should be used as part of a wider NbS train
- Detention depths may be constrained by system inlet and outlet levels
- Design can be constrained by groundwater levels. During periods of high groundwater, the storage capacity of the detention basin and the hydraulic connectivity between the surface runoff and groundwater may be impacted. A high seasonal groundwater table may not always disrupt facility operations but can lead to a muddy base that might be viewed as unattractive unless it is developed into a permanent wetland feature
- Where catchments are less than 3ha the diameter of any outlet may have to be very small (<150mm diameter) to achieve pre-development outflow rates. This raises the risk of clogging and, so, this outlet area and flow control should be carefully designed

Figure 14: Detention Basin - City West, Dublin

#5: Detention Basins

See Chapter 4 (p23-37) for case studies showing the NbS Toolbox used across different typologies of development at a variety of scales

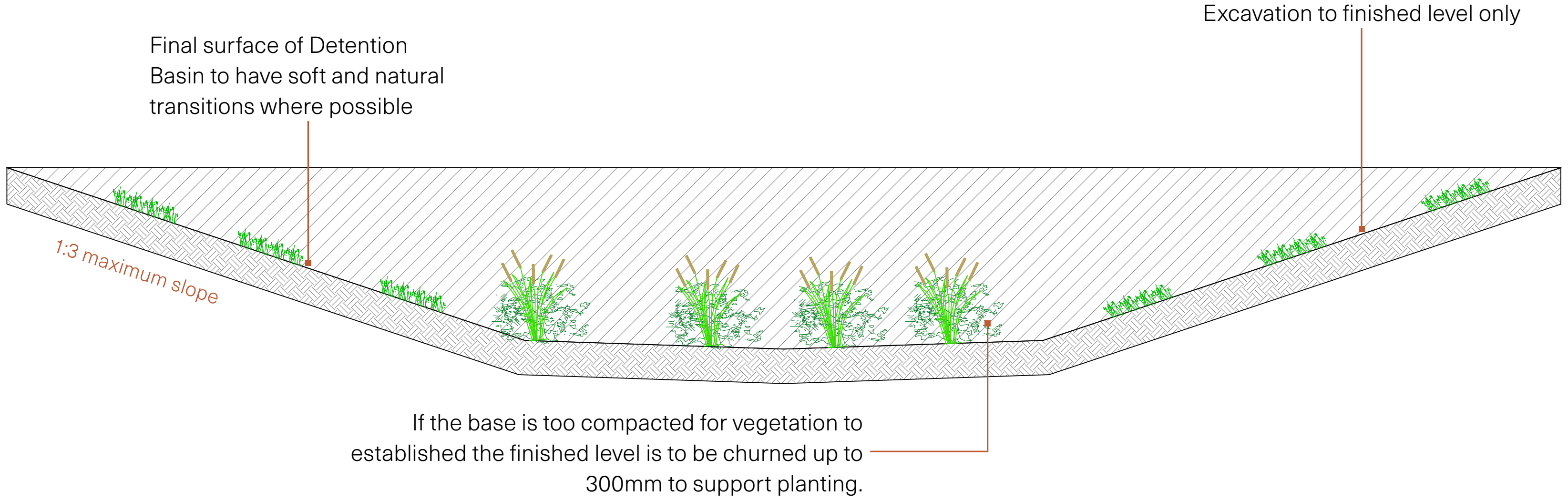


Figure 15: Typical Detention Basin Detail

3.6 Ponds & Wetlands

Definition: Depressions designed to temporarily store surface water above permanently wet pools that permit settlement of suspended solids and biological removal of pollutants

Design Sources:
CIRIA SuDS Manual – Chapter 23
CIRIA Guidance on the construction of SuDS (C768) – Chapter 36
CIRIA Small Embankment Reservoirs, Report R 161 (1996)

Ponds & Wetlands are features with a permanent pool of water that provide both attenuation and treatment of surface water runoff.

Key benefits:

- Strong capacity to remove urban pollutants, and when lined can be used in circumstances with vulnerable groundwater
- High ecological, aesthetic and amenity benefits with value added to surrounding properties

Key considerations:

- Ponds and wetlands can be integrated into site contours
- The permanent pool of water is the primary treatment area and prevents fine deposited sediments from re-suspension. The top water level should align with the outlet invert level or include an 'infiltration' depth if specified[i]
- Consideration needs to be given to the attenuation storage volume, that is the temporary volume above the permanent pool that fills as water levels rise during rainfall, providing flow attenuation
- An aquatic bench[ii] should be provided. Increased planting may create additional 'islands.' For high proportions of shallow water, evapotranspiration should be accounted for to ensure adequate water for plant growth year round
- Attention should be given to safe access and exceedance routes, a flat safety bench around the pond perimeter (to provide a suitable distance before open water), and an easement for maintenance purposes
- Larger ponds should be divided into zones, providing water quality treatment and volume storage across independent cells which can create increased attenuation, provide longer pollutant removal pathways, enhanced pollution removal, an easier maintenance regime and more varied ecology. This allows for enhanced biodiversity as zones downstream typically have cleaner water. Ponds should be designed such that entering flows are at a gradual rate, spread out to avoid creating dead zones, and travel along maximised flow paths to optimise the sedimentation process
- The placement of inlets and outlets should maximise flow paths, with the ideal ratio of flow path length to width being 4:1 or 5:1, with a minimum value of 3:1
- For sites with sensitive groundwater, vulnerable aquifers or pollution risks, a hydrogeological risk assessment is required to determine appropriate separation distance from the annual maximum water table, where a liner is not proposed. Where the subsurface is permeable, a liner may be required to prevent leakage or infiltration
- For larger ponds, a 300mm freeboard is usually adequate, with additional allowance if risks are high

i The depth of the permanent pool should not exceed 2m to prevent stratification (the separation of water into layers based on density), with a typical maximum of 1.2m. For small to medium ponds the temporary storage depth above the permanent pool should generally be 0.5m. Note that these depths are industry standards.
ii An aquatic bench is shallow water zone along the permanent pool's edge supports wetland planting, acting as a biological filter and offering ecological, aesthetic, and safety benefits

Risks/Constraints:

- Where storm events exceed designed capacity exceedance flow routes need to be determined
- Requires baseflow and have high land take with a limited depth range for flow attenuation
- May release nutrients during non-growing season
- Limited reduction in runoff volume
- Not suitable for steep sites
- Susceptible to colonisation by invasive species and are trickier to maintain once invasive species have taken hold
- Performance is vulnerable to high sediment inflows

Figure 16: Wetland - Newmarket Pitch & Putt Club, Newmarket, County Cork

#6: Ponds & Wetlands

See Chapter 4 (p23-37) for case studies showing the NbS Toolbox used across different typologies of development at a variety of scales

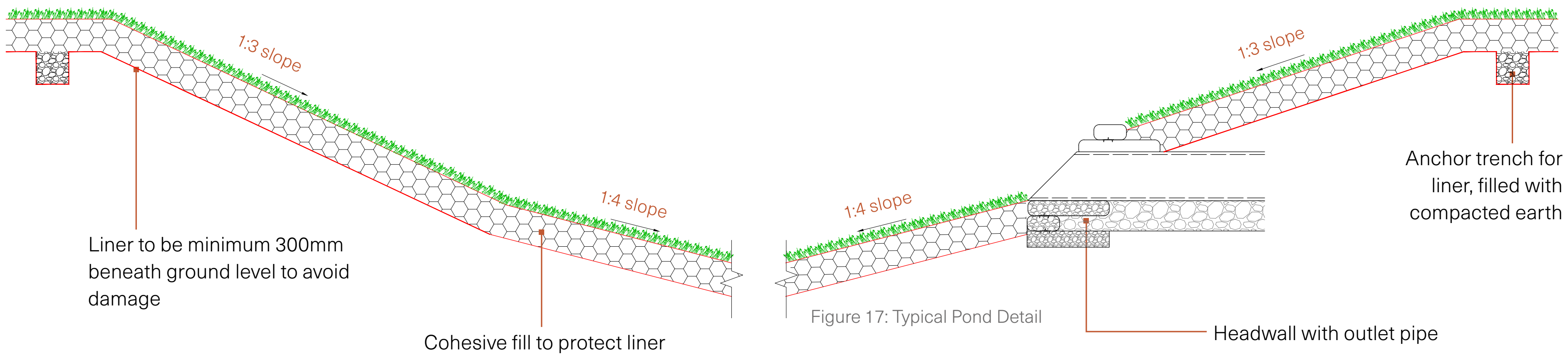


Figure 17: Typical Pond Detail

3.7 Green & Green-Blue Roofs

Definition: Roofs with a vegetated surface that provide a degree of retention, attenuation and treatment of rainwater and promote evapotranspiration

Design Sources:
CIRIA SuDS Manual – Chapter 12
CIRIA Guidance on the construction of SuDS (C768) – Chapter 24
Dublin City Council – Green & Blue Roof Guide 2021
Irish Building Regs (Technical Guidance Document B – Fire Safety)

A green roof is designed around living vegetation to reduce surface water runoff, whereas a blue roof is explicitly designed to store water before a controlled release. There are two sub-types of green roof – Extensive and Intensive roofs. An **Intensive roof** has a deeper substrate and higher loads but requires more intensive accessible maintenance. An **Extensive roof** has a lower substrate and lower maintenance requirements and tend to not be accessible.

It should be noted that a true blue roof refers to the attenuation capacity of the roof. Where a blue roof is incorporated that does not include the additional benefits of a green roof (water quality treatment, amenity and biodiversity) it does not constitute an NbS component. Blue roofs should only be used as part of a green-blue roof system.

Key benefits:

- Imitates the pre-development state of hydraulics and hydrology eg greenfield depending on location
- Flexible in application, suitable for higher density developments and retrofit scenarios
- Provide ecological, aesthetic, amenity and air quality benefits, with the capability to remove atmospherically deposited urban pollutants
- Do not require additional land to provide NbS benefit
- Mitigate the impact of the urban heat island effect, and vegetated cover can protect the underlying roof waterproofing materials
- Provides insulation against temperature extremes
- Reduces the effects of expanding and contracting roof membranes and provides a level of sound absorption mitigating noise pollution effects

Key considerations:

- Crucial factor is the structural capacity of the proposed or existing roof to manage the additional loading and waterproofing. This includes the load-bearing capacity of the roof deck and structure, the saturated weight of the system and any imposed loads such as maintenance loading, snow cover and wind
- Integration of an NbS roof with other required rooftop equipment, for example there are competing requirements with solar panels and other plant, especially in high density, constrained urban areas
- Consideration to root penetration resistance of the proposed waterproof membrane
- Accessibility requirements to the roof for public or maintenance access
- The aesthetic objective of the roof, its desired visual impact and how it fulfils biodiversity objectives
- Drainage management of the runoff on the roof, the location of rainwater pipes and how and where it connects into the wider NbS train
- Growing medium of the plants and their suitability for a rooftop habitat. The depth of soil medium provided should typically be a minimum of 80mm

Green and Gree-blue roofs are not typically designed by a Civil Engineer - advice should be sought from and design should be undertaken with a specialist

Risks/Constraints:

- Cost constraints in comparison to conventional roof structures. Existing roof structures may limit retrofitting possibility in some cases, NbS roofs are not appropriate for steep pitches
- Maintenance of the NbS feature and access to the roof. Should be safe and efficient with walkways that are clear of obstructions. There is a risk of damage to the waterproof membrane
- Fire resistance of green roofs should be considered. All openings should be protected by non-vegetative materials (pavers or pebbles or other proprietary fire retardant products). Where there are adjacent roofs fire resistance requirements may preclude certain planting of green roof system options


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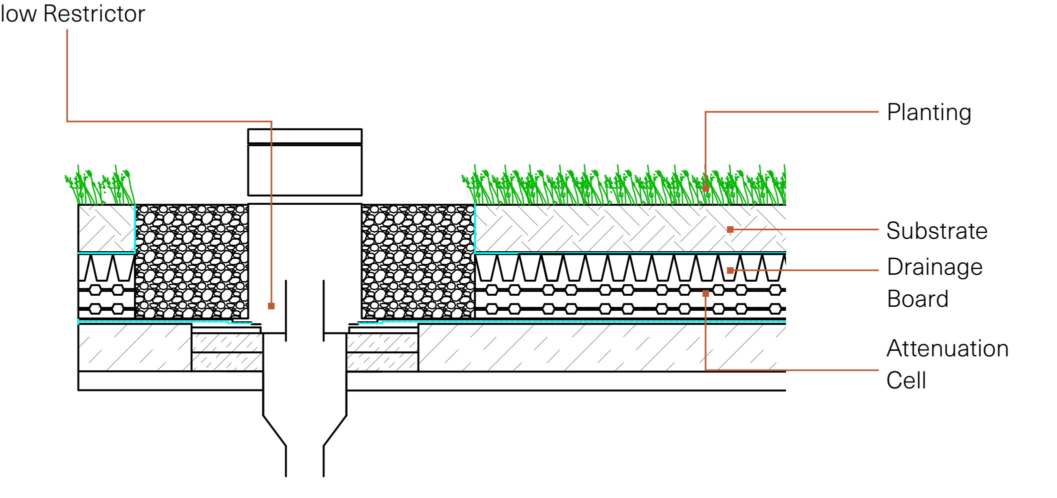
Figure 18: Green Roof - Engineers Ireland, Clyde Road, Dublin

#7: Green & Blue Roofs

See Chapter 4 (p23-37) for case studies showing the NbS Toolbox used across different typologies of development at a variety of scales



Note:
Green and Green-Blue Roof design should be undertaken in collaboration with a specialist

Figure 19: Typical Green-Blue Roof Detail

3.8 Proprietary Reinforced Grass Systems

Definition: Proprietary Reinforced Grass Systems are a variant of previous pavements that fulfil the NbS criteria. It should be noted that it is recommended that Proprietary Reinforced Grass systems are used in localised areas, such as in parking spaces, to ensure design robustness and improved maintenance

Design Sources:
CIRIA SuDS Manual – Chapter 20
CIRIA Guidance on the construction of SuDS (C768) – Chapter 33
Design Manual for Urban Roads & Streets – Advice Note 5 Roads and Street Drainage using Nature-based Solutions
Reinforced Grass Paving, Paving Expert [https://www.pavingexpert.com/grasspav]
GrassConcrete Design Guide 2022#

Proprietary Reinforced Grass Systems refer to surfacing that promotes water infiltration, through the porous surface of a paving material or through the joints between the paving units and into the underlying structural and foundational layers. Different proprietary systems provide differing ratios of hard pavement to grass but the principle between all is to provide grass in between paving or cells.

Key benefits:

» Reduced peak flows
» Reduces pollutants through water treatment measures
» Shallow feature, which can reduce need for deep excavations
» Allow for the multi-functional use of space
» Eliminate risks of surface ponding and surface ice
» Pavement stays cool in summer due to the circulation of precipitation and water
» Re-establishes a natural hydrological balance
» Easily adaptable pathways as part of a wider NbS train
» Positive construction in connection with trees, allowing air and water to enter the soil

Key considerations:

» Surfacing and planting types
» System of water management: Total Infiltration, Partial Infiltration, or No Infiltration (refer to p10)
» Structural resistance to manage the level of loading anticipated over the pavement
» Controlled discharge of a design storm to the subgrade or drainage system
» Exceedance flow design for storm events in which the NbS feature overflows
» CBR value / modulus used for structural design

Risks/Constraints:

» Infiltration potential constrained by groundwater and aquifer vulnerability concerns
» Must account for location of any existing buried services
» Must account for geological make up of existing ground
» Paving loses its effective attenuation capacity on steeper slopes (can be mitigated through the use of check dams)

Figure 20: Proprietary Reinforced Grass - Min Ryan Park, Wexford

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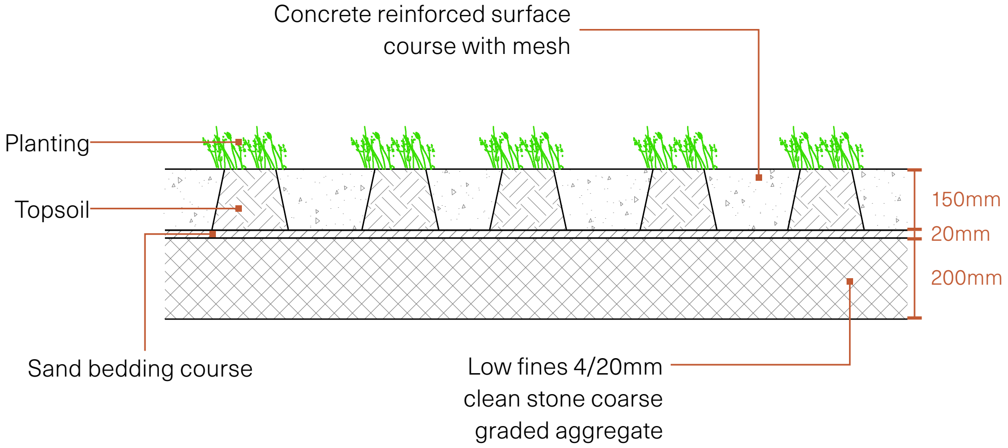
#8: Proprietary Reinforced Grass Systems

See Chapter 4 (p23-37) for case studies showing the NbS Toolbox used across different typologies of development at a variety of scales

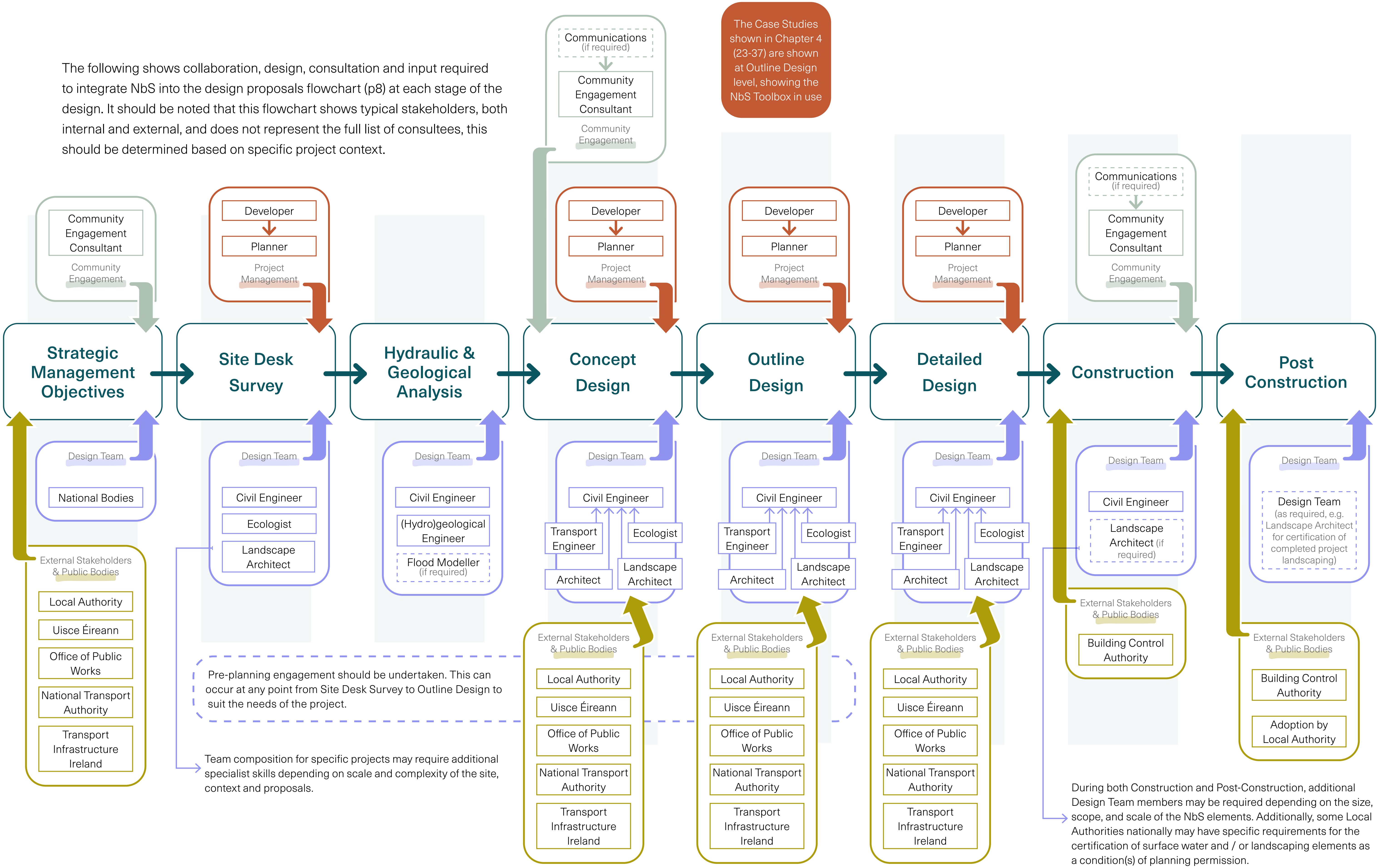


Note:
Detailed specification should be sought from manufacturer of proprietary product

Figure 21: Typical Proprietary Reinforced Grass System Detail

3.9 Holistic Design and Collaboration Flowchart

The following shows collaboration, design, consultation and input required to integrate NbS into the design proposals flowchart (p8) at each stage of the design. It should be noted that this flowchart shows typical stakeholders, both internal and external, and does not represent the full list of consultees, this should be determined based on specific project context.



4. NbS Case Study Examples

This chapter contains worked examples and case studies of Traditional and NbS Urban Drainage Designs across different development typologies at a variety of scales. These Case Studies are shown to Outline Design level, and should be read in conjunction with the Nature-based Solutions Toolbox (Chapter 3, pages 13-22).

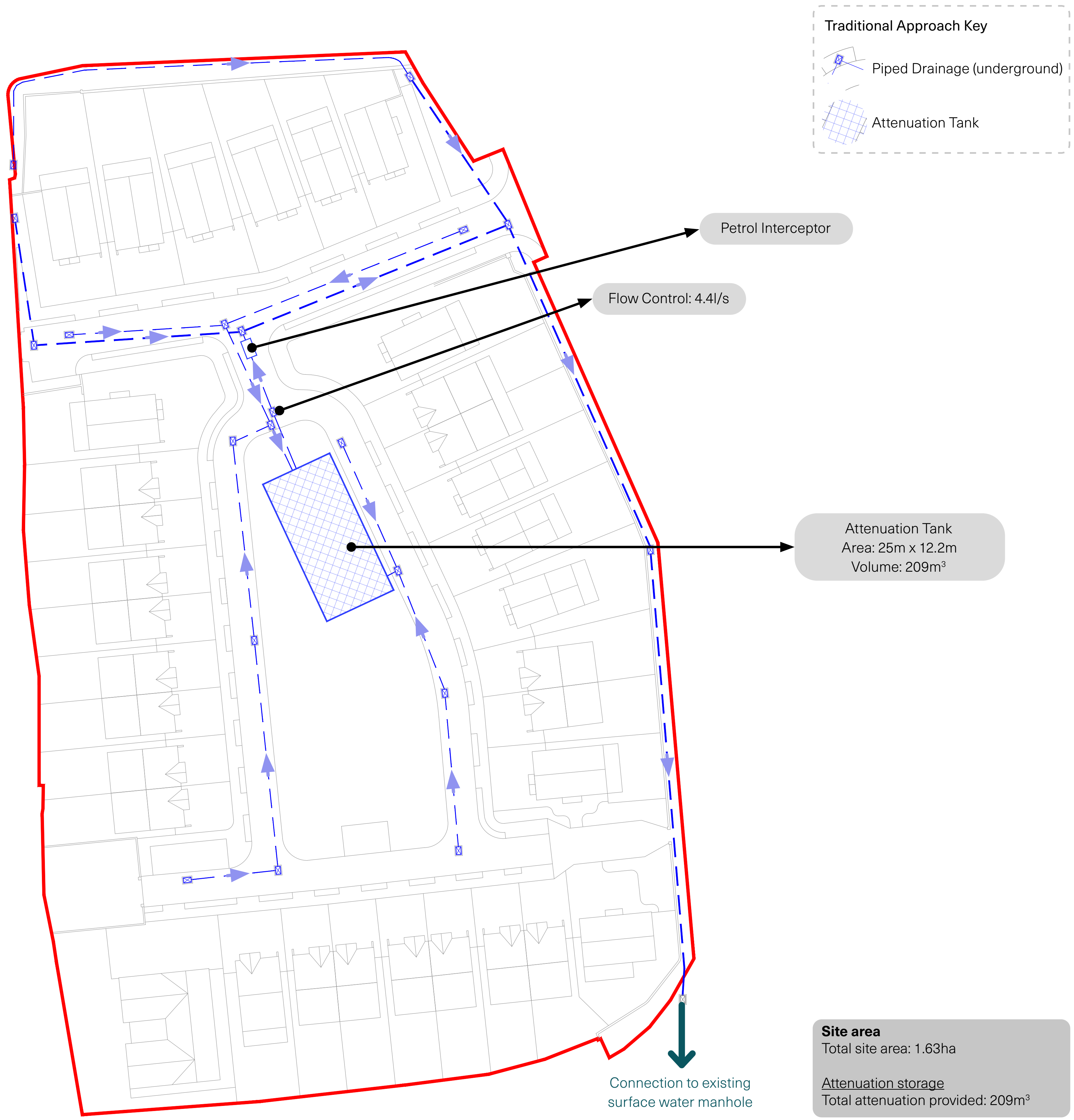
Wet Swale. Monksfield,
Dungarvan
County Waterford

4.1 Small Edge of Town Development

The development typology is a residential site of a traditional cul-de-sac style design.

The proposals comprise of 33 homes with front and rear gardens and a central green area for multi-amenity use.

The site is located just over 15minutes walk from the centre of town.



Site area
Total site area: 1.63ha

Attenuation storage
Total attenuation provided: 209m³

Traditional Hard Approach

NbS Approach Key

- Bioretention Systems
- Detention Basins
- Proprietary Reinforced Grass Systems

Refer to Appendix D (p51) **which explores the methodology behind this Case Study in detail.**

Site area
Total site area: 1.63ha
Total permeable development area: 0.66ha
Total impermeable development area: 0.97ha
Urban creep allowance: 10%
Total impermeable area modelled for storage: 1.07ha
m³/m² catchment storage coefficient: 0.05

Attenuation storage
Total required attenuation: 502m³
Total attenuation provided: 510m³

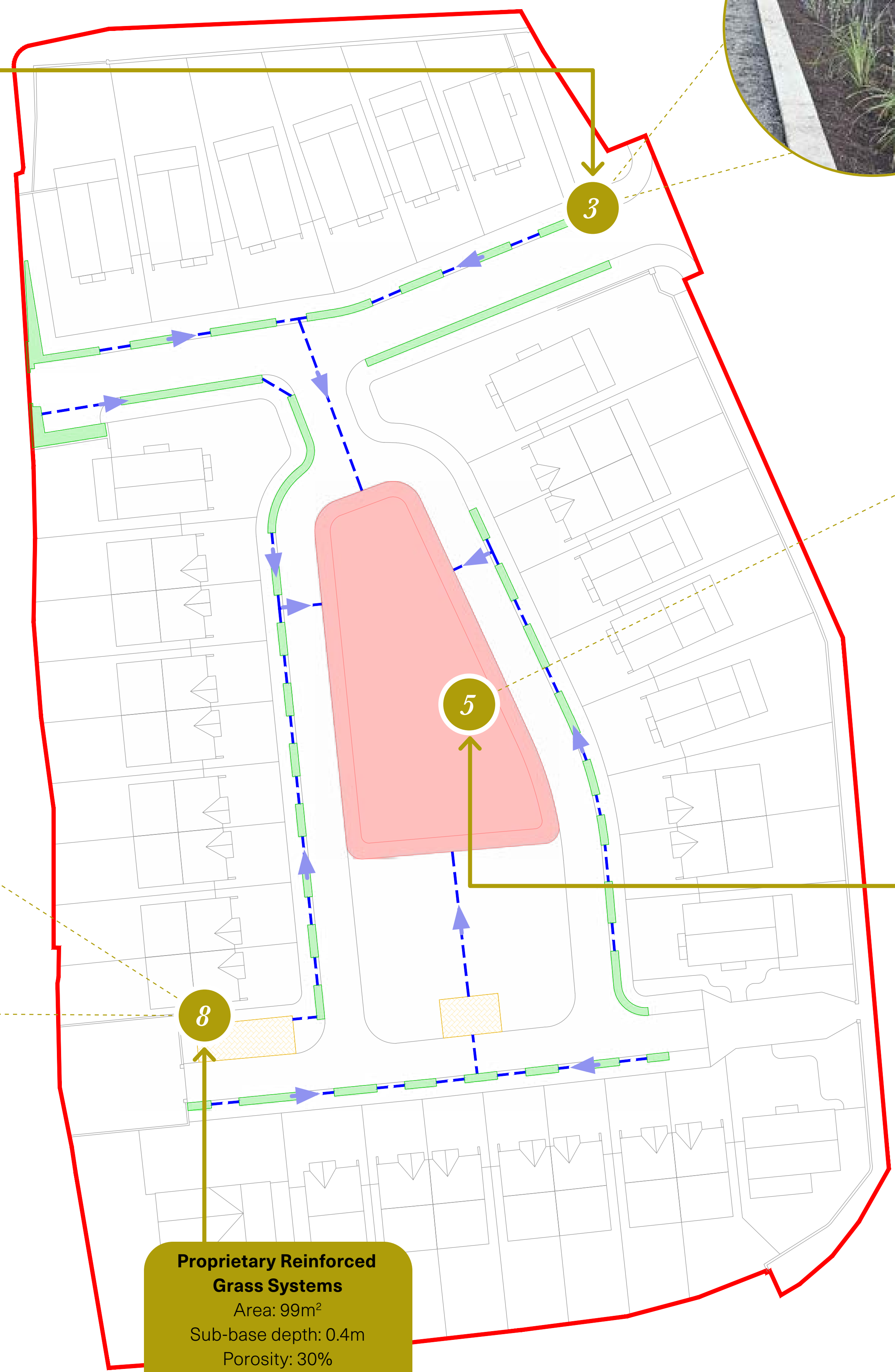
Water quality
Pollution hazard indices
- Land use: individual property driveways, residential car parks, low traffic roads and non-residential car parking with infrequent change
- Pollution hazard level: low
- Total suspended soils (TSS); metals; hydrocarbons: 0.5; 0.4; 0.4

NbS mitigation indices (TSS; metals; hydrocarbons)
- Bioretention underlain by a soil with good contaminant attenuation potential of at least 300mm in depth: 0.8; 0.8; 0.8
- Total SuDs mitigation indicies ≥ pollution hazard index (taking into account NbS trains)

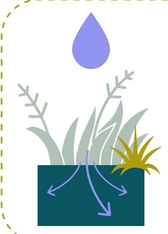
Site is considered to adequately deal with pollution risk

Hierarchy of Discharge
- 1. Infiltration
Quaternary sediments - gravels derived from limestone => infiltration is likely to be viable. Conservative infiltration rate assumed: 1.08m/hr

Bioretention Systems:
Total area: 277m²
Freeboard depth: 0.2m
Bioretention soil depth: 0.75m
Sub-base depth: 0.3m
Bioretention soil porosity: 30%
Sub-base porosity: 30%
Effective storage: 143m³



Detention Basin:
Top area: 1,017m²
Base area: 760m²
Basin depth: 0.4m
Above-ground storage: 355m³
Side slopes: 1 in 5



Type A, Total Infiltration

Proprietary Reinforced Grass Systems
Area: 99m²
Sub-base depth: 0.4m
Porosity: 30%
Effective storage: 12m³

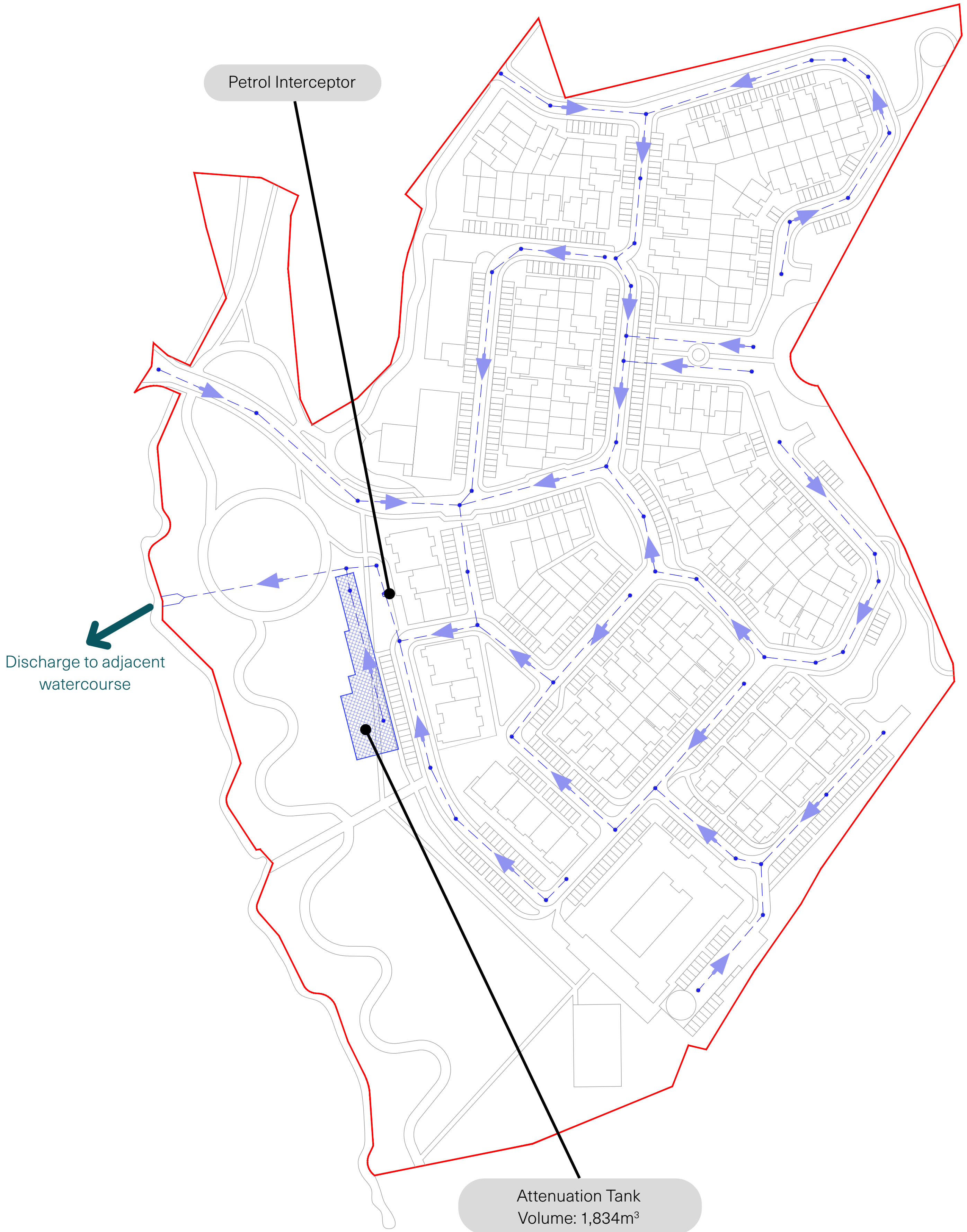
NbS Approach (Outline Design)

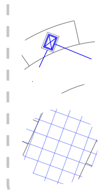
4.2 Large Urban Mixed Residential Development

The development typology is a large mixed residential site.

The site is relatively large, at 10ha, and sits parallel to an existing river. The proposals comprise 133 homes and 133 apartments, a nursing home, 2 office blocks, 2 commercial units, and a 4ha parkland provision with all associated required infrastructure.

The site is located just over 15minutes walk from the centre of town.





Site area
Total site area: 10.20ha

Attenuation storage
Total attenuation provided: 1,834m³

Traditional Hard Approach

NbS Approach Key

- Swales
- Bioretention Systems
- Ponds & Wetlands

Site area
Total site area: 10.20ha
Total permeable development area: 4.67ha
Total impermeable development area: 5.52ha
Urban creep allowance: 10%
Total impermeable area modelled for storage: 6.072ha
m^3/m^2 catchment storage coefficient: 0.05

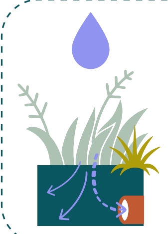
Attenuation storage
Total required attenuation: 2,743m^3
Total attenuation provided: 2,750m^3

Water quality
Pollution hazard indices
- Land use: individual property driveways, residential car parks, low traffic roads and non-residential car parking with infrequent change
- Pollution hazard level: low
- Total suspended soils (TSS); metals; hydrocarbons: 0.5; 0.4; 0.4

NbS mitigation indices (TSS; metals; hydrocarbons)
- Bioretention underlain by a soil with good contaminant attenuation potential of at least 300mm in depth: 0.8; 0.8; 0.8
- Total SuDs mitigation indicies ≥ pollution hazard index (taking into account NbS trains)

Site is considered to adequately deal with pollution risk

Hierarchy of Discharge
- 1. Infiltration
  Quaternary sediments - gravels => infiltration is likely to be viable.
  Conservative infiltration rate assumed: 1.08m/hr
- 2. Discharge to surface water body
  Discharge into adjacent surface water body at greenfield runoff rate: 17l/s
  Partial infiltration system proposed with smaller storm events primarily managed through infiltration and overflows providing discharge routes into the adjacent surface water body during higher storm events.

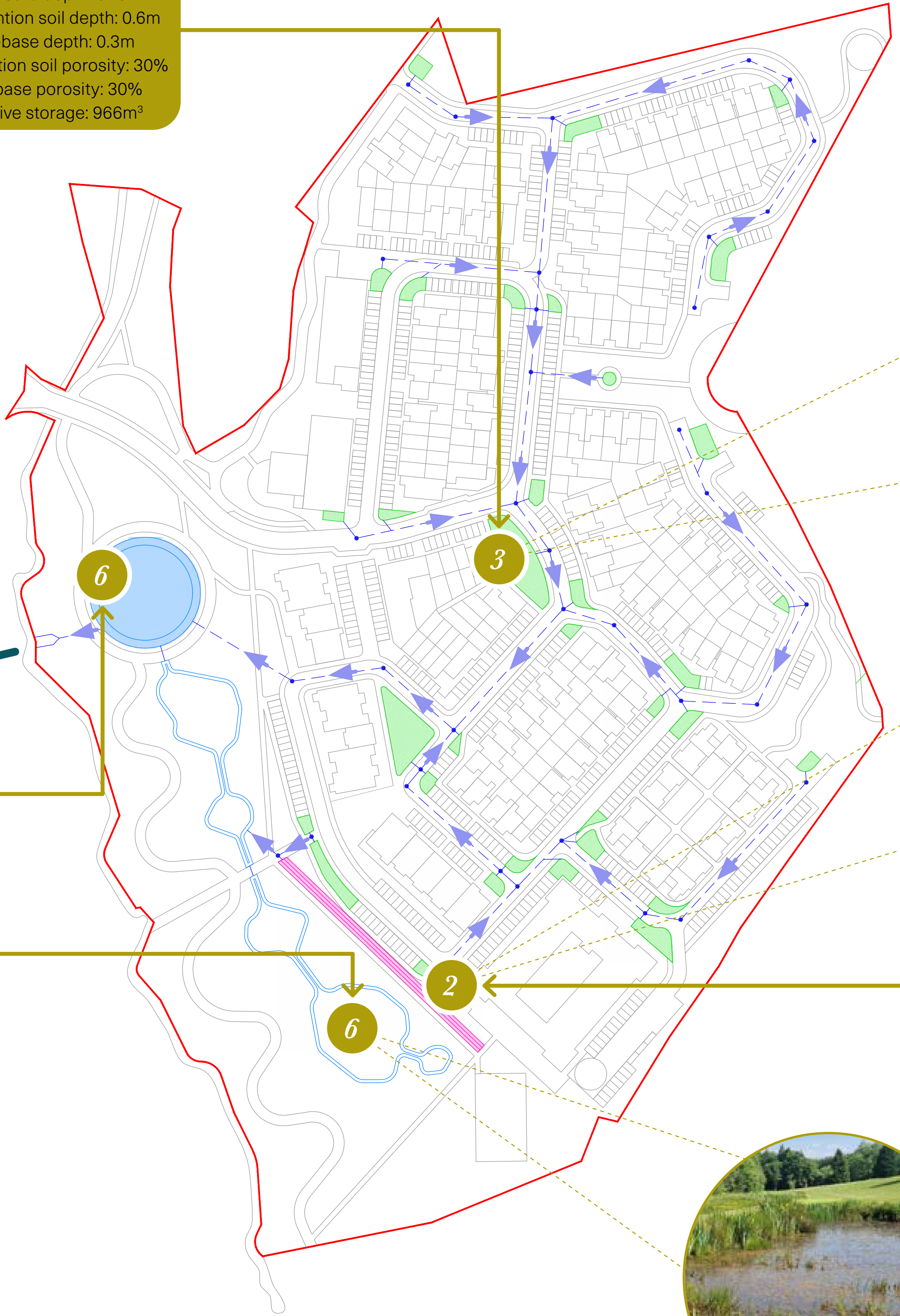


Discharge point into adjacent surface water body

Bioretention Systems:
Area: 2,300m^2
Freeboard depth: 0.15m
Bioretention soil depth: 0.6m
Sub-base depth: 0.3m
Bioretention soil porosity: 30%
Sub-base porosity: 30%
Effective storage: 966m^3

Pond
Top area: 1,404m^2
Base area: 1,035m^2
Depth: 0.6m
Effective storage: 732m^3
Side Slope: 1 in 5

Wetland Area
Top area: 2,813m^2
Base area: 2,111m^2
Depth: 0.4m
Effective storage: 985m^3
Side Slope: 1 in 3



Swale
Top area: 376m^2
Base area: 125m^2
Freeboard depth: 0.3m
Bioretention soil depth: 0.5m
Sub-base depth: 0.3m
Bioretention soil porosity: 30%
Sub-base porosity: 30%
Effective storage: 68m^3

NbS Approach (Outline Design)

4.3 Urban Educational Development

The development typology is a educational site. The site is central to its location, approximately 5minutes walk from the centre.

The proposals comprise the demolition of sections of an existing school with the construction of a new part single storey part two storey primary school.

The school will include 2 special needs classrooms, general purpose rooms and all required supporting infrastructure. Additionally included are outdoor areas including hard-courts and parking.

Site area
Total site area: 1.54ha

Attenuation storage
Total attenuation provided: 418m^3

Traditional Hard Approach

NbS Approach Key

- Filter Drain
- Bioretention Systems
- Proprietary Reinforced Grass Systems

Site area
Total site area: 1.54ha
Total permeable development area: 0.71ha
Total impermeable development area: 0.82ha
Urban creep allowance: 10%
Total impermeable area modelled for storage: 0.902ha
m^3/m^2 catchment storage coefficient: 0.10

Attenuation storage
Total required attenuation (m3): 834
Total attenuation provided (m3): 836

Water quality
Pollution hazard indices
» Land use: individual property driveways, residential car parks, low traffic roads and non-residential car parking with infrequent change
» Pollution hazard level: low
» Total suspended soils (TSS); metals; hydrocarbons: 0.5; 0.4; 0.4
NbS mitigation indices (TSS; metals; hydrocarbons)
» Filter Drain: 0.4, 0.4, 0.4
» Bioretention Areas: 0.8, 0.8, 0.8
» Permeable paving: 0.7, 0.6, 0.7
» Total SuDs mitigation indicies ≥ pollution hazard index (taking into account NbS trains)
Site is considered to adequately deal with pollution risk

Hierarchy of Discharge
» 1. Infiltration
Quaternary sediments - urban => infiltration is unlikely to be viable.
» 2. Discharge to surface water body
No suitable surface water body present within the vicinity of the site
» 3. Discharge to the public surface water sewer
Discharge into existing sewer at greenfield runoff rate: 3.65l/s

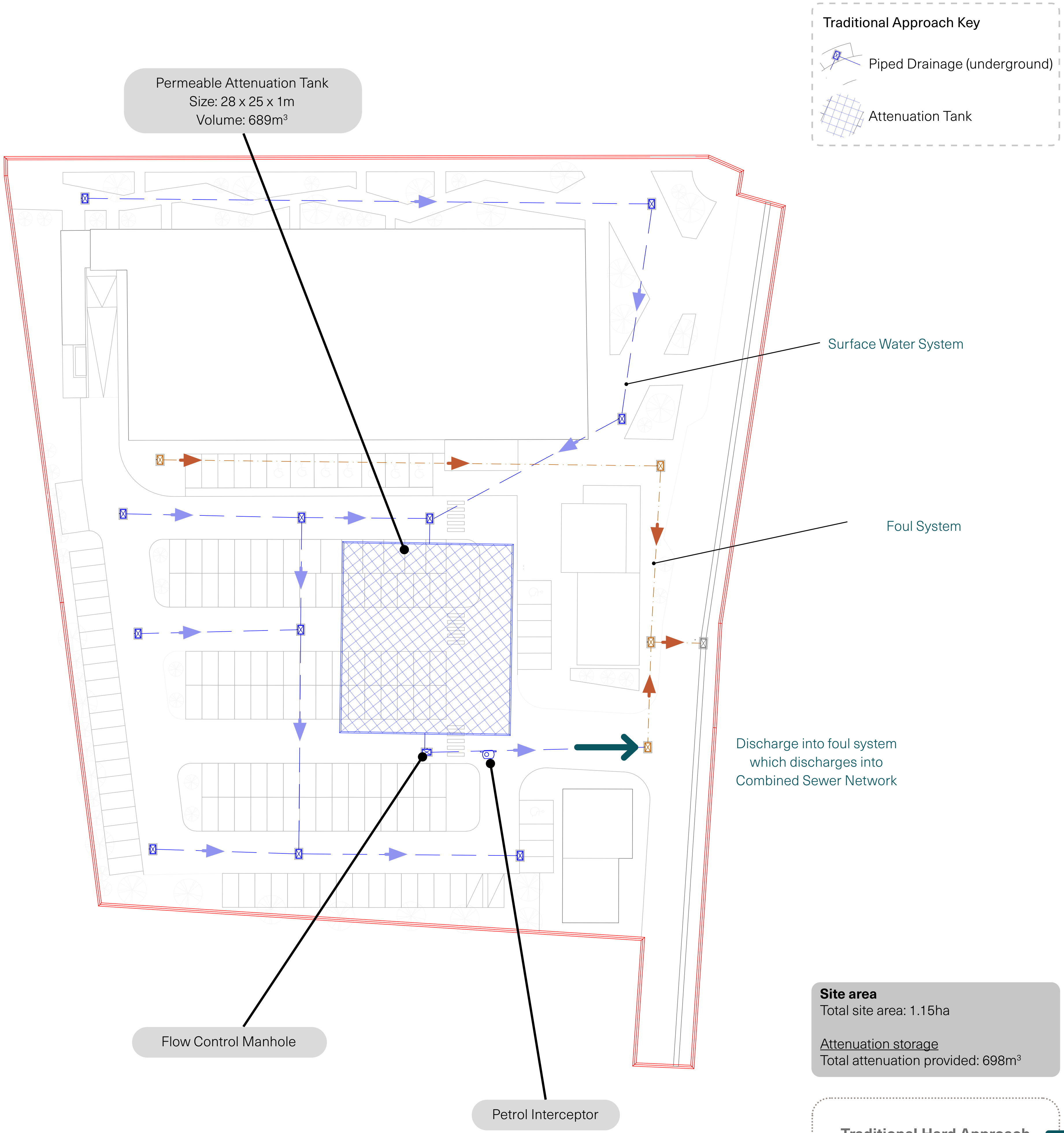
NbS Approach (Outline Design)

4.4 Urban Infill Commercial Development

The development typology is an infill commercial development.

The proposals comprise of two single storey commercial buildings with a larger retail unit identified for supermarket use.

The development includes a car park for retail use and is located within the extents of the town centre.



Site area
Total site area: 1.15ha

Attenuation storage
Total attenuation provided: 698m³

Traditional Hard Approach

NbS Approach Key

- Swales
- Bioretention Systems
- Green & Green-Blue Roofs
- Proprietary Reinforced Grass Systems

Site area
Total site area: 1.15ha
Total permeable development area: 0.13ha
Total existing highway catchment area: 0.11ha
Total impermeable development area: 0.92ha
Urban creep allowance: 10%
Total impermeable area modelled for storage: 1.01ha
m^3/m^2 catchment storage coefficient: 0.14

Attenuation storage
Total required attenuation: 1,369m^3
Total attenuation provided: 1,370m^3

Water quality
Pollution hazard indices
- Land use: commercial yard and delivery areas, non-residential car parking with frequent change, all roads except low traffic roads and trunk roads/motorways
- Pollution hazard level: medium
- Total suspended soils (TSS); metals; hydrocarbons: 0.7; 0.6; 0.7

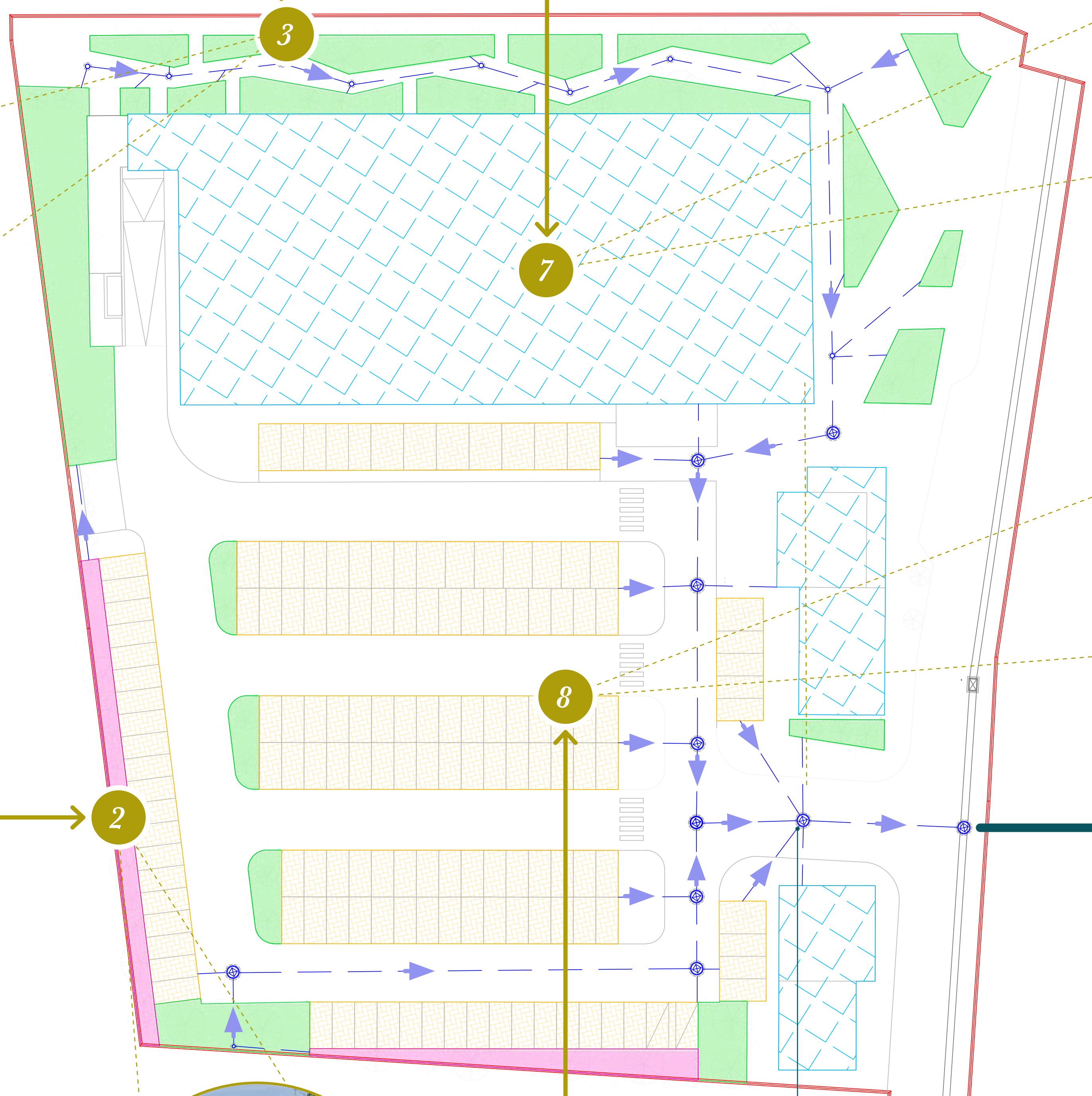
NbS mitigation indices (TSS; metals; hydrocarbons)
- Swale: 0.5, 0.6, 0.6
- Bioretention system: 0.8; 0.8; 0.8
- Permeable pavement: 0.7, 0.6, 0.7
- Total SuDs mitigation indices ≥ pollution hazard index (taking into account NbS trains)

Site is considered to adequately deal with pollution risk

Hierarchy of Discharge
- 1. Infiltration
  Quaternary sediments - urban => infiltration is unlikely to be viable.
- 2. Discharge to surface water body
  No suitable surface water body present within the vicinity of the site
- 3. Discharge to the public surface water sewer
  Discharge into existing sewer at greenfield runoff rate: 2.80l/s

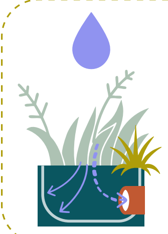
Bioretention Systems:
Area: 1042m^2
Freeboard depth: 0.2m
Bioretention soil depth: 0.8m
Sub-base depth: 0.4m
Bioretention soil porosity: 30%
Sub-base porosity : 30%
Effective storage: 583m^3

Blue-Green Roof:
Area: 2,585m^2
Attenuation depth: 0.2m
Porosity : 95%
Effective storage: 491m^3



Swales:
Area: 188m^2
Freeboard depth: 0.15m
Bioretention soil depth: 0.4m
Sub-base depth: 0.3m
Bioretention soil porosity: 30%
Sub-base porosity: 30%
Effective storage: 68m^3

Discharge point into adjacent sewer



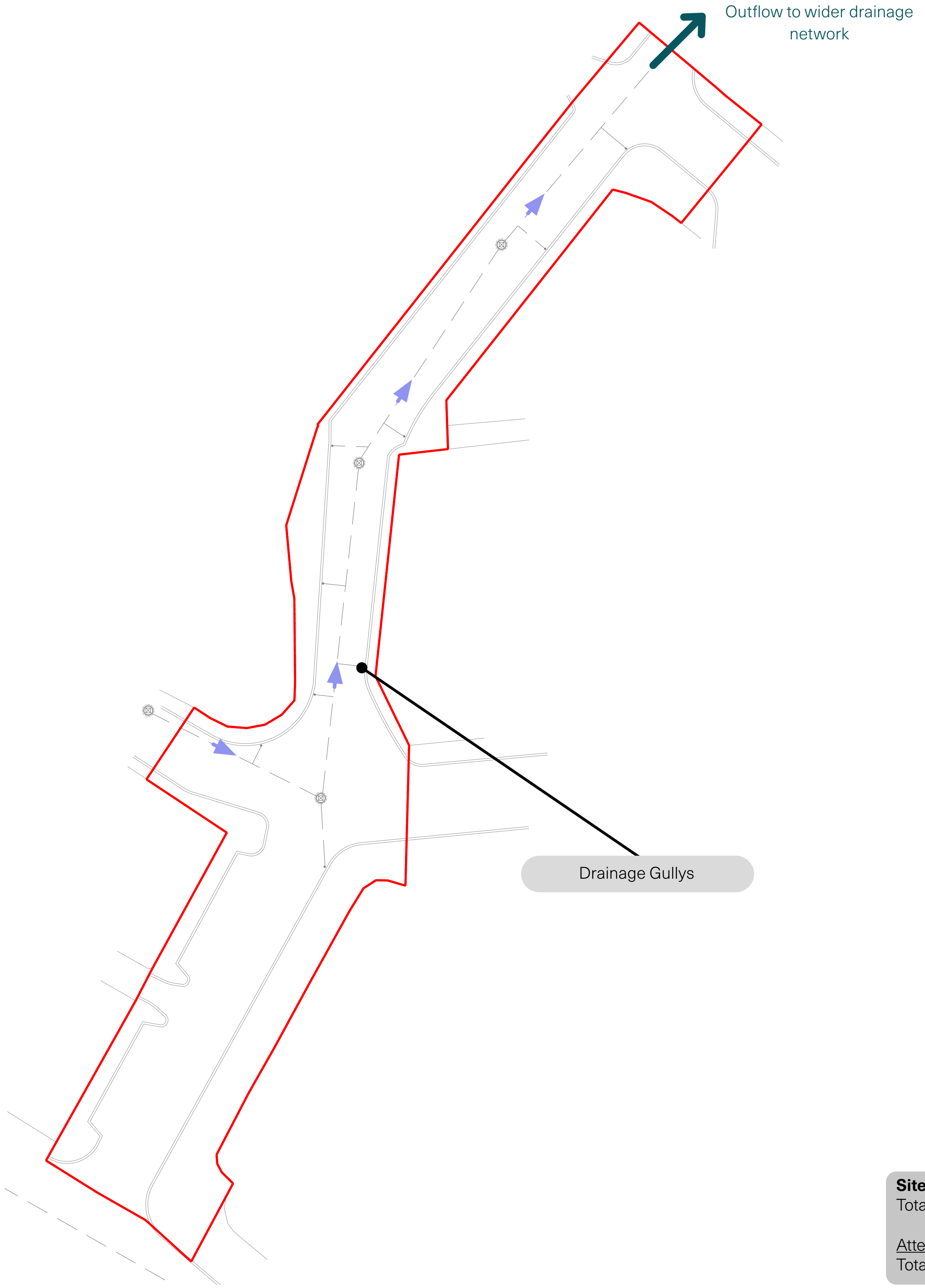
Proprietary Reinforced Grass Systems
Area: 1,901m^2
Sub-base depth: 0.4m
Porosity: 30%
Effective storage: 228m^3

NbS Approach (Outline Design)

4.5 Urban Public Realm Development

The development typology is a public realm regeneration scheme.

The proposals comprise of changes to the road layout to indicate the shift in the priority for users, through the use of shared-space, NbS features, kerbline adjustments and paving types.



Site area
Total site area: 0.34 ha

Attenuation storage
Total attenuation provided: 0m³

Traditional Hard Approach

NbS Approach Key
- Filter Drain
- Bioretention Systems
- Tree Pits
- Proprietary Reinforced Grass Systems

Site area
Total site area: 0.34ha
Total permeable development area: 0.05ha
Total impermeable development area: 0.29ha
m^3/m^2 catchment storage coefficient: 0.05

Attenuation storage
Total required attenuation: 147m^3
Total attenuation provided: 153m^3

Water quality
Pollution hazard indices
- Land use: commercial yard and delivery areas, non-residential car parking with frequent change, all roads except low traffic roads and trunk roads/motorways
- Pollution hazard level: medium
- Total suspended soils (TSS); metals; hydrocarbons: 0.7; 0.6; 0.7

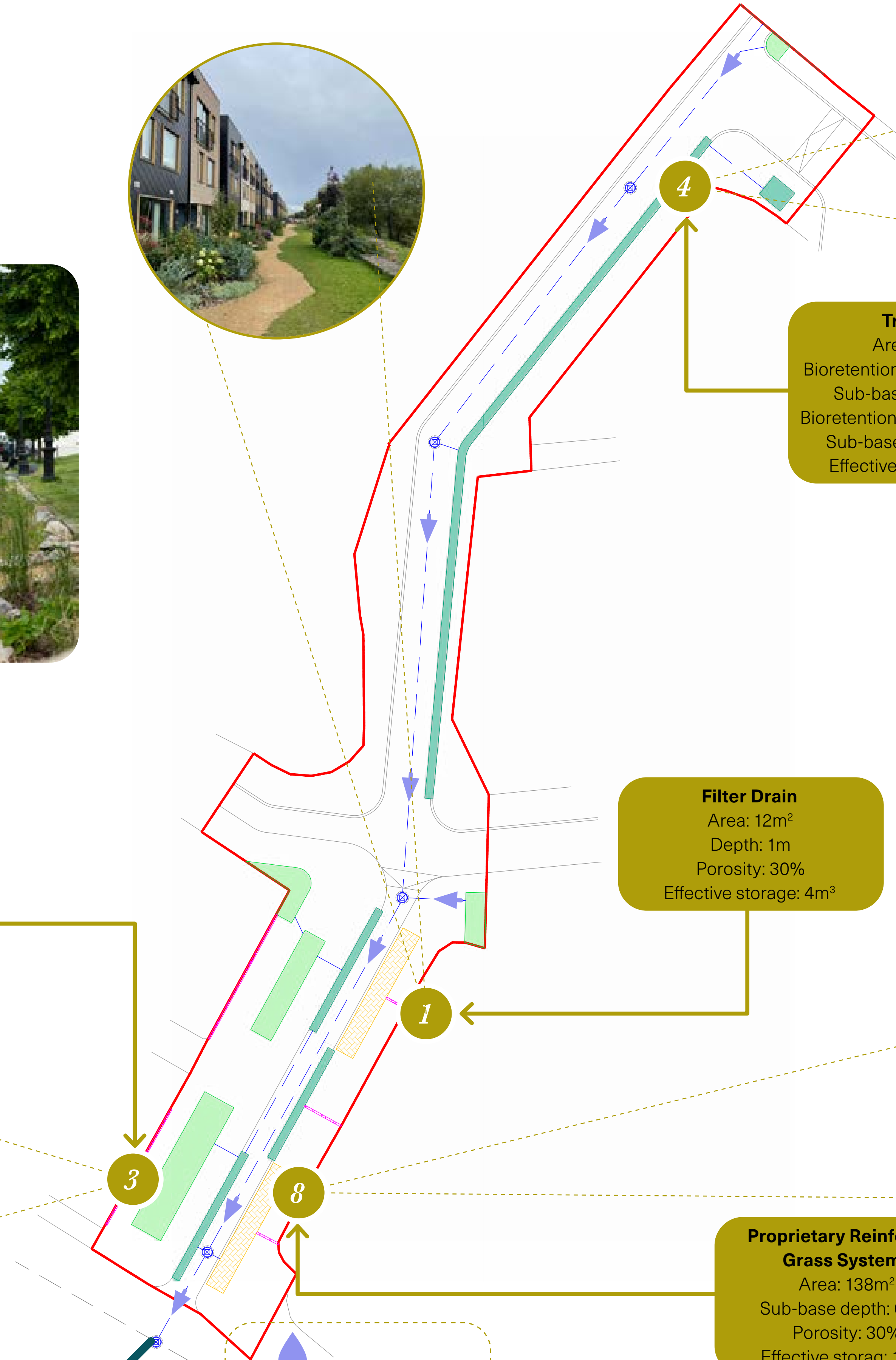
NbS mitigation indices (TSS; metals; hydrocarbons)
- Filter Drain: 0.4, 0.4, 0.4
- Bioretention areas: 0.8; 0.8; 0.8
- Permeable paving: 0.7, 0.6, 0.7
- Total SuDs mitigation indices ≥ pollution hazard index (taking into account NbS trains)

Site is considered to adequately deal with pollution risk

Hierarchy of Discharge
- 1. Infiltration
  Quaternary sediments - urban => infiltration is unlikely to be viable.
- 2. Discharge to surface water body
  No suitable surface water body present within the vicinity of the site
- 3. Discharge to the public surface water sewer
  Discharge into existing sewer at greenfield runoff rate: 2.37l/s

Exemplar Bioretention System specific to public realm example. Shoreditch, London

Bioretention Systems:
Area: 180m^2
Freeboard depth: 0.15m
Bioretention soil depth: 0.75m
Sub-base depth: 0.3m
Bioretention soil porosity: 30%
Sub-base porosity: 30%
Effective storage: 83m^3

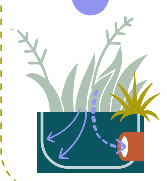


Tree Pits
Area: 165m^2
Bioretention soil depth: 0.75m
Sub-base depth: 0.3m
Bioretention soil porosity: 30%
Sub-base porosity: 30%
Effective storage: 52m^3

Exemplar Tree Pit System specific to public realm example. Altrincham, Manchester

Filter Drain
Area: 12m^2
Depth: 1m
Porosity: 30%
Effective storage: 4m^3

Proprietary Reinforced Grass Systems
Area: 138m^2
Sub-base depth: 0.3m
Porosity: 30%
Effective storag: 12m^3



Type C, No Infiltration

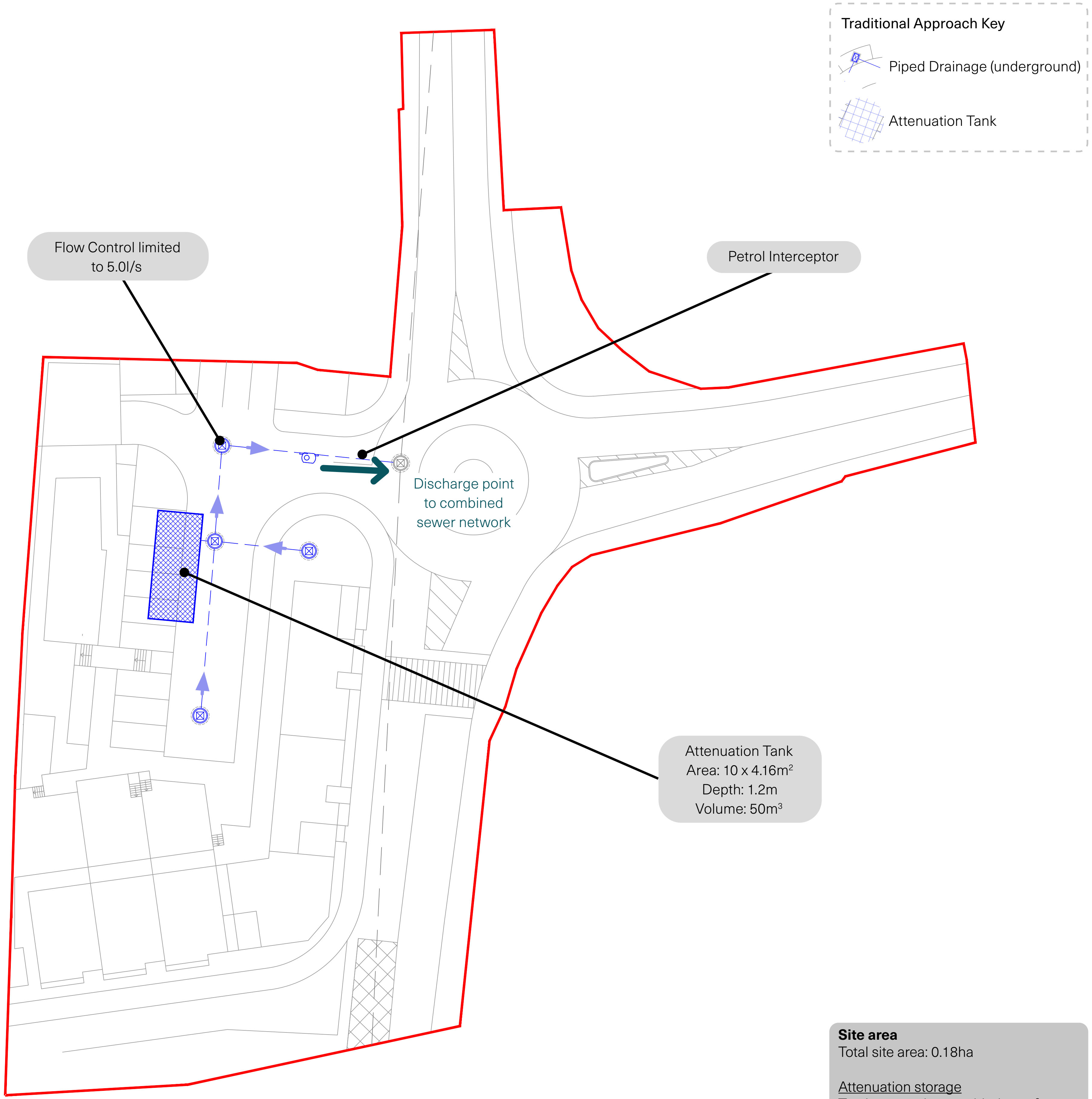
NbS Approach (Outline Design)

4.6 Small Urban Residential Infill Development

The development typology is a small infill urban residential scheme.

The proposals comprise of 10 homes in a mixture or terrace types with allocated parking and a small provision of outdoor amenity areas.

The development is an infill of land adjacent to a road and is located a 5minute walk from the centre of town.



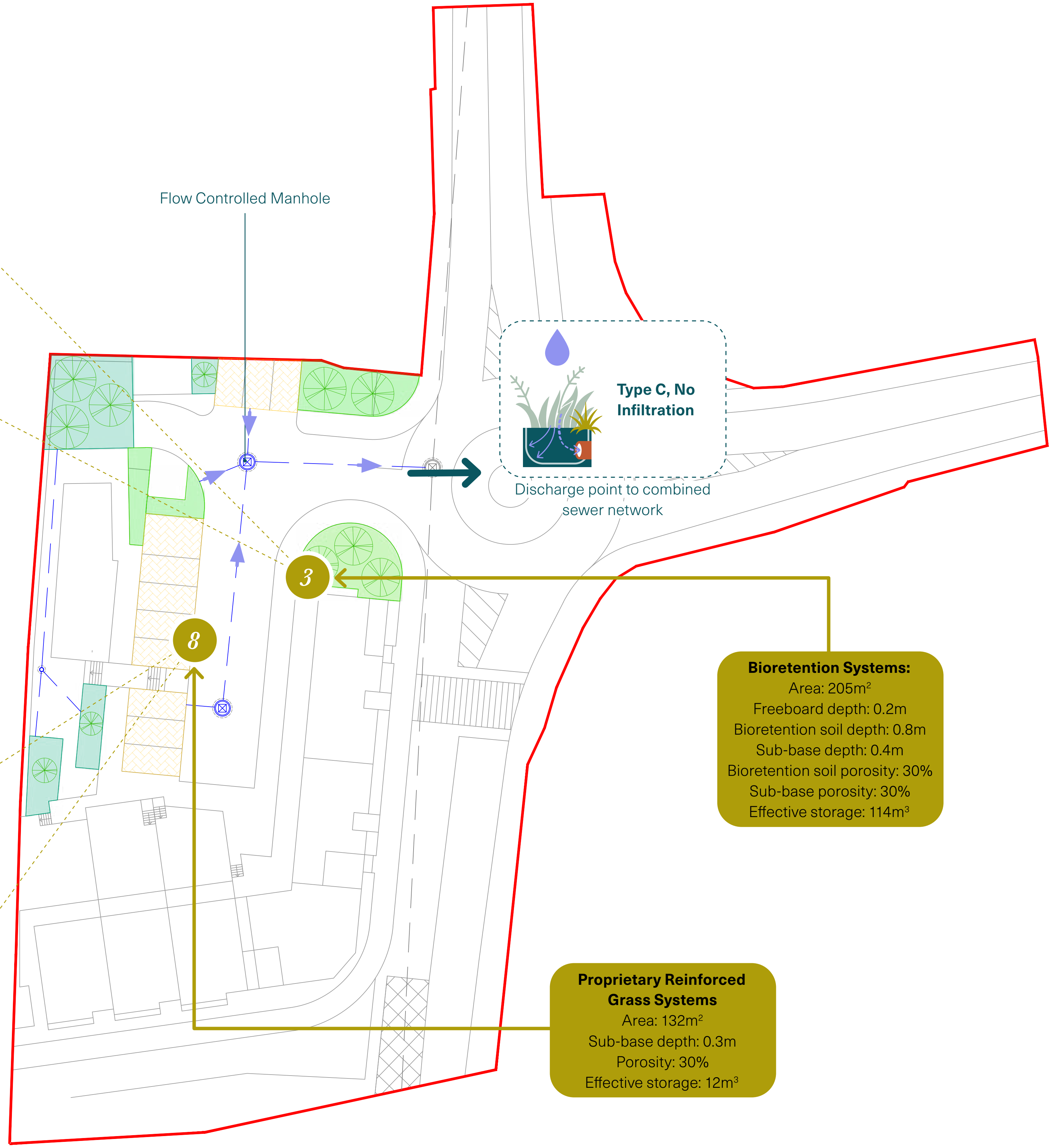
Site area
Total site area: 0.18ha

Attenuation storage
Total attenuation provided: 50m³

Traditional Hard Approach

NbS Approach Key

- Bioretention Systems
- Proprietary Reinforced Grass Systems



Site area
Total site area: 0.18ha
Total permeable development area: 0.05ha
Total impermeable development area: 0.13ha
Urban creep allowance: 10%
Total impermeable area modelled for storage: 0.143ha
$m^3/m2$ catchment storage coefficient: 0.09

Attenuation storage
Total required attenuation: 126m^3
Total attenuation provided: 126m^3

Water quality
Pollution hazard indices
- Land use: individual property driveways, residential car parks, low traffic roads and non-residential car parking with infrequent change
- Pollution hazard level: low
- Total suspended soils (TSS); metals; hydrocarbons: 0.5; 0.4; 0.4

NbS mitigation indices (TSS; metals; hydrocarbons)
- Bioretention areas: 0.8; 0.8; 0.8
- Permeable paving: 0.7, 0.6, 0.7
- Total SuDs mitigation indicies ≥ pollution hazard index (taking into account NbS trains)

Site is considered to adequately deal with pollution risk

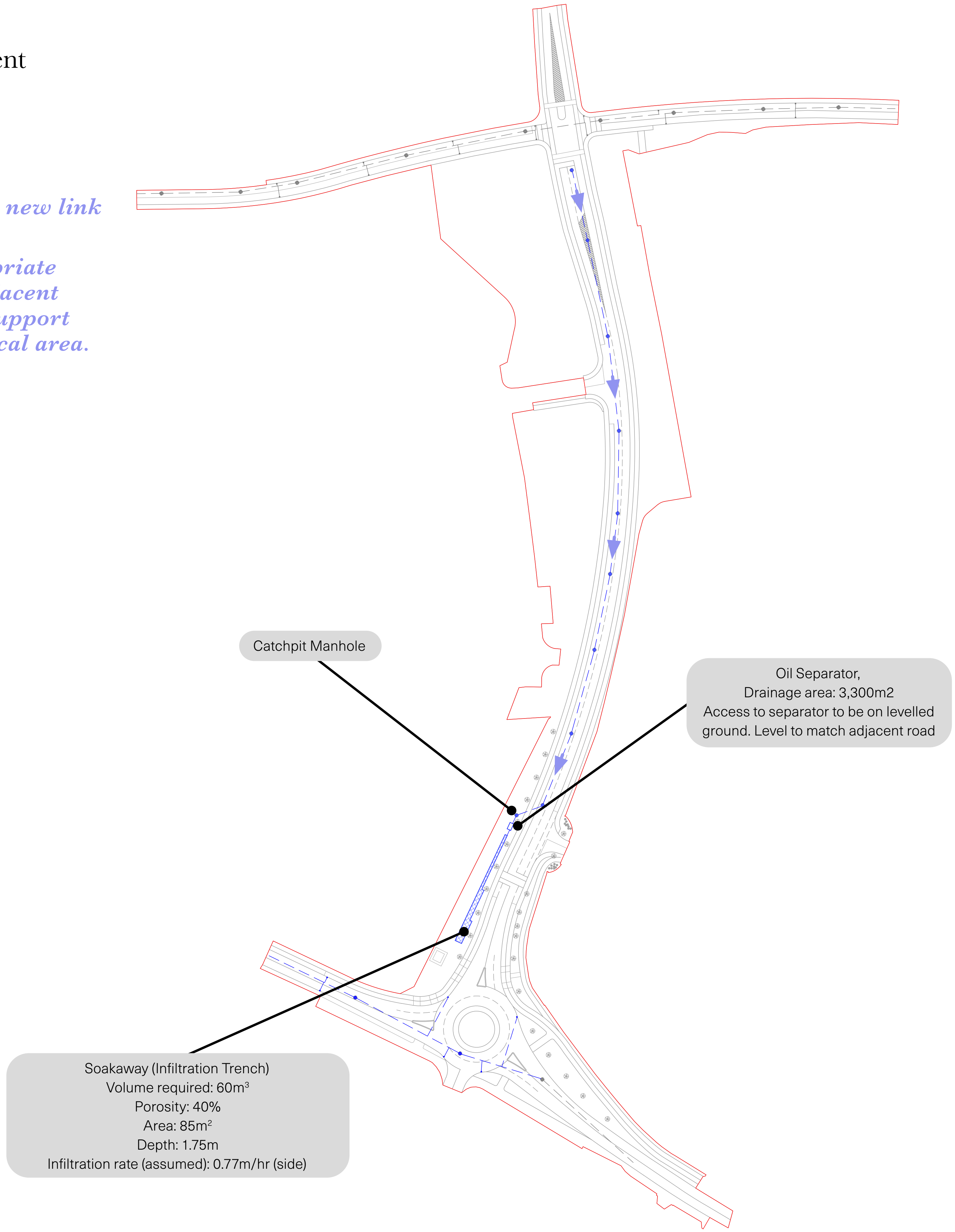
Hierarchy of Discharge
- 1. Infiltration
  Quaternary sediments - urban => infiltration is likely to be viable.
- 2. Discharge to surface water body
  No suitable surface water body present within the vicinity of the site
- 3. Discharge to the public surface water sewer
  Discharge into existing sewer at greenfiled run off rate: 0.44l/s

NbS Approach (Outline Design)

4.7 Urban Link Road Development

The development typology is a new link road.

The road is designed to appropriate widths with the addition of adjacent cycleways and is intended to support further developments in the local area.



Traditional Approach Key

- Piped Drainage (underground)
- Attenuation Tank

Site area
Total site area: 2.83ha

Attenuation storage
Total attenuation provided: 60m³

Traditional Hard Approach

NbS Approach Key

Swales

Bioretention Systems

Site area
Total site area: 2.83ha
Total permeable development area: 1.40ha
Total impermeable development area: 1.43ha
Urban creep allowance: 10%
Total impermeable area modelled for storage: 1.57ha
m^3/m^2 catchment storage coefficient: 0.05

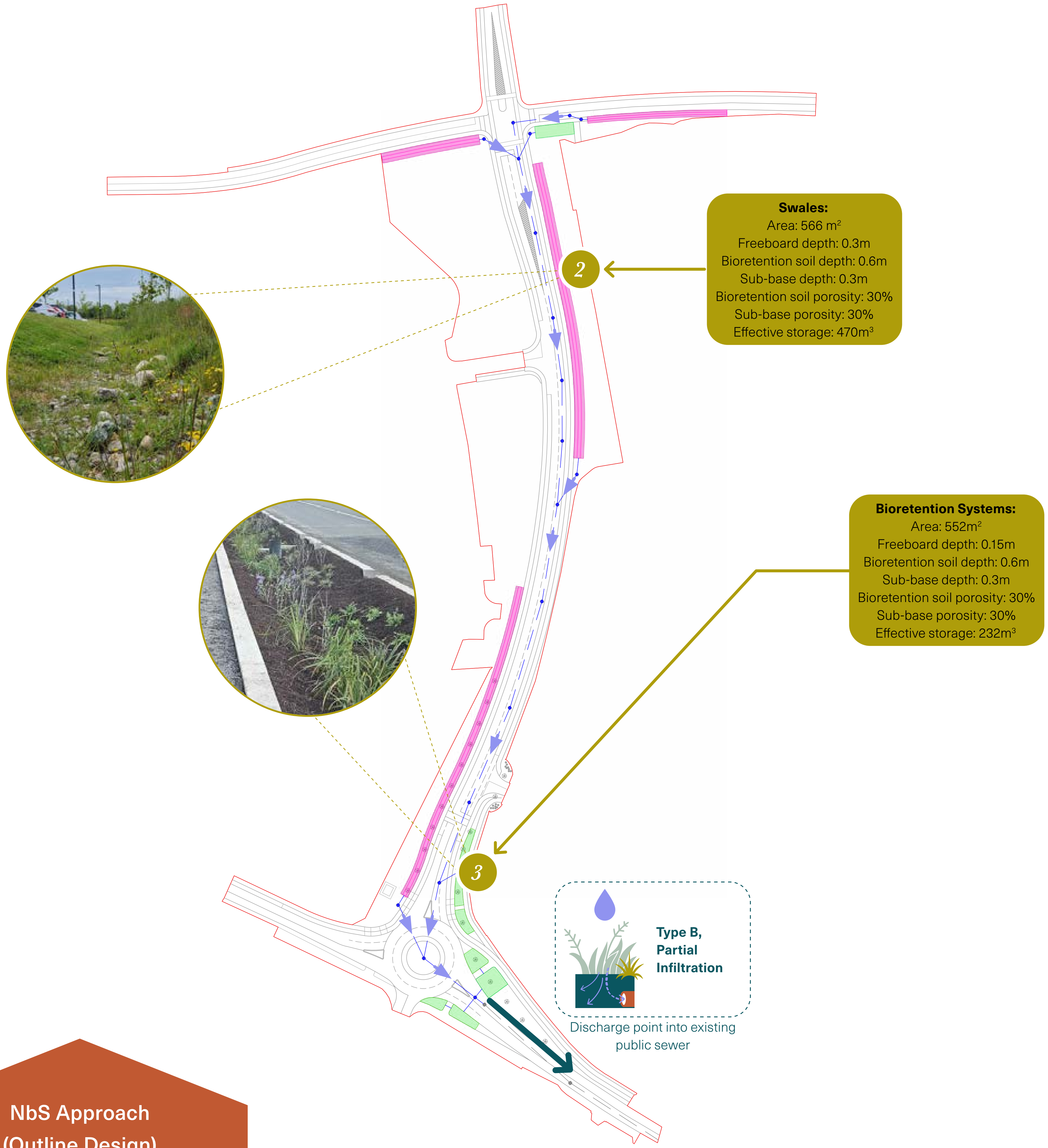
Attenuation storage
Total required attenuation: 701m^3
Total attenuation provided: 701m^3

Water quality
Pollution hazard indices
- Land use: commercial yard and delivery areas, non-residential car parking with frequent change, all roads except low traffic roads and trunk roads/motorways
- Pollution hazard level: medium
- Total suspended soils (TSS); metals; hydrocarbons: 0.7; 0.6; 0.7

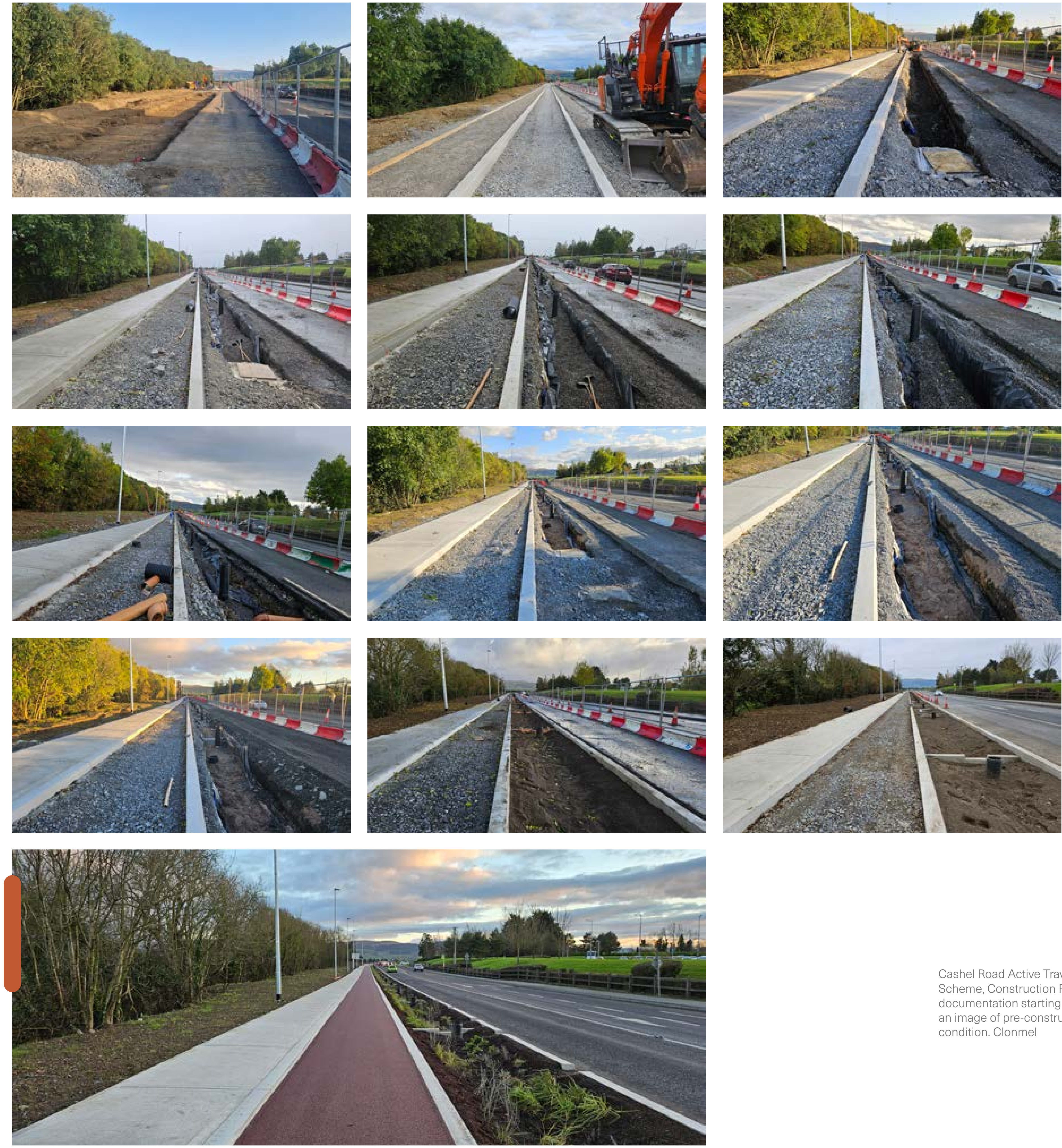
NbS mitigation indices (TSS; metals; hydrocarbons)
- Bioretention underlain by a soil with good contaminant attenuation potential of at least 300mm in depth: 0.8; 0.8; 0.8
- Total SuDs mitigation indicies ≥ pollution hazard index (taking into account NbS trains)

Site is considered to adequately deal with pollution risk

Hierarchy of Discharge
- 1. Infiltration
  Quaternary sediments - gravels => infiltration is likely to be viable.
  Conservative infiltration rate assumed: 1.08m/hr
- 2. Discharge to surface water body
  no suitable surface water body present within the vicinity of the site
- 3. Discharge to the public surface water sewer
  Discharge into existing sewer at greenfield runoff rate: 5.12l/s
  Partial infiltration system proposed with smaller storm events primarily managed through infiltration and overflows providing discharge routes into the existing sewer system during higher storm events.



NbS Approach (Outline Design)



Cashel Road Active Travel Scheme, Construction Phase documentation starting with an image of pre-construction condition. Clonmel

5. Management of NbS

Green Roof. Cliff House Hotel,
Ardmore, County Waterford

5.1 Maintenance and Management of NbS

Continued and long-term maintenance of NbS features is essential to ensuring efficient operation. Contrary to popular belief the maintenance requirements of NbS features are relatively low, and, not significantly more, or different to traditional drainage systems, conventional green or planted areas in the public realm. In many circumstances, maintenance of NbS features can be less onerous than traditional designs - especially in comparison to an attenuation tank. Given the landscaped nature of NbS features, much of their maintenance requirements can be incorporated into general landscape maintenance regimes.

The aim of NbS is to design for low maintenance, with appropriate materials and native or resilient planting schemes. Specialist expertise, is required at plan making and early design stages to achieve this.

The maintenance of NbS features and the principle of above ground storage allows for the early identification of spillages and blockages. This makes the features inherently less risky than underground or less accessible drainage measures (see Figure 22) as failure or the risk of failure can be identified earlier. NbS are more accessible, making regular maintenance significantly easier and likely to be undertaken. Adoption of NbS features is an opportunity to ensure that the NbS continues to deliver maximal benefits and should be discussed early between the local authority and developers. A maintenance plan should be produced by the designer and adopted by the relevant body (either the developer or the local authority). Where a Project Supervisor for Deign Process (PSDP)[i] is required, the PSDP shall compile a Safety File for the project and shall present the Safety File to the client upon completion. The Safety File should include an Operation and Maintenance (O&M) Manual for any installed NbS Features. This guidance document highlights inspections and intervention required to maintain the system at optimal level. The maintenance of NbS features can be broken down into four major components: Performance inspections; Drainage system operation and maintenance; Landscape management; Waste management

Maintenance Considerations

In addition to the maintenance types the following should be taken into consideration:

- Maintenance access across the whole NbS train
- Systems to trap sediment including forebays/pre-treatment
- Temporary drainage provisions, if required, during maintenance activities
- Green waste storage and disposal areas

Figure 22: Collapsed Attenuation Tank - Wexford County Council

Figure 23: NbS as a replacement solution to the traditional attenuation tank (see left) - Wexford County Council

Maintenance Guidance Further Reading
The following should be consulted for further information on maintenance requirements of NbS features:
The Ciria SuDS Manual C753
Manufacturers details for any proprietary products
HR Wallingford The Operation and Maintenance of Sustainable Drainage Systems (and Associated Costs) Report SR 626 (2004)
CIRIA Model agreements for sustainable water management systems. Model agreements for SuDS (C625)

i For overall health and safety requirements, reference should be made to the Safety, Health and Welfare at Work regulations, the HSA Guidelines on said regulations and other applicable legislation

Operation and Maintenance Activity	Filter Drain	Swale	Bioretention System	Tree Pits	Detention Basin	Ponds and Wetlands	Green and Blue Roofs	Proprietary Reinforced Grass
Regular								
Inspection	Required	Required	Required	Required	Required	Required	Required	Required
Litter/Debris Removal	Required	Required	Required	Required	Required	Required	n/a	Required
Grass Cutting	Required	Required	Required	Required	Required	Required	n/a	May be required
Weed and Invasive Plant Control	May be required	n/a	n/a	n/a	May be required	May be required	Required	May be required
Shrub Maintenance, including pruning	n/a	May be required	May be required	May be required	May be required	May be required	n/a	May be required
Shoreline Vegetation Management	n/a	n/a	n/a	n/a	May be required	Required	n/a	n/a
Aquatic Vegetation Management	n/a	n/a	n/a	n/a	May be required	Required	n/a	n/a
Occasional								
Sediment Management	Required	Required	Required	Required	Required	Required	n/a	Required
Vegetation Replacement	n/a	May be required	May be required	May be required	May be required	May be required	Required	n/a
Vacuum Sweeping and Brushing	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Required
Remedial								
Structure Rehab/ Repair	May be required	May be required	May be required	May be required	May be required	May be required	May be required	May be required
Infiltration Surface Reconditioning	May be required	May be required	May be required	May be required	May be required	n/a	n/a	May be required

Key: Required; May be required

Typical operation and maintenance activities for each of the NbS features highlighted in this document are shown in the table. More detailed maintenance activity schedules can be seen in Appendix E.

Table 5: Typical NbS component operation and maintenance activities (Source: Table 32.1 CIRIA SuDS Manual)

5.2 Conditioning of Planning Applications

The production of a maintenance plan should be a conditioned requirement for the granting of planning permission. Guidance on the wording of such a condition should follow the **OPR Practice Note PN03 Planning Conditions** with wording along the following lines:

Refer to Appendix E for further information.

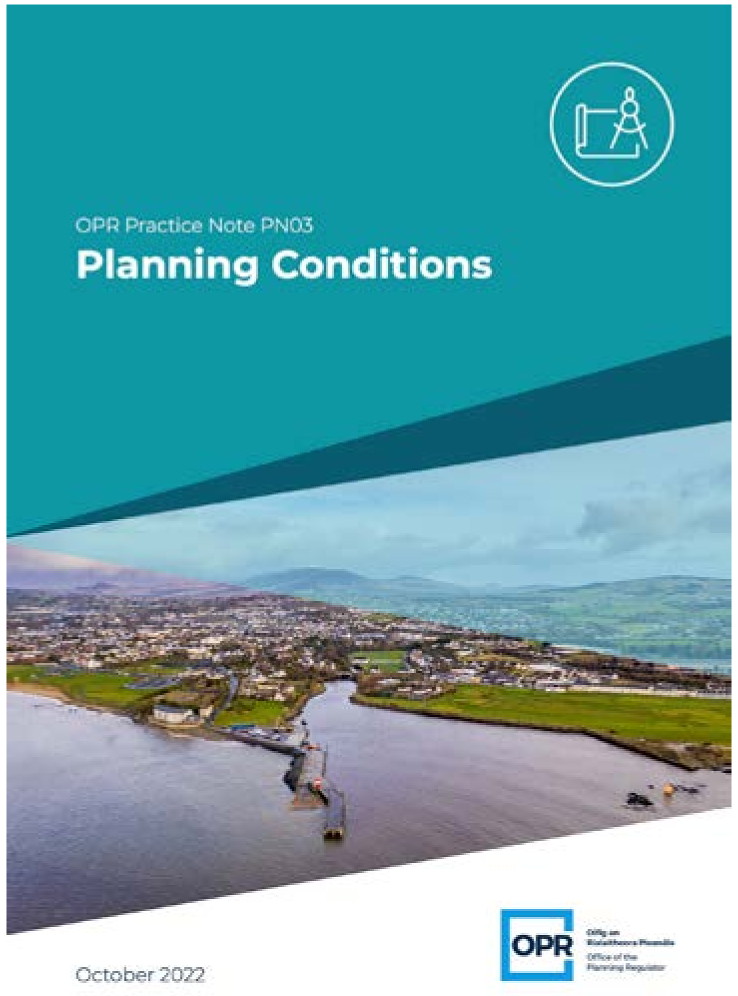


Figure 24: OPR Practice Note PN03 Planning Conditions (October 2022)

"Prior to the commencement of development, an NbS management and maintenance plan for the lifetime of the development shall be submitted to the Planning Authority and agreed in writing. The NbS management and maintenance plan shall include as a minimum:

- » The arrangements for adoption by an appropriate public body or statutory undertaker, or management and maintenance by a Site Management Company
- » Arrangements concerning appropriate funding mechanisms for its on-going maintenance of all elements of the NbS system and associated (buried components (pipes, flow controls, chambers, etc.) to include elements such as:
  - » On-going inspections relating to performance and asset condition assessments
  - » Operation costs for regular maintenance, remedial works and irregular maintenance caused by less sustainable limited life assets or any other arrangements to secure the operation of the NbS scheme throughout its lifetime
- » Means of access for maintenance and easements where applicable.

The development shall subsequently be completed, maintained and managed in accordance with the approved plan. Reason: To manage flood and pollution and to ensure that a managing body is in place for the NbS system and there is funding and maintenance mechanism for the lifetime of the development in accordance with the local policy. This information must be agreed prior to the commencement of development in order to ensure appropriate drainage of the site as the development proceeds."

Figure 25: Detention Basin – Kilgobbin, Dublin

Figure 26: Carlow Raingardens (image courtesy of Carlow County Council)

Filter Strip N24
Clonmel, County Tipperary

6. Health & Safety Risk Assessment

Dry Swale
Min Ryan Park, Wexford

6.1 Health & Safety Risk Assessments

NbS designs must fulfil regulatory and legal requirements, in line with the **Safety, Health & Welfare at Work (Construction) Regulations 2013** and the **Safety, Health and Welfare at Work Act 2005**, with health and safety risk assessments carried out in accordance with **IS EN IEC 31010:2019 Risk management**, risk assessment techniques. Health and safety should be considered throughout the lifetime of any project and should be discussed at conceptual and outline stages of design in congruence with a number of agreed principles.

When assessing an NbS scheme a health and safety assessment should be carried out by all duty holders[i]. This should be reviewed post-construction and during operation on a regular basis, in accordance with the **Health and Safety Authority (2017) Guidelines on the Procurement, Design and Management Requirements of the Safety Health and Welfare at Work (Construction) Regulations 2013**.

All parties involved in an NbS project have a health and safety duty and should consider health and safety in their actions. Health & Safety Risk Assessments should be undertaken by a competent professional and consultation with a Health & Safety specialist should be sought, where required.

Considerations should be made to the following in the assessment of risks of NbS:

» Public perception of risk and informing the public about any works
» Drowning risk management and fencing
» Siting of NbS components and access to the NbS components
» Water body and flood exceedance storage or conveyance design
» Life-saving equipment, signage and management of slip and fall risk
» Vertical drops, steep-sides, level changes and inlets, outlets and safety grills
» Structural integrity of the NbS component
» Risks from untreated or polluted water and water quality management
» Management of litter

i the client, the project supervisor design process (PSDP), the project supervisor for the construction stage (PSCS) and any other duty holders as per legislation

NbS Risk Assessment

An example NbS risk assessment matrix is in Table 6. The NbS Risk Assessment matrices provide a measure from which operational and design/construction risks can be categorised. The shown NbS Risk Assessment Matrix, explores the likelihood of a risk against its consequence.

A risk can therefore be categorised based on how frequently it will occur against the consequence of its occurrence.

Reading this matrix results in a risk category (from Low Risk (L) to Extreme Risk (E), which allows the derived risk category to determine appropriate action to be taken.

Categorisation of risk is broken down into operational and design and construction risk. Example risks in each category are shown below but constitute only a snapshot of standard risks.

Use the top table to determine risk based on the frequency and consequence of hazard. The bottom table will determine action based on the derived risk.

	Consequence				
	Insignificant	Minor	Moderate	Major	Extreme
Almost Certain (Frequent)	M	M	H	E	E
Likely (Probable)	L	M	H	H	E
Possible (Occasional)	L	M	M	H	H
Unlikely (Uncommon)	L	L	M	M	H
Rare (Remote)	L	L	L	L	M

Risk	Action
Extreme Risk (E)	» **Design stage** not acceptable, design must be changed » **Management stage** Immediate attention and response needed to reduce the level of risk
High Risk (H)	» **Design stage** not acceptable, design must be changed » **Management stage** attention and response needed to reduce the level of risk
Medium Risk (M)	» **Design stage** review if it is practical and reasonable to change design to reduce the level of risk » **Management stage** review options to see if there are practical and reasonable options to reduce risk
Low Risk (L)	» **Design stage** acceptable, no changes » **Management stage** no response needed to reduce the level of risk, continue to review on regular basis

Almost certain = is expected to occur/ recur frequently or within an short period of time (most weeks or months)
Likely = will probably occur/ recur in most circumstances (several times a year)
Possible = possibly will occur/ recur occasionally (once every few years)
Unlikely = uncommon might occur/ recur at some time in the future
Rare = unlikely to occur/ recur may only happen in exceptional circumstances

Insignificant = no injury or health effects
Minor = minor injury or health effects
Moderate = injury but not life threatening some ill health effects
Major = serious injury dangerous near miss serious ill health
Extreme = serious injury or death serious life-threatening disease

Table 6: NbS Risk Assessment Matrix (Source: Table 36.2 CIRIA SuDS Manual)

Risks should always be considered at a level specific to the project and its contextual environment.

Design/Construction Risks

- Drowning risk management
- Level changes
- Slip and fall risk
- Incorrect installation
- Soil compaction, erosion and sedimentation of proposed NbS features
- Damage top existing utilities
- Insufficiently designed maintenance access
- Design errors and miscommunication
- Disturbance to existing vegetation and to existing ground conditions, especially when infiltrating or if NbS feature is situated in relation to foundations

Operational Risks

- Drowning risk management
- Misuse, vandalism and lack of natural surveillance
- Flood exceedance storage and overflow
- Location of life saving equipment (if required)
- Poor/confusing signage
- Slips and fall risk
- Structural integrity
- Ill health from untreated or polluted water
- Litter management
- Lack of maintenance
- Accidental pollution spillages

Risk Assessment Further Reading

The following should be consulted for further information on risk assessments of NbS features. The list is not exhaustive, and any party should perform their due diligence in adhering to the appropriate legislation for their project. In all cases, the latest revision of the act or regulations should be followed:

- Safety Health and Welfare at Work Act 2005
- Safety, Health and Welfare at Work (Construction) Regulations 2013
- HSA Guidelines on the Procurement, Design and Management Requirements of the Safety Health and Welfare at Work (Construction) Regulations 2013
- The Building Control Regulations 1997 to 2024
- Environmental Protection Agency Act 1992
- Planning and Development Act 2000
- Local Government (Water Pollution) (Amendment) Act, 1990
- European Communities (Water Policy) Regulations 2014
- European Communities Environmental Objectives (Groundwater) Regulations 2010
- Water Framework Directive
- Urban Waste Water Treatment Regulations 2001

Swale taking water from carpark
Three Rocks Memorial
County Wexford

Appendices

Wetlands Pond
City West, Dublin

A. Guidance Document References

Policy, Legislation & Background

- Water Action Plan 2024 – A River Basin Management Plan for Ireland (September 2024)
- CIRIA report C753 The SuDS Manual (December 2015)
- EU Water Framework Directive (2000/70/EC)
- Transforming our World: The 2030 Agenda for Sustainable Development (UN, 2015)
- EU Urban Wastewater Treatment Directive (April 2024)
- Project Ireland 2024 National Planning Framework (February 2018)
- 15-Minute City: Decomposing the New Urban Planning Eutopia, Pozoukidou, G & Chatziyiannaki, Z (2021)
- Advice Note 5 Road and Street Drainage using Nature-based Solutions – Design Manual for Urban Roads & Streets (DMURS) (July 2023)
- National Transport Authority (NTA) Greening and Nature-based SuDS for Active Travel Schemes (September 2023)
- Dublin City Council Sustainable Design & Evaluation Guide (2021)
- Dublin City Council Green & Blue Roof Guide (2021)
- Southern Regional Assembly Blue Green Infrastructure & Nature-based Solutions Framework (2022)
- Nature Based Management of Urban Rainwater and Urban Surface Water Discharges, A National Strategy (May 2024)
- Sustainable Residential Development and Compact Settlements Guidelines for Planning Authorities (January 2024)
- Rainwater Management Plans Guidance for Local Authorities (May 2024)

NbS Toolbox

For all Toolbox Features refer to the relevant sections of :

- CIRIA SuDS Manual 2015
- CIRIA Guidance on the construction of SuDS (C768)
- NTA Greening anf Nature-based SuDS for Active Schemes (2023)

Feature specific reference documents given below:

Swales

- Advice Note 5 Road and Street Drainage using Nature-based Solutions – Design Manual for Urban Roads and Streets

Tree Pits

- Trees in Hard Landscape: A Guide for Delivery, Tree Design Action Group (TDAG)
- Advice Note 5 Road and Street Drainage using Nature-based Solutions – Design Manual for Urban Roads and Streets

Detention Basins

- CIRIA Small Embankment Reservoirs, Report R 161 (1996)
- Ponds & Wetlands
- CIRIA Small Embankment Reservoirs, Report R 161 (1996)

Green & Green-Blue Roofs

- Dublin City Council – Green & Blue Roof Guide 2021
- Irish Building Regs (Technical Guidance Document B – Fire Safety)

Proprietary Reinforced Grass Systems

- Design Manual for Urban Roads & Streets – Advice Note 5 Roads and Street Drainage using Nature-based Solutions
- Reinforced Grass Paving, Paving Expert [https://www.pavingexpert.com/grasspav]
- GrassConcrete Design Guide 2022

References in relation infiltration given below:

- BRE (2016) Soakaway Design, BRE Digest 365, Building Research Establishment, Bracknell, UK (ISBN: 0-85125-502-7)
- Bettess, R (1996) Infiltration drainage – manual for good practice (R156)
- Volume 4 Section 2 Part 1 of the National Roads Authority Design Manual for Roads & Bridges
- Groundwater Protection Schemes Report, Geological Surveys Ireland, 1999
- **Filter Drains**
- BRE (2016) Soakaway Design, BRE Digest 365, Building Research Establishment, Bracknell, UK (ISBN: 0-85125-502-7)
- CIRIA SuDS Manual 2015 – Chapter 16
- Higgins, N, Johnston, P, Gill, L, Bruen, M & Desta, M (2008) 'Highway runoff in Ireland and management with a 'French Drain' system
- TII Filter Drain Publications: CC-SCD-00101, CC-SCD-00520, CC-SCD-00529, CC-SCD-00540, CC-SCD00542

B. Water Quality

The following have been adapted from the **CIRIA (C753) SuDS Manual**. The CIRIA Simple Index Approach should be referred back to in all cases as the primary source of information for water quality calculations.

Where discharges to groundwater are proposed, please refer to the CIRIA Simple Index Approach tool for mitigation indices

Land Use	Pollution Hazard Level	Total Suspended Solids (TSS)	Metals	Hyrdocarbons
Residential Roofs	Very Low	0.2	0.2	0.2
Other roofs, typically commercial / industrial roofs	Low	0.3	0.2 (up to 0.8 where there is potential for metals to leach from the roof)	0.05
Individual property driveways, residential car parks, low traffic roads (cul-de-sacs, homezones and general access roads) and non-residential car parking with infrequent change (schools, offices), < 300 traffic movements/day	Low	0.5	0.4	0.4
Commercial yard and delivery areas, non-residential car parking with frequent change (hospitals, retail), all roads except low traffic roads and trunk roads/motorways1	Medium	0.7	0.6	0.7
Sites with heavy pollution (haulage yards, lorry parks, highly frequented lorry approaches to industrial estates, waste sites). Sites where chemicals and fuels (other than domestic fuel oil) are to be delivered, handled, stored, used or manufactured; industrial sites; trunk roads and motorways	High	0.8	0.8	0.9

These should only be used if considered appropriate as part of a detailed risk assessment. When dealing with high hazard sites, the environmental regulator should first be consulted for pre-permitting advice. This will help determine the most appropriate approach to the development of a design solution.

Table A: Pollution Hazard Indices for different land use classifications (refer to CIRIA (C753) SuDS Manual)

Refer to the Nature-based Solutions Toolbox (Chapter 3, pages 13-22)

	Mitigation Indices		
Types of NbS Component	Total Suspended Solids (TSS)	Metals	Hyrdocarbons
Filter Drain	0.4	0.4	0.4
Swale	0.5	0.6	0.6
Bioretention Systems	0.8	0.8	0.8
Detention Basin	0.5	0.5	0.6
Pond	0.7	0.7	0.5
Wetland	0.8	0.8	0.8
Proprietary Treatment Systems	These must demonstrate that they can address each of the contaminant types to acceptable levels for frequent events up to approximately the 1 in 1 year return period event, for inflow concentrations relevant to the contributing drainage area.		

Filter Drain: Filter drains can remove coarse sediments, but their use for this purpose will have significant implications with respect to maintenance requirements, and this should be taken into account in the design and Maintenance Plan.

Pond and Wetland: Ponds and wetlands can remove coarse sediments, but their use for this purpose will have significant implications with respect to the maintenance requirements and amenity value of the system. Sediment should normally be removed upstream, unless they are specifically designed to retain sediment in a separate part of the component, where it cannot easily migrate to the main body of water.

Wetland: Where a wetland is not specifically designed to provide significantly enhanced treatment, it should be considered as having the same mitigation indices as a pond.

Table B: Indicative NbS mitigation indices for discharges to surface waters (refer to CIRIA (C753) SuDS Manual)

C. Groundwater Protection Matrix Responses

The Groundwater Protection Scheme Report details the groundwater protection zones and response matrix.

As referred to in Section 2.2 the conditions for each level of response are supplied in this appendix. It should be noted that the Groundwater Protection Scheme report does not prescribe responses and leaves the response levels to the reviewing body to determine in relation to the potentially polluting activity.

The information shown in this section are the responses contained within **TII Publication: DN-DNG-03065 - Road Drainage and the Water Environment (2015)**.

Information regarding individual activities or for specific counties can be found on the **Geological Survey Ireland website**[i].

R1

Acceptable subject to minimum design standards in the NRA DMRB and Notes 1 & 2

i https://www.gsi.ie/en-ie/programmes-and-projects/groundwater/projects/protecting-drinking-water/what-is-drinking-water-protection/county-groundwater-protection-schemes/Pages/Groundwater-Protection-Scheme-Reports.aspx.

R2(1)

Acceptable subject to minimum design standards in the NRA DMRB and to meeting the following requirements:

1. There is a consistent minimum thickness of 1m unsaturated subsoil, or 2m in areas of karstified rock (Rk and Lk), beneath the invert level of the drainage system (Note 1)
2. During all stages of design particular attention must be paid to the presence of karst features and additional assessments undertaken if required
3. During all stages of design particular attention must be paid to receptors (such as: public wells, group schemes, industrial water supply sources and springs) and additional assessments undertaken if required

R2(2)

Acceptable subject to minimum design standards in the NRA DMRB, meeting requirements 1, 2 and 3 (above) and the following additional requirements:

4. Where the subsoil is classed using BS5930 as: SAND, GRAVEL or SILT (in circumstances where the clay content is <10%) and/or is underlain by limestone bedrock, there is a consistent minimum thickness of 2m unsaturated subsoil beneath the invert level of the drainage system
   - OR -
   There is a minimum consistent unsaturated thickness of 1m of "appropriate material" (Note 3) either natural or man-made beneath the invert level of the point of discharge
5. Where a gravel aquifer is present, a consistent minimum thickness of 3m unsaturated subsoil beneath the invert level of the drainage system to be present

R2(3)

Acceptable subject to minimum design standards in the NRA DMRB, meeting rquirements 1, 2, 3, 4, and 5 (above and left) and the following additional requirements:

6. The drainage system shall be at least 15m away from karst features that indicate enhanced zones of high bedrock permeability (eg swallow holes and doclines [collapse features])
7. The site investigation shall pay particular attention to the possibility of instability in these karst areas

R3(1)

Not generally acceptable, unless requirement 1, 2, 3 and 4 (above and left) and the following additional requirements are met:

8. If discharge to surface water is not possible then additional assessments by an appropriately qualified groundwater specialist are required to determine the risk to groundwater resources (the aquifer)

R3(2)

Not generally acceptable, unless requirement 1, 2, 3, 4, 5 (in karst areas), 6 (in karst areas), 7 and 8 (above and left) and the following additional requirements are met:

9. A risk assessment undertaken by a qualified hydrogeologist demonstrates that there will be no significant impact to groundwater or receptors
   - AND -
10. A treatment system which treats pollutants through filtration, sedimentation, absorption etc should be incorporated into the system prior to discharge

R4

Not acceptable

D. Nature-based Solutions Methodology

This appendix uses an example site where traditional hard drainage methods have been used and compares the strategy against an NbS design of the same site.

The methodology of these concept designs is detailed and applied to an urban residential site.

The Small Edge of Town Development example (shown previously in Section 4.1) is of a traditional cul-de-sac style design with thirty-three homes.

Traditional Hard Drainage Approach

The traditional drainage approach applied to this site shows a large single location of runoff control (an attenuation tank) with a petrol interceptor (to control water quality) and a flow control (limited to greenfield rate using the IH124 equation[i]) connected into the existing surface water sewer system (see Figure A).

i The IH124 method is an outdated approach, further discussion of which can be found later in this section (p55) under the determination of discharge rate section

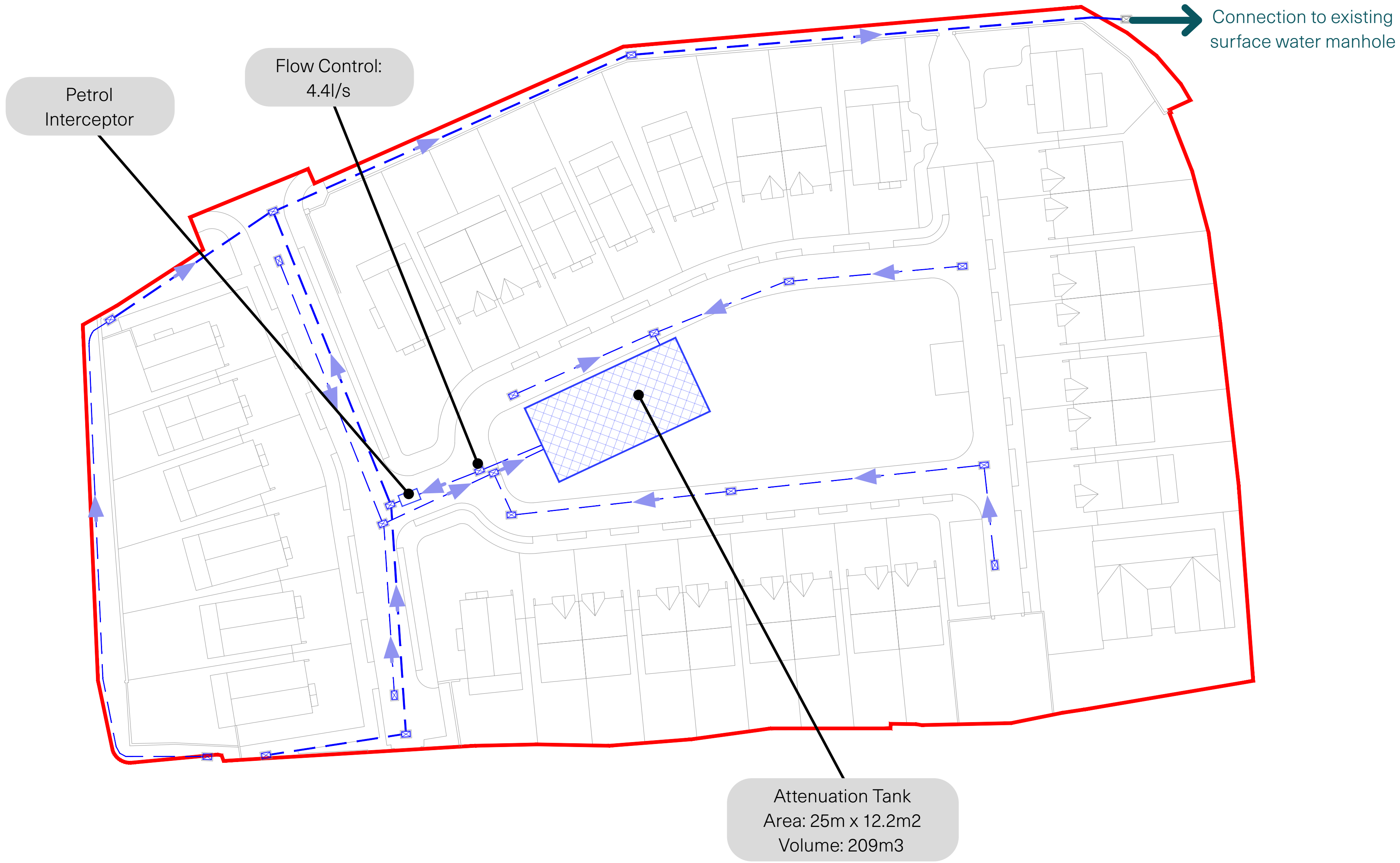


Figure A: Urban Residential Site - Traditional Approach

Refer to Chapter 4, pages 23-37 for case studies across different typologies. This is an example of the working methodology for one of the presented case studies: Small Edge of Town Development.

Outline Design Methodology

1. Define Existing Site information,

a. Location

The example site is of an urban nature with a strong propensity for active travel modes. Figure B (below) shows the location of the site, within the wider urban network – this demonstrates that the local centre is just over a 15-minute walk from the site.

In line with the Sustainable Residential Development and Compact Settlements guidance, the site should prioritise compact growth at an appropriate density. This categorisation and wider movement strategy impacts NbS opportunities, shifting the requirements for hard landscaped parking or highway towards softer Nature-based Solutions.

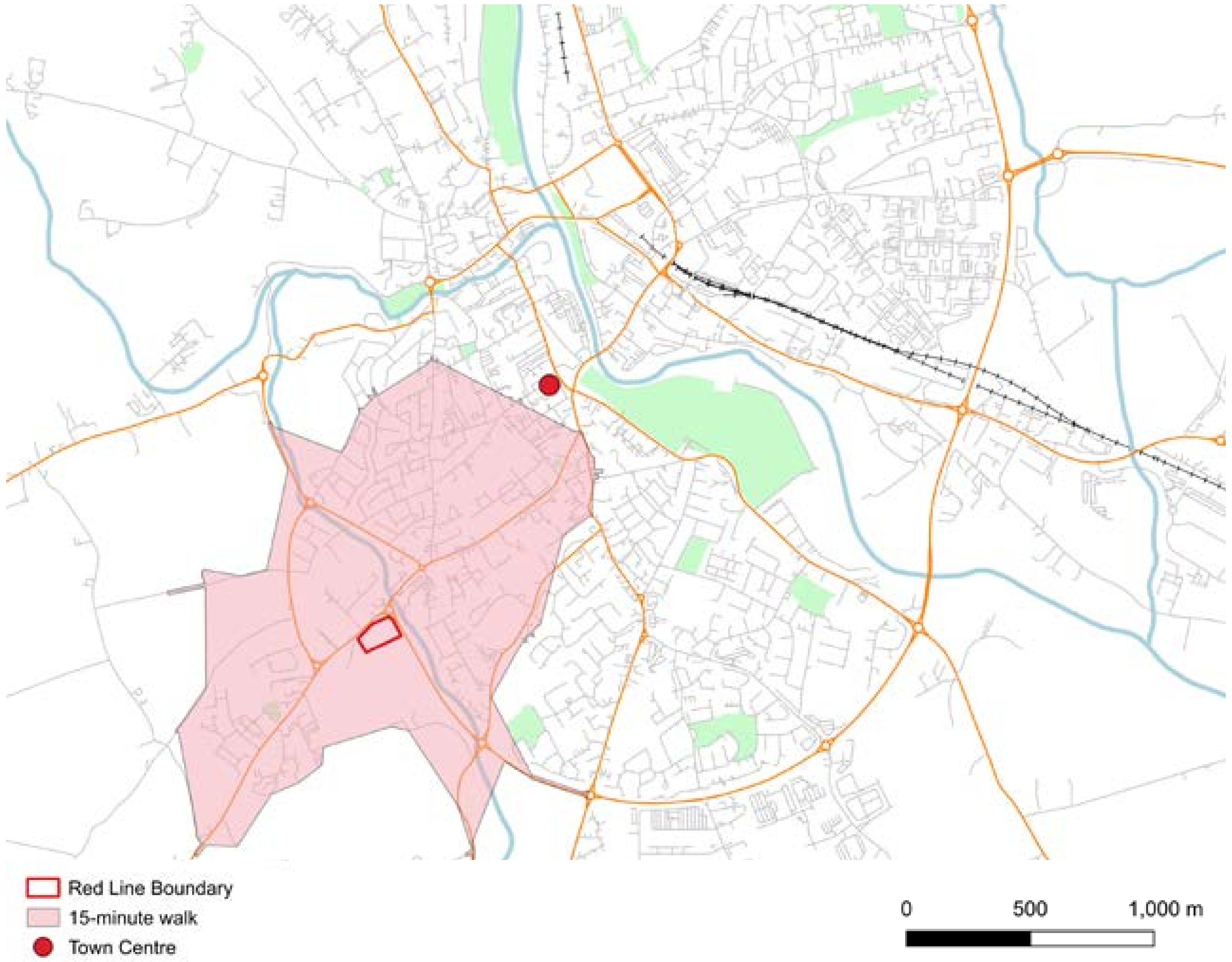


Figure B: Urban Residential Site - Site Location

b. Topography

The topography of the site is intertwined with the overland flow routes. A clear understanding of the site topography allows for an understanding of where the water is likely to go, how best to design an architectural solution to the site such that it works with the existing contours and flow rout es and where water should be locally managed. Figure C (below) shows the topography and flow routes of the existing site with all contours displaced showing the elevation in mAOD.

Definition: metres Above Ordinance Datum

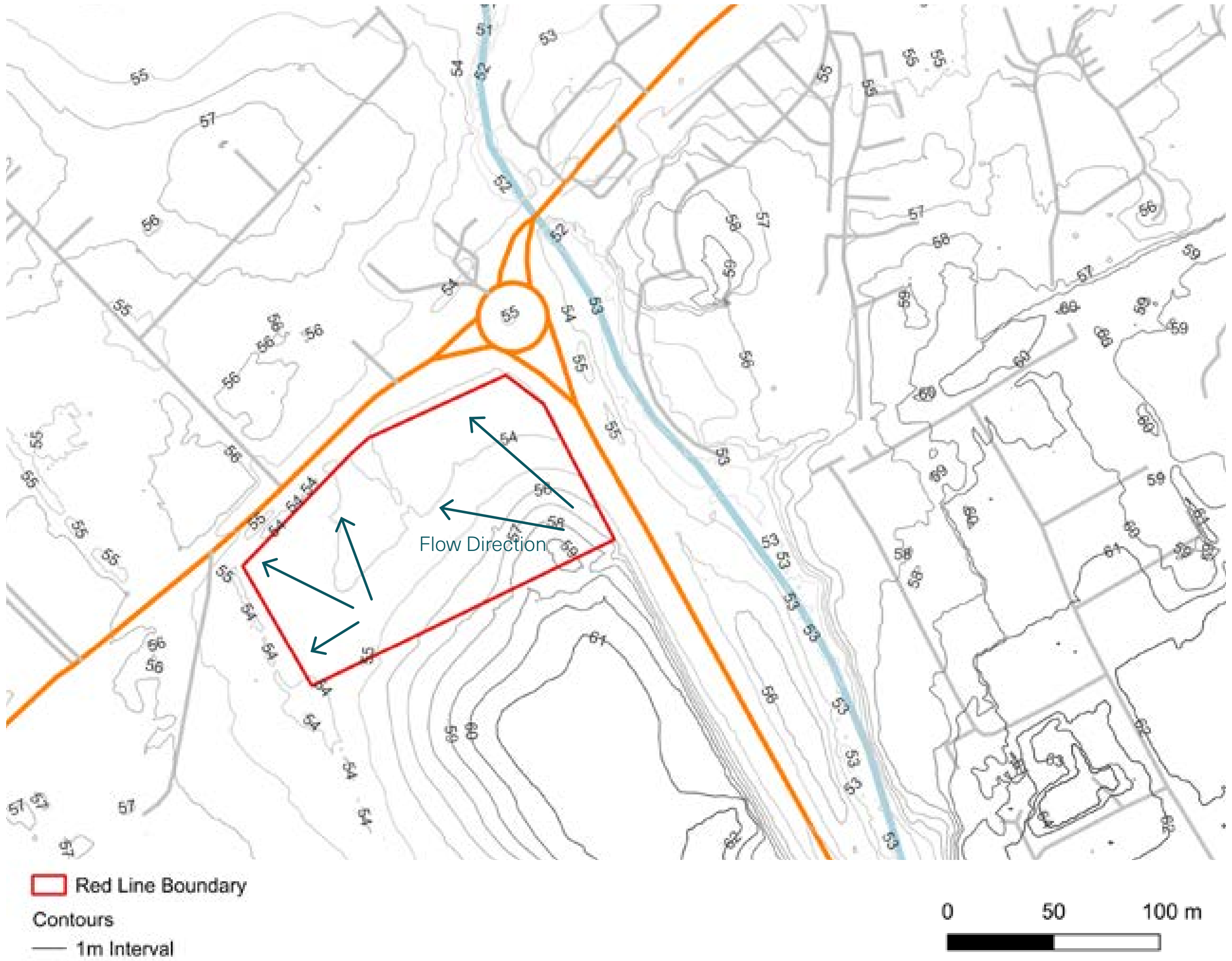


Figure C: Urban Residential Site – Topography

c. Flood Risk

The flood risk profile of the site, see Figure D (below), shows the northwestern most corner of the site lies within Flood Zone B, with a smaller segment lying within Flood Zone A.

- Flood Zone A refers to an area with the highest risk of flooding from rivers (that being a more than 1% probability or greater than 1-in-100 for river flooding)
- Flood Zone B refers to an area with a moderate risk of flooding from rivers (that being a probability of between 0.1% and 1% or between a 1-in-100 or 1-in-1000-year event)

The flood risk dictates where on the site development is most appropriate and in the areas at risk of flooding, what development is appropriate there. The flood mapping shown here is for fluvial flooding only and that all flooding sources, including pluvial and groundwater, should be considered.

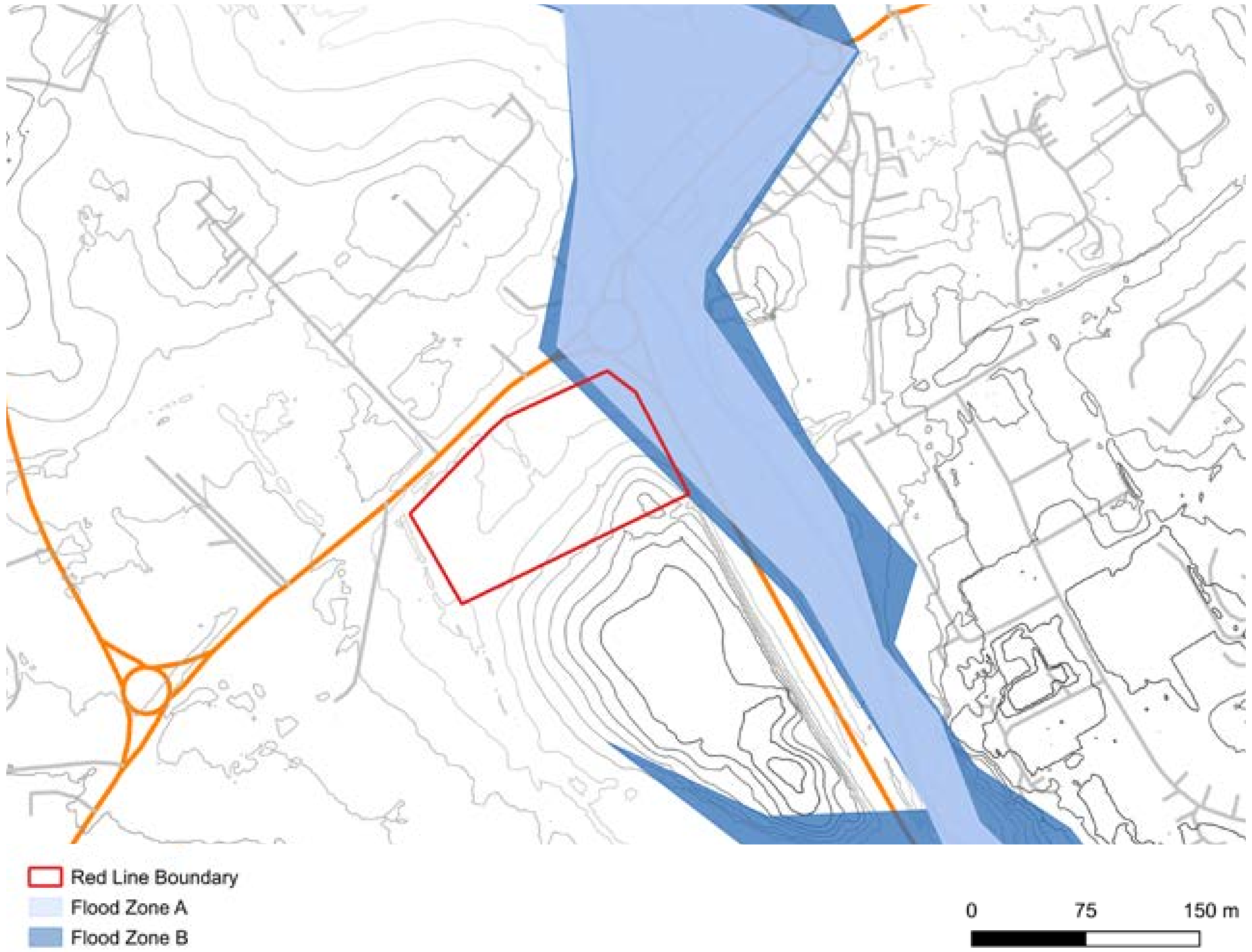


Figure D: Urban Residential Site - Flood Risk

d. Geology

Existing geology impacts the form which NbS can take. Where the geology is favourable, with good infiltration rates, this can allow for an infiltration led solution.

For the Small Edge of Town Site, the Geological Survey Quaternary Sediments mapping, (see Figure E, below), indicate that the majority of the site is underlain with 'Gravels derived from Limestone'. This indicates that there is infiltration potential and therefore, at this high-level, a conservative estimate (see p11) of 3×10^{-4}m/s has been assumed. This estimate is subject to further detailed infiltration testing on site but provides a basis for outline design.

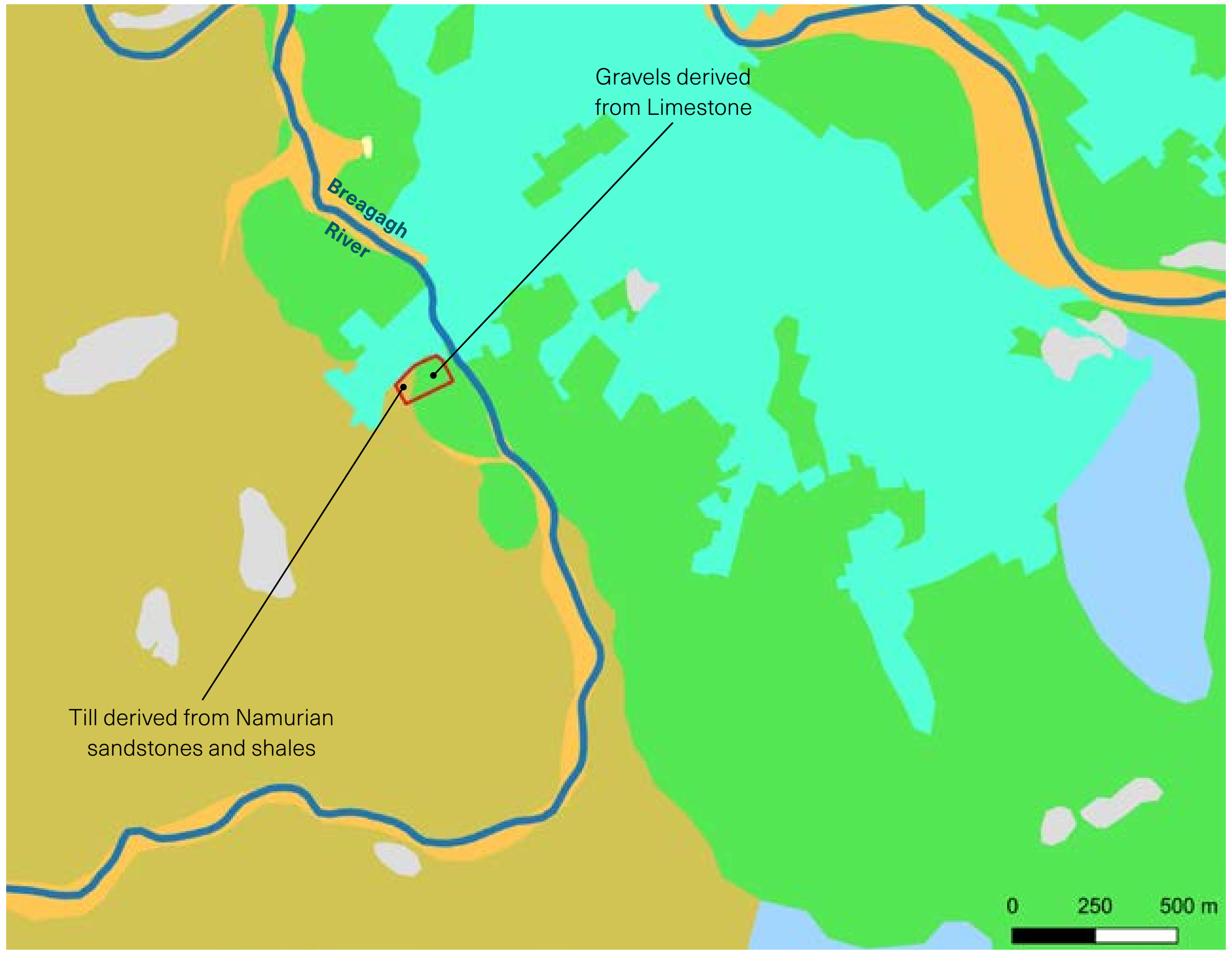


Figure E: Urban Residential Site - Superficial Geology

Determination of Site Areas

The site is broken down into areas of permeability and areas of impermeability, see Figure F (below). The area of impermeability is taken as the drained area of the site in future calculations.

Urban Creep Considerations

The site areas, shown in Figure F (below), assume that the rear gardens of the properties are permeable. A conservative 10% urban creep factor has been applied to the impermeable area to give a modelled impermeable area of 1.07ha.

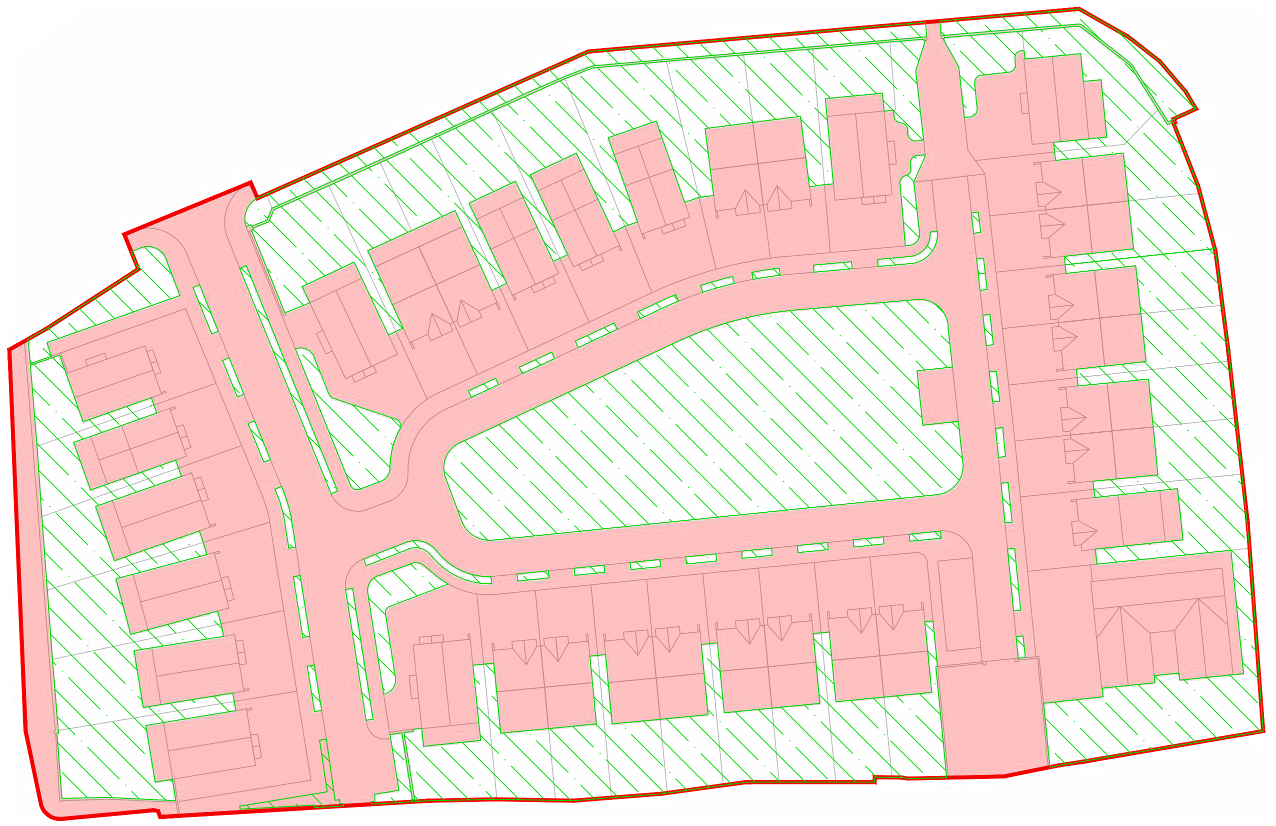


Figure F: Urban Residential Site – Topography

Hierarchy of Surface Water Discharge

Runoff discharges should follow the hierarchy of surface water discharge (see p9). Each method of discharge should be considered to its fullest, prior to the consideration of the next sequential option. It should be noted that discharging runoff from a site may use one or more means of discharge

1. Use surface water runoff as a resource

2. Provide interception of rainfall through the use of nature-based SuDS approaches

3. Where appropriate, infiltrate runoff into the ground

4. Discharge to an open surface water drainage system

5. Discharge to a piped surface water drainage system (requires a connection agreement with Local Authority)

6. Discharge to a combined sewer (requires a connection agreement with Uisce Éireann)

Determination of Discharge Rate

The Greenfield Runoff Rate for the site should be determined using the Flood Studies Update (FSU) department website and the FSU 7-variable equation. The equation is listed below:

$$QMED_{Rural} = 1.257 \times 10^{-5} (AREA)^{0.937} (BFIsoil)^{-0.922} (SAAR)^{1.306} (FARL)^{2.217} (DRAIND)^{0.341} (S1085)^{0.185} (1+ARTDRAIN)^{20.408}$$

$$QMED_{Urban} = QMED_{Rural} (1+URBTEXT)^{1.482}$$

$$QBAR = QMED_{Urban} = 3.05 \text{ l/s}$$

where:
URBTEXT = Index of urban extent
QMED = median annual flow rate, the 1 in 2 year event.
QBAR = annual average flow rate, approximately equal to a return period of 2.3 years.

QMED has been converted to QBAR in this example using a factor of 1.05.

where:
AREA = Catchment area (km2),
BFIsoil = Base flow index derived from soils,
SAAR = Standard period average annual rainfall (1961 – 1990) (mm)
FARL = Flood attenuation by reservoirs and lakes
DRAIND = Drainage density
S1085 = Mainstream slope
ARTDRAIN2 = Percentage of the catchment river network that is included in the drainage schemes

The values in Table C (below) are taken from the FSU department website. Variables can be determined manually using the Flood Studies Update (FSU) Stations, Node Points, Catchment Boundaries and Physical Catchment Descriptors[i].

Variable	Value
Catchment Area (km2)	0.016
BFIsoil	0.625
SAAR (mm)	945.44
FARL	0.998
DRAIND (km/km²)	0.913
S1085 (m/km)	0.779
ARTDRAIN2	0.0031
URBEXT	0.00098

Table C: Urban Residential Site Greenfield Runoff Variables

Infiltration Rate

The majority of the site is underlain by 'Gravels derived from Sandstone' which gives a conservative infiltration rate of 3×10^{-4} m/s. This is subject to confirmation from on-site testing.

i available on the DATA.GOV.IE website

Discharge of Runoff

In line with the hierarchy of surface water discharge, infiltration is to be used to model the storage estimate for the site and where infiltration is unfeasible or unable to fully drain the site QBAR is to be used for additional discharges.

In 2005, the Office of Public Works (OPW) began the Flood Studies Update (FSU) Programme, in line with the recommendation of the 2004 Report of the Flood Policy Review Ground which stated that the development of new or recalibrated flood estimation methods in Ireland could significantly improve the quality and facility of flood estimation for the purposes of flood risk management.

The FSU programme has developed the 7-variable equation used throughout this guidance document which is recommended as the preferred method for flood estimation in Ireland.

This preference over other commonly used methods, such as the IH124, is based on research undertaken by the FSU [reference - '09-Flood Estimation in Small and Urbanised Catchments in Ireland (2012), Gebre, F & Nicholson, O, National Hydrology Conference' and 'FSU Works Package 2.3']. Testing the methods using regression equations against catchment data found that the IH124 significantly overestimates the runoff rate with the FSU 7-variable equation providing a much accurate result.

To access to FSU information, email: FSUhelpdesk@opw.ie

Climate Change Factors

The determination of the climate change allowance follows the guidance set out in the National Adaptation Framework.

The Mid-Range Future Scenario (MRFS) is to be considered for most development scenarios whilst the High-End Future Scenario (HEFS) is to be considered for high value, high vulnerability development which cannot be relocated.
The example site falls within the remit of the MRFS and is therefore to be designed to accommodate the 1-in-100-year + 20% climate change storm event.

Parameters	Mid-Range Future Scenario (MRFS)	High-End Future Scenario (HEFS)
Extreme Rainfall Depths	+20%	+30%
Peak Flood Flows	+20%	+30%
Mean Sea Level Rise	+500mm	+1000mm

Table D: Climate Change Allowances (Source: Flood Risk Management Climate Change Sectoral Adaptation Plan)

Estimation of Storage Requirements

For the Small Edge of Town site, the storage has been estimated using Causeway Flow. Storage estimations can be done using any industry-standard drainage software.

The storage estimate for the site, using infiltration only, is $502m^{3}$ with the application of a conservative safety factor of 10 (see p10). The factor of safety is applied to the infiltration rate, in this case $3x10^{-4}$ m/s by the following means:

Infiltration Rate (used in model) = Assumed Infiltration Rate/FoS = $3x10^{-4}/10 = 3x10^{-5}$m/s

Catchment Area Derivation

Site catchment areas, based on the topography (see Figure G), should be derived to allow for drainage design to consider control of runoff as close to the source as possible. Derived catchments should have a required storage expressed in terms of m^3 for each m^2 of developed area. This allows for the dispersal of NbS features across each sub-catchment as opposed to the allocation of storage in a single location (such as through the use of a tank). This approach maximises opportunities for NbS across the whole site and integrates the NbS thinking at an early stage, allowing for:

- Easy storage allocation to each sub-catchment
- More flexibility during design iterations
- More transparent figure for evaluation

The m^3/m^2 value refers to the calculated attenuation volume/developed site area. In the Small Edge of Town example this value is equal to 0.05 m^3/m^2. Expressed in full this means that for every m^2 of site area $0.05m^3$ of attenuation storage is required.

Water Quality Management – Pollution Indices

One of the key components of NbS is the adherence to all four of the principles of SuDS. Best practice for water quality treatment design is listed as follows:

- Manage surface water runoff close to source
- Treat surface water runoff on the surface
- Treat surface water runoff to remove a range of contaminants
- Minimise risk of sediment remobilisation
- Minimise impact from accidental spills

Table E (overleaf), dictates the minimum water quality management requirements for discharges to receiving surface water or groundwater, as dictated in the **CIRIA SuDS Manual (Section 4)**.

For the Small Edge of Town site pollution hazard profile can be obtained based on identified areas of pollution risk (see Table F, overleaf). The CIRIA Simple Index Approach should be consulted for pollution hazards for other risk classifications. The highest pollution level hazard on each site is to be considered.

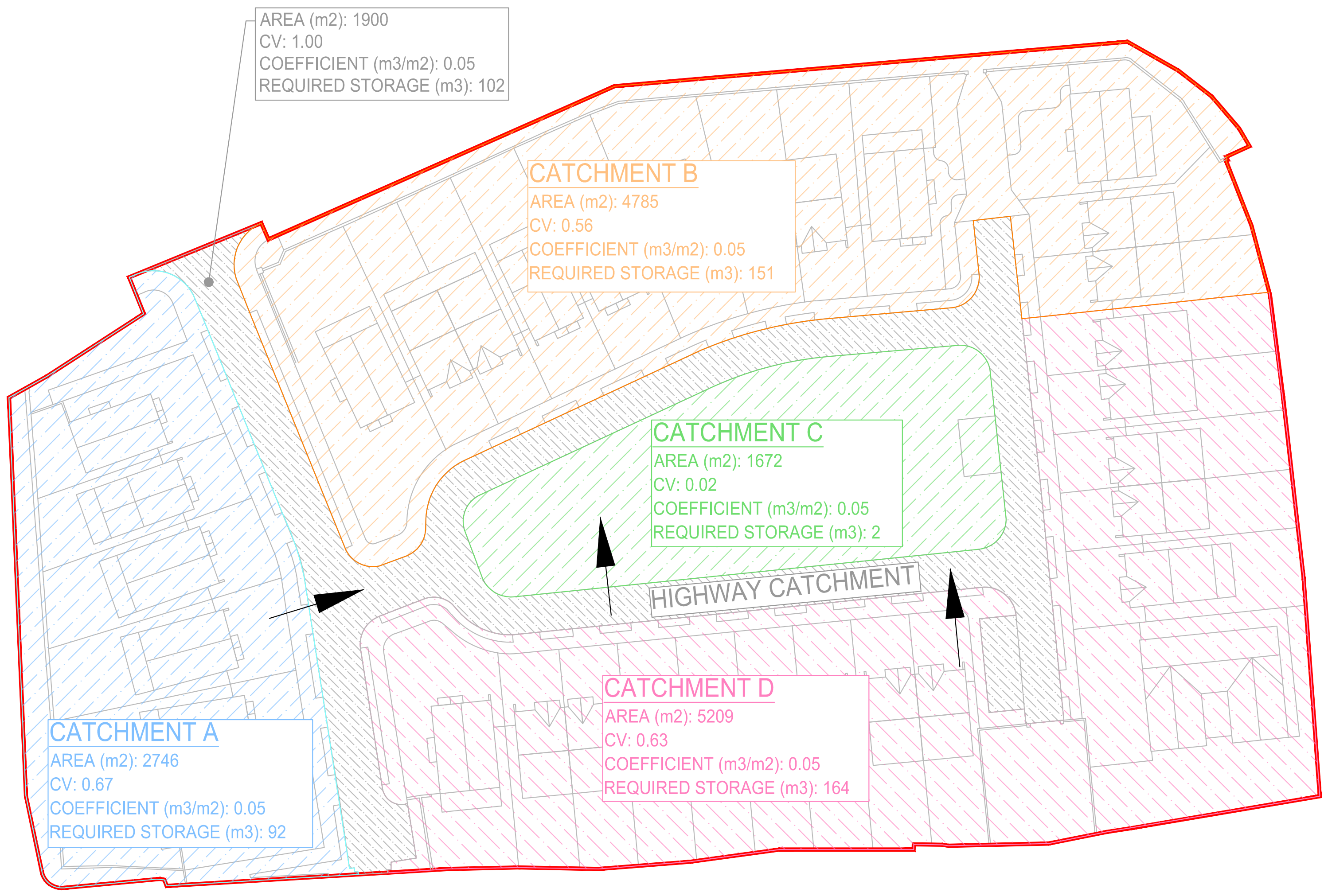


Figure G: Urban Residential Site - Catchments

Land Use	Pollution Hazard Level	Requirements for Discharge
Residential Roofs	Very Low	Removal of gross solids/ sediments
Individual property driveways, roofs (excluding residential), Low traffic roads, Non-residential car parking with infrequent change	Low	Simple Index Approach
Commercial yard and delivery areas, Non-residential car parking with frequent change, All roads (except otherwise mentioned)	Medium	Simple Index Approach
Trunk Roads and Motorways	High	Guidance and risk assessments process set out in HA (2009)
Sites with heavy pollution, Sites where chemical and fuels (other than domestic fuel oil) are to be delivered, handled, stored, used or manufactured, Industrial sites	High	Discharges may require an environmental licence or permit. Obtain pre-permitting advice from the environmental regulator. Risk assessment likely to be required.

Table E: Minimum water quality management requirements for discharges to receiving surface waters and groundwater (Source: Table 4.3 Section 4 CIRIA SuDS Manual)

Land Use	Pollution Hazard Level	Total Suspended Solids	Metals	Hydro-carbons
Residential Roofs	Very Low	0.2	0.2	0.05
Individual property driveways, roofs, Low traffic roads, Car parking ... (see Table E for full description)	Low	0.5	0.4	0.4

Table F: CIRIA Simple Index Approach - pollution hazard indices for different land use classifications

Minimising & Maximising NbS

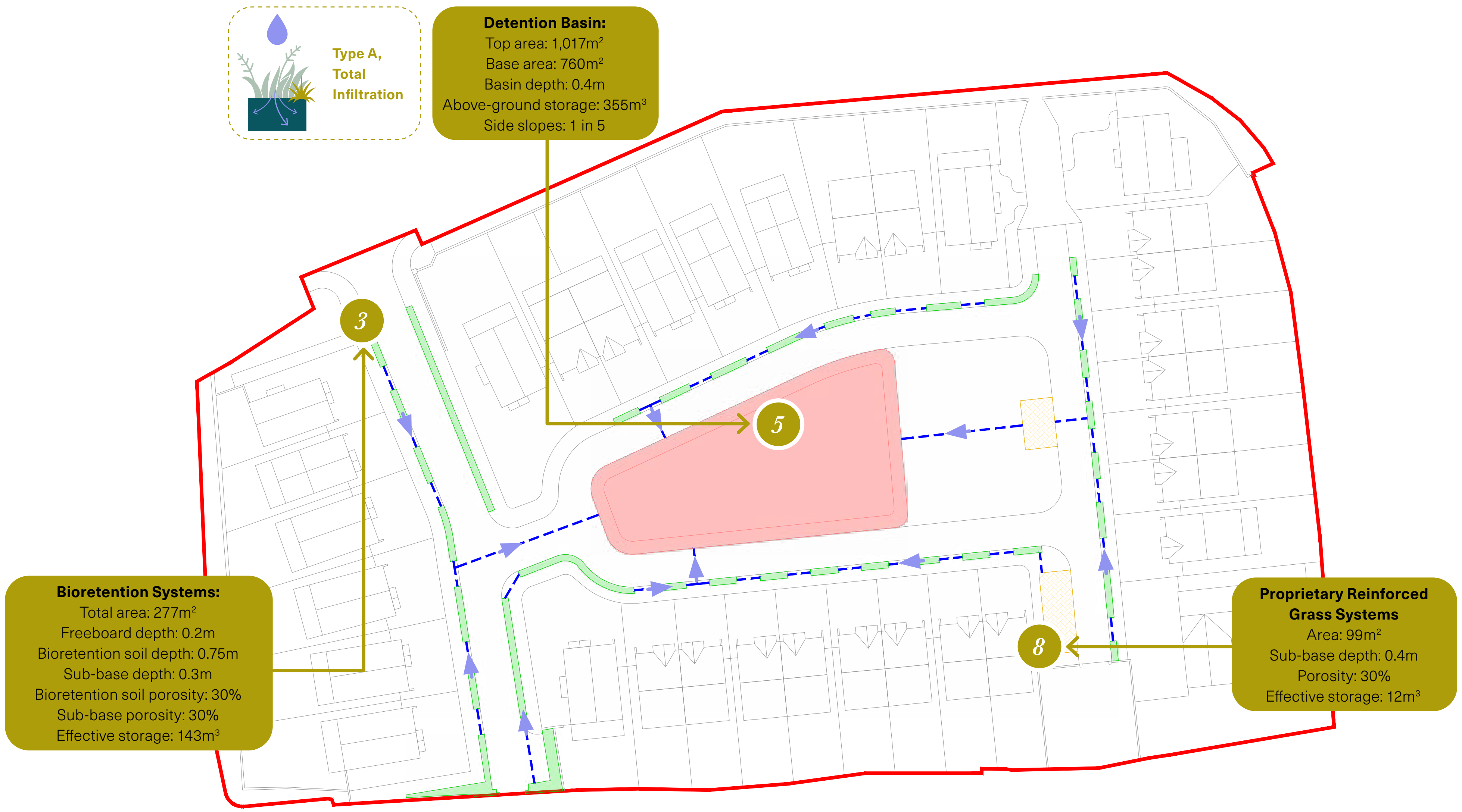
Min/Max diagrams covering a whole site demonstrate the wide ranging ways in which NbS features can be applied. An example of this approach for the Small Edge of Town site is shown in Figure H (below). It should be noted that the NbS Min/Max diagram does not show the full gamut of NbS options but instead categorises possible areas of NbS interventions.

Figure H: Urban Residential Site - NbS Min/NbS Max

NbS Approach Design

An NbS approach for the Small Edge of Town site can be seen in Figure I (see also p25).

The NbS design uses a combination of NbS features to attenuate runoff, with larger storm events being directed toward the central detention basin before infiltration into the ground.



This drawing references the Nature-based Solutions Toolbox (Chapter 3, pages 12-21)

Figure I: Urban Residential Site - NbS Design

Water Quality Management – NbS Feature Mitigation Indices

In determining the appropriateness of a design in managing the risk of pollution to surface and groundwater on a site, the mitigation indices for NbS features should be determined. For the site to deliver appropriate treatment the NbS features should have pollution mitigation indices such that:

Total NbS Mitigation Index ≥ Pollution Hazard Index

Where the mitigation index of an individual component is insufficient, two components (or more) in series will be required, forming an NbS train, where:

Total NbS Mitigation Index = Mitigation Index$_1$ + 0.5(Mitigation Index$_2$)

A factor of 0.5 is used to account for the reduced performance of secondary or tertiary components associated with already reduced inflow concentrations.

The CIRIA Simple Index Approach provides mitigation indices for NbS feature discharges to surface waters, and for characteristics of the material overlying the proposed infiltration surface for discharges to groundwater. For the Small Edge of Town site, the runoff is designed to infiltrate with no upstream NbS treatment component. As such its NbS mitigation indices for discharges to groundwater (see Table G, below).

As the NbS mitigation indices for TSS (0.8), Metals (0.8) & Hydrocarbons (0.8) are all greater than the worst case pollution indices, those being TSS (0.5), Metals (0.4) & Hydrocarbons (0.4) this demonstrates that the pollution mitigation proposed by the NbS design is sufficient.

Characteristics of the material overlying the proposed infiltration surface, through which the runoff percolates	Total Suspended Solids	Metals	Hydro-carbons
Bioretention underlain by a soil with good contaminant attenuation potential of at least 300mm in depth	0.8	0.8	0.8

Table G: CIRIA Simple Index Approach - pollution hazard indices for different land use classifications

E. Nature-based Solutions Maintenance Schedules

1 Filter Drains

for further information refer to p14

	Frequency	Maintenance Responsibility
Regular Maintenance		
Remove litter (including leaf litter) and debris from Filter Drain surface, access chambers and pre-treatment devices	Monthly (or as required)	To be confirmed
Inspect Filter Drain surface, inlet/outlet pipework and control systems for blockages, clogging, standing water and structural damage	Monthly	To be confirmed
Inspect pre-treatment systems, inlets and perforated pipework for silt accumulation, and establish appropriate silt removal frequencies	Six monthly	To be confirmed
Remove sediment from pre-treatment devices	Six monthly (or as required)	To be confirmed
Occasional Maintenance		
Remove or control tree roots where they are encroaching the sites of the fitler drain, using recommended methods	As required	To be confirmed
At locations with high pollution loads, remove surface geotextile and replace, and wash or replace overlying filter medium	Five yearly, or as required	To be confirmed
Clear perforated pipework of blockages	As required	To be confirmed

2 Swales

for further information refer to p15

	Frequency	Maintenance Responsibility
Regular Maintenance		
Remove litter and debris	Monthly (or as required)	To be confirmed
Cut grass – to retain grass height within specified design range	Monthly during growing season (or as required)	To be confirmed
Manage other vegetation and remove nuisance plants	Monthly at start, then as required	To be confirmed
Inspect inlets, outlets, and overflows for blockages, and clear if required	Monthly	To be confirmed
Inspect infiltration surfaces for ponding, compaction, silt accumulation, record areas where water is ponding for > 48 hours	Monthly, or when required	To be confirmed
Inspect vegetation coverage	Monthly for 6 months, quarterly for 2 years, then half yearly subsequently	To be confirmed
Inspects inlets and facility surface for silt accumulation, establish appropriate silt removal frequencies	Half yearly	To be confirmed
Occasional Maintenance		
Reseed areas of poor vegetation growth, alter plant types to better suit conditions, if required	As required or if bare soil is exposed over 10% or more of the Swale treatment area	To be confirmed
Remedial Actions		
Repair erosion or other damage by re-turfing or reseeding	As required	To be confirmed
Relevel uneven surfaces and reinstate design levels	As required	To be confirmed
Scarify and spike topsoil layer to improve infiltration performance, break up silt deposits and prevent compaction of the soil surface	As required	To be confirmed
Remove build-up of sediment on upstream gravel trench, flow spreader or at top of filter strip	As required	To be confirmed
Remove and dispose of oils or petrol residues using safe standard practices	As required	To be confirmed

3 Bioretention Systems

for further information refer to p16

	Frequency	Maintenance Responsibility
Regular Inspections		
Inspect infiltration surfaces for silting and ponding, record de-watering time of the facility and assess standing water levels in underdrain (if appropriate) to determine if maintenance is necessary	Quarterly	To be confirmed
Check operation of underdrains by inspection of flows after rain	Annually	To be confirmed
Assess plants for disease infection, poor growth, invasive species etc and replace as necessary	Quarterly	To be confirmed
Inspect inlets and outlets for blockages	Quarterly	To be confirmed
Regular Maintenance		
Remove litter and surface debris and weeds	Quarterly (or more frequently for tidiness or aesthetic reasons)	To be confirmed
Replace any plants, to maintain planting density	As required	To be confirmed
Remove sediment, litter, and debris build-up from around inlets or from forebays	Quarterly to biannually	To be confirmed
Occasional Maintenance		
Infill any holes or scour in the filter medium, improve erosion protection if required	As required	To be confirmed
Repair minor accumulations of silt by raking away surface mulch, scarifying surface of medium and replacing mulch	As required	To be confirmed
Remedial Actions		
Remove and replace filter medium and vegetation above	As required but likely to be >20 years	To be confirmed

4 Tree Pits

for further information refer to p17

	Frequency	Maintenance Responsibility
Regular Maintenance		
Remove litter and debris	Monthly (or as required)	To be confirmed
Manage other vegetation and remove nuisance plants	Monthly (at start, then as required)	To be confirmed
Inspect inlets and outlets	Inspect monthly	To be confirmed
Occasional Maintenance		
Check tree health and manage tree appropriately	Annually	To be confirmed
Remove silt build-up from inlets and surface and replace mulch as necessary	Annually, or as required	To be confirmed
Water trees/vegetation	As required (in periods of drought)	To be confirmed
Remedial Actions		
Remove and replace filter medium and vegetation above	Half yearly	To be confirmed

5 Detention Basins

for further information refer to p18

	Frequency	Maintenance Responsibility
Regular Maintenance		
Remove litter and debris	Monthly	To be confirmed
Cut grass – for spillways and access routes	Monthly (during growing season), or as required	To be confirmed
Cut grass – meadow grass in and around basin	Half yearly (before Nesting Season and Autumn)	To be confirmed
Manage other vegetation and remove nuisance plants	Monthly (at start, then as required)	To be confirmed
Inspect inlets, outlets, and overflows for blockages, and clear if required	Monthly	To be confirmed
Inspect banksides, structures, pipework etc for evidence of physical damage	Monthly	To be confirmed
Inspect inlets and facility surface for silt accumulation. Establish appropriate silt removal frequencies.	Monthly (for Year 1), then annually or as required	To be confirmed
Check any penstocks and other mechanical devices	Annually	To be confirmed
Tidy all dead growth before start of growing season	Annually	To be confirmed
Remove sediment from inlets, outlet and forebay	Annually (or as required)	To be confirmed
Manage wetland plans in outlet pool – where provided	Annually	To be confirmed
Occasional Maintenance		
Reseed areas of poor vegetation growth	As required	To be confirmed
Prune and trim any trees and remove cuttings	Every 2 years, or as required	To be confirmed
Remove sediments from inlets, outlets, forebay and main basin when required	Every 5 years, or as required (likely to be minimal requirements where effective upstream source control is provided)	To be confirmed
Remedial Actions		
Repair erosion or other damage by reseeding or re-turfing	As required	To be confirmed
Realignment of rip-rap	As required	To be confirmed
Repair/rehabilitation of inlets, outlets, and overflows	As required	To be confirmed
Relevel uneven surfaces and reinstate design levels	As required	To be confirmed

6 Ponds & Wetlands

for further information refer to p19

	Frequency	Maintenance Responsibility
Regular Maintenance		
Remove litter and debris	Monthly (or as required)	To be confirmed
Cut the grass - public areas	Monthly (during growing season)	To be confirmed
Cut the meadow grass	Half yearly (before Nesting Season and Autumn)	To be confirmed
Inspect marginal and bank-side vegetation and remove nuisance plants (for first 3 years)	Monthly (at start, then as required)	To be confirmed
Inspect inlets, outlets, bank-sides, structures, pipework etc for evidence of blockage and/or physical damage	Monthly	To be confirmed
Inspect water body for signs of poor water quality	Monthly (May - October)	To be confirmed
Inspect silt accumulation rates in any fore-bay and in main body of the pond and establish appropriate removal frequencies; undertake contamination testing once some build-up has occurred, to inform management and disposal options	Half yearly	To be confirmed
Check any mechanical devices, eg penstocks	Half yearly	To be confirmed
Hand cut submerged and emergency aquatic plants (at minimum of 0.1m above pond base; include maximum 25% of pond surface)	Annually	To be confirmed
Remove 25% of bank vegetation from water's edge to a minimum of 1m above water level	Annually	To be confirmed
Tidy all dead growth (scrub clearance) before start of growing season (Note: tree maintenance is usually part of overall landscape management contract)	Every 1-5 years, or as required	To be confirmed
Remove sediment from any fore-bay	Every 5 years, or as required	To be confirmed
Remove sediment and planting from one quadrant of the main body of ponds without sediment fore-bay management contract)	With effective pre-treatment, this will only be required rarely, eg every 25-50 years	To be confirmed
Occasional Maintenance		
Remove sediment from the main body of big ponds when pool volume is reduced by 20%	With effective pre-treatment, this will only be required rarely, eg every 25-50 years	To be confirmed
Remedial Actions		
Repair erosion or other damage	As required	To be confirmed
Replant, where necessary	As required	To be confirmed
Aerate pond when signs of eutrophication are detected	As required	To be confirmed
Realign rip-rap or repair other damage	As required	To be confirmed
Repair/rehabilitation of inlets, outlets, and overflows	As required	To be confirmed

7 Green & Green-Blue Roofs

for further information refer to p20

	Frequency	Maintenance Responsibility
Regular Inspections		
Inspect all components including soil substrate, vegetation, drains, irrigation systems (if applicable), membranes and roof structure for proper operation, integrity of waterproofing and structural stability	Annually and after severe storms	To be confirmed
Inspect soil substrate for evidence of erosion channels and identify any sediment sources	Annually and after severe storms	To be confirmed
Inspect drain inlets to ensure unrestricted runoff from the drainage layer to the conveyance or roof drain system	Annually and after severe storms	To be confirmed
Inspect underside of roof for evidence of leakage	Annually and after severe storms	To be confirmed
Regular Maintenance		
Remove debris and litter to prevent clogging of inlet drains and interference with plant growth	Six monthly and annually or as required	To be confirmed
During establishment (ie year one), replace dead plants as required	Monthly	Usually the responsibility of the manufacturer
Post establishment, replace dead plants as required (where >5% of coverage)	Annually (in autumn)	To be confirmed
Remove fallen leaves and debris for deciduous plant foliage	Six monthly or as required	To be confirmed
Remove nuisance and invasive vegetation, including weeds	Six monthly or as required	To be confirmed
Mow grasses, prune shrubs and manage other planting (if appropriate) as required – clippings should be removed and not allowed to accumulate	Six monthly or as required	To be confirmed
Remedial Actions		
If erosion channels are evident, these should be stabilised with extra soil substrate similar to the original material, and sources of erosion damage should be identified and controlled	As required	To be confirmed
If drain inlet has settled, cracked, or moved, investigate and repair as appropriate	As required	To be confirmed

8 Proprietary Reinforced Grass Systems

for further information refer to p21

	Frequency	Maintenance Responsibility
Regular Maintenance		
Brushing and vacuuming (standard cosmetic sweep over whole surface). Maintenance requirement based on site-specific observations of clogging or manufacturer's recommendations – pay particular attention to areas where water runs onto previous surface from adjacent impermeable areas as this area is most likely to collect the most sediment.	Once a year, after Autumn leaf fall, or reduced frequency as required	To be confirmed
Occasional Maintenance		
Stabilise and mow contributing and adjacent areas	As required	To be confirmed
Removal of weeds or management using glyphospate applied directly into the weeds by an applicator rather than spraying	As required – once per year on less frequently used pavements	To be confirmed
Remedial Actions		
Remediate any landscaping which, through vegetation maintenance or soil slip, has been raised to within 50 mm of the level of the paving	As required	To be confirmed
Remedial work to any depressions, rutting and cracked or broken blocks considered detrimental to the structural performance or a hazard to users, and replace lost jointing material	As required	To be confirmed
Rehabilitation of surface and upper substructure by remedial sweeping. More regular maintenance required if infiltration performance is reduced due to significant clogging.	Every 10 to 15 years or as required	To be confirmed
Monitoring		
Initial inspection	Monthly for three months after installation	To be confirmed
Inspect for evidence of poor operation and/or weed growth – if required, take remedial action	Three-monthly, 48 h after large storms in the first six months	To be confirmed
Inspect silt accumulation rates and establish appropriate brushing frequencies	Annually	To be confirmed
Monitor inspection chambers	Annually	To be confirmed

F. Nature-based Solutions Checklist

This NbS Checklist is designed to be used by Local Authorities when corresponding with developers and designers regarding drainage aspects of the proposals. The Local Authorities may request the Checklist be built out and submitted alongside a planning submission. The Checklist acts as a prompt covering all aspects of the NbS design, detailed in this guidance document.

1. Project & Site Details

Project / Site Name (including sub-catchment / stage / phase where appropriate)	
Address & Post Code	
Irish Grid Reference (Easting, Northing)	
Description of proposed work	
Total site area	m^2
Total existing impermeable area	m^2
Total proposed impermeable area	m^2
Fluvial Flood Risk	
Pluvial Flood Risk	
Other Flood Risk (note type and flood risk)	
Overall Flood Risk categorisation	
Existing drainage connection type and location	
Design Name	
Designer Position	
Designer Company	

2. Proposed Discharge Arrangements

2a. Infiltration Feasibility	
Superficial geology classification	
Bedrock geology classification	
Site infiltration rate	m/s
Infiltration rate source	
Depth to groundwater	m below ground level
Aquifer designation	
Groundwater vulnerability categorisation	
Is the site located within a Source Protection Area?	
Is infiltration feasible?	
Justification of feasibility of infiltration	

2b. Drainage Hierarchy	Feasible (Y/N)	Proposed (Y/N)
1. Use surface water runoff as a resource		
2. Provide interception of rainfall through the use of NbS approaches		
3. Where appropriate, infiltrate runoff into the ground		
4. Discharge to an open surface water drainage system		
5. Discharge to a piped surface water drainage system (requires a connection agreement with Local Authority)		
6. Discharge to a combined sewer (requires a connection agreement with Uisce Éireann)		

2c. Proposed Discharge Details	
Proposed discharge location	
Has the owner/regulator of the discharge location been consulted?	

3. Drainage Strategy

3a. Discharge Rates & Required Storage	
Qbar	l/s
Method of Qbar calculation	
Justification of Qbar calculation method	
Climate change allowance used	%
Urban creep	%
Justification of Urban creep %	
Storage requirement for Qbar rate	m^3
Method of storage estimation calculation	
Proposed discharge rate	l/s
Principal method of flow control	
Storage requirement for proposed discharge rate	m^3
m^3/m^2 value	

3b. Proposed NbS Features	Catchment Area (m^2)	Plan Area (m^2)	Storage Volume (m^3)
Filter Drains			
Swales			
Bioretention Systems			
Tree Pits			
Detention Basins			
Ponds & Wetlands			
Green & Green-Blue Roofs			
Proprietary Reinforced Grass Systems			
Total			

4. Water Quality Considerations

4a. Water Quality Considerations	
Land use, as per the CIRIA SuDS Manual Chapter 26	
Corresponding Pollution Hazard level	
Water Quality Mitigation assessment approach	

4b. Pollution Hazard Indices (if CIRIA Simple Index Approach is applicable, otherwise point to document location)	
Total Suspended Solids (TSS)	
Metals	
Hydrocarbons	

4c. Surface / Groundwater Mitigation Indices (if CIRIA Simple Index Approach is applicable, otherwise point to document location)	
Primary NbS Train Mitigation Component	
Secondary NbS Train Mitigation Component	
Tertiary NbS Train Mitigation Component	
Total NbS Mitigation Indicies for each hazard	
Total Suspended Solids (TSS)	
Metals	
Hydrocarbons	
Is the mitigation index of the NbS features proposed for the site sufficient?	

5. Supporting Information

5a. Discharge & Drainage Strategy	Page/Section of Drainage Report
Infiltration feasibility (2a) - geotechnical factual and interpretive reports, including infiltration results	
Drainage hierarchy (2b)	
Proposed drainage details (2c) - utility plans, correspondance / approval from owner/regulator of discharge location	
Discharge rates & storage (3a) - detailed hydrologic and hydraulic calculations	
Proposed NbS features & specifications (3b)	

5b. Other Supporting Details	Page/Section of Drainage Report
Detailed development layout	
Detailed catchment drawings, demonstrating a source control approach to attenuation dispersal	
Detailed drainage design drawings, including exceedance flow routes	
Detailed landscaping plan	
Maintenance plans	
Demonstrating of how the proposed NbS measures improve:	
a) water quality of the runoff (4c)	
b) biodiversity	
c) amenity	

Carlow Rain Gardens
Carlow County Council

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Local Authority Waters Programme
vibrant communities | catchment assessment | healthy waters

CIVIC ENGINEERS
New Practice PART OF CIVIC