BS 8582:2013

BSI Standards Publication

# Code of practice for surface water management for development sites

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# Contents



**Summary of pages**

This document comprises a front cover, an inside front cover, pages 1 to 50, an inside back cover and a back cover.

# Foreword

## Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 30 November 2013. It was prepared by Technical Committee CB/501, *Flood risk and watercourses*. A list of organizations represented on this committee can be obtained on request to its secretary.

## Relationship with other publications

This British Standard is complementary to:

- BS 8533, *Assessing and managing flood risk in development – Code of practice*;
- BS EN 752, *Drain and sewer systems outside buildings*;
- BS 8595:2013, Code of practice for the selection of water reuse systems

## Information about this document

The initial drafting of this British Standard was produced in association with BIS as part of their ongoing programme of support for standardization.

The focus of this British Standard is on the sustainable management of flood risks arising from surface water run-off on development sites, although criteria relating to the management of a wider suite of environmental risks is given. The benefits that can accrue from surface water drainage systems are highlighted and relevant references provided.

This British Standard has been developed to support:

1) planners and drainage approval bodies: in setting consistent drainage criteria and principles (for new developments and redevelopments) that deliver effective surface water flood risk management as sustainably as possible while contributing towards the delivery of relevant environmental, sustainability and urban design planning objectives for the site and local area.
2) designers: in planning and implementing safe, robust surface water management systems that meet the criteria and principles referred to in 1).

## Use of this document

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this British Standard is expected to be able to justify any course of action that deviates from its recommendations.

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

## Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is "should".

*Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.*

The word "should" is used to express recommendations of this standard. The word "may" is used in the text to express permissibility, e.g. as an alternative to the primary recommendation of the Clause. The word "can" is used to express possibility, e.g. a consequence of an action or an event.

Notes and commentaries are provided throughout the text of this standard. Notes give references and additional information that are important but do not form part of the recommendations. Commentaries give background information.

## Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

**Compliance with a British Standard cannot confer immunity from legal obligations.**

# Introduction

Surface water drainage systems have historically comprised subsurface pipe conveyance and tank storage systems that drain and control run-off from development sites. These drainage systems have generally been designed to meet the criteria set out in Sewers for Adoption [N1], Sewers for Scotland [N2] and Sewers for Adoption Northern Ireland [N3]) in order to secure long-term adoption and ownership of the infrastructure from local sewerage undertakers.

It is recognized that the rapid subsurface drainage of developed impermeable surfaces, even with controlled discharges for extreme events, is still likely to increase flood risk for the receiving catchment and adversely affect the local hydrological and morphological balances. In addition, there is a significant risk of pollution to the receiving environment as a result of:

a) urban surface water run-off contaminants being discharged directly to watercourses;

b) foul sewage contaminants contained within the discharged surface water run-off as a result of misconnections; and/or

c) the operation of combined sewer overflows during periods of extreme rainfall.

Sustainable drainage systems (SuDS) are required to:

a) minimize the change in the hydrological regime resulting from the urbanization of the area (and associated negative impact on downstream flood risk);

b) protect or enhance:

   1) receiving watercourse water quality and morphology,

   2) natural drainage patterns on the development site,

   3) habitat diversity and biodiversity, and

   4) public health and amenity;

c) protect the safe replenishment of groundwater resources and river baseflows and conserve surface water resources;

d) manage run-off in excess of the drainage system capacity to mitigate on-site flood risk to people and property.

In England and Wales, the Flood and Water Management Act 2010 [1] makes provision for the formation of SuDS Approving Bodies (SABs) within Lead Local Flood Authorities (LLFAs) to approve all surface water management systems in new developments and redevelopments to national standards, prior to taking responsibility for their long-term operation and maintenance (where the system serves more than one property). At the time of publication, the national standards were still being developed. The Flood and Water Management Act 2010 [1] also amended the Water Industry Act 1991, Section 106 [2], by making the right to connect surface water to the public sewer conditional on a SAB approving the site drainage system. In England, the National Planning Policy Framework [3] encourages the use of SuDS. Where local authorities do not adopt these systems, water companies or other private organizations might take ownership of the systems for a fee.

In Wales, the following planning policy technical advice notes (TANs) promote the implementation of SuDS:

- TAN 15: Development and flood risk [4];
- TAN 5: Nature conservation and planning [5].

In Scotland, the Water Environment and Water Services (WEWS) (Scotland) Act 2003 [6] makes provision for the protection of the water environment. The WEWS Act 2003 [6] made the use of SuDS obligatory when dealing with surface water drainage for all new developments (except single dwellings and discharges to coastal waters). Scottish Water were made responsible for the future maintenance and capital replacement of shared public SuDS that manage run-off from roofs and paved surfaces, providing they are designed to Scottish Water specifications as set out in Sewers for Scotland [N2]. The Flood Risk Management (Scotland) Act 2009 [7] introduced requirements for a more sustainable approach to flood risk management. The Scottish Environment Protection Agency (SEPA) have set out regulatory guidance on the management of surface water discharges from built developments in WAT-RM-08 [8]. The Scottish Planning Policy [9] includes policies on flooding and drainage and is supported by the following Planning Advice Notes (PANs) relating to SuDS:

- PAN 61: Planning and Sustainable Urban Drainage Systems [10];
- PAN 69: Planning and Building Standards Advice on Flooding [11];
- PAN 79: Water and Drainage [12].

Where SuDS are adopted by local roads authorities, the SuDS for Roads [13] manual is used to set the appropriate adoption standards.

In Northern Ireland, Planning Policy Statement (PPS) 15: Planning and Flood Risk [14] sets out the Department of the Environment's planning policies on minimizing flood risk through sustainable development and the Department of Agriculture and Rural Development (DARD) Rivers Agency is responsible for consenting discharges to watercourses. The Northern Ireland Environment Agency has been charged with the responsibility of meeting a range of the Water Framework Directive [15] requirements, some of which encourage the wider application of SuDS for treating contaminated urban run-off.

Surface water drainage within the property curtilage is also dealt with in the Building Regulations 2010, Approved Document H [16] and the Building Regulations (Northern Ireland) Order [17].

# 1 Scope

This British Standard gives recommendations on the planning, design, construction and maintenance of surface water management systems for new developments and redevelopment sites in:

a) minimizing and/or mitigating flooding and other environmental risks arising from:

   1) site surface water run-off as a result of rain falling onto the development site;

   2) run-off conveyed across or arising on the site from other sources.

   *NOTE 1 Run-off resulting from snow melt is not covered in this British Standard.*

b) maximizing the societal and environmental benefits arising from the:

   1) use of surface water run-off to protect and enhance local water resources and supplies;

   2) contribution of surface water management systems in mitigating climate risks associated with urbanization;

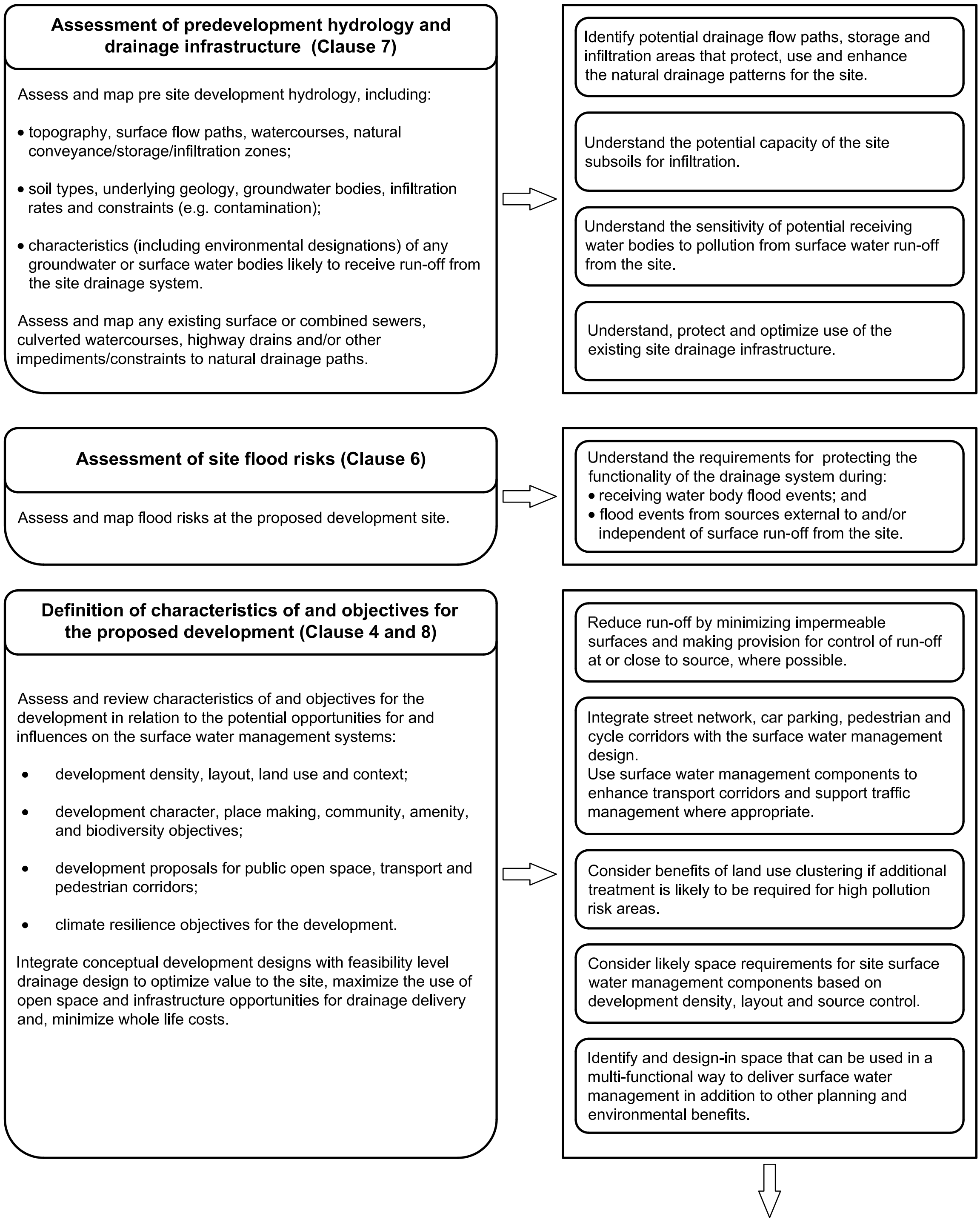
   3) integration of surface water management systems with urban design in delivering amenity and community value and in repairing, protecting and enhancing landscape and/or townscape character;

   4) repair, protection and enhancement of biodiversity.

*NOTE 2 For further information on the planning, design, construction and maintenance of SuDS see the CIRIA SuDS Manual [18].*

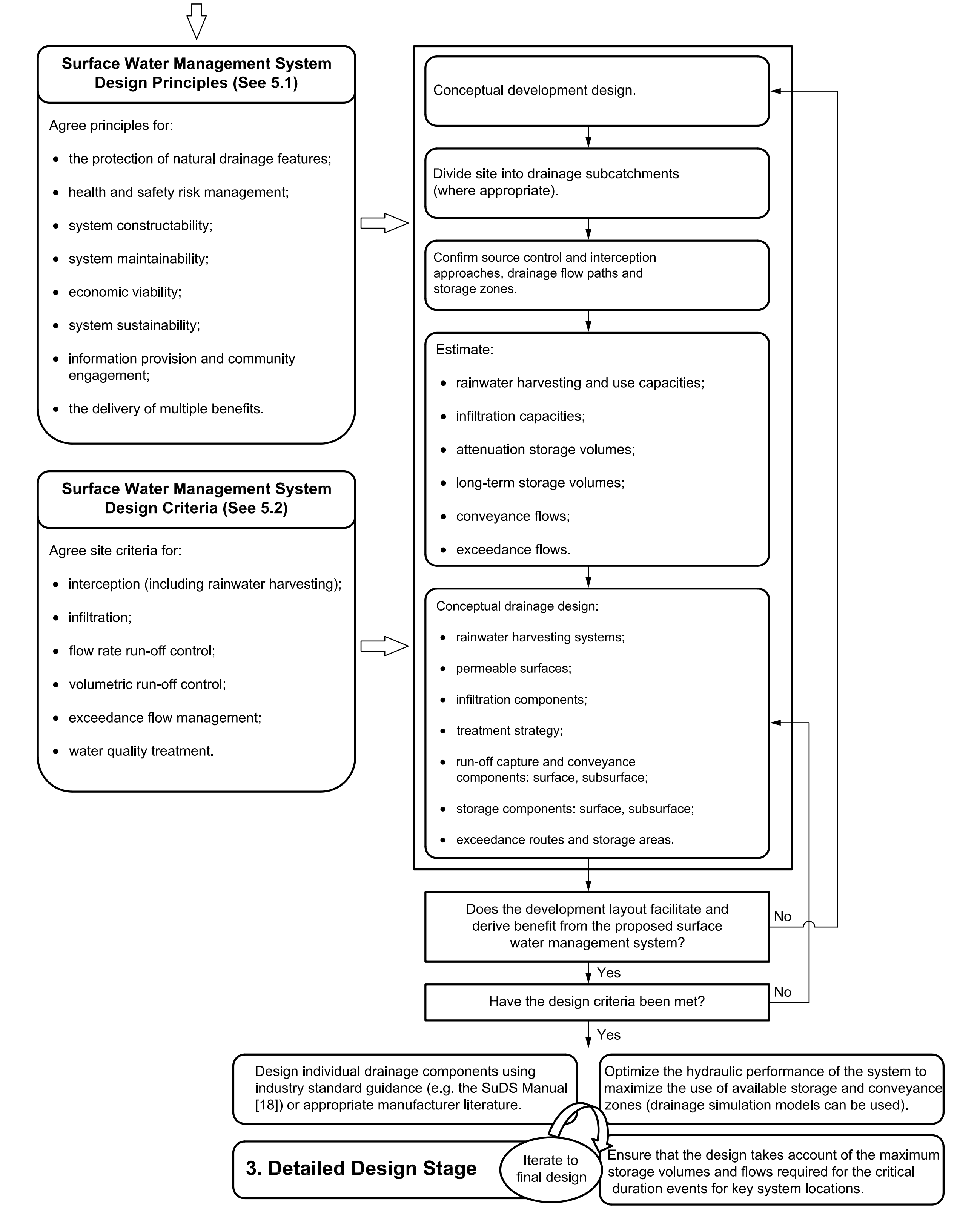
*NOTE 3 A design process map for surface water management is set out in Figure 1, which supports effective navigation through this standard. This map works in conjunction with Figure 2, which shows how the surface water management design process is linked with the development planning process.*

Figure 1 **Surface water management: design process map**




a) Stage 1

Figure 1 **Surface water management: design process map**




b) Stages 2 and 3

## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 5930, *Code of practice for site investigations*

BS 8533:2011, *Assessing and managing flood risk in development – Code of practice*

BS 8515, *Rainwater harvesting systems – Code of practice*

BS 10175, *Investigation of potentially contaminated sites – Code of practice*

BS EN 752, *Drain and sewer systems outside buildings*

**Other publications**

[N1]WRc plc. *Sewers for Adoption – A design and construction guide for developer.* Seventh edition. Swindon: WRc plc., 2012. ISBN: 978 1 898920 65 6.

[N2]WRc plc. *Sewers for Scotland*. Second edition. WRC plc., 2007. ISBN: 978 1 898920 60 1.

[N3]WRc plc. *Sewers for Adoption, Northern Ireland.* WRc plc., 2010. ISBN: 978 1 898920 66 3.

[N4]BUILDING RESEARCH ESTABLISHMENT. *Soakaway design: Digest 365*. BRE 365. London: BRE Bookshop, 1991. ISBN: 1 86081 604 5.

[N5]BETTESS, R. 1996. *Infiltration drainage: manual of good practice*. CIRIA Report R156. London: CIRIA. ISBN: 978 0 86017 457 8.

[N6]ENVIRONMENT AGENCY, SCOTTISH ENVIRONMENT PROTECTION AGENCY AND ENVIRONMENT & HERITAGE SERVICE. *Working at construction and demolition sites:* PPG6. Available at http://www.environment-agency.gov.uk/business/topics/pollution/39083.aspx [last viewed 4 November 2013].

## 3 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply:

**3.1 adaptive capacity**
ability or potential of a system to respond successfully to climate variability and change

**3.2 attenuation**
storage and subsequent slow release of run-off

**3.3 bioretention**
method by which run-off is collected, stored and allowed to percolate through vegetation and soil to facilitate treatment, prior to disposal via infiltration or collection and discharge downstream

**3.4 combined sewer**
sewer designed to carry foul sewage and surface run-off in the same pipe

*NOTE Excess rainfall-generated flow is relieved by combined sewer overflows to the receiving watercourse.*

**3.5 contamination**
presence of substances that, when present in sufficient quantities or concentrations, are likely to have detrimental effects on the receiving environment

**3.6 conveyance**
movement of water from one location to another along a defined flow path

**3.7 conveyance capacity**
capacity of a system to convey flow

**3.8 critical duration**
duration of rainfall event likely to cause the highest peak flows or maximum storage volume at a particular location for a specified return period

**3.9 development**
building, engineering, mining or other operations in, on, over or under land, or the making of any material change in the use of a building or land [BS 8533:2011, **3.2**]

**3.10 detention basin**
drainage component (basin or other facility) in which run-off is stored temporarily when outflows are controlled, to attenuate and (where processes allow) treat run-off from storm events

**3.11 exceedance flows**
flows on the surface that result from:

a) the occurrence of events that exceed the design capacity of the drainage system; or

b) run-off that is unable to enter the drainage system; or

c) blockage and/or structural failure of any part of the drainage system; or

d) flood levels in the receiving water body limiting the capacity of the drainage system

**3.12 flood extent**
area that is susceptible to flooding [BS 8533:2011, **3.3**]

**3.13 flood risk**
combination of the probability of a flood event and the potential adverse consequences for human health, the environment, cultural heritage and economic activity associated with a flood event [EC Directive 2007/60/EC [19]]

**3.14 flood risk management**
action that manages and/or reduces the consequences of flooding on people, land and/or buildings, or environmental assets

**3.15 fluvial flooding**
flooding from a river or other watercourse

**3.16 greenfield run-off**
hydrological run-off characteristics of an area in its natural state where no form of development has ever taken place

**3.17 green infrastructure**
network of green spaces, water and other environmental features in both urban and rural areas that can be designed and managed as a multifunctional resource, delivering a wide range of environmental and quality of life benefits for local communities

*NOTE This can be either natural or manmade.*

**3.18 infiltration capacity**
measure of the extent to which the ground allows infiltration to occur

**3.19 interception**
prevention of the run-off from an initial depth of rainfall from leaving the site

**3.20 long-term storage volume (LTS)**
increase in volume of run-off from the site, as a result of the proposed development, for the 100 year 6 hour rainfall event

**3.21 management train**
series of drainage techniques that incrementally reduce pollution, flow rates and/or volumes of run-off before discharge to a receiving water body or outfall

**3.22 morphology**
river channel form, structure, geometry, topography and bed sediment composition

**3.23 overland flow**
water flowing over the ground surface that has either not entered, or has escaped from, a natural or artificial drainage system

**3.24 pervious surface**
surface that allows water to soak through it into the ground or into subsurface storage

**3.25 pluvial flooding**
flooding caused by overland flow due to rainfall

**3.26 predevelopment**
status of the site, prior to the proposed new development

**3.27 rainwater harvesting**
system that collects run-off from roofs (or other impermeable surfaces) and makes it available for non-potable use

**3.28 residual flood risk**
flood risk that remains after taking account of all flood mitigation measures over the development lifetime allowing for climate change and urban creep, and the long-term performance of infrastructure

**3.29 return period**
average time interval, usually in years, between occurrences of a flood or a rainfall event of a given magnitude or larger

*NOTE For example, a one in one hundred year storm is one that occurs, on average, once every 100 years.*

**3.30 soakaway**
subsurface voided structure in which run-off is stored and from which it infiltrates to the ground

**3.31 source control**
hydraulic control and treatment of run-off at or near its source

**3.32 stakeholder**
individuals or organizations with responsibilities for, or interest in, the implementation, management or use of surface water management systems for the site

**3.33 sustainable drainage system (SuDS)**
individual or multiple linked drainage components designed to collect, manage, control and treat surface water run-off and, where possible, provide amenity, biodiversity and climate resilience benefits

**3.34 tidal flooding**
flooding from the sea or an estuary

**3.35 treatment component**
component of the drainage system that is specifically designed to reduce the levels of contaminants in the run-off from regular rainfall events

**3.36 urban creep**
increase in the impermeable surfaces of a development over time, usually as a result of property enhancements

*NOTE For example, patios, conservatories, small extensions, etc.*

**3.37 whole life carbon footprint**
total greenhouse gas emissions caused directly and indirectly by the planning, construction, operation/maintenance and disposal of the drainage system, over its whole life cycle

# 4 Linking surface water management and development planning

## 4.1 Process integration

The options for, and the layout of, the surface water management system should be assessed at the very start of a development project in order to:

a) make best use of the topography for routing and storing water;

b) maximize opportunities for using space in a multi-functional way;

c) enable water storage and conveyance zones to form part of the character of the development;

*NOTE 1 For details on integrating water storage and conveyance routes within urban areas see Developing Urban Blue Corridors – a Scoping Study [20].*

d) provide the greatest opportunity for the drainage system to deliver multiple planning and environmental benefits;

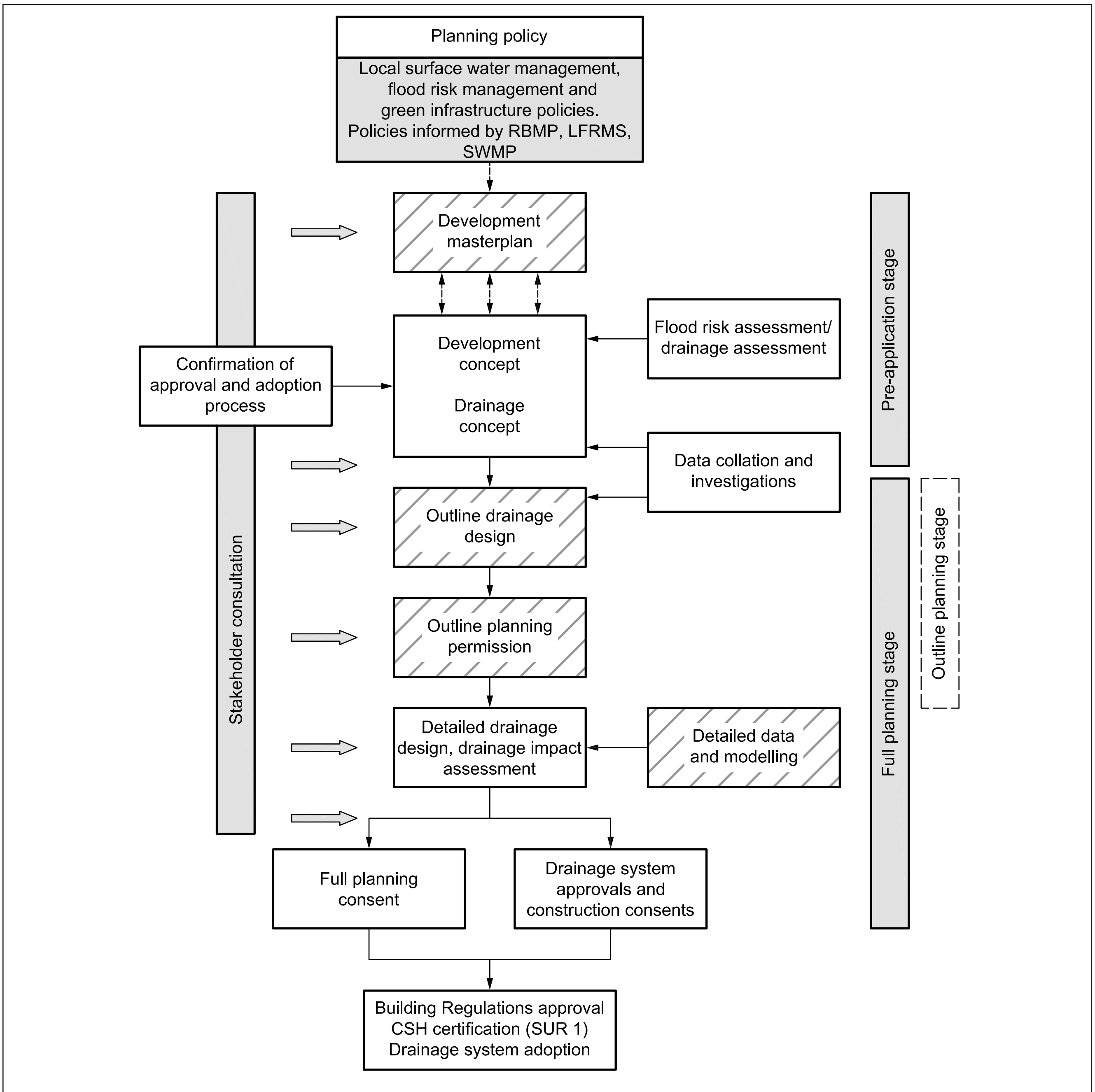
e) minimize life cycle costs (including design) of the surface water management system and development as a whole;

f) facilitate the use of the system in supporting future urban adaptability to climate change hazards.

*NOTE 2 Figure 2 sets out the key links between the development planning process and the drainage system design process, emphasizing the involvement of stakeholders throughout.*

*NOTE 3 The planning and design of drainage systems is required to take full account of relevant local planning policies as well as national planning policy and guidance.*

Figure 2 **Process integration**




*NOTE The need for the steps given in the cross hatched boxes would depend on the nature and/or scale of the development and type of planning application and is determined by agreement with the planning authority and drainage approval body.*

## 4.2 Stakeholder engagement

### 4.2.1 General

To facilitate effective integration of the surface water management system with the site and wider environmental objectives, the key stakeholders should be identified and involved in the design and decision-making process as early as possible, e.g. when land purchase negotiations are being considered.

*NOTE 1 The key drainage stakeholders, together with their responsibilities and interests in the surface water management process can be found in Annex A.*

Stakeholders should be engaged in the process through consultation.

*NOTE 2 The scale of the consultation process depends on the scale and nature of the development/ planning application, see **4.2.2** and **4.2.3**.*

*NOTE 3 Ongoing stakeholder involvement usually gives the greatest benefit.*

*NOTE 4 It might be appropriate to merge the initial and main consultation phases (discussed in the following sections) for smaller developments.*

### 4.2.2 Initial consultation phase (pre-application dialogue)

The initial consultation phase should establish the following:

a) planning and environmental objectives for the site that could influence the drainage strategy;

b) environmental or technical constraints to drainage design for the site;

c) opportunities for the surface water management system to deliver multiple benefits (see **4.4.2**);

d) land and infrastructure ownership for drainage routes and points of discharge (including sewerage assets) and any work consents required;

e) stakeholder responsibilities and requirements, including timescales for any likely approvals/consents;

f) local community involvement and the societal impact of drainage features;

g) an appropriate consultation plan to facilitate and support stakeholder interaction;

h) cost implications of stakeholder obligations;

i) requirements of the local drainage approval and adoption processes;

j) drainage criteria for the design of the site surface water management system.

For larger sites or multi-plot developments, where the land is sub-divided into separate plots owned by different landowners, or where there is an intention to develop the land in phases, the specification for a drainage master plan should be agreed at this stage. The master plan should be designed to ensure effective communication between all developers and identified stakeholders in establishing the selection, implementation and phasing of source control, site and regional drainage components.

### 4.2.3 Main consultation phase (outline planning dialogue)

During the main consultation phase, the following information should be presented to stakeholders for feedback:

a) the proposed approach to managing surface water run-off from the site in order to mitigate on-site and downstream flood risk (taking into account all sources of existing flood risk for the site);

b) the proposed approach to managing surface water run-off from the site in order to mitigate the risk of pollution to receiving water bodies;

c) the proposed drainage design including source control (interception), treatment, conveyance, storage, flood flow paths and storage locations;

d) the proposals for the multi-functional use of drainage "space" to meet community and environmental requirements;

e) the definition of proposed "private" (i.e. within curtilage) and public (i.e. in public open space or adoptable highways) surface water management components, and confirmation of approval and adoption arrangements; and

f) the contribution of the surface water management strategy to delivery of the development design objectives for climate resilience.

## 4.3 Drainage submissions

### 4.3.1 General

The surface water management design should be developed and presented via a clearly documented, staged approach. The documentation should be used to support:

a) outline and/or full planning application submissions;

b) effective stakeholder consultation;

c) drainage approval and adoption submissions.

### 4.3.2 Conceptual design/drainage strategy

The conceptual design should include:

a) the design criteria for the development site;

b) an assessment and characterization of the natural site's hydrological patterns, the receiving water bodies for the surface water management system and any existing site drainage infrastructure;

c) a review of the site flood risk assessment (FRA)/flood consequences assessment (FCA) and an assessment of the implications for the drainage design;

d) an assessment of the need, opportunities and proposals for rainwater harvesting and use;

e) evidence of infiltration capacity at the site and the suitability of, opportunities and proposals for infiltration drainage;

f) an indication of the range of components to be included in the detailed design and their use in meeting the design criteria (hydraulic and water quality) for the site;

g) evidence that permeable surfaces and surface based conveyance and storage systems are to be used wherever practical;

h) pre- and post-development run-off calculations and storage estimates to determine the scale (and associated land-take) of conveyance and storage structures; and

i) draft proposals for delivering multi-functional benefits, adaptability and green infrastructure in line with the development objectives.

### 4.3.3 Detailed design

The final statement on the detailed design and layout of the surface water management system should update and enhance the conceptual design submission, taking into account the stakeholder inputs, and should include:

a) final design calculations to demonstrate conformity with the design criteria for the site;

b) a description of the techniques and processes used to deliver the design principles;

c) the maintenance plan (see **11.4**);

d) a set of guiding principles for the construction of the system;

e) the process for information delivery to, and community engagement with, relevant stakeholders; and

f) system valuation (including capital costs, operation and maintenance costs and commuted sums if applicable, cost contributions, and valuation of any required non-performance bonds).

## 4.4 Maximizing the value of surface water management systems

### 4.4.1 Multi-site/off-site surface water management components

At project feasibility and planning stages of the development, the following issues should be investigated as part of the option appraisal process:

a) whether local surface water management plans have identified land potentially of value in managing run-off from a number of development projects;

b) whether there might be opportunities to cost effectively share surface water management systems (where other developments are planned adjacent or close to a proposed site) in ways that benefit multiple projects and communities;

c) whether the proposed site might be able to provide shared opportunities where surface water management measures are needed to reduce risks and/or deliver benefits for existing areas; and

d) whether there might be opportunities to cost-effectively use adjacent or downstream public open space for run-off control while delivering multiple community and planning objectives, where enhancements to that space are desired.

*NOTE Where land is used for surface water management that is external to the development itself, it is important to ensure that access for operation and maintenance in perpetuity is guaranteed.*

### 4.4.2 Maximizing environmental value through the delivery of surface water management systems with multiple functionality

Where possible, surface water management systems should:

a) be linked to the delivery of other required development infrastructure (e.g. car parking, transport routes, public open space, commercial roof areas);

b) form an integral part of the design and delivery of green infrastructure for a site, with the objective of maximizing the overall environmental value that can be achieved.

*NOTE 1 Increasingly, a key focus of planning policy is promoting integrated green infrastructure within the fabric of urban development; see Green Infrastructure Guidance [21] and Scottish Government 2011 Planning Advice – Green Infrastructure: Design and Placemaking [22].*

*NOTE 2 Methods and opportunities for delivering surface water management systems with multiple functionality are set out in Table 1.*

Table 1 **Multi functional surface water management design**

| **Infrastructure objective** | **Multi-functional surface water management system design and associated environmental value** |
|---|---|
| 1. Recreational opportunities | • Subsurface attenuation storage systems can be sited below permeable surfaces used for recreation<br>• Infrequently flooded detention zones can also serve as recreational/amenity areas<br>• Vegetated conveyance and/or storage systems can be designed to promote education, play and amenity value<br>• Intensive green roofs can provide amenity landscape in dense urban settings<br>• Surface water management components can be integrated with sustainable transport corridors (e.g. cycle routes) to maximize benefits |
| 2. Water resources conservation | • Surface water run-off from roofs and uncontaminated paved surfaces, can be captured and stored for use<br>• Rainwater harvesting systems can be designed to deliver surface water management benefits in addition to water supply (see BS 8515) |
| 3. Habitats/biodiversity enhancement | • Vegetated surface water management components, which store or convey water either temporarily or permanently, can often deliver locally important habitat<br>• Such areas can contribute to urban "corridors" and "networks" of green (vegetated) and blue (water) spaces that support the movement of species |
| 4. Traffic management | • Appropriately designed roads can provide, during times of extreme rainfall, short-term effective management of flood waters, either for conveyance or storage<br>• Local road surfaces and pavements can often be designed to be pervious and allow run-off to infiltrate into the sub-base<br>• Bioretention/biofilter zones can be integrated within pavement design to provide both traffic calming and stormwater management units<br>• Vegetated swales running alongside roads can be designed to treat and control road run-off<br>• Tree pits can be included to intercept run-off (with additional subsurface storage included within or adjacent to the pit) |
| 5. Car parking | • Where the car parking surface is designed to be pervious, surface water can be stored and treated within the sub-base, prior to either controlled discharge, infiltration to the ground, or use.<br>• Car parks can store additional volumes of floodwater above the surface during extreme events.<br>• Vegetated strips, swales, bioretention systems and basins can be designed adjacent to the car park to treat and control run-off |

Table 1 **Multi functional surface water management design**

| Infrastructure objective | Multi-functional surface water management system design and associated environmental value |
|---|---|
| 6. Public education/awareness | Local community engagement strategies can deliver:<br>• an understanding of the functionality and environmental importance of the surface water management system in mitigating human impacts<br>• a commitment towards contributing to the management of the drainage components<br>• an understanding of the health and safety risk management strategy for the site in relation to surface water<br>• ideas as to how the system could be used to promote children's education strategies and increased local amenity benefits |
| 7. Air temperature / urban heat island mitigation | • Urban cooling can be promoted via the return of moisture to the air through evaporation and evapotranspiration from vegetated surface water management features<br>• Direct cooling can be provided by trees integrated within the surface water management system providing shade<br>• Green roofs and vegetative surfaces reflect more sunlight and absorb less heat |
| 8. Reduced energy use | • Green roofs provide good building insulation |
| 9. Air quality improvement | • Trees, larger shrubs and vegetated surfaces used as part of the surface water management strategy can filter out airborne pollutants |
| 10. Landscape character | • Well designed and integrated SuDS features can enhance aesthetic appeal and local landscape and townscape character and distinctiveness |
| 11. Health benefits | • Green and blue space within developments promotes health benefits linked to increased outdoor recreation and a feeling of well being |

# 5 Surface water management design: principles and criteria

## 5.1 Design principles

A surface water management strategy for any proposed development site should deliver a safe, functional, cost-effective and, as far as possible, sustainable drainage system. A framework of design principles should therefore be established (that guide the design process) to ensure:

a) that natural drainage features are protected;

b) that public health and safety risks are taken into account and managed;

c) the constructability of the surface water management system;

d) the maintainability of the surface water management system;

e) the long-term economic viability of the system;

f) that sustainability issues are taken into account;

g) that the information requirements of stakeholders are adequately addressed;

h) that the potential value of the surface water management system, in enhancing the rural and urban environment is recognized and optimized.

*NOTE The value of SuDS can be measured in terms of their contribution to an enhanced community sense of place, aesthetic and biodiversity value, amenity and recreational opportunities and the resilience of the development to climate change risks.*

### 5.1.1 Protecting natural drainage features

Natural and existing artificial drainage features of greenfield sites should be identified and mapped so that they can be integrated with the surface water management system.

*NOTE 1 This encourages appropriate layout of the development.*

*NOTE 2 Natural features can be considered to include:*

*a) ephemeral or perennial watercourses, including existing ditches;*

*b) floodplains;*

*c) wetlands;*

*d) permeable areas (e.g. sands and gravels);*

*e) zones of high water table;*

*f) natural depressions;*

*g) steep slopes.*

Buildings should not be constructed over existing drainage features, including field drains, without specific alternative flow routing capacity being provided.

### 5.1.2 Designing for health and safety

Any potential health and safety risks to construction or maintenance operatives, or those living in or visiting the site, associated with:

- the system design and operation;
- the construction process;
- the construction materials; and
- the maintenance requirements;

should be assessed, mitigated where possible and reduced to acceptable levels (as determined by a risk assessment).

*NOTE 1 Attention is drawn to the Construction (Design and Management) Regulations 2007 [23].*

*NOTE 2 Guidance on the design of individual drainage components to minimize risks can be found in the CIRIA SuDS Manual [18].*

### 5.1.3 Designing for constructability

The design of the surface water management system should take into account the constructability of the drainage scheme in accordance with Clause **10** to ensure that:

a) the site is effectively drained during the construction process;

b) the constructed drainage system performs to the criteria for which it was designed;

c) sediment build up in the constructed system only occurs where designated by the design and where provision for removal has been made in the maintenance plan;

d) there is no initial or ongoing erosion of soil or vegetated surfaces; and

e) there is no damage to the site or receiving environment as a result of construction of the surface water management system.

*NOTE Temporary drainage components might be required for the duration of construction to manage runoff and to address potentially high levels of sediment.*

### 5.1.4 Designing for maintainability

The design of the surface water management system should take into account the maintenance requirements of both surface and subsurface components of the drainage scheme in accordance with Clause **11**, allowing for:

a) any personnel, vehicle or machinery access required to undertake this work;

b) any equipment which is likely to be needed by those taking ownership of the drainage system;

c) any on-site or off-site waste disposal requirements;

d) the need for system rehabilitation/repair without causing major disruption to system performance;

e) the need to protect the performance of infiltration components (i.e. by designing the system so that fine silts/sediments can be captured and periodically removed upstream of the component);

f) clear visibility of failures (e.g. as a result of blockage or clogging) in order that maintenance and rehabilitation works can take place in a timely manner;

g) any potential impacts of maintenance on the flora and/or fauna associated with the stormwater management system; and

h) the health and safety of the public and all maintenance operatives.

### 5.1.5 Long-term economic viability

When estimating the costs of the surface water management system, both capital and long-term maintenance costs should be taken into account using a whole life costing approach.

Cost impacts for a proposed development should include both on- and off-site measures, where relevant.

To reduce the cost associated with land-take, drainage components should be located within designated public open space, or maximize the value of land by delivering systems with multi-functionality.

*NOTE Demonstrating and valuing scheme benefits can often be beneficial when justifying scheme investment, particularly where there are multiple stakeholder beneficiaries (see **4.4.1** and **4.4.2**).*

### 5.1.6 Designing for sustainability

The whole life carbon footprint and energy demand of the system should be taken into account and minimized where possible.

Operational pumping should only be used where it is not possible to use gravity drainage, to reduce the need for operational carbon use, and to minimize the performance risks associated with inadequate maintenance and/or product or power failures. Any required pumping stations should be designed in accordance with **9.10**.

Construction materials that do not contribute to the depletion of finite natural resources nor the generation of polluting or waste products in their production should be selected where possible, taking into account the design life of the material and the potential for reuse or recycling.

System components should be designed to deliver adaptive capacity where possible.

*NOTE 1 The flood risk from exceedance events (that might occur more frequently as a result of climate change and/or urban creep) is lower from surface based systems than subsurface drainage components.*

*NOTE 2 It is easier to design surface based systems to allow for the storage or conveyance capacity of components to be enhanced if higher levels of performance are required at a later date.*

System components should be designed so that they can be constructed, maintained and, at the end of their life, decommissioned, with the minimum negative environmental impact.

### 5.1.7 Meeting the information requirements of stakeholders

The design of the surface water management system should address the information requirements of contractors, owners, operators and those living and/or working close to the system in accordance with Clause **12**. Sufficient information should be provided at all stages of drainage implementation to:

a) ensure the systems are constructed to a quality that achieves the performance intended (especially those components which depend on the use of infiltration);

b) minimize health and safety risks to contractors, operators and local communities;

c) ensure the drainage system is correctly operated and maintained; and

d) maximize public awareness and support for the scheme, and the community benefits provided.

### 5.1.8 Designing to deliver multiple benefits

The surface water management system design should be integrated with, and be complementary to, the development layout and design. Wherever practical, it should incorporate measures that deliver multiple environmental, community and planning benefits through the implementation of multi-functional drainage components (see **4.4**).

## 5.2 Design criteria

### 5.2.1 General

Design criteria should be set for the site drainage system in order to ensure that:

a) the drainage system provides the appropriate level of flood protection for the site; and

b) the receiving environment is protected.

The suite of criteria and the processes through which they deliver the hydraulic performance and environmental protection objectives are set out in Figure 3.

Figure 3 **Summary of design criteria**

| Design criteria | | Delivery process | | Design objectives |
|---|---|---|---|---|
| Intercept small rainfall events | ⇨ | Rainwater harvesting<br>Soil moisture deficit replenishment<br>Evapotranspiration<br>Infiltration | ⇨ | Reduce pollution loads to receiving waterbody<br>Protect resource availability<br>Protect hydrological regime<br>Protect receiving morphology |
| Protect and promote infiltration | ⇨ | Infiltration | ⇨ | Reduce pollution loads to receiving waterbody<br>Reduce run-off rates and volumes<br>Protect river baseflows<br>Protect groundwater recharge |
| Mitigate environmental risk from urban run-off contaminants (up to the 1 in 1 year event) | ⇨ | Risk-based treatment | ⇨ | Protect receiving surface water quality<br>Protect receiving groundwater quality |
| Control peak run-off rate from the site to the greenfield or predevelopment flow rate (for the 1 in 1 year event) | ⇨ | Infiltration<br>Attenuation | ⇨ | Protect receiving waterbody morphology |
| Restrict on-site flooding (for the 1 in 30 year event) | ⇨ | Convey 30 year event within drainage system | ⇨ | On-site flood protection |
| Control peak run-off rate from the site to the greenfield or predevelopment flow rate (for the 1 in 100/200 year event) | ⇨ | Infiltration<br>Attenuation | ⇨ | Minimize impact on receiving waterbody flood risk |
| Control run-off volume to the greenfield or predevelopment flow volume (for the 1 in 100 year, 6 hour event) | ⇨ | Rainwater harvesting<br>Infiltration<br>Long Term Storage + slow release<br>Attenuation + slow release | ⇨ | Minimize impact on receiving waterbody flood risk |
| Manage exceedance flows (up to 1 in 100/200 year with consideration given to larger events) | ⇨ | Manage flooding from the drainage system for extreme events | ⇨ | On-site flood risk management |

## 5.2.2 Detailed design criteria

*COMMENTARY ON* ***5.2.2***

*The local planning authority/drainage approving body (or DARD's Rivers Agency) could set local criteria for surface water management that might vary the criteria given in* ***5.2.2.1*** *to* ***5.2.2.8****.*

### 5.2.2.1 Interception

Surface water management systems should be designed to meet an interception criterion such that a specified initial rainfall depth (typically 5 mm) from a large proportion of all rainfall events is prevented from leaving the site.

*NOTE 1 The interception criterion aims to prevent run-off from a large proportion of small rainfall events (that might otherwise, cumulatively, discharge a significant pollution load to receiving surface waters). Interception protects the morphology and ecology of the receiving water body in attempting to mimic greenfield response characteristics, where small rainfall events do not generally produce any run-off.*

*NOTE 2 It is accepted that compliance with the interception criterion might not be achievable during extended wet periods. In these conditions, the risks to ecology, morphology and water quality as a result of failing to meet the criterion are likely to be significantly reduced.*

Interception should be provided for all impermeable surfaces.

*NOTE 3 Table 2 provides information on possible surface water management techniques that can be used to deliver interception.*

For a system to comply with the criterion, the interception depth should be removed within a reasonable time period (as agreed with the drainage approving body).

Table 2 **Options for interception delivery**

| Impermeable surface type | Surface water management techniques that deliver interception [A)] |
|---|---|
| Roofs | Infiltration systems [B)]<br>Rainwater harvesting systems [C)]<br>Rain gardens, bioretention systems, swales [D)]<br>Permeable pavements [E)]<br>Green roofs [F)] |
| Roads, car parking and other impermeable surfaces (e.g. synthetic sports pitches) | Infiltration systems [B)]<br>Bioretention systems, filter strips, swales, filter trenches, detention basins [D)]<br>Pervious surfaces with subsurface stone storage and filtration media (unlined or lined) [E)] |

A) Definitions of these systems can be found in the CIRIA SuDS Manual [18].
B) All drainage components designed as infiltration systems can be used to deliver the interception criterion.
C) All rainwater harvesting units can be used to deliver the interception criterion where regular daily water demand takes place.
D) For soil-based drainage components, it should be demonstrated that the system can remove the specified interception rainfall depth through the use of evaporation/evapotranspiration/infiltration processes.
E) Permeable pavements can be used to deliver the interception criterion where they drain only the overlying surface. Where they are used to drain additional roof or paved area run-off, then it should be demonstrated that the system can remove the specified interception rainfall depth through the use of evaporation/evapotranspiration/infiltration processes.
F) Green roofs can be used to deliver the interception criterion for the roof area only.

#### 5.2.2.2 Infiltration

*NOTE 1 Infiltration components are used to capture surface water run-off and allow it to soak into and filter through the subsoils. This acts to:*

*a) recharge local groundwater resources and local hydrological processes (e.g. the maintenance of river baseflows);*

*b) remove urban run-off pollutants via absorption and biodegradation within the subsoils; and*

*c) reduce the rate and volume of surface water run-off from the site.*

Infiltration should be prioritized as the first option to be considered for disposal of surface water run-off, unless the infiltration process can be demonstrated to pose a risk to people, property or the environment and that risk cannot be adequately mitigated.

Potential risks resulting from infiltration should be assessed in accordance with **7.6**.

*NOTE 2 Infiltration elements can be incorporated within a range of SuDS components; some examples are given in Table 3.*

Table 3 **Examples of infiltration drainage components**

| System location | Infiltration drainage component |
|---|---|
| Subsurface systems | Soakaways<br>Infiltration trenches<br>Bioretention systems<br>Pervious surfaces with infiltration from beneath the subsurface storage |
| Surface systems | Infiltration basins<br>Raingardens<br>Vegetated systems (e.g. swales, detention basins) where infiltration is possible |

Infiltration systems should be designed in accordance with **9.3**.

### 5.2.2.3 Peak flow control

For greenfield sites, the peak run-off rate from the development site for the 1 in 1 year return period event should be constrained to the equivalent peak greenfield run-off rate to minimize the impact to the receiving watercourse morphology.

*NOTE 1 The rate at which rainfall runs off impermeable surfaces is considerably higher than from permeable greenfield catchments. This is as a result of the lack of infiltration and other natural features that slow and store the run-off.*

*NOTE 2 A 1 in 1 year event is difficult to define in hydrological terms (it refers to an event that has a 100% chance of occurring in any one year and thus could refer to a range of events beneath a certain threshold). For clarification, the requirement is for control of events that occur, on average, once a year.*

For greenfield sites, the peak run-off rate from the development site for the 1 in 100 year event (up to 1 in 200 year in Scotland) should be constrained to the equivalent, present day, peak greenfield rate to minimize any adverse impact on downstream flood risk associated with the receiving water body.

The critical duration design rainfall events should be applied and should include the recommended climate change allowance (see **8.4**) over the proposed development lifetime. The impermeable area of the development should also include an allowance for urban creep (see **8.3**) over the proposed development lifetime.

For previously developed sites, site run-off rates should be reduced to the greenfield rates wherever possible. Allowable discharge rates should not be greater than for the predevelopment scenario.

To limit the need for excessively large volumes of storage, 2 l/s/ha should be considered as a minimum flow rate requirement for any return period event, unless otherwise specified by the drainage approving body.

For small sites, where the above criteria lead to very low flow rate requirements, an acceptable minimum threshold (below 5 l/s) should be agreed with the drainage approving body on a site specific basis (taking account of the need to minimize the risk of blockage (see **9.6**).

*NOTE 3 The allowable peak rates of run-off from the site might be influenced by the delivery of the volume control criterion (see **5.2.2.4**).*

*NOTE 4 Methods for calculating greenfield run-off rates for the site are given in **7.4**. Methods for calculating rates for the predevelopment scenario are set out in **7.5**.*

Where site run-off is to be discharged to a sewerage undertaker's surface water sewer or combined sewer, the sewerage undertaker should be consulted as to whether any additional criteria or limiting discharge rates are required (see **4.2**).

Flow control systems required to deliver the peak flow criteria should be designed in accordance with **9.6**, with associated attenuation storage systems designed in accordance with **9.7**.

#### 5.2.2.4 Volume control

For greenfield sites, the surface water management system should be designed so that the volume of surface water run-off discharged from the site for the 1 in 100 year, 6 hour event is constrained to the equivalent volume associated with the greenfield condition.

*NOTE 1 While the industry continues to use a design storm approach for sizing systems (rather than continuous series rainfall and flood impact models), the 1 in 100 year, 6 h event has been selected as the most appropriate event with which to assess that adequate control of run-off volume is delivered by the site drainage system.*

Where the additional volume resulting from the development cannot be used or disposed of on site, this volume (referred to as the LTS volume) should be controlled using one of the following approaches:

a) the LTS run-off volume should be discharged from the site at a rate of 2 L/s/ha or less; or

b) all the run-off for the 1 in 100 year event from the site should be discharged at a rate of 2 L/s/ha or Qbar (whichever is the greater).

For previously developed sites, the surface water management system should be designed so that the volume of surface water run-off discharged from the site for the 1 in 100 year, 6 hour event is constrained to the equivalent volume associated with the greenfield condition, wherever possible.

Where the additional volume resulting from the development of a previously developed site exceeds the volume for the pre-development scenario, this volume should be discharged from the site at a rate of 2 L/s/ha or less.

*NOTE 2 The research under-pinning the criteria on the use of peak flow rates and volume control of discharges is provided in HR Wallingford, 2002 [24].*

*NOTE 3 Methods for calculating LTS volumes for greenfield sites are set out in **9.8.1**.*

*NOTE 4 Methods for calculating LTS volumes for previously developed sites are set out in **9.8.2**.*

#### 5.2.2.5 Drainage system capacity

The surface water conveyance system should be designed so that run-off is completely contained within the designated drainage system for all events up to the 1 in 30 year return period (for the critical duration event for the system).

*NOTE This may include specific locations that are designed to flood at a lower return period.*

The design rainfall for this scenario should include an allowance for climate change (see **8.4**).

The impermeable area for the site should include an allowance for urban creep (see **8.3**).

#### 5.2.2.6 Flow exceedance management

Properties on site should be fully protected against flooding from the site drainage system, for the 1 in 100 year (and also 1 in 200 year in Scotland) return period event. This analysis should include the relevant urban creep (see **8.3**) and climate change (see **8.4**) allowances.

For the 1 in 100 year (1 in 200 year in Scotland) return period event (including relevant design allowances) for the site, flood levels associated with the surface water drainage system should be not less than 300 mm below the finished ground floor levels and the level of any opening into any basement of the proposed buildings on the site.

Access should be provided into and through the site for emergency vehicles for the 1 in 100 year (and also 1 in 200 year in Scotland) site run-off events and where the site could be flooded from other sources. Any additional requirements for the protection of critical infrastructure should be agreed with the appropriate local authority prior to the submission of any application.

The design of the drainage system for exceedance flow management should take account of any residual flood risks for the site (see **6.2**). An assessment should also be made of the likely significance of risks associated with the following scenarios:

a) a blockage or failure of a drainage system component;

b) failure of any embanked storage facility; and

c) rainfall events that are larger than the storms used for the design of the drainage system.

*NOTE 1 Short duration storms are particularly relevant for pipe networks.*

*NOTE 2 Longer duration storms are likely to be critical for surface conveyance and attenuation storage systems.*

*NOTE 3 It is impractical to avoid flooding from very severe storms. A balance therefore has to be drawn between cost and the consequences of flooding.*

Where any of the scenarios in a) to d) are considered to present a significant risk for the site, a risk assessment should be undertaken to determine adequate risk mitigation measures and agreed with the local flood authority.

When assessing the risks associated with conveyance routes or storage areas for exceedance flows, flow depths, velocities, duration and impact of the flooding to people and property on and off the site should be taken into account.

#### 5.2.2.7 Treatment of surface water run-off discharges to surface waters

Surface water run-off from development sites contains urban contaminants and the run-off should be treated in order to minimize risks to the receiving environment and to support the improvement of receiving water quality, where required.

For all frequent rainfall events (e.g. up to the 1 in 1 year return period event), surface water run-off should be treated using one or more treatment components in series (see **9.4**).

*NOTE 1 The need for treatment is reduced as the size of the event increases. The 1 in 1 year event is normally the lowest, easily computable event that can be used to assess the performance of drainage systems without using time series rainfall.*

An assessment of the potential risk posed by the run-off to the surface water body should be carried out and agreed with the appropriate regulator. The assessment should determine the acceptability of the proposed surface water management system in delivering adequate treatment, and whether a license to discharge might be required.

The level of hazard posed by the site land use (see **8.5**) and the sensitivity of the receiving water body to pollution (see **7.7.2**) should be established to inform this risk assessment process.

*NOTE 2 See BS EN 752 for the protection of surface receiving waters.*

*NOTE 3 In England, the requirements for risk assessments are set out by the Environment Agency [1)].*

*NOTE 4 In Scotland, guidance on the level of treatment required to manage characterized risks and on the risk assessment process is set out in WAT-RM-08 [8]. Surface water discharges from SuDS require authorization under the WEWS Act 2003 [6] and the Water Environment (Controlled Activities) (Scotland) Regulations 2011 [25]. General Binding Rule 10 of the Water Environment (Controlled Activities) (Scotland) Regulations 2011 [25] sets out the treatment requirements for surface water run-off. For the following sites:*

*a) >1 000 residential houses;*

*b) >1 000 car parking spaces;*

*c) industrial areas;*

*d) major roads/motorways;*

*a license and a site-specific risk assessment are required. Further information on authorizations required can be found in SEPA Controlled Activity Regulations: A Practical Guide [26].*

*NOTE 5 In Northern Ireland, under the Water (Northern Ireland) Order 1999 [27], the consent of the Department of the Environment is required to discharge any trade or sewage effluent to any waterway, including site drainage liable to contamination. This includes effluent from any commercial, industrial or domestic premises. These consents lay down conditions relating to the quality and quantity of effluent that may be discharged. Under Schedule 6 of the Drainage (Northern Ireland) Order 1973 [28], the consent of the DARD Rivers Agency is also required in order to discharge to a watercourse.*

#### 5.2.2.8 Treatment of surface water run-off discharges to groundwater

To protect groundwater resources from pollution, surface water run-off should be treated using one or more treatment components prior to any allowable infiltration to the ground (see **9.4**).

An assessment of the potential risk posed by the polluted run-off to the groundwater body should be carried out and agreed with the drainage approval body. The assessment should determine the acceptability of the proposed surface water management system in delivering adequate treatment and whether a license to discharge might be required.

The level of hazard posed by the site land use (see **8.5**) and the sensitivity of the groundwater body to pollution (see **7.6.1**) should be established to inform this risk assessment process.

*NOTE 1 See BS EN 752 for the protection of receiving ground waters.*

*NOTE 2 In England, the requirement for risk assessments are set out by the Environment Agency [2)]. Further information can be found in GP3 [29]*

*NOTE 3 In Scotland, guidance on the level of treatment required to manage characterized risks and on the risk assessment process is set out in WAT-RM-08 [8].*

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1) The requirements can be found at www.environment-agency.gov.uk [last viewed 7 April 2013].

2) The requirements can be found at www.environment-agency.gov.uk [last viewed 7 April 2013].

*NOTE 4 In Northern Ireland, under the Water (Northern Ireland) Order 1999 [27], the consent of the Department of Environment is required to discharge any trade or sewage effluent to any water contained in underground strata, including site drainage liable to contamination. This includes effluent from any commercial, industrial or domestic premises. These consents lay down conditions relating to the quality and quantity of effluent that might be discharged.*

Where pollution risks are identified, intercepted water (see **5.2.2.1**) should be prevented from infiltrating prior to sufficient treatment, as indicated by the risk assessment, has been implemented; this might require the use of impermeable liners.

# 6 Predevelopment flood hazards: assessment of risk and impacts on surface water management design

## 6.1 Predevelopment FRA/FCA

*COMMENTARY ON **6.1***

*In England, Scotland this is referred to as a flood risk assessment (FRA), in Northern Ireland this is referred to as a drainage assessment, and in Wales this is referred to as a flood consequences assessment (FCA).*

*NOTE At any development site there could be a range of existing sources of flooding (flood "hazards") that might pose a risk to either the proposed development, site infrastructure and community, or to the effective functioning of the surface water management system for the site.*

To evaluate the predevelopment risk of flooding for the site, an assessment should be undertaken to determine:

a) the source of any flood hazards;

b) the magnitude of the hazards;

c) their likelihood of occurrence;

d) any potential impacts to the site.

This assessment should be carried out in accordance with the National Planning Policy Framework [3] in England; TAN 15 in Wales [4]; PPS 15: Planning and Flood Risk [14] in Northern Ireland and Scottish Planning Policy [9] in advance of surface water management system design.

The following predevelopment sources of flooding should be taken into account in the design and construction of surface water management systems for the site:

1) fluvial and tidal sources;

2) pluvial sources, i.e. direct overland flow (as a result of intense rainfall) on or adjacent to the site, including flooding from existing sewers and drains;

3) groundwater sources; and

4) infrastructure sources, e.g. failure of water supply infrastructure (mains pipelines), failure of embankments (canals, reservoirs).

The risk assessment for each flood source should be in accordance with Table 4.

Table 4 **Flood risk assessment requirements**

| Source of flood hazard | FRA/FCA requirements A) | Relevant datasets B) | Guidance on risk assessment methodologies A), C) |
|---|---|---|---|
| 1) Fluvial and tidal flooding | Extreme flood levels, frequencies and extents for site (or area of proposed drainage system, if off-site) | Historical records, flood hazard mapping, flood model outputs,<br>extreme sea level analyses, hydrological catchment characteristics, rainfall characteristics | BS 8533:2011, **4.4.2**<br>Flood Estimation Handbook [30] Revised Flood Hydrograph Method (ReFH) [31] D) |
| 2) Surface water flooding | Characterization of contributing catchments, peak run-off estimation, likely flow paths for run-off | Historical records of permanent and ephemeral flows across site, terrain mapping showing natural drainage paths and floodplains, drainage features and detailed local contouring for both the site and for land naturally draining towards or across the site, surface water flood risk mapping, hydrological catchment characteristics, rainfall characteristics | BS 8533:2011, **4.4.2**<br>Flood Estimation Handbook [30] and ReFH [31] D) |
| 3) Flooding from sewers and drains | Identification of flood prone areas, the route and level of service of existing surface water sewerage systems within or adjacent to the site, culvert locations and blockage risks, gully inlets: locations and blockage risks, depths, durations and extents of likely pluvial flooding/flooding from existing, limited capacity drainage infrastructure | Historical records, level of service of existing site drainage system and drainage systems adjacent to the site, digital terrain modelling to determine low points and flow routes, information from sewerage owners and those responsible for sewerage maintenance, rainfall characteristics | BS 8533:2011, **4.4.4** |
| 4) Groundwater flooding | Extreme groundwater flood levels, frequencies and groundwater flood extents for site (or area of proposed drainage system, if off-site) | Historical evidence, groundwater flood risk maps, groundwater model outputs, analysis of extreme groundwater levels relevant to the site | BS 8533:2011, **4.4.5** |

Table 4 **Flood risk assessment requirements**

| Source of flood hazard | FRA/FCA requirements A) | Relevant datasets B) | Guidance on risk assessment methodologies A), C) |
|---|---|---|---|
| 5) Infrastructure flooding | Location and capacity of water containing infrastructure (including supply pipework) within or adjacent to the site, likelihood of failure, consequences of failure | Water containing infrastructure map, water containing infrastructure capacity, consultation with infrastructure asset owners and operators | BS 8533:2011, **4.4.6** |

A) The policies for flood risk assessments and mitigations for developments are set out in National Planning Policy Framework 2012 [3]; Planning and flood risk, Annex D (PPS 15) [14]; TAN 15 [4]; Technical flood risk guidance for stakeholders [32].

B) Relevant strategic information should be available in the strategic FRA/FCA/surface water management plan for the area. Site specific datasets and risk assessments should be available in the site FRA/FCA, where this is already published for the site. All relevant available information relating to flood risk at the site should be sought from local stakeholders (e.g. the planning authority, historical archives, water supply and sewerage undertakers, environmental regulator, surface water drainage regulator, other stakeholders with responsibility for infrastructure assets that could pose a potential flood hazard).

C) Risk assessment and management principles are given in BS 31100. The type and scale of any assessment is likely to depend on the catchment scale and characteristics.

D) See Table 5 for small catchments.

## 6.2 Impact of predevelopment flood risk on surface water drainage design

### 6.2.1 Fluvial/tidal flood risk

*NOTE 1 High fluvial or coastal water levels can influence the functioning of the drainage system in two possible ways, i.e. by:*

*a) constraining the free discharge from the drainage system to the river, estuary or sea; or*

*b) inundating the drainage system.*

Where the discharge is constrained during extreme events, the likelihood of extreme water levels in the receiving water body coinciding with design events for the drainage system should be evaluated and accounted for as part of the design process.

When discharging to rivers where the critical duration event for the drainage system is similar to that for the receiving water body, the design should initially assume return periods of receiving water levels equal to those being used for the drainage system design.

Where the critical duration rainfall event for the receiving watercourse is significantly different to that of the drainage system, the design should initially check the 1 in 1 year performance of the drainage system with the 1 in 100 year (or 1 in 200 year for Scotland and where specified) receiving water level scenario with climate change, and vice versa (see Annex B).

Where, for either of the above scenarios, the implications for the drainage system performance are significant, more detailed combined probability assessments should then be undertaken, or conservative design criteria used in order to refine the design.

*NOTE 2 The selected combination of events determines the required receiving water body water levels, associated inundation extents and rainfall return period to use for the drainage design.*

*NOTE 3 Combined probability assessments are complex and simple tests can be used first to assess the sensitivity of the size and cost of the scheme to a conservative combination of events for the site and receiving water body. This determines whether it is important to determine event combinations based on an accurate joint probability analysis.*

Where extreme tidal and surge events are likely to be independent of site rainfall events, the drainage system performance for extreme rainfall events should be checked against the highest annual tidal (HAT). Where such events constrain the free discharge of the drainage system, then the 1 in 1 year performance of the drainage system should also be checked for the 1 in 100 year (1 in 200 year for Scotland) tidal level.

Where any part of the drainage system is at risk of being inundated from external sources during extreme conditions, the impact of the loss of storage, where it exists, on the drainage system performance should be assessed.

Where the drainage system is at risk of being inundated from external sources during extreme conditions, the implications of sediment deposition and any other consequences and the resulting maintenance requirements should be assessed.

### 6.2.2 Surface water flood risk

The layout of the development site and the drainage system should be designed so that any surface water that enters the site from off-site sources is conveyed safely around or through the site, without compromizing the level of service of the proposed drainage system or introducing unacceptable additional risks on-site or downstream.

Where run-off from off-site sources is drained together with the site run-off, the contributing catchment should be modelled as part of the drainage system in order to take full account of the additional inflows.

Where run-off from off-site sources is conveyed separately to the proposed drainage system, flood risks should be managed in accordance with BS 8533.

The layout of the development site and the drainage system should be designed so that natural low-lying areas and overland conveyance pathways are used to manage surface run-off, where appropriate, where they do not pose an unacceptable risk to the new development or downstream areas.

*NOTE See* ***4.4.1*** *for drainage measures that deliver both site and wider flood risk management benefits.*

### 6.2.3 Flood risk from sewers and drains

Where existing piped surface water systems pass through or adjacent to the site, the following should be established with the owners of the system (relevant sewerage undertaker, highway or drainage authority):

a) the route and level of service of the existing drainage network and any relevant downstream sewerage infrastructure;

b) the extent to which the previously developed site drains to the network;

c) estimated design flow rates in the network;

d) the likelihood of flooding associated with the network; and

e) existing risks associated with culverts, network blockage or collapse, or pumping station failure.

### 6.2.4 Groundwater flood risk

An assessment of the likelihood and consequence of groundwater flooding in or around the development should be undertaken in accordance with BS 8533:2011, Clause **4**, and risks to the development managed in accordance with BS 8533:2011, Clause **5**.

Surface water management components should be located away from areas of potential groundwater flooding, unless the design specifically takes groundwater flood risk into account.

### 6.2.5 Water containing infrastructure risk

The likelihood and consequence of any potential infrastructure failure of water based systems should be taken into account to ensure that any significant associated flood risks are mitigated to agreed levels.

# 7 Evaluating the predevelopment site characteristics relating to surface water run-off

## 7.1 General

The predevelopment site characteristics should be evaluated to define the:

a) site drainage processes and run-off characteristics;

b) extent to which infiltration can be used to dispose of surface water run-off from the site (including an assessment of any potential contamination on the site);

c) sensitivity of any potential surface or groundwater receiving water bodies to potentially contaminated discharges of surface water run-off.

## 7.2 Predevelopment run-off processes

The run-off processes and characteristics for the site prior to the proposed development should be evaluated in order that:

a) the proposed surface water management system layout can be aligned with, support and enhance the natural patterns of drainage where possible; and

b) the characteristics (in terms of peak rates and volumes) of the run-off that is allowed to discharge from the development can be determined.

## 7.3 Predevelopment drainage patterns

Existing and historical man-made watercourses, ditches, culverts, sewers, and general land drainage and surface water storage areas, both within and directly adjoining the site, should be:

a) identified from current/historical mapping, site records and site observations;

b) examined to determine their current level of functionality, service, and ecological importance and potential; and

c) mapped onto plans of the site.

## 7.4 Greenfield state: run-off rates

For developments on greenfield sites, the greenfield peak run-off rates for the 1 in 1 year and 1 in 100 year return period events should be established for use as limiting discharge rates for site run-off control (the 1 in 200 year may be specified by the local authority in Scotland).

*NOTE 1 Where discharges are to the coast, estuaries or large water bodies and where downstream conveyance capacity is not a constraint, the drainage regulator might agree that allowable rates can be higher.*

*NOTE 2 Where the discharge from the site is to the sewerage system, the sewerage undertaker might request information on flow rates (either greenfield or previously developed site rates if relevant) for the 1 in 30 year return period. The sewerage undertaker may apply these or other limits of discharge for a connection to the sewerage system.*

Flow rates should be calculated in accordance with Table 5.

*NOTE 3 An alternative calculation method might be recommended or required by the environmental regulator or local authority.*

Table 5 **Methods for calculating greenfield run-off peak flow rates**

| **Development size**<br>ha | **Method** |
|---|---|
| 0–50 | One of the two following methods should be used. Method 1 depends on access to the Flood Estimation Handbook (FEH) documentation and software.<br>**Method 1** A)<br>The FEH statistical method correlation equation should be used where FEH parameters can be established; see SC050050/SR [33]. Checks should be made of the soil class suggested by FEH [30], by inspection on site.<br>This FEH equation outputs a greenfield flow rate value for Qmed (the 1 in 2 year return period event) that should be converted to Qbar B) and then factored by appropriate growth curves C) to calculate the greenfield peak flow rates for the required return periods.<br>**Method 2** A)<br>The IH Report 124: Flood Estimation for Small Catchments [34] method outputs Qbar (the mean annual flood: the average annual peak flow).<br>This equation outputs an estimate of the greenfield site flow rate, Qbar, which should be factored by the appropriate growth curves to calculate the greenfield peak flow rates for the required return periods. |
| 50 + | IH Report 124 [34], the FEH statistical method correlation equation [33], and/or other more detailed FEH methods [30] can be used to predict flow rates. Other FEH methods should only be used:<br>a) where appropriately skilled hydrologists can undertake the assessment;<br>b) where the catchment is representative of the site's hydrological conditions.<br>The preference is for FEH methods to be used in the first instance to determine greenfield peak flow rates with the following exceptions:<br>• on highly permeable catchments (where FEH parameter BFIHOST > 0.65) where ReFH [31] should be avoided; and<br>• in Scotland (unless explicitly approved) where the application of ReFH has not been formally accepted. |

A) The calculation of plot scale flow rates should use 0.5 $km^2$ (50 ha) in the formulae and linearly interpolate the resultant flow rate value based on the ratio of the development area to 0.5 $km^2$.

B) FSSR 14 [35] can be used to convert Qmed to Qbar.

C) FSSR 2 [36] (for return periods <2 years) and FSSR 14 [35] (for all other return periods) regional growth curves can be applied.

## 7.5 Previously developed state: run-off rates

*NOTE Land that has been previously developed, prior to the proposed site development, is likely to have had a positive drainage system to drain surface water run-off from the site.*

Where previously developed systems can be demonstrated to be operational, records should be checked (if they exist) or information should otherwise be obtained on the drainage system, e.g. pipe diameters, levels, gradients, lengths, hydraulic controls, etc. These details should be used, along with the contributing area characteristics of the site, to set up a drainage model (or to inform another assessment method) in order to evaluate the peak flow rates at the outfalls from the existing site for the design return period events.

Where records of the previously developed system are not available and system characteristics cannot otherwise be determined, or if the drainage system is broken or blocked (or no longer operational), then the run-off characteristics should be defined as greenfield. Where the previously developed site is defined as greenfield, the IH Report 124 method [34] (Method 1 given in Table 5) should be applied using an FSR soil type 5 to reflect the likely higher levels of run-off that probably take place.

## 7.6 Infiltration potential

### 7.6.1 Infiltration constraints

Potential constraints to infiltration at the site should be established, i.e. whether:

a) there are any ground conditions on the site where the introduction of water could have negative impacts on the stability of nearby services, foundations and/or slopes, or could cause collapse or settlement of geological formations;

b) the site subsoils are contaminated;

c) the maximum likely groundwater level is less than 1 m from the likely formation level of any infiltration system for the site;

d) the introduction of increased volumes of water to the subsoils could lead to groundwater emerging at downstream/down-slope locations and presenting risks to people, property or environmental assets;

e) there are groundwater resources beneath the site that are likely to be sensitive to pollution.

A preliminary desk study and risk assessment should be carried out to evaluate possible constraints to infiltration through:

a) existing geological and hydrogeological studies and mapping for the site;

b) geohazard mapping;

*NOTE 1 Mapping is available from the British Geological Survey (BGS) of the relative susceptibility of an area to the six types of geohazards (collapsible deposits, compressible ground, landslides (slope instability), running sand, shrink swell, soluble rocks (dissolution). Mapping is based on an assessment of national scale data and the geology might be subject to variation at the site scale.*

c) records of potential contamination at or beneath the site;

*NOTE 2 Infiltration systems have the potential to mobilize contaminants into groundwater.*

d) borehole records or groundwater observations relevant to the site; and

*NOTE 3 Borehole data can be sourced from the BGS, local water supply companies or the environmental regulator.*

e) aquifer designations at the site.

*NOTE 4 Where underlying aquifers are particularly sensitive to contamination, infiltration might only be acceptable following appropriate treatment of the run-off (see **5.2.2.8**).*

The nature, extent and depth of any contamination should be established, together with details for any remediation or contamination "sealing" strategies, either previously undertaken or proposed as part of the site design.

The ground through which infiltration is designed to occur should be unsaturated to a depth of at least 1 m below the base of the infiltration unit. The maximum elevation of the groundwater table beneath the site should be established through analysing local borehole water level records and assessments of the underlying hydrogeology. Where there is a risk that existing data might not be representative of water levels beneath the site, this should be supplemented with site-based monitoring at appropriate times of the year.

Where the constraints do not automatically rule out the use of infiltration but hazards are identified, a site-specific geotechnical and geo-environmental ground investigation should be designed to evaluate the extent and significance of potential risks, and the options available for managing these risks to acceptable levels.

Investigations should be carried out in accordance with BS 5930 and BS 10175.

### 7.6.2 Infiltration capacity

*NOTE 1 The rate at which infiltration might occur depends on the characteristics of the soils or underlying geology through which the water is discharged.*

For soil, underlying bedrock or superficial geology to be suitable, it should be permeable, unsaturated to a depth of at least 1 m below the base of the infiltration unit (see **7.6.1**), and of sufficient thickness and extent to disperse the water effectively.

*NOTE 2 The likely potential for infiltration at the site can initially be assessed through infiltration mapping (available from the BGS or often from local drainage approval bodies, environmental regulators or lead local flood authorities). Further details on infiltration mapping is given in the CIRIA SuDS Manual, C697, Appendix B [18].*

Site infiltration rates should be confirmed using on-site infiltration testing carried out at trial pits (excavated for this purpose) in accordance with BRE 365 [N4] or CIRIA R156 [N5]. The testing programme should be designed to establish any variability in the site subsoils, their infiltration capacities and groundwater levels; with the number of trial pits reflecting the size of the proposed infiltration units and the size of the site.

The following should be taken into account:

a) water in the pits should always soak away to below 25% of the starting depth;

b) the infiltration capacity should not be extrapolated from very small reductions in water level; and

c) the estimation of the infiltration capacity should be carried out with due consideration given to the homogeneity of the soils around the test site.

## 7.7 Characterizing receiving water body sensitivity

### 7.7.1 Groundwater sensitivity

The designated sensitivity of any groundwater body to which potential infiltration drainage solutions might discharge should be established.

*NOTE 1 In Scotland, WAT-RM-08 [8] (section 7.8) does not require a groundwater sensitivity assessment for low hazard run-off sources (e.g. roof water, car park run-off).*

*NOTE 2 This can be done through reference to the groundwater designation mapping for England and Wales [available on the Environment Agency website [3]], the SEPA groundwater vulnerability map [available on the SEPA website [4]]. The aquifer designation dataset is available on request from the British Geological Survey. In Northern Ireland aquifer classification is based on potential productivity (high, moderate, limited and poor) and regional information on aquifer vulnerability class which can be obtained from the Geoindex on the BGS/Geological survey of Northern Ireland websites [5].*

*NOTE 3 The level of groundwater sensitivity reflects the importance of the underlying aquifer as a resource (drinking water supply) but also any role it might have in supporting environmentally sensitive surface water bodies.*

### 7.7.2 Surface water sensitivity

To determine the sensitivity of any receiving surface water body to the discharge of potentially contaminated surface run-off from a development site, the following designations should be checked:

a) the ecological status of the water body and its established future ecological potential (Water Framework Directive [15] status and environmental designations);

b) whether the water body is designated for the abstraction of water for human consumption; and

c) whether the water body is designated for recreational use.

*NOTE Where the drainage system discharges to a public surface water sewer or highway drainage system, then this is considered as a conduit/pathway to the receiving surface water body.*

# 8 Evaluating the proposed development site characteristics relating to surface water run-off

## 8.1 General

The development site characteristics that specifically influence the rate, volume and likely contamination levels of the surface water run-off should be determined in accordance with **8.2** to **8.5**.

## 8.2 Size and sub-catchment delineation of the drainage area

The development drainage area should be established and delineated into sub-catchments or drainage zones to reflect the proposed development layout, likely run-off conveyance routes and storage zones, and land use.

## 8.3 Development density and percentage impermeability (including urban creep allowances)

For each of the proposed sub-catchments/drainage zones, the percentage impermeability of the contributing run-off areas should be evaluated to determine the proportion of rainfall that is discharged into the surface water management system during rainfall events.

[3] See http://www.environment-agency.gov.uk [last viewed 27 July 2013].
[4] See http://www.sepa.org.uk/ [last viewed 27 July 2013].
[5] See http://www.bgs.ac.uk/geoindex/ and http://www.bgs.ac.uk/gsni/data/ [last viewed 27 July 2013].

For green space and gardens, the likely run-off contributions of these areas to the drainage systems should be estimated.

To allow for future urban expansion within the development (urban creep), an increase in paved surface area of 10% should be used, unless this would produce a percentage impermeability greater than 100%, or unless specified differently by the drainage approval body or planning authority.

### 8.4 Rainfall characteristics (including climate change allowances)

Rainfall depths for all relevant return periods and for a range of durations should be determined for the site using the FEH rainfall depth-duration-frequency (DDF) model [30]. Where FEH rainfall information is not available, the Flood Studies Report [37] rainfall depths can be used; FSR:FEH rainfall maps in W5-074, Appendix A [38] should be used to provide suitable uplifts to the FSR rainfall for the relevant location.

Uplifts on rainfall intensities that take account of future climate change should be applied (see Table B.1), unless alternative approaches to increasing the resilience of systems to climate change risks (adaptability) are specified by the drainage approval bodies. All approaches should be confirmed as being applicable for development with the planning and/or drainage approval authority.

### 8.5 Land use

The type of development proposed within each of the sub-catchments should be mapped and characterized to define the potential contamination hazard posed by the run-off from each area.

The pollution hazard assessment should be evaluated in conjunction with the sensitivity of the receiving water body (see **7.7**) to determine the level of treatment required for the surface water run-off.

*NOTE 1 In Scotland the number of properties or car park spaces drained to the drainage system has an influence on the level of assumed hazard posed: WAT-RM-08 [8] gives guidance on how to characterize the system.*

*NOTE 2 Guidance on when discharges are classified as trade effluent and environmental permitting for point source discharges to surface water or groundwater can be sourced from the relevant environment regulator.*

## 9 Drainage design methods and tools

### 9.1 Development site run-off simulation

The performance of the proposed drainage system for the site should be analysed (using appropriate tools and/or models) to show conformity of the system with the surface water management criteria for the site.

The analysis should take into account the different critical durations of storms relevant to each of the drainage elements when determining maximum water levels, storage volumes and flow rates through the system.

### 9.2 Rainwater harvesting and use design

*NOTE 1 The capture and use of stormwater presents an opportunity to conserve water resources.*

*NOTE 2 Where infiltration is not possible and evapotranspiration is low, rainwater harvesting is the only way to reduce the volume of runoff (**5.2.2.4**)*

The use of rainwater harvesting systems to deliver both water supply and surface water management objectives for the site should be evaluated, taking account of any potential operation and maintenance risks associated with the ownership of the systems.

Designers and planners should obtain information from the environmental regulator and/or local authority regarding the degree of water scarcity (including climate change implications for water resource security and likely increases in demand) in the area of the development.

*NOTE 3 Water scarcity might inform the case and set the value for using rainwater harvesting or waste water reuse on the site.*

The design, installation, testing and maintenance of rainwater harvesting systems supplying non-potable water should conform to BS 8515.

*NOTE 4 The requirements for rainwater harvesting design to achieve stormwater management control are given in BS 8515.*

*NOTE 5 All rainwater harvesting systems designed to BS 8515 for water supply are accepted as meeting the interception criteria (unless otherwise stated by the drainage approval body).*

Rainwater harvesting systems should always include an overflow to cater for extreme events.

## 9.3 Infiltration system design

Where the suitability of a proposed location for infiltration has been established (see **7.6.1**) and the infiltration capacity evaluated (see **7.6.2**), the infiltration system should be sized to dispose of the run-off from the rainfall event required by the design.

The hydraulic design of infiltration systems should be designed in accordance with BRE 365 [N4] or CIRIA RP156 [N5].

As the rate of infiltration is normally lower than the run-off rate from the surface being drained, a storage volume should be provided as part of the system to temporarily store the water when run-off to the system occurs.

Where infiltration systems are designed to manage run-off from events smaller than the design event for the site, exceedance routes or overflow facilities should be designed to convey the additional run-off to appropriate downstream components.

## 9.4 Treatment design

To reduce pollution levels in stormwater, vegetated drainage components or components that filter run-off through soil, sand or gravel media, or other proprietary treatment products should be used.

Drainage components should be designed using a management train approach with the objectives of delivering:

- effective reduction in contaminant levels;
- reductions in concentrations of a range of contaminants through the use of a number of different and complementary treatment process types; and
- the opportunity to trap accidental spill events, and clean up and dispose of polluted material, minimizing the potential impact on the receiving water body [18].

## 9.5 Conveyance design

Vegetated conveyance systems such as swales, channels, ditches, etc., should be designed to carry the established peak design flow using Manning's equation calculation (see Equation 1) or hydrodynamic simulation modelling:

$$Q = \left(\frac{1}{n}\right) AR^{\frac{2}{3}} S^{\frac{1}{2}}$$

where:

- $Q$ is the flow rate, in cubic metres per second ($m^3/s$);
- $n$ is Manning's coefficient, a roughness coefficient dependent upon the channel characteristics, in metres per one third of a second ($s/m^{-1/3}$);
- $S$ is the overall slope of the channel, in metres per metre (m/m);
- $R$ is the hydraulic radius (calculated by A/P), in metres (m);
- A is the cross-sectional area, in square metres ($m^2$);
- P is the wetted perimeter, in metres (m).

All pipe networks should conform to BS EN 752; this specifies minimum pipe diameters and gradients. Pipes that are to be adopted by the sewerage undertaker should conform to Sewers for Adoption [N1], Sewers for Scotland [N2] and Sewers for Adoption Northern Ireland [N3].

*NOTE Attention is drawn to the Building Regulations 2010, Approved Document H, [16] and Building Regulations (Northern Ireland) Order 1979 [17], which gives the specifications for drainage pipework serving single properties.*

Pipes and manufactured channel components should be sized to carry the maximum peak design flow rate using product literature, pipe capacity tables or hydraulic simulation modelling.

## 9.6 Flow control design

To meet peak flow rate design criteria for the site (see **5.2.2.3**), there should be a form of hydraulic control provided at the point of discharge.

*NOTE 1 Flow control options include (but are not limited to):*

*a) restricted diameter pipes;*

*b) orifice plates;*

*c) slot weirs;*

*d) vortex flow control systems or other approved hydraulic regulation devices.*

Any minimum requirements for pipe or throttle sizes (see **5.2.2.3**) should be agreed with the future drainage owner. The likelihood and consequence of blockage from sediment or other debris should be minimized by including mitigation measures in the design.

*NOTE 2 Control systems can be designed with very small orifice sizes (e.g. <25 mm), where the control element is protected against blockage (e.g. at the outlet of permeable pavement systems).*

Where a bypass system is provided to facilitate maintenance of the flow control unit, the system should be designed to ensure its long-term performance under very limited and irregular use.

*NOTE 3 Further guidance on the design of flow control systems is given in the CIRIA SuDS Manual [18].*

## 9.7 Storage design

*NOTE 1 Attenuation storage is needed to temporarily store water during periods when the run-off rates from the development site exceed the allowable discharge rates (see* ***5.2.2.3****) from the site.*

The storage can be designed as an on-line or off-line system, either on or below the surface, and should be located within the site. Where practicable, above ground systems should be used to enhance amenity and biodiversity, increase flexibility of capacity, and for ease and safety of maintenance.

Detailed design should take into account the depth-storage relationship of the structure and the hydraulic characteristics of the control unit to demonstrate the adequacy of the storage volume provided and that design discharge criteria have been met.

Methods of removing sediment upstream of any storage system should be included in the design to facilitate effective maintenance and protect the storage unit.

*NOTE 2 This is particularly important where underground storage or storage in ponds is provided as sediment removal tends to be difficult and costly from such components.*

For drainage elements likely to trap sediment, sediment removal zones should be designed, where possible, to minimize the risk of re-suspension of sediments during subsequent events.

Where any LTS or storage designed to manage exceedance flows is normally used for an alternative purpose (e.g. car park, agriculture, recreation or amenity area); the location and use should be appropriate for the frequency and depth of flooding that might take place.

Post-event clean-up requirements for storage areas should be defined as part of the maintenance plan (see **11.4**).

## 9.8 Long term storage sizing

### 9.8.1 Greenfield sites

The difference in run-off volume between the greenfield and developed scenarios should be estimated (1 in 100 year, 6 h event) as follows:

$$Vol_{xs} = RDA10\left[\frac{PIMP}{100}(\pm 0.8) + \left(1 - \frac{PIMP}{100}\right)(^{2}\ SPR) - SPR\right]$$

where:

- $Vol_{xs}$ is the extra run-off volume of development run-off over Greenfield run-off, in cubic metres ($m^3$);
- *RD* is the rainfall depth for the 1 in 100 year, 6 hour event, in millimetres (mm);
- *PIMP* is the impermeable area as a percentage of the total area, in percent (%);
- *A* is the area of the site, in hectares (ha);
- *SPR* is the "SPR" index for the SOIL or HOST class (specified as a decimal proportion. This specifies the proportion of run-off from pervious surfaces;
- $\alpha$ is the proportion of paved area draining to the network (values from 0 to 1) with 80% assumed run-off;

$\beta$ is the proportion of the pervious area draining to the network or directly to the river (values from 0 to 1).

If SPRHOST values are used, then the minimum value should be set to 0.1.

*NOTE 1 The value of 0.8 in Equation 2 reflects the assumption that 80% run-off occurs from impermeable surfaces. This can be increased to as much as 1.0 where appropriate.*

*NOTE 2 Equation 2 can be simplified to that given in Equations 3 and 4 under the given assumptions with regards to the constants $\alpha$ and $\beta$. If the paved area is assumed to drain to the network, and all the permeable areas are landscaped so that they do not enter the drainage system or river, Equation 2 simplifies to:*

$$Vol_{xs} = RDA10\left(0.8\frac{PIMP}{100} - SPR\right)$$

*But where all the permeable areas are assumed to continue to drain to the river or network as well as all paved areas, Equation 2 becomes:*

$$Vol_{xs} = RDA10 - \left(0.8\frac{PIMP}{100} - \frac{PIMP}{100}SPR\right)$$

*NOTE 3 If no run-off is assumed to take place from pervious areas after development, and based on 80% run-off rates for a 70% level of impermeability and a 100 year, 6 h rainfall of 60 mm, Table 6 gives values for the LTS volume required.*

Volumes should be calculated on a site-specific basis for the final design.

Table 6 **Indicative long-term storage volumes for a typical greenfield development (to be used for initial feasibility only [18])**

| FSR soil type | Storage volume<br>$m^3$/ha |
|---|---|
| 1 | 320 |
| 2 | 180 |
| 3 | 130 |
| 4 | 60 |
| 5 | 20 |

### 9.8.2 Previously developed sites

For previously developed sites where a positive drainage system can be demonstrated to be operational (see **7.5**), Equation 5 should be used to determine the difference in run-off volume between the new and existing development scenario:

$$Vol_{xs} = RDA10(0.8 - SPR)\left[\frac{PIMP_2}{100} + (SPR - 0.8)\frac{PIMP_1}{100}\right]$$

where:

$PIMP_2$ is the percentage impermeability of the proposed site (%);

$PIMP_1$ is the percentage impermeability of the previously developed site (%).

*NOTE If this is not the case, the site is assumed to be functioning as a greenfield site, with soil type 5 (see **9.8.1**).*

## 9.9 Exceedance flow management design

Exceedance flow management on the site should be designed to mitigate the risks to people and property associated with:

a) run-off exceeding the designed capacity of the drainage system (for both conveyance and storage components);

b) restrictions on outflows from the drainage system due to high levels in the receiving water body; and

c) system blockage or other failure.

The design of exceedance flow management systems should take account of:

a) location, use and capacity of exceedance flood pathways;

b) low spots within the development that may act as temporary storage areas for exceedance flows;

c) location of properties and sensitive/critical infrastructure away from areas at risk of inundation; and

d) potential consequences of exceedance flows (to people and/or property) when they are discharged from the site.

The level of assessment should accord with the needs of the site.

*NOTE 1 For guidance on the assessment and management of exceedance flow risks see Designing for Exceedance [39].*

Surface flood conveyance paths or storage zones for extreme events should:

a) not detract from the primary function except during extreme events;

b) be protected and maintained to ensure their continued availability as a flood management feature;

c) include a freeboard allowance to allow for wave action and any design uncertainties;

   *NOTE 2 This can often be included within the site landscaping.*

d) be designed so that flood depths and velocities are limited to reduce risks both on-site and downstream to acceptable levels (see Designing for Exceedance [39]); and

e) not block pathways that the public would need to use to escape from flooded areas.

Roads should not be used to store water for significant periods of time unless they are specifically designated as flood management features and operational protocols are put in place.

Roads should not be used to store water where the speed of the traffic is such that any stored water poses a potential accident risk.

## 9.10 Surface water pumping station design

Where surface water management for the site cannot avoid the use of pumping, the pumping station should be designed in accordance with BS EN 752. Where the pumping station is to be adopted by the sewerage undertaker, it should also be designed in accordance with Sewers for Adoption [N1], Sewers for Scotland [N2] and Sewers for Adoption Northern Ireland [N3].

# 10 Drainage construction

## 10.1 Construction processes and programming

*NOTE 1 Surface-based surface water management systems demand different construction processes and programming to those required by sub-surface pipe and storage systems (which tend to be implemented early in the construction process; guidance on the construction of SuDS is set out in C698 [40]).*

All construction methods and processes should conform to the Working at Construction and Demolition Sites: PPG6 [N6].

*NOTE 2 The construction of SuDS requires the use of typical civil engineering construction and landscaping operations, such as excavation, filling, grading, top-soiling, seeding, planting, etc. These operations are detailed in the Civil Engineering Specification for the Water Industry (CESWI) [41].*

Proprietary SuDS components should be constructed in accordance with the manufacturer's guidelines.

To ensure the constructability of the system, the following issues should be taken into account:

a) the construction method and processes for surface water management systems should be planned and implemented so that they do not damage the future functionality or level of service of the proposed drainage system (particularly where infiltration systems are being used) or cause environmental damage;

   *NOTE 3 This might require the use of temporary drainage basins during the construction process that are removed once the development is close to completion (see CIRIA on the control of water pollution from construction sites [42]).*

b) sensitive ground, such as chalk, should be protected against damaging impacts from construction traffic to prevent compaction that affects the infiltration performance and soil stability; no construction traffic should be allowed to run on permeable or infiltration surfaces without adequate protection;

c) permeable and infiltration surfaces and soils should not be used as temporary storage areas for construction materials as this promotes clogging of the surface and reduced permeability; such surfaces may be used if protection measures are put in place;

d) if subsoil across a site is compacted by construction activities, it should be scarified to a suitable depth prior to the re-application of topsoil to garden areas and other areas of public open space to try and restore the natural infiltration performance of the ground;

e) if land is cleared and soil is exposed or removed as part of the construction process, any resulting areas of unstable or easily erodible soils (particularly steep slopes) and the consequences of increased erosion and sediment in the run-off should be taken into account;

f) the risk of increased rates of run-off from soil stripping (especially in areas with steep slopes), and the potential flooding that might result, should be taken into account; and

g) accurate levelling and grading to design specification should be undertaken to ensure effective drainage and prevent the accumulation of silt, the ponding of water, and/or the development of preferential flow paths (channelling) in areas where this is not intended.

The issues given in a) to d) should be taken into account:

a) during design;

b) when defining contractor terms of references;

c) when reviewing contractor method statements; and

d) during construction inspection and review.

For surface systems, the timing of drainage construction should be planned to take account of:

a) the requirements for protection of the receiving environment (including ecological impacts and habitat protection) during construction;

b) the climate required to ensure germination, establishment and stabilization of vegetated surfaces; and

c) any likely drainage rehabilitation works once construction works on the site are completed.

*NOTE 4 Details on landscaping and planting for sustainable drainage features are given in the CIRIA SuDS Manual [18].*

## 10.2 Construction management

Where surface water management systems are to be adopted by the sewerage undertaker, construction guidance set out in Sewers for Adoption [N1], Sewers for Scotland [N2] and Sewers for Adoption Northern Ireland [N3] should be followed to ensure that the system is approved for vesting.

Where surface water management systems are to be adopted by a local authority or other organization, guidance on appropriate construction processes should be sought from the adopting body.

Construction method statements should be developed and approved (where required), prior to disseminating to all relevant site managers and operatives. The method statement should state when the site should be inspected during construction to ensure adequate quality control.

*NOTE Inspection at key points in the programme, checking subsurface or subsequently hidden features, helps to minimize risks to future system performance.*

Gully inlets and control devices that are in operation during the construction period should be inspected on a regular basis as these represent the highest risk due to the potential for blockages from construction debris.

For surface-based systems, where operatives might be less familiar with the required construction processes than for subsurface (piped) systems, method statements should be used in conjunction with briefings to operatives. Method statements for the construction of surface water drainage systems should:

a) emphasize the specific requirements of surface-based systems;

b) the importance of construction programming (in relation to long-term drainage performance);

c) describe construction processes and specify the installation of critical items;

d) set out an agreed construction inspection checklist for use by the drainage approval body during and immediately following construction.

Construction work should not start on site until the drainage approval body has formally approved the design plans and specification in writing, and has also been notified of the proposed start of construction and provided with a programme of works.

Following construction of the scheme, an inspection should be carried out to identify any defects and subsequent remedial works required to reinstate the drainage features to their design specification. The inspection should be attended by a representative of the contractor, the design team and the adopting organization. Remedial measures should be agreed and recorded on a checklist, which forms the basis of a formal inspection report, including details of their satisfactory completion.

Once the scheme is operational, a defects liability period should be entered into, during which time maintenance and defect repairs are undertaken by the contractor, prior to final inspection and adoption.

# 11 Maintenance of surface water drainage systems

## 11.1 Maintenance requirements and programming

There are three categories of maintenance activities (see Table 7) that should be carried out over the life time of the surface water management system to minimize the risks to short- and/or long-term design performance.

These activities should be evaluated and costed as part of scheme feasibility studies, and specified in detail within the maintenance plan (see **11.4**) for the drainage scheme.

*NOTE 1 For further information on maintenance and waste management activities, see the CIRIA SuDS Manual [18].*

Table 7 **Operation and maintenance of surface water management systems**

| Maintenance frequency | Typical tasks |
|---|---|
| Regular inspection, together with routine maintenance | Regular system inspections should identify any potential faults/failures that might pose a risk to system performance, i.e.:<br>• inlet blockages;<br>• poor infiltration rates;<br>• soil or slope erosion, channelling;<br>• vegetation death or deterioration;<br>• growth of unsuitable/inappropriate vegetation;<br>• structural deterioration or failures.<br>Basic maintenance tasks done on a frequent and predictable schedule, including vegetation management, litter and debris removal, unblocking of pipes and control structures. |
| Occasional maintenance | Tasks that are required occasionally, but on a much less frequent and less predictable basis than routine maintenance. |
| Infrequent maintenance | Remedial work required to rectify faults associated with the system (following a flood or pollution incident, or as identified by inspection). |

Regular maintenance of areas that manage exceedance management flows should be undertaken as part of the delivery of the primary (i.e. daily) function of the area.

*NOTE 2 Exceedance flow management routes and storage areas require inspections to be undertaken to ensure their required flood management functionality and performance.*

*NOTE 3 If an exceedance event takes place, post operation inspection is required to define any required clean up and remedial works.*

*NOTE 4 A summary of key maintenance items for exceedance flow management systems is given in Designing for Exceedance [39].*

Where maintenance activities could disturb habitats or the amenity value of the system (e.g. aquatic or bankside vegetation removal), the maintenance plan (see **11.4**) should be developed to minimize such risks (e.g. removal of a proportion of the vegetation at a time of year that is least disruptive to flora and fauna).

## 11.2 Waste management

Where sediment accumulates in drainage systems in planned locations, it should be removed at suitable intervals to ensure the system performs as designed.

*NOTE The extraction and disposal of waste such as sediments, vegetation, contaminated geotextiles and other structural material arising from the maintenance or rehabilitation of surface water management systems is governed by environmental regulation. In England and Wales, details on the deposit and dewatering of limited quantities of non-hazardous sediments to an area adjacent to the drainage system are given in MWRP, RPS 055 [43].*

The environmental regulator should always be contacted to confirm the required protocols for the proper handling of sediment or waste at a particular site, where disposal to bankside is or is not appropriate and when an application for a license might be required.

Green waste should be disposed to wildlife piles or on/off site composting systems (see the CIRIA SuDS Manual [18] for detail of these activities). Disposal to waste management centres should only be considered where local management is not possible.

A waste management plan should be developed as part of the maintenance plan (see **11.4**); this should document:

a) proposed vegetation removal, management and/or disposal schedules (including any temporary storage locations and sites for permanent disposal);

b) proposed sediment testing, removal, management and/or disposal schedules (including any temporary storage locations and sites identified for management processes and/or disposal).

Disposal schedules should be developed using a risk assessment process that takes account of:

a) the characteristics of the contributing surface water catchment area (e.g. land use, level of impermeability, upstream construction activities and erosion risks), which dictate the sediment yield of the catchment and likely level of contamination of the sediment;

b) the likely sediment control provided by upstream source control components;

c) the extent to which the performance of the system is likely to be compromised by sediment accumulation;

d) any risks posed by sediment accumulation (e.g. to public/aquatic health); and

e) the likely costs of and disruption (to the system performance, flora and fauna, and amenity value of the system) posed by sediment removal (and disposal) activities.

### 11.3 Monitoring

A review of the maintenance plan should be undertaken by the drainage adoption body annually (or as appropriate) to ensure that maintenance activities and frequencies are delivering effective long-term system operation.

The drainage adoption body should undertake system monitoring of a range of sites as part of a robust asset management strategy to:

a) confirm that the drainage systems meet the required surface water management design objectives, over both the short and longer term;

b) improve operational procedures;

c) provide evidence/feedback to improve the development of future criteria, design and construction processes;

d) provide evidence of public acceptance and community views on the benefits and risks associated with site surface water management systems.

### 11.4 Maintenance plan

The maintenance plan for the drainage system should be developed in co-operation with the adopting authority and the information therein should be presented and discussed verbally with all those involved in inspecting and maintaining the drainage systems.

The maintenance plan should fully detail the access that is required to each surface water management component for maintenance purposes. It should include a plan for the safe and sustainable removal and disposal of waste periodically arising from the drainage system (see **11.2**).

The maintenance plan should include the following two documents:

a) the maintenance specification: detailing the materials to be used and the standard of work required; the specification should detail how the work should be carried out and should contain clauses giving general instructions to the maintenance contractor; and

b) the maintenance schedule of work: itemizing the tasks to be undertaken and the frequency at which they should be performed so that an acceptable long-term performance standard is secured.

*NOTE Maintenance responsibility for drainage systems serving single properties usually lies with the property or site owner.*

## 12 Information provision and community engagement

The following information should be prepared and delivered to contractors and should also, where possible, form a part of the submission for drainage approval:

a) location of all drainage and conveyance components within the site, including both temporary and permanent water features, low flow, design and exceedance storage areas and flood exceedance routes;

b) a brief summary of how the drainage system should work in terms of hydraulic management and water quality treatment;

c) locations and drawings of all maintenance access points;

d) the maintenance plan (see **11.4**), including:
   1) maintenance schedules for each drainage component;
   2) the waste management plan;
   3) explanation of the consequences of not carrying out the maintenance that is specified;
e) identification of areas where certain activities are prohibited (e.g. stockpiling materials on permeable surfaces);
f) an action plan for dealing with accidental spillages and the communication pathways that need to be maintained.

The information in a) to f) should be made available and actively transferred to people who own or are considering the purchase of property on the development site. They should also be informed of the ownership of the drainage system, and the details of relevant contacts in case of performance concerns.

As part of community engagement strategies, property owners should be made aware of their responsibilities for maintenance of drainage features.

The design should include information boards that raise awareness of the existence, purpose and functionality of the surface water management system. Where possible, the local community should be engaged in the decision-making processes relating to the design, maintenance and amenity performance.

*NOTE Effective information sharing and community engagement can lead to public acceptance, a sense of community empowerment and a responsible attitude towards the drainage components.*

# Annex A (informative) Stakeholders to the surface water management process

The stakeholders and their responsibilities for a surface water management system are set out in Table A.1.

Table A.1 **Stakeholders to the surface water management process**

| Stakeholder A) | Role | Desired outcomes |
|---|---|---|
| **Developers** | Responsible for delivery of the development, including the surface water management system for the site | • to secure planning permission, and approval and adoption of the surface water management system from an appropriate organization<br>• to provide a cost-effective, attractive development that will easily sell and/or to provide a development that meets the required commercial objectives<br>• to comply with recommended building codes (e.g. Code for Sustainable Homes [44]) |
| **Local authority: planners, ecologists and landscape officers**<br>**Department of the Environment Planning, Northern Ireland** | Determines planning applications in accordance with the local development plan. Consults stakeholders to understand site-specific opportunities and constraints. | • to approve new developments in accordance with the development policy<br>• to ensure any site is effectually and safely drained and that environmental impacts are acceptable |
| **Local authority: drainage**<br>**DARD Rivers Agency, Northern Ireland** | Local drainage, flood alleviation and regulation of watercourses, apart from designated main rivers.<br>DARD Rivers Agency is responsible for designated watercourses B). | • to define and manage flood risk resulting from all sources, for the local area (under EU Floods Directive [19]) |
| **Local authority: highways**<br>**Department for Regional Development Roads Service, Northern Ireland** | The construction and management of local highways. The provision of standards for the construction and adoption of highways, including highway drainage. | • to ensure that drainage systems for new highways meet local standards<br>• to ensure new highways are effectually and safely drained and that environmental impacts are acceptable |
| **Building control inspectors** | Determine and authorize that a development's drainage complies with the Building Regulations 2010, Approved Document H [16], Building Regulations (Northern Ireland) Order 1979 [17] and does not affect the integrity of any buildings. | • to understand any potential interactions between the proposed site drainage system and adjacent buildings |

Table A.1 **Stakeholders to the surface water management process**

| Stakeholder A) | Role | Desired outcomes |
|---|---|---|
| **Sewerage undertakers** | Scotland and Northern Ireland: provides a public sewer connection. Responsible for adopted surface water drainage from development sites.<br>England and Wales: maintains existing surface water sewers.<br>No obligation to adopt site surface water sewers unless a Section 104 agreement (Water Industry Act, 1991) [2] is in place. | • to ensure surface water drainage systems conform to Sewers for Adoption [N1], Sewers for Scotland [N2] and Sewers for Adoption Northern Ireland [N3], where they are adopting the system (or local guidance documents produced by the sewerage undertaker, i.e. relating to their SuDS adoption policy)<br>• to guide the developer on the likely capacity of the local surface water or combined sewer where these are the required receiving water bodies for the surface water run-off from the site, and any environmental implications of site discharges |
| **Surface water drainage approval and adoption organizations** | Approve surface water management proposals to set criteria.<br>Take responsibility for long-term system adoption and maintenance. | • to ensure that all surface water management systems are designed, constructed, operated and maintained to set standards |
| **Water supply companies** | Provides an adequate supply of water to all customers, and to maintain safe and secure long-term resources. | • to guide the developer on the level of water resource “stress” in the area of the development, and the benefits and likely savings of implementing rainwater harvesting systems as part of both the stormwater management and water supply strategy |
| **Internal Drainage Board**<br>**DARD, Rivers Agency Northern Ireland** | Permissive powers to manage watercourses (and adjacent land) and control surface water discharges within their district. C) | • where the desired outfall is to an IDB or Rivers Agency managed water body, they guide the developer on the acceptability and level of the proposed discharge |
| **Canals and Rivers Trust** | Responsible for maintaining and managing waterways so that they fulfill their full economic, social, environmental and heritage potential. | • where the desired outfall is to a waterway, they guide the developer on the acceptability, level and cost of the proposed discharge. |

Table A.1 **Stakeholders to the surface water management process**

| **Stakeholder** [A)] | **Role** | **Desired outcomes** |
|---|---|---|
| **Environmental regulator** [D)] | To implement EU Directives, e.g. [15] and [19], and national flood risk management strategies and guide stakeholders on the assessment and mitigation of flood risk. | • to implement national flood risk management strategies and guide stakeholders on the assessment and mitigation of flood risk<br>• to promote sustainable development and protect against environmental damage<br>• to understand where environmental hazards resulting from the development might be high, and to review and approve required risk assessments undertaken as part of the design process |
| Conservation organizations [E)] Planning/landscape officers for designated sites (e.g. National Parks, areas of outstanding natural beauty, etc.) | Sustainable stewardship of the land and sea for people and nature, both now and in the future. Conservation and enhancement of designated site areas. | • to protect sites of special scientific interest, conservation areas and areas recognized as locally, nationally or internationally important in terms of biodiversity, habitat and landscape<br>• to promote high quality, sustainable development |
| Public/local community groups | Accept and live with the site's surface water management system.<br>Own, maintain and operate any part of the drainage system that serves only their property.<br>Insure their property against flooding. | • to ensure a safe, effective and attractive site drainage system that has a secure owner and operator through its design life |
| Insurers | Insure properties against flooding (where such insurance is purchased by the property owner) and where the risks are considered acceptable. | • to understand the residual risks to the site from all sources of flooding including the site drainage system<br>• to guide the developer on likely insurance options |

[A)] Statutory consultees are indicated in bold.
[B)] England and Wales have designated flood management duties, Scotland has primary flood management duties and Northern Ireland has designated flood risk management duties.
[C)] This usually only exists in low-lying areas in England and Wales.
[D)] The environmental regulator for England and Wales is the Environment Agency, for Scotland is the Scottish Environment Protection Agency and for Northern Ireland is the Environment Agency with the DARD Rivers Agency responsible for flood risk management.
[E)] The key conservation body for England is Natural England, for Wales is The Countryside Council for Wales, for Scotland is the Scottish Natural Heritage and for Northern Ireland is the Northern Ireland Environment Agency.

*NOTE This table has been adapted from Planning for SuDS [45].*

## Annex B (informative) Climate change

The contingency climate change allowances for uplifts on future river flows and rainfall intensities for England are given in Table B.1. Normally residential sites use the 2085 to 2115 design horizon. Commercial and industrial developments often use a shorter horizon.

For Scotland, the local authority provides guidance on climate change factors. Sewers for Scotland [N2] requires uplift on the rainfall hyetograph of 10%, unless otherwise specified for drainage systems to be adopted by Scottish Water.

For Northern Ireland, the allowances given in the Tables B.1 can be used in the absence of current guidance.

Table B.1 **National precautionary sensitivity ranges for peak rainfall intensities and peak river flows**

| Parameter | 1990 to 2025 | 2025 to 2055 | 2055 to 2085 | 2085 to 2115 |
|---|---|---|---|---|
| Peak rainfall intensity | +5% | +10% | +20% | +30% |
| Peak river flow | +10% | +20% | | |

*NOTE This table was adapted from National Planning Policy Framework: Technical Guidance [46].*

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