
Service activities relating to drinking water supply, wastewater and stormwater systems — Stormwater management — Guidelines for stormwater management in urban areas

Activités de service relatives aux systèmes d'alimentation en eau potable, aux systèmes d'assainissement et aux systèmes de gestion des eaux pluviales — Gestion des eaux pluviales — Lignes directrices pour la gestion des eaux pluviales en zones urbaines





COPYRIGHT PROTECTED DOCUMENT

© ISO 2019

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword	vi
Introduction	vii
1 Scope	1
2 Normative reference	1
3 Terms and definitions	1
4 General overview	1
4.1 Principles	1
4.2 Basic concepts	2
4.3 Stormwater management process	3
5 Objectives	4
6 Functional requirements	8
6.1 General	8
6.2 Protection from surface water flooding	9
6.3 Protection from sewer flooding	9
6.4 Protection of surface receiving water bodies	10
6.5 Protection of groundwater	10
6.6 Maintainability	10
6.7 Integrity of structures	10
6.8 Sustainable use of products and materials	10
6.9 Sustainable use of energy	10
6.10 Protection of adjacent structures and utility services	10
6.11 Maintaining the flow	10
6.12 Watertightness	10
6.13 Prevention of odours and emission of toxic, explosive and corrosive gases	10
6.14 Prevention of noise and vibration	11
6.15 Input quality	11
6.16 Protection of downstream drainage systems	11
6.17 Protection from natural disaster events	11
6.18 Health and safety	11
6.18.1 General	11
6.18.2 Public health and safety	11
6.18.3 Occupational health and safety	11
7 Performance requirements	12
7.1 General	12
7.2 Examples of performance requirements	12
7.2.1 Protection of receiving water bodies	12
7.2.2 Protection from flooding	14
7.2.3 Structural integrity and design working life	15
8 Design criteria	15
8.1 Introduction	15
8.2 Hydraulic design criteria	16
8.2.1 Introduction	16
8.2.2 Full pipe design rainfall criteria	16
8.2.3 Flooding design criteria	17
8.2.4 Effect on downstream water bodies	18
8.3 Environmental design criteria	19
8.4 Structural design criteria	20
8.5 Operation and maintenance (O&M) design criteria	20
8.6 Amenity and biodiversity design criteria	20
8.6.1 Amenity design criteria	20
8.6.2 Biodiversity design criteria	20

9	Investigation	21
9.1	Introduction	21
9.2	Purpose of investigation	21
9.3	Review of performance information	22
9.4	Determine the scope of investigation	23
9.5	Review existing information	23
9.6	Inventory update	24
9.7	Hydraulic investigation	25
9.8	Hydrology	25
9.8.1	Selection of the design rainfall	25
9.8.2	Flood occurrence probability	27
9.8.3	Water quantity	27
9.8.4	Water quality	27
9.9	Environmental investigation	28
9.10	Structural investigation	28
9.11	Operational investigation	29
9.12	Existing facilities	29
9.13	Social consequences	29
10	Assessment	29
10.1	Introduction	29
10.2	Assessment of the hydraulic performance	30
10.3	Assessment of environmental impact	30
10.4	Assessment of structural condition	31
10.5	Assessment of operational performance	31
10.6	Assessment of social and economic benefits and public satisfaction	31
10.7	Comparison with performance requirements	31
10.8	Identification of unacceptable impacts	31
10.9	Identification of causes of performance deficiencies	31
10.10	Setting goals	31
10.11	Prioritization of measures	31
11	Planning	32
11.1	Planning principles	32
11.2	Basic planning concepts	32
11.3	System components	33
11.3.1	Overview	33
11.3.2	Components for quantity control	33
11.3.3	Components for quality control	34
11.4	Asset-related solutions	35
11.4.1	General	35
11.4.2	Stormwater network	36
11.4.3	Sustainable drainage systems	36
11.4.4	Utilization of existing components	37
11.4.5	Asset-related solutions through collaboration with other projects	38
11.5	Non-asset-related solutions	40
11.5.1	General	40
11.5.2	Demand control	40
11.5.3	Flood resilience approaches	41
11.5.4	Disaster preparedness and response	41
11.5.5	Emergency response and recovery	43
11.5.6	Utilization of information and communication technology (ICT)	44
11.5.7	Insurance	44
11.6	Management aspects of planning	45
11.7	Phased implementation plan	45
12	System performance evaluation	46
12.1	General	46
12.2	Cost-benefit analysis	46
12.3	Evaluation of system performance	46

12.4	Monitoring of system performance.....	47
12.5	Retrospective evaluation.....	47
Annex A	(informative) The concept of the largest recorded rainfalls.....	48
Annex B	(informative) Cost-benefit analysis: example of calculation methodologies.....	50
Bibliography		54

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 224, *Service activities relating to drinking water supply, wastewater and stormwater systems*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The objectives of stormwater management systems include effective control and management of flows; protection of water quality; preservation of water quantity; protection of the built, public and natural environments; water conservation and reuse; protection or enhancement of ecosystem health; protection or enhancement of public health, safety and welfare; protection or enhancement of social values; and facilitation of sustainable development and climate adaptation.

The Intergovernmental Panel on Climate Change^[5] warns that many global risks of climate change are concentrated in urban areas. It indicates that risks are amplified for those lacking essential infrastructure and services or living in poor-quality housing and exposed areas. The key risks, all of which are identified with high confidence, include those of severe ill-health and disrupted livelihoods for urban populations due to flooding from a range of sources including pluvial, fluvial, storm surges and coastal flooding.

According to the UN Department of Economic and Social Affairs^[6], the world urban population is expected to increase by 72 % by 2050, from 3,6 billion in 2011 to 6,3 billion in 2050, i.e. by the same amount as the world's total population was in 2002. Virtually all of the expected growth in the world population will be concentrated in the urban areas of the less developed regions, which are deemed to be vulnerable to flooding. The report states that flooding is the most frequent and greatest hazard for the 633 largest cities or urban agglomerations analysed. Mud slides are often associated with severe weather conditions and flooding, particularly in rural areas, and commonly will impact rural villages and small towns, or their associated transportation infrastructures.

Thus, climate change and urbanization with rapid growth in population in cities and surrounding areas are most likely to increase flooding and the risks associated with stormwater worldwide. Serious challenges for stormwater management are posed for an increasing number of stormwater utilities, which are responsible for the control of pluvial flooding, which is caused by rainwater entering and surcharging stormwater systems or remaining on surfaces and flowing overland or into local depressions and topographic lows to create temporary ponds.

The immediate impacts of urban flooding can include loss of human life, damage to property, disruption of traffic and other services and deteriorations of limited freshwater resources, water ecosystems and hygienic living conditions. Effective stormwater management systems can enhance the resilience of communities by reducing the likelihood and severity of pluvial, fluvial and coastal flooding.

Planning methods for stormwater systems have been established in most developed countries but they do not always apply directly to other countries with different conditions. In order to help deliver the best solution to the targeted area, the framework and planning processes should be standardised.

Urban stormwater management is usually the responsibility of municipal water and wastewater service providers. However, in some countries the urban stormwater system management is performed by separate entities specially established for this purpose. Sometimes these services are not financially supported from the municipal water and wastewater revenues but from stormwater levies applied to flood-vulnerable properties concerned and created for that purpose or a local governing authority.

While it is largely historically true that urban stormwater management has been the responsibility of municipal wastewater authorities, it is increasingly recognized that stormwater management may be best or additionally served through collaboration with other relevant stakeholders, such as forestry commissions (for forested hill and mountain sides), agricultural commissions (for upstream farming properties), river authorities or port commissions (for the management of tidal surges on both marine and freshwater bodies) or local governing authorities.

This document can be used for the evaluation of design, operation and performance of stormwater systems. When various kinds of measures are proposed, selecting the best option requires evaluation. The comparison between prospective and retrospective evaluations can lead to the continuous improvement of stormwater management. In providing a common process for the evaluation of proposals to plan/design/procure stormwater systems, this document facilitates fair trade among suppliers.

Service activities relating to drinking water supply, wastewater and stormwater systems — Stormwater management — Guidelines for stormwater management in urban areas

1 Scope

This document provides guidance to stormwater management authorities and relevant stakeholders on both structural and non-structural stormwater management approaches. The guidance includes consideration of relevant policies, planning, design criteria and implementation processes for stormwater management, and performance evaluation. This document can be applied to new stormwater systems and to the extension or improvement of existing systems for both fully separated and combined storm and sanitary sewers.

This document is applicable to stormwater sewer systems as well as combined sewer systems.

This document is not applicable to sanitary sewer systems.

2 Normative reference

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 24513, *Service activities relating drinking water supply, wastewater and stormwater systems — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 24513 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

4 General overview

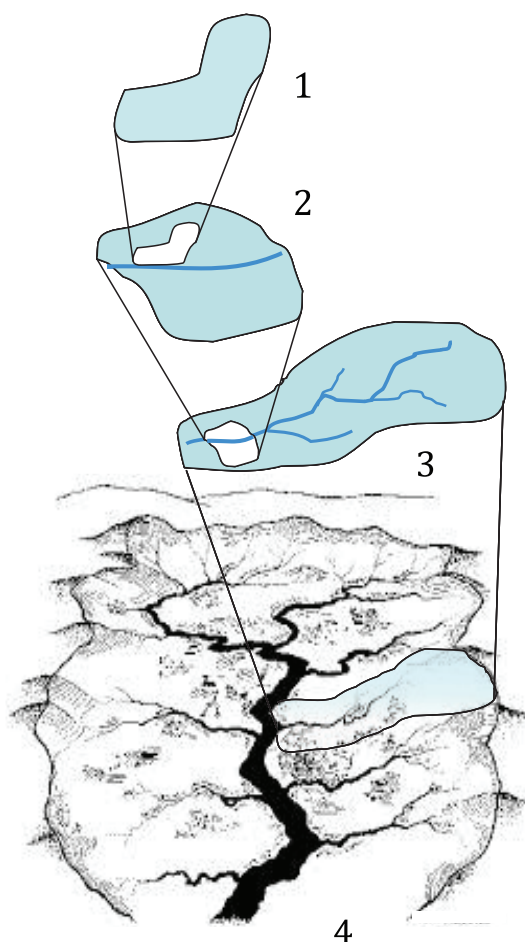
4.1 Principles

The role of the stormwater system should be determined within the context of the whole river basin catchment and the other elements of the urban drainage system (see [Figure 1](#)). To determine this role account should be taken of integrated water policies reflected in any national or local regulations or by the relevant authority together with any requirements of the integrated river basin management plan. Account should also be taken of any policies resulting from integrated urban drainage management.

The principles for effective stormwater management include:

- **hydrology**: minimize the impact of urbanization and land management practices on the hydrology of a catchment, including base and peak flows;

- **water quality:** minimize pollution entering into and discharged from the stormwater system;
- **vegetation:** maximize the value of riparian, floodplain and bank vegetation for flood attenuation, erosion control and water quality improvements;
- **aquatic habitat:** minimize the negative impacts of stormwater discharges on the integrity of aquatic habitats within the stormwater system; and
- **stormwater use:** promote opportunities to identify and use collected stormwater as an alternative water source.



Key

- 1 local drainage area
- 2 urban sub-catchment
- 3 city area
- 4 river basin

Figure 1 — Relationships between local drainage areas, urban catchments and river basin

4.2 Basic concepts

There are a number of basic concepts that support the objectives for urban stormwater management and that should be addressed during the process:

- flood-resilience and holistic risk analysis for new and existing systems;
- sustainability and responsible resource management;

- community consultation and involvement;
- consideration of interrelationships between catchments;
- consideration of changing climate, extreme weather and operational stress;
- consideration of lifecycle costs when selecting stormwater management alternatives;
- consideration of asset condition and rate of deterioration.

Figure 2 gives an illustration of a basic concept of a stormwater management system.

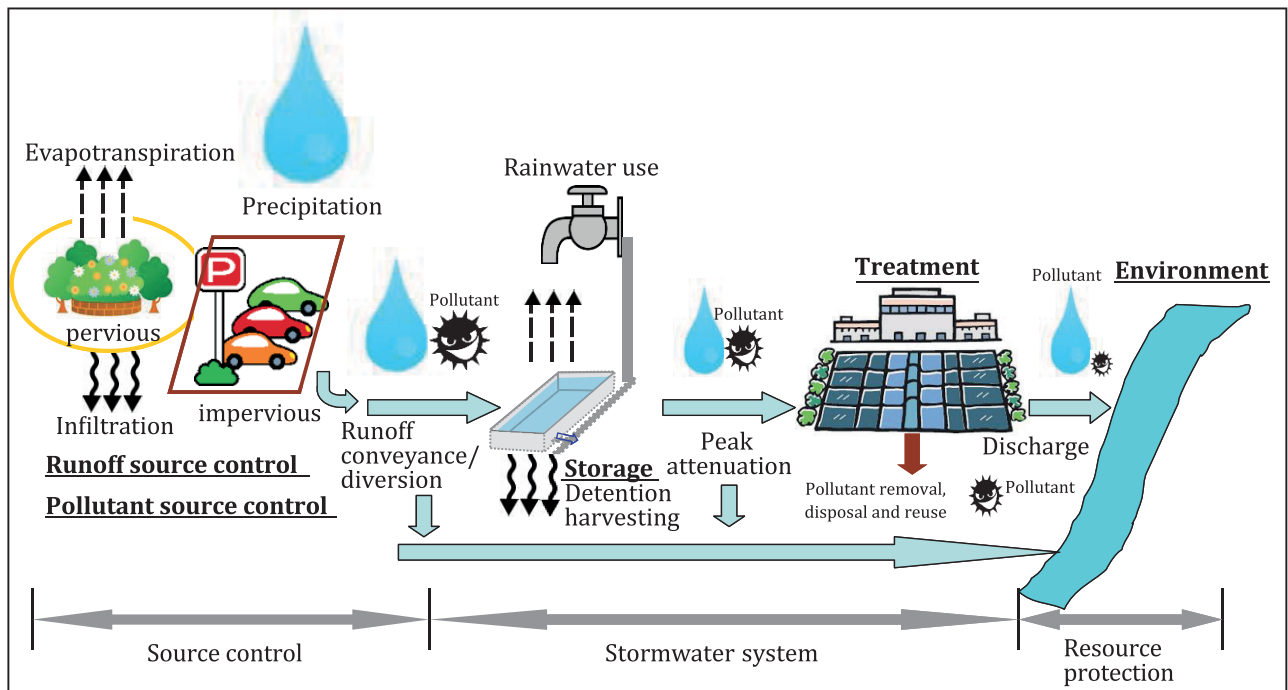


Figure 2 — Illustration of the basic concept of a stormwater management system

4.3 Stormwater management process

As illustrated in Figure 3, the stormwater process relies on the definition of functional and performance requirements adapted to the local objectives of the stormwater system. To ensure the fulfilment of these requirements a continuous management process can be followed that consists of investigation, assessment, planning and performance evaluation.

Both asset-related and non-asset-related solutions can be implemented to achieve the required level of performance.

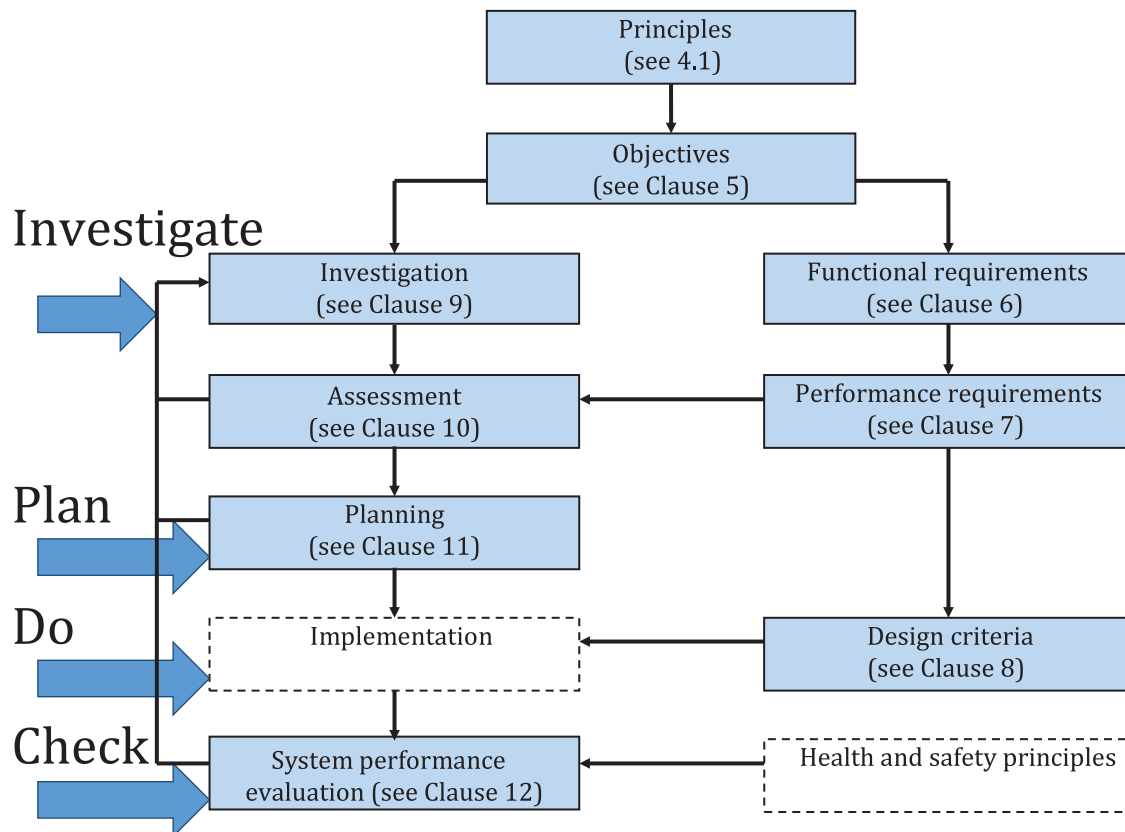


Figure 3 — The stormwater management process

5 Objectives

The objectives to be established by a wastewater or stormwater management utility should:

- be consistent with the stormwater management policy;
- be measurable (if practical).

Objectives can be short-, medium- or long-term and can vary according to the risk and opportunities within the catchment to public and environmental benefit. As such, urban stormwater management systems adopt a number of objectives to ensure that the risks are managed and opportunities realized.

The objectives of stormwater management are:

- effective control and management of flows;
- protection of water quality;
- preservation of water quantity;
- protection of the built, public and natural environments — infrastructure, property and resources;
- water conservation and reuse;
- protection or enhancement of ecosystem health;
- protection or enhancement of public health, safety and welfare;
- protection or enhancement of social values;
- facilitation of sustainable development and climate adaptation.

The objectives listed in [Table 1](#) are the basis for determining the functional and performance requirements of an urban stormwater management system as illustrated in [Figure 4](#).

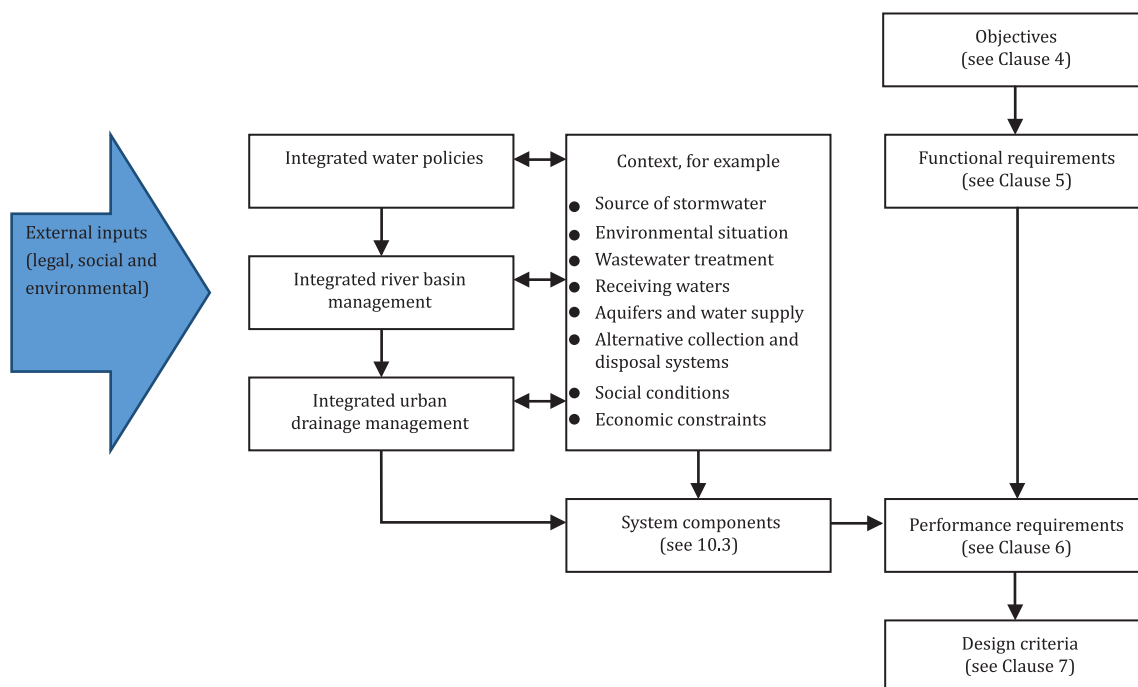


Figure 4 — Process for determining performance requirements from objectives

Table 1 — Urban stormwater management objectives

Objective	Purpose
Effective control and management of flow volumes	— to optimize the stormwater system (e.g. pipe network, flow control device, storage, pumping facility) — to improve the operation of the stormwater system — to set up the stormwater system balancing risk and cost
Protection of water quality	— to support the management of water quality in the receiving surface waters and groundwater — to maintain or improve the surface and groundwater quality in the receiving environment — to reduce the potential for pollutants from the built environment entering the receiving environment — to protect the stormwater at the nearest point of rainfall — to design system resilience to cope with future change
Preservation of water quantity	— to support the management of water quantity in the receiving water — to reduce negative quantitative impact of stormwater drainage from the stormwater system

Table 1 (continued)

Objective	Purpose
Protection of the built, public and natural environments: infrastructure, property and resources	— to use surface water runoff as a resource — to support the management of flood risk in the receiving catchment — to minimize the risk of flooding during rainfall events, including upstream flood risk — to protect the built environment from flooding and waterlogging — to reduce damage to infrastructure and property, and associated financial impacts — to protect resources from occupational health and safety hazards — to reduce and control the potential for erosion and instability of stream banks, vegetation and combined sewer assets — to protect morphology and ecology in receiving surface waters — to preserve and protect natural hydrological systems on the site — to drain the site effectively — to manage on-site flood risk — to design system flexibility/adaptability to cope with future change
Water conservation and reuse	— to maintain the total water cycle balance — to minimize runoff and water wastage — to maximize stormwater reuse through rainwater harvesting to supplement household, commercial/industrial, streetscape and parkland water supply needs — to contribute to recharging of groundwater aquifers
Protection or enhancement of ecosystem health	— to preserve, retain or enhance natural drainage systems and protect ecosystem health — to replicate natural flow regimes so that storm runoff hydrographs resemble pre-development patterns — to support and protect natural local habitats and species — to protect, conserve and retain aquatic habitats and biodiversity through preservation and restoration of natural habitats for flora and fauna — to mitigate deterioration in environmental health — to contribute to the delivery of local biodiversity objectives — to contribute to habitat connectivity — to create diverse, self-sustaining and resilient ecosystems
Protection or enhancement of public health, safety and welfare	— to minimize the risk of injury or loss of life and disruptions to human life, including flooding hazards — to eliminate standing water and consequences of danger from mosquito- and other vector-related diseases

Table 1 (continued)

Objective	Purpose
Protection or enhancement of public social values	— to ensure that social, aesthetic and cultural values are recognized and maintained when managing stormwater — to contribute to attractive and liveable communities — to promote land- and water-based recreational activities and stakeholder satisfaction — to maintain the variety of uses available to the community — to enhance wildlife habitat — to protect and increase property values — to maximize multi-functionality — to enhance visual character — to deliver safe surface water management systems — to support development resilience/adaptability to future change — to support community environmental learning
Facilitation of sustainable development and climate adaptation	— to ensure the delivery of best practice stormwater management through planning and development — to integrate urban drainage into landscape design as part of the initial design phase — to implement stormwater management systems that are economically viable in the long term — to create functional, energy-efficient, low-carbon, climate-resilient cities — to increase potential for land development — to provide an alternative water source to reduce demand and increase reliability of long-term water supplies

These objectives can and should be given full consideration for all types of development. The extent and way in which each purpose can be fulfilled will depend on site characteristics, development context and local objectives. The water quantity and water quality are likely to be the main drivers in determining the design philosophy for a site and these will be supported by expected levels of service for the stormwater management system. Maximising delivery of amenity and biodiversity objectives will often deliver on a range of other required planning outcomes/objectives for the site.

The objectives are not independent of each other. For example, using runoff as a resource will support both water quantity and amenity design objectives.

Generic criteria of good design are required to ensure a safe, functional and cost-effective sustainable drainage scheme. These generally fall into the categories listed in [Table 2](#). In order to maximize opportunities and the associated benefits, these criteria should be considered at an early stage and fully integrated into the stormwater management and urban design process. In so doing, it is then possible to ensure that the scheme is truly multi-functional and delivering the highest return for the developer and for the community who will live there.

Table 2 — Generic criteria of good design

Generic criteria	Explanation
Constructability	The design of a sustainable drainage system should ensure that it can be effectively and safely constructed.
Maintainability	The design of a sustainable drainage system should ensure that it can be easily and safely maintained.
Acceptability	The design of a sustainable drainage scheme should be acceptable to the public and other stakeholders.
Cost-effectiveness	The design of a sustainable drainage system should ensure that the site is drained to meet the required standards of service, while maximising the potential benefits from delivery of the criteria, at an affordable cost both initially to the developer and for those responsible for the long-term operation and maintenance of the system.
Health and safety	The design of a sustainable drainage system should ensure that it is safe for those living near or visiting the system, and for those involved in its operation and maintenance.

6 Functional requirements

6.1 General

The function of an urban stormwater system at the broadest level is to collect, transport, store and treat stormwater in order to mitigate the water quantity and quality impacts of stormwater flows on the receiving environment. However, for each of these functional requirements, there can be legal requirements, public expectations and financial constraints, which include performance requirements.

Functional requirements are also linked to system goals and cover the drainage system (and sewer systems for combined sewer systems), pumping installations and other components, including requirements resulting from external constraints (e.g. effects on surface receiving water bodies and wastewater treatment plants). The requirements should be considered in respect of the whole system to ensure that additions or modifications to the system do not result in failure to meet the target standards. Asset deterioration monitoring, affordability and the need for society to understand the constraints of the system are critical factors.

Typical detailed functional requirements of an urban stormwater management system include:

- protection from surface water flooding;
- protection from sewer flooding;
- protection of surface receiving water bodies;
- protection of groundwater;
- maintainability;
- structural integrity and design working life;
- sustainable use of products and materials;
- sustainable use of energy;
- protection of adjacent structures and utility services;
- maintenance of the flow;
- watertightness;
- prevention of odours and emission of toxic, explosive and corrosive gases;
- prevention of noise and vibration;

- input quality;
- protection of downstream drainage systems;
- protection from natural disaster events;
- health and safety principles.

Functional requirements should be determined to ensure that the objectives of the urban stormwater management utility as listed in [Clause 5](#) are achieved. Each functional requirement can relate to more than one objective.

6.2 Protection from surface water flooding

Surface water flooding has an impact on the health of people affected. It can also cause damage to buildings and urban infrastructure. The economic impact can be high and depends on the type of location flooded.

Pluvial flooding should be limited to nationally or locally prescribed frequencies, taking into account:

- the health and safety effects of the surface water flooding (whether it is from stormwater or a combined sewer system);
- the costs arising from surface water flooding;
- the extent to which any flooding on the surface can be controlled without causing damage;
- whether surcharge is likely to lead to surface water flooding of basements.

The hydraulic capacity of the drainage system should limit surface water flooding to nationally or locally prescribed levels and frequencies, taking into account backwater levels. The hydraulic capacity should allow for foreseeable increases in flow over the design working life of the system, including climate change projections.

Other forms of flooding can also impact on stormwater and combined sewer systems, including:

- a) fluvial flooding – water from rivers and lakes which flows onto the land;
- b) coastal flooding – water from the sea which flows onto the land;
- c) sewer flooding – wastewater from drains and sewers which surcharges and flows onto land or backs up into a property;
- d) groundwater flooding – water on land when the groundwater level rises and enters into underground structures, such as basements or garages.

The focus of this document is to deal with pluvial flooding. The interaction with other forms of flooding should be taken into consideration.

The effects of flows discharged into downstream receiving water bodies as well as erosion control and runoff reduction should be considered and managed appropriately.

Where there are components in the system which have a high risk of failure, measures should be taken to avoid or minimize the risk of surface water flooding in the event of failure of those components.

6.3 Protection from sewer flooding

Structures, including basements, connected to stormwater or combined sewer drainage systems should be protected from sewer backup caused by surcharge in the system.

6.4 Protection of surface receiving water bodies

Surface receiving water bodies should be protected from pollution.

The quality of discharges or other impacts from stormwater systems on the surface receiving water bodies should meet the local requirements (including environmental requirements).

6.5 Protection of groundwater

Groundwater should be protected from pollution. The effect of the stormwater system and any cumulative effect of multiple stormwater systems on the local recharge of aquifers and groundwater flood risk should be considered. Where infiltration drainage systems are proposed, the effects of runoff quality and quantity should be considered.

6.6 Maintainability

The system should be planned, designed, constructed and rehabilitated to allow effective maintenance activities that are safe (e.g. risk to personnel is controlled) and cost efficient. Adequate access and working space should be provided for maintenance purposes.

6.7 Integrity of structures

All the components of a stormwater system should be planned, designed, constructed, maintained, operated and rehabilitated to ensure structural integrity over the design working life.

6.8 Sustainable use of products and materials

Products, materials and their use/construction methods should be selected that minimize depletion of finite resources having regard to the design working life of the component and the potential for reuse or recycling, for example minimizing the volume of excavated material and its reuse.

6.9 Sustainable use of energy

The design and operation of the stormwater system should, so far as is practical, minimize the use of energy over the life of the system.

6.10 Protection of adjacent structures and utility services

The planning, design, construction, maintenance, operation and rehabilitation of any component of the stormwater system should not endanger existing adjacent structures or utility services.

6.11 Maintaining the flow

The system should be planned, designed, constructed, operated and maintained to reliably convey all permissible flows that can be collected by the system to the point of discharge, ensuring that the operation of the system is safe, environmentally acceptable and economically efficient.

6.12 Watertightness

All drains, pipes and ancillary structures should be watertight, unless designed to infiltrate to the ground (i.e. sustainable drainage systems).

6.13 Prevention of odours and emission of toxic, explosive and corrosive gases

Stormwater systems should be planned, designed, constructed, maintained, operated and rehabilitated as far as practicable to avoid odour nuisance, or emission of toxic, explosive or corrosive gases.

6.14 Prevention of noise and vibration

The system should be planned, designed, constructed, maintained, operated and rehabilitated so that noise and vibration are minimised.

6.15 Input quality

The stormwater system can be designed to receive stormwater runoff from both domestic and non-domestic sources. The quality of the non-domestic stormwater inputs should be controlled so that they do not compromise the integrity of the fabric of the system or its function or constitute a danger for the environment. National or local regulations or the relevant authority can give requirements for input quality.

6.16 Protection of downstream drainage systems

Flows and pollutant loads should be reduced or maintained to minimize impacts on receiving (downstream) drainage systems.

6.17 Protection from natural disaster events

The design and operation of the stormwater system should, so far as is practical, consider the potential impacts from a natural disaster event, for example storm surges, dam breaks or tsunamis.

6.18 Health and safety

6.18.1 General

Functional requirements should cover both public and occupational health and safety.

National or local regulations or the relevant authority might include more requirements regarding the health, safety and welfare of the public and/or personnel than indicated in this document.

6.18.2 Public health and safety

Stormwater systems should be planned, designed, constructed and operated so that the risk of public exposure to flooding and contaminated water in the case of a combined sewer system is minimized.

Appropriate communication measures should be taken to ensure public awareness.

Drinking water sources should be protected from contamination by stormwater runoff, infiltration and discharges.

6.18.3 Occupational health and safety

Stormwater systems should be designed, constructed and operated so that the occupational health and safety risks to personnel undertaking work associated with the stormwater system are minimised. In addition, welfare facilities should be provided where appropriate.

Those who are responsible for work in stormwater systems should ensure that the work does not present a risk to the health or safety of any person carrying out the work or any person who can be affected by their actions.

In addition, it is generally the responsibility of owners and operators to:

- provide safe systems of work, including arrangements for safe access to and egress from the stormwater system, and sufficient working space while in the system;
- ensure that their employees are properly instructed, trained and supervised in the work being carried out and in the safe systems of work in use.

7 Performance requirements

7.1 General

Performance requirements are targets to be met by the stormwater management system and components to achieve the overall objectives and stakeholder priorities for a catchment. They should represent protection of an existing valuable condition, or an improvement over existing conditions which are deficient.

The performance requirements should be defined according to the functional requirements described in [Clause 6](#). They vary between countries and can be constrained by legal requirements, public expectation and financial factors.

Performance requirements involve establishing a goal, quantifying the necessary control, and determining the emissions from the system. Stormwater systems should be designed to achieve the desired outcomes, for example to prevent property flooding during a 10-year event, to prevent erosive velocities from damaging infrastructure or to maintain appropriate quality for reuse.

The determination of performance requirements should be supported by:

- **monitoring:** the effect of stormwater on its environment can be assessed through local measurements and used to define requirements that are specifically adapted to the local context;
- **modelling:** the use of mathematical and/or physical modelling can help to explore a wide range of scenarios and thus define more precisely the performance requirements. Monitoring data can be used to validate such models;
- **generic values:** when monitoring and modelling data are not available, data from literature may also be used, but previous methods are preferred whenever possible.

Performance requirements should be reviewed periodically and updated if necessary. The performance requirements for the system should be updated after major extension, augmentation, maintenance or rehabilitation.

In principle, the performance requirements for a rehabilitated system should be the same as those for a new stormwater system.

7.2 Examples of performance requirements

7.2.1 Protection of receiving water bodies

National or local regulations or the relevant authority can specify performance requirements in relation to the environmental performance of stormwater systems.

Environmental performance requirements for stormwater systems can be set in terms of emission limits for discharges or in terms of the impact on the status of the receiving water body (including inland surface water bodies, coastal water bodies and groundwater). The requirements should take into account the impact of other emissions, the anticipated frequency of discharges, and physical (e.g. scour due to flow velocity), chemical, biochemical and other relevant considerations.

Proposed controls on discharges from the stormwater systems should take account of the water environment in the river basin (see [Figure 5](#)).