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Assessing and managing flood risk in development — Code of practice

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Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 December 2017. 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.

Supersession

This British Standard supersedes BS 8533:2011, which is withdrawn.

Relationship with other publications

This British Standard is complementary to BS EN 752 which covers drain and sewer systems outside buildings.

Information about this document

This British Standard complements existing statutory regulations and guidance to help the user prepare a comprehensive flood risk assessment that can be used for the purposes of planning and deciding upon appropriate flood mitigation measures.

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.

Where words have alternative spellings, the preferred spelling of the Shorter Oxford English Dictionary is used (e.g. “organization” rather than “organisation”).

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.

Particular attention is drawn to the following specific regulations:

- the Reservoirs Act 1975 [1];
- the Flood and Water Management Act 2010 [2];
- the Flood Risk Management (Scotland) Act 2009 [3];
- the Reservoirs (Scotland) Act 2011 [4];
- the Water Environment (Controlled Activities) (Scotland) Regulations 2011 [5];
- the Town and Country Planning Act 1990 [6]; and
- the Building Regulations 2010 [7].

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Introduction

This British Standard has been created to help the user to analyse the flood risk of a particular site and to guide the selection of appropriate risk management solutions.

This standard is applicable after the need to carry out a flood risk assessment has been established.

NOTE In Wales, a flood risk assessment is known as a "flood consequence assessment" and has the same meaning. For the purposes of this document, the term flood risk assessment is used.

A flood risk assessment seeks to assess the probability (likelihood) of a flood event occurring and the potential adverse consequences of that event. Flood risk can arise from many sources, including rivers, the sea, surface water run-off, heavy rainfall, groundwater and artificial sources (e.g. sewers, canals, reservoirs). The assessment also needs to pay due regard to the effects of a changing climate over the lifetime of the development.

1 Scope

This British Standard gives recommendations and guidance on the appropriate assessment and management of flood risk in developments.

It is intended to provide practical assistance for understanding and dealing with the flood risk associated with a proposed development.

NOTE Intended users include developers and their consultants, designers, planning authorities, water companies, land drainage authorities, internal drainage boards, and other regulatory bodies.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

3.1 annual exceedance probability (AEP)

probability of a flooding event being exceeded in any year

NOTE For example, a 1% AEP flood event has a 1% probability of being exceeded within any year. The use of AEP is preferred over other terminology, such as return period (e.g. 1 in 100 year event), which has incorrectly been associated with a regular occurrence rather than an average recurrence interval.

3.2 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 other land

3.3 flood extent

area covered by water during a flood event that is usually dry

3.4 flood risk

combination of the probability of a flood event and of the potential adverse consequences for human health, the environment, cultural heritage and economic activity associated with a flood event

3.5 flood risk management infrastructure

structure or feature designed to manage flood water

NOTE The structure or feature can be permanent or temporary and can have multiple ownership.

3.6 reservoir

natural or artificial pond or lake, loch or lough, used for the storage, supply and regulation of water

3.7 residual risk

assessment of flood risks that remain after taking account of all flood mitigation measures over the development lifetime, allowing for climate change and the long-term performance of infrastructure

3.8 sustainable drainage system (SuDS)

drainage systems designed to maximize the opportunities and benefits from surface water management in existing or new developments

3.9 watercourse

any passage through which water flows

NOTE For example, all rivers and streams, and all ditches, drains, cuts, culverts, dikes and sluices.

4 Assessing the risk of flooding

4.1 General

Users of this document should consult all relevant national and local planning policies and regulatory guidance for their area of interest.

A development-based flood risk assessment should be undertaken to determine:

a) the probability and consequence of flooding in and around the development, from all sources, in accordance with **4.3**, **4.4** and **4.6**;

b) how the development might alter the existing flooding regime, potentially increasing the risk of flooding elsewhere, in accordance with **4.5**; and

c) the design measures needed to manage the risk of flooding in and around the development, in accordance with **5.4** and **5.5**.

NOTE By undertaking the flood risk assessment at an early stage, it can be used to influence the conceptual layout and design of the development and reduce (or avoid) the risk of flooding for the lifetime of the development.

4.2 Site information

Before undertaking an assessment of the risk of flooding, information about the site and surroundings should be obtained, including:

a) details of existing infrastructure (e.g. watercourses, reservoirs, canals, water mains, flood risk management infrastructure and/or drainage infrastructure);

b) details of existing raised flood risk management infrastructure (e.g. the level of protection afforded by them and their condition);

c) evidence of historical flooding;

NOTE 1 This is sometimes available from published media and risk management authorities, including for example reports required under section 19 of the Flood and Water Management Act 2010 [2]. Local residents might also be able to provide anecdotal information.

d) topographic mapping (including local features, e.g. boundary walls and watercourses/drainage features); and

e) information on site ground conditions.

NOTE 2 This information can be found from British Geological Survey borehole logs and the National Soil Resources Institute (NSRI) and site specific ground investigations.

NOTE 3 Published sources of information relating to the risk of flooding include, for example, existing assessments of the risk of flooding, e.g. strategic flood risk assessments (SFRAs), strategic flood consequence assessments (SFCAs) or site-based flood risk assessments; flood risk management strategies, plans and maps; surface water management plans (SWMP); river basin management plans (RBMP); catchment flood management plans (CFMP); shoreline management plans (SMP); estuary management plans (EMP); strategic asset management plans (SAMPS); drainage assessments; water cycle studies; water level management plans (WLMP); and coastal habitat management plans (CHAMP).

NOTE 4 Regulatory authorities and stakeholder groups that can be useful sources of information include, for example, the Environment Agency, Natural Resources Wales, Scottish Environment Protection Agency or Rivers Agency of Northern Ireland; lead local flood authorities (LLFAs); local authorities; sewerage undertakers and water companies; internal drainage boards; highway authorities; the British Geological Survey; infrastructure (e.g. reservoir, canal and railway) operators; and harbour authorities.

4.3 Assessing the risk of flooding to the development site and beyond

The risk of flooding associated with a proposed development should be assessed as the combination of the probability of flooding and its consequence.

The following factors should be assessed:

a) how likely, and to what extent, the site might flood and the source and nature of that flood hazard;

b) the impact that the development could have on flooding elsewhere, including residual risk; and

c) the consequence of flooding (e.g. damage to property, injury to people or loss of life).

The assessment of flood risk should quantify the risk of flooding, both to and from the site, from the following sources:

1) sea, estuarine and fluvial (watercourse) (see **4.4.2** and **4.5.2**);

2) surface water (see **4.4.3** and **4.5.3**);

3) sewers and drains (see **4.4.4**);

4) groundwater (see **4.4.5** and **4.5.4**); and

5) failure of infrastructure (see **4.4.6**).

4.4 Assessing the probability of flooding to the development site

4.4.1 General

The probability of flooding to the proposed development site, from all sources, should be assessed in accordance with **4.4.2**, **4.4.3**, **4.4.4**, **4.4.5** and **4.4.6**. The effects of climate change on flood risk should be assessed in accordance with **4.6**.

4.4.2 Sea, estuarine and fluvial (watercourse) flooding

NOTE Sea flooding is flooding at the open coast caused by elevated sea levels (tides, wave action and storm surge). In estuarine areas, flooding might arise from either fluvial or tidal flooding, or a combination of the two. Fluvial flooding is flooding caused by rivers, watercourses or ditches overflowing.

4.4.2.1 Flood maps

Flood maps and registers should be used in the first instance to assess the probability of flooding in and around the development.

4.4.2.2 Developments outside the 0.1% AEP flood extent

In England, Scotland and Wales, evidence of historical flooding within the site, the potential risk of flooding from other sources and the potential impact on the probability of tidal and fluvial floods elsewhere as a result of the development should be investigated in accordance with **4.4.3**, **4.4.4**, **4.4.5** and **4.4.6**.

NOTE In Northern Ireland, the 0.1% AEP flood extent is not published and therefore cannot be taken into consideration for development planning.

4.4.2.3 Between the 0.1% AEP and the 0.5% AEP tidal flood extent or the 1% AEP fluvial flood extent

*COMMENTARY ON **4.4.2.3***

Predicted flood levels can be obtained from a number of sources, such as the Environment Agency or the relevant internal drainage board (England and Wales), as applicable.

Detailed hydraulic modelling is not usually necessary for assessments of developments outside the 0.5% AEP tidal flood extent or the 1% AEP fluvial flood extent.

Where the development is situated outside the 0.5% AEP tidal flood extent, or outside the 1% AEP fluvial flood extent in England (or 0.5% AEP fluvial flood extent within Scotland), an assessment of the anticipated depth of flooding within the development during the 0.1% AEP event should be carried out. This assessment should be based upon:

a) the development site topography; and

b) the predicted flood levels.

The assessment should include evidence of historical flooding within the site, the potential risk of flooding from other sources and the potential impact on the probability of tidal and fluvial floods elsewhere as a result of the development.

NOTE In Northern Ireland or Wales, an assessment of the anticipated depth of flooding to developments outside of the 0.5% AEP tidal flood extent, or 1% AEP fluvial flood extent, is not required and therefore this subclause does not apply to proposed developments in these regions.

4.4.2.4 Within the 0.5% AEP tidal flood extent or the 1% AEP fluvial flood extent

Where the development is situated within:

- the 0.5% AEP tidal flood extent or 1% AEP fluvial flood extent in England and Northern Ireland;
- the 0.5% AEP tidal flood extent or 0.5% AEP fluvial flood extent in Scotland; or
- the 0.1% AEP tidal flood extent and fluvial flood extent in Wales;

a more detailed assessment of the probability of flooding should be carried out.

This detailed assessment should determine:

a) the depth of flooding in and around the development;

b) the velocity of the floodwaters in and around the development;

c) the flood hazard posed by floodwaters in and around the development based on the flood depth and velocity;

d) the length of time for which the area in and around the development remains inundated;

e) the rate of rise of flood waters and the length of time available to forewarn of a potential flooding event at the development;

f) whether the development is likely to be cut off from other areas by floodwaters; and

g) the presence and level of protection provided by flood risk management infrastructure.

Information relating to the risk of flooding within (and around) the development should be obtained from historical evidence, previous flood risk assessments or detailed analysis and modelling.

NOTE 1 Such information might be available from the risk management authorities.

Advice should also be obtained (see Note 1) regarding the suitability of any existing data for the purposes of assessing the probability of flooding and the need for further investigations. Any existing flood risk management infrastructure should be taken into account when determining these characteristics (see **4.4.6**).

NOTE 2 Risk management authorities might have published guidance on the calculation of flood hazard.

To provide a thorough understanding of the risk posed by flooding in and around the development, the characteristics of flooding should be assessed for a range of flooding events, including the 5% AEP, the 1% AEP and the 0.5% AEP. The 0.1% AEP flood extent should also be assessed in Wales.

The flood hazard assessment should cover the hazard posed by the floodwaters over the three phases of flooding:

1) within the site as the floodwaters start to spill into the development;

2) during the flood event; and

3) as the floodwaters retreat.

The probability of floating debris, contaminants in the water, induced NaTECH hazards or unseen obstructions beneath the water that can increase the hazard should also be included in the assessment.

NOTE 3 Natural disasters can trigger negative technological impacts; these are termed NaTECH hazards.

4.4.3 Surface water flooding

*COMMENTARY ON **4.4.3***

Surface water flooding can occur as a result of either overland flow or ponding. Overland flow occurs following heavy or prolonged rainfall, or snow melt, where water can no longer be absorbed on the surface and results in surface run-off. Unless it is channelled elsewhere, the run-off travels overland, following the natural gradient of the land. Ponding occurs as the overland flow reaches natural depressions or blockages in the local topography.

The probability of surface water flooding should be assessed by examining the following information:

a) maps of surface water flood risk and reports of observed flooding incidents in and around the development, where available;

NOTE 1 These are sometimes available from published media and risk management authorities, including for example reports required under section 19 of the Flood and Water Management Act 2010 [2]. Water and sewerage companies, highways authorities and local residents might also be able to provide anecdotal information.

b) a study of the site-specific and surrounding topography to identify areas that might be susceptible to ponding and overland flow routes. This study should include:

1) an assessment of the on-site run-off characteristics for a range of storm events, from the 50% AEP to the 1% AEP design rainfall (or 0.5% AEP design rainfall in Scotland) for a range of storm durations, including but not limited to the critical storm duration;

2) an assessment of the off-site run-off characteristics for a range of storm events, from the 50% AEP to the 1% AEP design rainfall (or 0.5% AEP design rainfall in Scotland) for a range of storm durations, including but not limited to the critical storm duration;

3) the rate and volume of run-off that naturally drains towards the identified overland flow routes and areas of ponding, and therefore the depth of surface water that might occur, as determined by the run-off characteristics;

NOTE 2 The critical duration of the storm event is defined by the local catchment characteristics.

c) published reports including strategic flood risk assessments (SFRA), strategic flood consequence assessments (SFCA), surface water management plans (SWMP) or previous site specific assessments; and

NOTE 3 These studies can usually be sourced from the local authority website. SWMPs are only applicable to England and Wales.

d) a review of the existing drainage system, and its susceptibility to blockages and hydraulic locking, e.g. due to tide locking or high flood levels downstream. This should be discussed with the drainage authority.

4.4.4 Flooding from sewers and drains

*COMMENTARY ON **4.4.4***

Sewer and highway drainage flooding occurs when the capacity of systems is exceeded, or the function of the system is impeded (e.g. temporary blockage or tide locking), which results in the surcharging and/or failure of the system and water being forced to the surface via gullies, manholes, dedicated overflows or connected infrastructure (e.g. toilets).

To assess the probability of flooding from sewers, open drains (natural and constructed) and SuDS, the level of service of the existing sewer or drainage system serving the development (and surrounds) should be discussed with those responsible for its operation (e.g. the local authority, the water utility, the highway authority or private owner). Any known incidents of historical flooding should also be discussed.

4.4.5 Groundwater flooding

*COMMENTARY ON **4.4.5***

Groundwater flooding can occur on sites which are located on permeable ground. After a prolonged period of rainfall, a considerable rise in the water table can result in inundation for extended periods of time.

The probability of groundwater flooding in and around the development should be assessed through:

a) collating and reviewing observed incidents of groundwater flooding in and around the development;

NOTE 1 This information might be available from the risk management authorities.

NOTE 2 Place names often identify locations where ground water is likely to appear at certain times, e.g. lavant, spring.

b) reviewing published information to identify significant groundwater influences such as potential sub-surface flow paths, e.g. groundwater vulnerability mapping, groundwater susceptibility mapping, geological mapping, pumping records and borehole records;

NOTE 3 Such information can be obtained from the British Geological Survey (see www.bgs.ac.uk) and risk management authorities.

c) reviewing a qualitative appraisal of the potential impact of the cessation of groundwater management activities;

d) investigating the difference between the 1% AEP river level and ground levels within the development, in areas of permeable geology; and

e) collating and reviewing observed incidents of groundwater emergence in the surrounding areas that could result in overland flooding of the development.

4.4.6 Flooding caused by the failure of infrastructure

4.4.6.1 Water containment infrastructure

4.4.6.1.1 General

Water containment infrastructure, such as reservoirs, canals or water mains, situated above or upstream of the development should be identified and documented. It should be recorded whether the development is situated on higher or lower ground than the water containment structure, as failure of water containment structures can cause flooding with little or no warning to areas situated on lower ground. Any development planned within the vicinity of an existing reservoir could change its risk categorization; the reservoir owner and local planning authority should be consulted with regard to any implications.

4.4.6.1.2 Reservoir failure

The probability and consequence of dam failure at a reservoir should form part of the assessment.

A risk-based approach should be taken to assess the level of detail of analysis that is appropriate for the site, as follows.

a) Where a sudden reservoir failure might result in the rapid inundation of the development with insufficient warning to allow a safe evacuation, a hydraulic assessment should be undertaken. The depth and velocity of the resulting flood wave as it approaches (and flows through) the site should be taken into account in this assessment.

b) The structural integrity of the reservoir should be assessed in discussion with the reservoir owner or reservoir operator. Consideration should be taken of the long-term maintenance of the structure over the lifetime of the development.

c) Where the development is situated at a sufficient distance from the reservoir that it can be evacuated safely in case of a sudden structural failure, or the predicted depth of flooding through the site as a result of the structural failure of a reservoir is less than 250 mm, it is not necessary to undertake a detailed assessment.

NOTE Due to security concerns, sufficient information to assess the hazard is usually unavailable. Instead, the owner of the infrastructure often assesses the hazard to the development site and provides confirmation of the flood risk.

4.4.6.1.3 Canal failure

For canals, a flood risk assessment should be carried out to determine:

a) the probability of structural failure; and

b) the consequence of structural failure, including the likely depth and velocity of the floodwaters through the site, and the warning time available for evacuation of the development site.

The need for detailed appraisal, and the scope of the analysis required, should be discussed at an early stage with the relevant regulating authority.

4.4.6.2 Land drainage infrastructure

*COMMENTARY ON **4.4.6.2***

Some low lying areas are reliant upon artificial land drainage infrastructure to reduce the risk of regular and prolonged surface water and/or groundwater flooding. Examples of land drainage infrastructure include pumping stations, open drainage ditches and sluices. The operation and failure of such land drainage infrastructure can result in localized flooding and for this reason it is important to be aware of the impact and importance of land drainage infrastructure.

An assessment of the condition, capacity and ownership of any land drainage infrastructure, including watercourses, should be undertaken. In particular, the agreements to connect and future maintenance arrangements should be taken into account.

An assessment of the probability and consequence of the failure of land drainage infrastructure should be undertaken (i.e. whether or not this failure increases the risk of flooding to the site). An assessment of the probability and consequence of the cessation of land drainage management activities should also be undertaken.

4.4.6.3 Culverts and bridges

Limits to hydraulic capacity and/or blockage of culverts, bridges or other structures in the vicinity of the development should be assessed. Structures should be assessed based on upstream catchment characteristics, land use, stream morphology, stream vegetation, the size, shape and capacity of the structure, and the presence, design and maintenance of a trash or security screen.

The impact of blockages should be evaluated in terms of:

a) the frequency and depth of flooding in and around the development due to the backing up of water;

b) possible alternative flood flow routes;

c) rapid release of stored water;

d) integrity of structures that might act as temporary dams.

The following instances should be taken into account:

1) for bridge openings and culverts that are less than 1 m^2, the increase in the depth and frequency of flooding within the site as a result of a 90% blockage of the cross-sectional area; and

2) for bridge openings and culverts that are greater than, or equal to, 1 m^2, the increase in the depth and frequency of flooding within the site as a result of a 50% blockage of the cross-sectional area.

4.4.6.4 Flood risk management infrastructure

Where the development is situated within an area that is protected by the presence of raised flood risk management infrastructure it should be assessed for structural integrity.

The residual risk of flooding to the development site as a result of overtopping and/or sudden breach of a raised flood risk management infrastructure should be assessed. The probability and consequence of a failure at different locations should be used to determine the maximum risk to the development.

The residual risk of flooding to the site owing to the failure of flood risk management infrastructure should be assessed. (This infrastructure might include, for example, flood gates or sluices that prevent floodwaters from entering the site during a flooding event.) The responsibility for maintaining and operating this infrastructure should be understood, and the likelihood and consequence of a system failure (i.e. whether or not this increases the risk of flooding to the site) should be assessed.

The depth and duration of flooding in and around the development, the velocity of floodwaters entering the site and the resulting hazard should be assessed (see DEFRA Technical Report FD2320/TR2 [8]). Detailed hydraulic modelling might be needed.

NOTE The intention to commit to the long-term maintenance and operation of flood risk management infrastructure might be discussed in published plans including, for example, catchment flood management plans.

4.5 Assessing the risks of flooding as a result of the development

4.5.1 General

The plans for the development should aim to ensure that there is no increase to the risk of flooding as a result of the development. The following analyses should be carried out to assess the impact that the proposed changes to the site are likely to have upon the existing flooding regime (see **5.3**). This information should be used to inform the development of mitigation measures in accordance with Clause **5**.

Possible future changes to the probability of flooding as a result of climate change should be assessed in accordance with **4.6**.

NOTE Hydraulic modelling is normally used to assess the impact of the development on flood risk.

4.5.2 Sea, estuarine and fluvial (watercourse) flooding

4.5.2.1 Developments outside the 0.1% AEP flood extent

Where the development is situated outside the 0.1% AEP flood extent, no further assessment of the likelihood of tidal or fluvial floods as a result of the proposed development is normally needed; however, the impact that the development might have upon the risk of flooding from other sources should still be investigated in accordance with **4.3** and **4.4**.

NOTE Within Northern Ireland, the 0.1% AEP flood extent is not published and is not taken into consideration for development planning.

4.5.2.2 Developments within the 0.1% AEP flood extent

Where the development is situated within the 0.1% AEP flood extent, within the 0.5% AEP flood extent in Scotland, or within the 0.5% AEP tidal and 1% AEP fluvial flood extent in Northern Ireland, a more detailed assessment of the likelihood of flooding should be carried out to determine:

a) the change to the depth of flooding as a consequence of the proposed development;

b) the change to overland flow routes as a consequence of the proposed development;

c) the loss of available floodplain storage as a consequence of the proposed development at increments appropriate to the depth of flooding; and

d) the change to the level of protection provided by flood risk management infrastructure (where present) as a consequence of the proposed development.

Where flood risk management infrastructure is present, it should be taken into account when determining these characteristics (see also **4.4.6**).

Any changes to the characteristics of flooding, including climate change, should be assessed for a range of flooding events, including the 5% AEP, the 1% AEP, and the 0.5% AEP. In Wales, the 0.1% AEP flood event should also be included.

4.5.3 Surface water flooding

The increase in the probability of surface water flooding should be assessed through:

a) a study of the changes to topography and drainage within the site. This study should include:

   1) an assessment of where overland flow paths might be altered or blocked;

   2) an assessment of where areas of surface water ponding or existing ditches might be lost, resulting in the displacement of water to other areas; and

b) a study of the changes in the rates and volume of run-off as a result of the proposed development. This study should include an assessment of the changes to the permeability and topography of the local catchment area for a range of storm events.

4.5.4 Groundwater flooding

The increase in the probability of groundwater flooding should be assessed through a study of the changes to sub-surface flow paths as a result of underground structures (e.g. basements and piling).

4.6 The impact of climate change

An assessment should be carried out of the potential impact that changes to the climate might have upon the risk of flooding. This assessment should cover changes to the risk of tidal, fluvial and/or surface water flooding that might occur over the lifetime of the proposed development and should examine on-site and off-site impacts.

The assessment of the impact of climate change should be used for developing flood management measures, in accordance with Clause **5**.

NOTE An assessment of the possible impact of climate change is given in guidance issued by the environmental regulators.

4.7 The consequence of flooding

*COMMENTARY ON **4.7***

*The recommendations given in **4.4** and **4.5** cover the probability of flooding and the characteristics of the floodwaters. To fully ascertain the flood risk to a development, or changes to the risk of flooding elsewhere as a result of the proposed development, it is important to assess the consequences of flooding to people, infrastructure and the environment.*

Effective flood management measures conforming to Clause **5** should be implemented to reduce the potential consequences of flooding by minimizing the damage that is sustained to property as a result of flooding, to help safeguard inhabitants within the development during a flooding event and, where practicable, to maintain access to all areas by emergency services during flooding conditions.

5 Managing the risk of flooding

5.1 A risk-based approach for managing flood risk within a development

A sequential, risk-based approach should be taken to managing flood risk within a development. Each stage in this hierarchical process should be completed before moving onto the next. The stages should be completed as follows.

- *Stage 1 – Assessing and understanding the flood risk.* The first stage in this approach is to assess and understand the risk that is posed by flooding, in accordance with Clause **4**. Until a sound understanding of the variation in flood risk across the development site (and the surrounding area) has been achieved, it is not practicable to plan to avoid and manage the risk.

- *Stage 2 – Avoiding the risk.* Having assessed and understood the risk of flooding, the next stage is to avoid the risk (see 5.2), where practicable. Developers should avoid building within flood affected areas of their site (see 5.2).
- *Stage 3 – Substitution*. Where flood risk cannot be avoided completely then the consequence of flooding within the development should be managed through substitution. This could include substituting land uses for ones that are less vulnerable to flooding, or orientating the development within the site so that more vulnerable uses are situated in areas that are least likely to flood frequently and/or to a significant depth, in accordance with 5.3.
- *Stage 4 – Land raising, flood control/surface water management incorporation*. Where the flood risk cannot be managed completely through development location, land raising, flood control and surface water management infrastructure should be incorporated into the development, including (for example) SuDS, overland flow pathways or flood barriers in accordance with 5.4.
- *Stage 5 – Resistant/resilient building techniques.* As a final measure after stages 1 to 4 have been exhausted, the risk of flooding should be mitigated by adopting resistant and/or resilient building techniques to minimize the damage and disruption that is caused by flooding in accordance with 5.5.
- *Stage 6 – Safety.* The safety of occupants in the event of flooding should be taken into account in accordance with 5.7 for any residual risks.

5.2 Avoidance

Wherever practicable, development should be avoided in areas that are susceptible to flooding.

NOTE 1 This might involve reducing the developable area of the site, and restricting development to elevated areas of the site that are not susceptible to flooding.

NOTE 2 Although raising the level of the development above flood level can be deemed to be a form of avoidance, in this document it is taken as a form of flood control (see 5.4.2).

5.3 Substitution

5.3.1 Appropriate development and land uses

The proposed layout of development and associated land uses should be appropriate to the identified flood risk.

Users of this document should consult the current planning policies for their development area to identify various building and land uses in terms of their vulnerability and whether or not these are likely to be appropriate.

NOTE The potential impact of a flooding event might increase if vulnerable members of the community, or critical infrastructure needed by the wider community, are situated in areas that are known to be at risk.

5.3.2 Site layout within an area without raised flood risk management infrastructure

The layout of the site should be in accordance with the following hierarchy:

a) all development should be situated outside of the flood affected area;

b) where a) is not practicable, buildings, utilities and access routes should be situated outside of the flood affected area, restricting only landscaping to areas at risk of flooding;

c) where b) is not practicable, buildings, utilities and access routes should be situated in areas of the site that are at the lowest risk of flooding; and

d) where c) is not practicable, the design measures set out in 5.4 to 5.5 should be integrated into the development to mitigate the risk of flooding.

5.3.3 Waterway corridors and overland flow routes

Where a development site is situated immediately adjacent to an open or a culverted watercourse or the landward side of a flood risk management infrastructure, a buffer zone should be provided, free of obstruction and at existing ground level, to allow access to the waterway for maintenance purposes. Discussions should be held with the relevant regulatory authority at an early stage to confirm the buffer requirements. In the absence of any other information, buffers should be 10 m wide.

NOTE 1 In tidally affected areas the buffer zone is likely to be wider than 10 m. During extreme conditions, buffer zones may also serve as conveyance routes.

The landscape design should be such that it provides a free and unimpeded passage of any likely flood flows; the highway network can be utilized as an overland flow route in extreme events. Provision should be made for easy and unobstructed evacuation to higher land and access for emergency services. Areas of isolated higher ground that could become islands in flooding conditions should be avoided for development. Landscaping furniture (e.g. seating) should be appropriately located and firmly fixed to minimize the risk of causing downstream blockages.

NOTE 2 Natural (or introduced) overland flow routes can, in flood or exceedance conditions, become waterways, even where they would usually be dry. Further guidance regarding designing for drainage can be found in the CIRIA publication, Designing for exceedance in urban drainage – Good practice [9].

5.3.4 Use of floor space within a building

Where a site is at risk of flooding, developments that could leave inhabitants vulnerable (for example, residential uses) should be situated on upper floors of the building, above the 1% AEP flood level, or within Scotland, the 0.5% AEP flood level. The ground floor should, wherever practicable, be restricted to non-residential uses (for example, commercial or industrial uses).

Basements should be planned and developed with internal access to a higher floor (above flood level) and they should be constructed using flood resistant and/or resilient design techniques. Basement space in an area susceptible to flooding should not be used for sleeping accommodation due to the significant safety risk.

NOTE It is important that developers check with the regulating authorities, including the local planning authority regarding the acceptability of basements in areas at risk of flooding.

The provision of industrial land uses at ground level can lead to a risk of pollution during flooding conditions. The risk of pollution should be taken into account at the design stage of the development process, and where it is believed that there might be a risk of pollution, appropriate measures should be incorporated into the development to manage it (e.g. through the raising and/or bunding of chemical stores).

5.4 Control

5.4.1 General

Where the risk of flooding cannot be avoided (see **5.2**), then measures should be taken to control flood waters on the site; these might comprise land raising, defences or improvement works. Any control measures should not increase the flood risk to others.

Improvement works to watercourses, bridges and culverts, drainage infrastructure (including land drainage and sewers) can reduce the flood risk and should be assessed alongside the need for land raising or other defensive infrastructure.

5.4.2 Land raising

Raising the ground levels reduces the risk of flooding of the development site, but should not be implemented so as to cause an increase in flood risk elsewhere. Alternative flood routing and compensatory storage should be provided if necessary (see **5.5.6**).

NOTE Raising ground levels is likely to result in a change to the passage and storage of flood flows within the floodplain, which in turn can increase the frequency and severity of flooding to other areas.

5.4.3 Flood risk management infrastructure

Developments should not rely on new raised flood risk management infrastructure to protect against flooding.

NOTE 1 Raised flood risk management infrastructure provide a barrier to reduce the risk of flooding to a development. However, the overtopping and/or sudden failure of the defence can pose a risk to life. For this reason, development proposals that involve the construction of new raised flood risk management infrastructure are generally thought to be unsuitable.

The development proposals should document ownership and responsibilities for the operation and maintenance of flood risk management infrastructure.

NOTE 2 The developer could take on responsibility for the maintenance of flood risk management infrastructure, or the structure could be adopted (and maintained) by an appropriate authority.

Existing raised flood risk management infrastructure should be assessed and any defects rectified to ensure it is structurally sound.

NOTE 3 For example, this could look at standard of protection, condition rating, maintenance plans, probability of failure and consequences of failure.

5.4.4 Bridges and culverts

The effects of blockages of bridges or culverts upon the risk of flooding within the site should be assessed, in accordance with **4.4.6.3**.

Where the assessment indicates that a blockage would increase the risk of flooding to the development site, then ownership and responsibility for the bridge or culvert should be established. Where an increase in flood risk is likely, contingency measures should be introduced, such as improvements to the structure and introduction of an unobstructed bypass flow route.

5.4.5 Water containment infrastructure

The consequence of failure of water containment infrastructure should be assessed in accordance with **4.4.6**. Where the assessment indicates a potential risk to life as a result of the sudden failure of a reservoir or canal, it should be evaluated whether to avoid building a development at this location. Where it is not practicable to avoid building the development, then the long-term safety of the users of the site should be ensured, in light of the risk that has been identified, either through control measures or mitigation (see **5.5**). As a minimum, the responsibility for the long-term maintenance of reservoirs and/or canals should be established.

NOTE Attention is drawn to the Reservoirs Act 1975 [1] and the Flood and Water Management Act 2010 [2].

5.4.6 Existing sewer and drainage infrastructure

The consequence of failure of existing sewer and drainage systems should be assessed in accordance with **4.4.4**. Where the assessment indicates a risk of flooding due to the serviceability or structural condition of the existing sewer system, then the rehabilitation of the sewer system should be evaluated as part of the development process. In all circumstances, the responsibility for the long-term maintenance of the systems over the lifetime of the development should be established and documented.

5.4.7 Surface water management

The rate and volume of surface water flowing on to the site from elsewhere and that generated within the development site should be assessed. The surface water system for the development should be designed to accommodate this run-off, such that the frequency and severity of surface water flooding to surrounding areas does not increase as a result of the proposed development. Where practicable, the risk of surface water flooding to surrounding areas should be reduced. Developers should check with regulating authorities, including the local planning authority, regarding the requirements of the development's surface water drainage strategy.

NOTE Sustainable drainage systems (SuDS) are designed to mimic the response of the natural environment, mitigating the impact of the proposed development upon the local flooding regime. Further guidance for developers regarding the selection, design and implementation of SuDS can be found in the CIRIA SuDS manual [10].

5.4.8 Groundwater management

The consequence of groundwater flooding should be assessed (see **4.5.4**). Where a risk of groundwater flooding has been identified then basement areas should be waterproofed to avoid the ingress of water. The ground floor level should be raised above the predicted groundwater flood level and flood resistant building techniques should be adopted to minimize the damage sustained as a result of prolonged flooding (see **5.5.4**). Access routes should be designed in such a way that they remain safe during periods of groundwater flooding.

5.5 Mitigation

5.5.1 General

Where the risk of flooding cannot be avoided, and the development site cannot be defended or protected against flooding, then the risks should be safely managed and rapid recovery techniques incorporated into the building design in accordance with **5.5.2** to **5.5.6** and **5.6**.

5.5.2 Mitigation within an area with raised flood risk management infrastructure

The standard of protection of existing raised flood risk management infrastructure should be assessed. Where a minimum standard of protection of 1% AEP within fluvial areas, or 0.5% AEP in tidal areas, is not provided, then the infrastructure should be upgraded to achieve this. The existing defences should also be assessed and any defects rectified to ensure it is structurally sound. Where existing infrastructure cannot be upgraded, additional mitigation or control measures should be provided.

Where a site is protected against flooding by flood risk management infrastructure, the consequence of overtopping or breach should be assessed, in accordance with Clause **4**.

The layout of the site should be arranged to reduce the risk of flooding to buildings or access routes by orienting these away from areas that would be inundated as a result of defence failure, wherever practicable.

Buildings should be designed so that floor levels are situated 300 mm above the 1% AEP fluvial flood level, or 0.5% AEP tidal flood level (whichever is higher) and include an allowance for climate change in accordance with **4.6**. This should be computed using the overtopping or breach of the flood risk management infrastructure, whichever results in the worst case conditions within the site. Where climate change has not been calculated, or there is low confidence in the computation of overtopping or breach, floor levels should be situated 600 mm above the design flood level.

Within Scotland, floor levels should be situated a minimum of 500 mm above the 0.5% AEP fluvial or tidal flood level (whichever is higher) and include an allowance for climate change in accordance with **4.6**.

Building floor levels should be situated above the predicted 1% AEP surface water flood level, or maximum anticipated groundwater flood level, whichever is higher.

Where floor levels cannot be raised due to access and/or planning constraints, flood resistance and/or resilience techniques should be incorporated into the building fabric, in accordance with **5.5.4** and **5.5.5**.

A commitment should be in place for the long-term maintenance and safe operation of the existing flood risk management infrastructure in accordance with **4.4.6**.

5.5.3 Mitigation within an area without raised flood risk management infrastructure

Where buildings cannot be moved outside the flood risk area, finished floor levels should be raised above the 1% AEP flood level in areas at risk of surface water and/or fluvial flooding, or raised above the 0.5% AEP flood level in areas at risk of tidal flooding. Within Scotland, finished floor levels should be raised above the 0.5% AEP fluvial or tidal flood level, whichever is greater. The building floor level should be raised by applying a freeboard to a height above the maximum predicted flood level that takes into account:

a) the height of waves that might occur; and

b) any anticipated increase in the predicted flood level as a result of climate change.

NOTE 1 The minimum freeboard is generally 600 mm where there is a lack of information on which to base the flood level, or 300 mm where there is confidence in the predicted flood level.

Building floor levels should be situated above the predicted 1% AEP surface water flood level, or maximum anticipated groundwater flood level, whichever is higher.

The design of buildings should also take into account the potential for surface water and groundwater flooding.

Before raising floor levels, discussions should be held with the local planning authority regarding the impact that raised floor levels could have on:

1) disabled access into buildings; and

2) roof levels of buildings within designated heritage or character areas.

NOTE 2 Loss of available floodplain storage due to raising floor levels can result in an increase in the risk of flooding elsewhere. It might be necessary to look at other measures to compensate for this loss.

5.5.4 Building design — resistance to flooding

Where it is not feasible to raise floor levels or development site ground levels above the flood level, buildings should be constructed using water-resistant materials.

NOTE 1 This is designed to resist the full hydrostatic head of flood water, with an allowance for uncertainty and the potential effects of debris in flowing flood water.

Water should be allowed to enter the building once the depth of flooding exceeds 600 mm. In these circumstances, resilient building techniques should be adopted, in accordance with **5.5.5**.

NOTE 2 Allowing water to enter the building once the flood depth has exceeded 600 mm can help to reduce the risk of structural damage due to differential hydrostatic heads. Guidance for developers regarding resilient building techniques is provided in BS 85500.

5.5.5 Building design — resilience to flooding

Where it is not practicable to raise floor levels above the flood level, or to construct the building using resistant materials, the building should be constructed using materials that are not affected by water

or are sacrificial. Where such building materials are used, services should be located above the 1% AEP peak design flood level, including an allowance for climate change in accordance with **4.6**.

NOTE Guidance for developers is provided in BS 85500.

5.5.6 Mitigating the impact of development (compensatory floodplain storage)

Where a proposed development reduces the available storage volume of a flood plain, compensatory floodplain storage should be provided to prevent a net increase in the frequency or severity of flooding elsewhere.

The compensatory floodplain storage should:

a) be in close proximity to the development, where practicable;

b) include an allowance for climate change;

c) provide the same volume at the same topographic level as that lost;

d) be connected hydraulically to the flood plain and able to freely fill and drain by gravity;

e) be open and unlikely to be enclosed throughout its life;

f) not affect the flow of water over land; and

g) be protected from future development through the planning process.

For b), the net volume of available floodplain storage should be measured at increments appropriate to the depth of flooding, up to (and including) the maximum predicted 1% AEP design flood level, or the 0.5% AEP design flood level in Scotland.

5.6 Construction issues

The assessment should take into account management and mitigation of flood risk during the construction phase. This could include evaluation of the impact of temporary works and the phasing of construction activities.

In terms of surface water management, for a construction site there should be an accepted phasing plan showing how SuDS maintenance is intended to be carried out during construction due to the effects of siltation.

NOTE Such maintenance is required to protect new and downstream properties from flood risk.

Gullies/highway surface water systems should be kept clear during construction and, if any temporary features are required to provide mitigation, they should be designed appropriately.

5.7 Public safety

5.7.1 General

Public safety should be taken into account in all aspects of managing flood risk. (Although the development might not be directly affected by flooding, access routes to the site could be hindered by floodwater.) The provision of a safe evacuation route and access for emergency services, together with an emergency plan should be provided in accordance with **5.7.2** and **5.7.3**.

5.7.2 Safe access to the development site and evacuation of people during flooding

A safe evacuation route for the development site should be provided in accordance with **5.7.2**a) or **5.7.2**b). These should be evaluated in hierarchical order, from **5.7.2**a) to **5.7.2**b). Within Scotland, access and egress routes should be designed for the 0.5% AEP flood event.

a) Wherever practicable, the safe access route should be situated above the 1% AEP fluvial flood level or 0.5% AEP tidal flood level, including an allowance for climate change, in accordance with **4.6**. The safe access route should be constructed to allow those within the development

site to be able to exit the development to an area of safety while remaining dry. In addition, occupants should have the ability to safely evacuate the site during the extreme flood – generally understood to be the 0.1% flood.

b) Where it is not practicable to construct an access route to the development site that is situated above the design flood level given in **5.7.2**a), the flood hazard along the access route should be assessed for the 1% AEP fluvial flood event, or 0.5% AEP tidal flood event, including an allowance for climate change, in accordance with **4.6**. The assessment should be carried out as follows.

   1) Where flood depth is ≤0.25 m, flood hazard = [(velocity + 0.5) x depth] + 0.5.

   2) Where flood depth is >0.25 m, flood hazard = [(velocity + 0.5) x depth] + 1.0.

   Wherever practicable, the access route should be designed such that the flood hazard in the 1% AEP fluvial flood event or 0.5% AEP tidal flood event, including an allowance for climate change in accordance with **4.6**, is less than 0.75 for residential and 1.25 for commercial areas.

NOTE Under these circumstances, it is likely that most occupants would be able to evacuate the site without undue danger. Some people such as young children, older and disabled people might require the assistance of the emergency services.

In all instances, an emergency plan should be prepared, in accordance with **5.7.3**.

5.7.3 Emergency planning

*COMMENTARY ON **5.7.3***

Where a development is situated within an area that is at risk of flooding, it is important that the users of the site are made aware of that fact. This can help them to prepare for a flood, when one occurs, thereby reducing not only the physical danger, but also the stress of being flooded and, potentially, the damages sustained. There are, however, some situations where it is preferable for people to remain in a place of safety within a flooded property, rather than risk injury during the evacuation.

The developer is expected to submit an evacuation plan as part of the planning application process.

The developer should submit a draft emergency plan for approval to the relevant authority. The emergency plan should include:

a) the availability of flood warnings, and how these can be accessed;

b) the roles and responsibilities for all those covered by the emergency plan;

c) the procedures for monitoring and acting upon flood warnings;

d) the triggers for action in response to a flood warning;

e) the procedure required for safely evacuating people from the site including those who require assistance;

f) the route by which people can be safely evacuated;

g) the safe area to which evacuees should proceed; and

h) the safe shut down procedures for machinery or plant.

Buildings should be provided with an on-site refuge for people who cannot be evacuated easily. However, a safe access route conforming to **5.7.2** should also be provided for evacuation in case of an emergency (e.g. medical or fire) or where the flooding exceeds predicted levels.

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