Bath & North East Somerset Council

Strategic Flood Risk Assessment of Bath and North East Somerset

Level 2 SFRA for Bath

July 2009

CAPITA SYMONDS

successful people | successful projects | successful performance

Contents

The B&NES SFRA is a 'live' document. The current version has been developed using the best information and concepts available at the time. As new information and concepts become available the document will be updated and so it is the responsibility of the reader to be satisfied that they are using the most up-to-date information and that the SFRA accounts for this information. All revisions to this summary document are listed in the table.

Version	Issue Date	Issued by	Issued to
DRAFT v 1.0	06/04/2009	Capita Symonds Ltd	B&NES
DRAFT FINAL v 1.0	26/05/2009	Capita Symonds Ltd	B&NES
FINAL v 1.0	29/07/09	Capita Symonds Ltd	B&NES

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Foreword

Bath and North East Somerset (B&NES) Council are required to prepare a Strategic Flood Risk Assessment (SFRA) to support the production of their Local Development Framework (LDF).

The SFRA creates a strategic framework for the consideration of flood risk when making planning decisions. It has been developed in accordance with Planning Policy Statement 25: Development and Flood Risk (PPS25), PPS25 Practice Guide, as well as additional guidance provided by the Environment Agency.

The guidance provided in PPS25 requires local authorities and those responsible for development decisions to demonstrate that they have applied a risk-based, sequential approach in preparing development plans and considered flooding through the application of a Sequential Test. Failure to demonstrate that such a Test has been undertaken potentially leaves planning decisions and land allocations open to challenge during the planning process.

The underlying objective of the risk-based sequential allocation of land is to reduce the exposure of new development to flooding and reduce the reliance on long-term maintenance of built flood defences. Within areas at risk from flooding, it is expected that development proposals will contribute to a reduction of flood risk.

A SFRA is essential in enabling a strategic and proactive approach to be applied to flood risk management. The assessment allows us to understand current flood risk on a wide-spatial scale and how this is likely to change in the future.

The SFRA is presented in a number of documents:

Level 1 SFRA for the whole of B&NES

- Non technical summary leaflet
- VOLUME I – decision support guide
- VOLUME II – technical report and flood maps
- VOLUME III – management and update guide

Level 2 SFRA for key areas

- Level 2 SFRA Report for each key area (Part 1)
- Sequential Test Report (Part 2)
- Scoping Study for Flood Risk Management Strategy (Part 3)

The partitioning of the SFRA into this series of reports enables B&NES to assess flood risk in increasing detail as they progress their Local Development Framework (see Figure A).

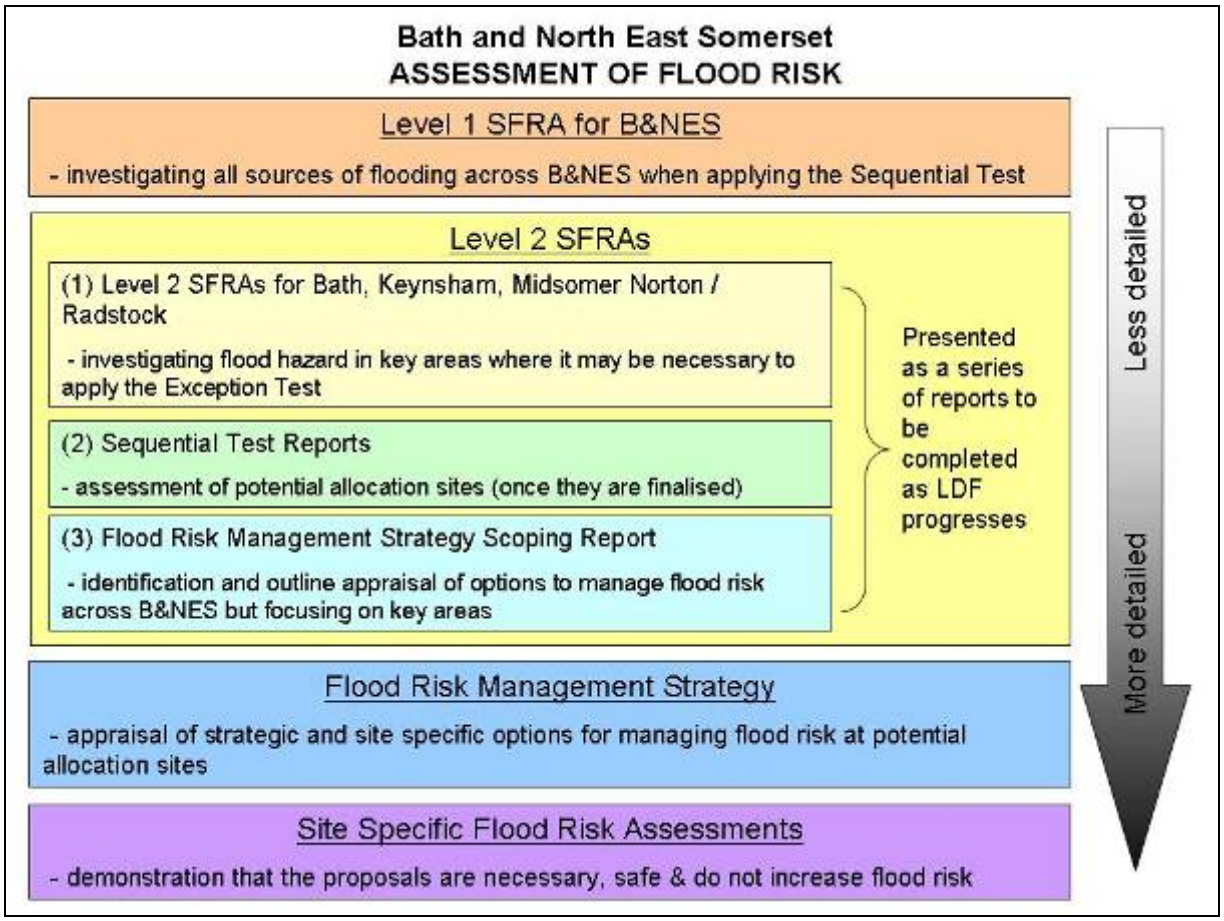

Figure A. Hierarchy of flood risk investigations

The SFRA are live documents which are intended to be updated as new information and guidance becomes available. The outcomes and conclusions of the SFRA may not be valid in the event of future changes. It is the responsibility of the user to ensure they are using the best available information when making a land planning decision.

1. Introduction

Purpose of this report

This Bath and North East Somerset (B&NES) SFRA has been developed to inform the Local Development Framework (LDF). The SFRA must be robust and be evidence-based so that it does not leave planning decisions and land allocations open to challenge through the land use planning process. It is crucial that there is transparency in the data and methods used in the assessment.

This volume of the Bath & North East Somerset Strategic Flood Risk Assessment is the

Level 2 Strategic Flood Risk Assessment for Bath

This report is the first of a series of reports to provide Level 2 SFRA information for key areas within B&NES. This report builds upon all of the technical information and methods used in the Level 1 assessment of flood risk across the study area. This report is intentionally partitioned from the Level 1 SFRA, as it does not repeat guidance contained within the Level 1 SFRA. However, it is intended that the reader of this document refers to the Level 1 SFRA for further technical guidance where appropriate.

The other Level 2 SFRA reports (Sequential Test and Scoping Reports) will provide more specific flood risk information for potential allocation sites, and an outline appraisal of flood risk management options available to B&NES.

The need for a Level 2 SFRA is primarily driven by regeneration and new housing requirements outlined in the B&NES Local Plan and the draft South West Regional Spatial Strategy. A combination of urban infilling and urban extension has been proposed to meet this housing need and some areas identified for this development were shown to have a high probability of flooding (Flood Zone 3) in the Level 1 SFRA.

A Level 2 SFRA has been undertaken to provide greater understanding of the factors contributing to the probability of flooding in the potential development areas, provide guidance for LDF policy to ensure that the development would be safe from flooding and would not increase flood risk elsewhere, and identify the need for additional more detailed assessment to reduce uncertainty. The scope of the Level 2 SFRA is defined in the PPS25 (December 2007), and expanded in the recently published PPS25 Practice Guide (June 2008). This Level 2 assessment is structured to address the requirements of PPS25 and the Practice Guide and in doing so includes sections on sources of flood risk, managing flood risk today, and in the future, and recommendations for implementing the Level 2 SFRA.

The user is referred to Volumes II and III of the SFRA for guidance on how to interpret the information in this technical report and how to update the SFRA following improvements in data or changes in guidance. The SFRA is based on a range of data from different sources and of various degrees of certainty. It is the responsibility of the user to understand and take account of the source and certainty of the data when referring to the flood risk summaries and flood maps.

Overview of Bath

Bath is a historic and world heritage city, famous for its naturally occurring hot springs. The land surrounding the city is designated as an Area of Outstanding Natural Beauty (AONB). Approximately half the population of the B&NES area live in the city of Bath. Historically, water has played a key role in defining the city's character. From the Roman baths which utilised the thermal springs, to the importance of the River Avon as a shipping route. Over hundreds of years, the floodplain has been developed right up to the river's edge and the city centre has experienced significant flooding in recent years.

Location

Bath is situated in the north east corner of the B&NES district, as shown on Map O.

Physical characteristics

The city of Bath lies within seven hills between the Mendips and Cotswolds. The River Avon flows from east to west with a significant meander in city centre. Two smaller tributaries; the Twerton watercourse and Lam Brook also flow through the city into the River Avon, in addition to the Newton Brook and St Catherine's Brook which flow into the River Avon just upstream and downstream of Bath respectively. A significant proportion of built development within the city is adjacent to watercourses.

Bath is underlain by limestone and clays, mainly Lower Lias, with some Upper Lias, Middle Lias and Inferior Oolite. Soils in the study area are shallow, lime rich and freely draining. Map T2 provides an indication of the ground topography in Bath.

Human influences

Bath owes its modern existence to its proximity to the hot springs. The town developed to accommodate the growing tourism industry which was fuelled by interest in the hot springs. The service sector is still the largest local employer, particularly within hotels, restaurants and the local authority. In addition, an extensive number of warehouses and mills were built along the riverside, to support the thriving industrial and commercial activity in the city supported by the inland port which allowed trade between Bristol and Bath before the Kennet and Avon canal was built.

Residential, industrial and commercial development in the city has heavily modified the River Avon. Bridges and riverside development constrain flow within the channel and the system of sluice gates, weirs and the Kennet and Avon canal have altered the natural flow regime.

The Bath and North East Somerset Core Strategy will present a long term spatial development plan for the district that looks forward to 2026. At Bath, the emerging spatial strategy pursues the regeneration of the River Avon corridor, alongside an urban extension to the south/ south west of the city and the redevelopment of a number of publicly owned 'suburban' sites.

The 'river corridor' is conceptualised as comprising four distinct zones; Central Zone (City centre and BWR East), Riverside Zone, Lower Bristol Road Zone and Newbridge Industrial Zone. Various mixtures of residential, retail and commercial development will be directed to these areas which are all partially located within the 1% AEP flood extent. Western Riverside is already allocated in the Local Plan and is one of the largest brownfield regeneration projects in the South West where 2,500 – 3,000 new dwellings and other commercial uses are planned.

All sites in Bath allocated in the existing Local Plan (2007) are identified in Map N.

The Core Strategy will allocate the river corridor and the zones within it for a particular quantity and mix of development and present a number of place-making principles to shape new high quality areas of functional townscape. Subsequent LDF documents will set out specific requirements for individual sites within each zone and for sites beyond the river corridor.

The urban extension will be allocated as a strategic site (showing location and function) in the Core Strategy. A master plan supplementary planning document will be prepared to set out requirements for the urban extension.

2. Sources of flood risk

Introduction

PPS25 identifies six sources of flooding to be investigated in an SFRA as flooding from rivers, the sea, groundwater, land, sewers and artificial sources. Bath is prone to flooding from a range of sources including rivers, sewers, surface water, artificial sources and to a lesser degree from groundwater (springs).

Summary of flood risk in Bath

The dominant sources of flood risk in Bath are rivers and sewers although there is some risk from surface water, artificial sources and a very minor risk from groundwater sources. The main areas at risk are:

- Rivers - Map F shows the SFRA Flood Zones within Bath as defined in PPS25 and flood extents ignoring the presence of flood defences. Map A1 shows the actual extent of flooding when the impact of existing flood defences is considered. The most number of properties are at risk in Grosvenor, central Bath (St John's Road and recreation/cricket grounds), Kingsmead (Riverside Road), Lower Weston (around the confluence) and Locksbrook.

  Map A2 indicates the depth of flooding during a 1% AEP event in and around Bath. The existing flood defences do not prevent flooding during a 1% AEP flood event. Map A3 indicates the velocity of flooding during a 1% AEP event. The velocity of floodwater through Bath is expected to be fairly low (<0.5m/s), although some faster velocities are expected around the Cleveland Bridge and around the A367/A36 interchange.

- Sewers / Land – Map L shows the areas potentially more prone to flooding from land. Within urban areas the management of surface water relies on sewer systems and therefore for the purposes of this assessment flooding from land has been defined as potential areas of inundation as a consequence of direct runoff from agricultural land on the edges of urban areas.

  Large parts of the city are shown to be highly prone to flooding from runoff from the land, due to the topography and soils characteristics in the area. These are mainly located in the vicinity of the River Avon. There are few recorded incidents of surface water flooding, and these are located close to watercourses, indicating that river flooding may also have contributed to these incidents. As drainage infrastructure is important to the management of surface water in Bath, a more detailed technical assessment of its performance would be required to more precisely define the level and spatial distribution of risk (see Recommendation 1 in Section 5).

  Map S shows recorded incidents of sewer flooding within Bath. There are a relatively high number of recorded incidents within the city centre, and near the River Avon, indicating that the sewer infrastructure plays an important part in surface water flooding in the city. The drainage system throughout Bath is historic and aging, and may require a significant upgrade in the future. Incidents of sewer flooding have occurred throughout the City including Central Bath, Larkhall, Walcot, Locksbrook, Weston Park and Southdown.

- Artificial sources - the Kennet and Avon Canal runs along the eastern boundary of the City through to the centre. The canal is embanked and at times perched above the surrounding ground levels. Overtopping or a breach in the canal embankments is considered an artificial source of flooding. The area potentially at risk is shown on Map R in the main Level 1 SFRA Report.

- Groundwater - small risk of flooding from springs in the north east extents of the City. Map G3 shows the results of a spatial analysis to show broad areas that may be at risk of this type of flooding.

Climate change is expected to increase the 1% AEP floodplain along the Lower Avon and tributaries. In particular, the extent of flooding is expected to increase near Great Putney Street, Dolemeads, Kingsmead, Lower Weston, Locksbrook and Newbridge. Map C1 shows the defended 1% AEP flood extent for the 100 year time horizon in Bath.

Flood risk statistics in Bath

Table 2.2 provides a summary of the key flood risk statistics across Bath.

Table 2.2 Key flood risk statistics for the urban area of Bath

	Approximate area or number	Percentage of total area or number
Bath statistics		
Bath city area	29 km²	100%
Flood statistics		
Flooding from rivers and sea		
Area of Bath within Flood Zone 3b (Functional Floodplain)	0.5km²	2.1%
Area of Bath within Flood Zone 3a (High flood risk)	0.8 km²	2.8%
Area of Bath within Flood Zone 2 (Medium flood risk)	0.7 km²	2.4%
Area of Bath within Actual Risk extent (1% AEP flood outline with flood defences in place)	<0.1 km²	<0.34%
Area of Bath covered by a flood warning service	0.9 km²	3.1%
Area of Bath covered by a flood emergency plan	All	All
Other sources of flooding		
Area of Bath potentially prone to flooding from land (high)	5 km²	16%
Area of Bath potentially prone to flooding from groundwater (high)	0 km²	0%
Area of Bath known to be affected by flooding from sewers (high)	19 Incidents	N/A
Area of Bath potentially at risk of flooding from artificial sources (high)	<1 km²	<1%

* based on the broadscale spatial analysis undertaken during the Level 1 SFRA

Flood risk from rivers

Flooding from rivers occurs when water levels rise higher than bank levels, causing floodwater to spill across adjacent land (floodplain). The main reasons that water levels can rise in rivers are:

- intense or prolonged rainfall causing runoff rates and flow to increase in rivers, exceeding the capacity of the channel. This can be exacerbated by wet antecedent conditions and where there are significant contributions of groundwater,
- constrictions in the river channel causing flood water to backup,
- blockage of structures or the river channel causing flood water to backup,
- high water levels and/or locked flood gates preventing discharge at the outlet of the river.

The consequence of river flooding depends on how hazardous the floodwaters are and what the receptor of flooding is. The hazard of river floodwater is related to the depth, velocity, speed of onset and rate of rise, which depends on the:

- magnitude of flood flows;
- size, shape and slope of the river channel;
- width and roughness of the floodplain;
- types of structures that cross the channel; and
- hydrological characteristics of the catchment.

Flood hazard can vary greatly throughout catchments and even across floodplain areas. The most hazardous flows generally occur in steep catchments and towards the bottom of large catchments. Hazardous river flows can pose a significant risk to exposed people, property and infrastructure.

Whilst low hazard flows are of less risk to life, they can disrupt communities, require significant post-flood cleanup and can cause superficial and possibly structural damage to property.

Flood Zones

The definition, data used and approach for establishing Flood Zones for the Level 1 SFRA across the whole of B&NES is outlined in the Level 1 Technical Report (Vol II).

The flood information prepared for the SFRA is based on version 3.5 of the Environment Agency's Flood Zone maps which show the “undefended” flood scenarios for Bath. Map F1 in the annex to this document presents the Flood Zones for Bath (ignoring the presence of flood defences). Map A1, A2 and A3 in the annex to this document present more detailed information for the 1% AEP flood event with flood defences in place. This flood information has been based on additional 2D hydraulic model information. Further details of the source of information used in preparing the SFRA can be found in the Level 1 SFRA Technical Report. It is the responsibility of the user to confirm that this data is the latest available when undertaking further flood risk assessments.

The floodplain of the River Avon is generally well defined by the local topography and development alongside both banks and therefore the flood outlines for different events do not change significantly. Downstream of Bath, the flood extents are larger where river flows spread out over the flatter floodplain. The largest areas of Flood Zones 2 and 3a are therefore in this area. Map F1 in the annex to this document presents the Flood Zones for Bath (ignoring the presence of flood defences).

With a few exceptions, including the land immediately adjacent to the River Avon, the built up area of Bath generally lies outside of Flood Zone 3a. Particular locations of flooding in this zone are the area to the west of Bathwick, especially between the A36 and A3039 around Henrietta Park. Floodwater here is deep (around 2m) with low velocity (around 0.5-1m^3/s). The area between the A367 and A3604 west of Bath Spa railway station is also at risk from the 1% AEP flood event but floodwater is shallower (approximately 0.5-0.75m) with low velocity (approximately 0.5-1m).

Bath has a history of flooding owing to increased development in the floodplain and altered natural flow regime over hundreds of years. In response to a significant flood in 1960, the Bath flood defence scheme was completed in 1974 and significantly reduced flood risk in the city. Previous river and surface water flooding events in Bath are marked on Map H(a). Map H(b) illustrates the year and location of river flood events in Bath.

Whilst the improvements to the River Avon through Bath have been undertaken for flood risk management purposes, they have mainly focused on modifying the river, and as such are considered to be the "new" river, rather than formal flood defences. Map A1 in the annex to this document shows the "Actual Risk" for Bath, which is defined as the 1% AEP floodplain with flood defence in place.

Functional floodplain

Flood Zone 3b (the functional floodplain) comprises land where water has to flow or be stored in times of flood. The PPS defines the Functional Floodplain as;

> *'SFRAs should identify this Flood Zone (land which would flood with an annual probability of 1 in 20 (5 %) or greater in any given year or is designated to flood in an extreme (0.1 %) flood, or at another probability to be agreed between the LPA and Environment Agency, including water conveyance routes.'*

Map FF in the annex to this document illustrates just the Functional Floodplain for Bath. The impact of flood defences is included in the assessment. The 'functional floodplain' mainly encompasses rural land.

A tiered modelling approach was used in preparing the Level 2 SFRA for Bath. This approach made use of more detailed Environment Agency model data (with flood defences scenario) to define Flood Zone 3b for areas of interest or perceived to be at higher risk.

An amendment has been made to the 5% AEP outline used to define Flood Zone 3b at the recreation and cricket grounds, North Parade Road. Whilst the 5% AEP outline is initially considered when defining the functional floodplain, the PPS25 Practice Guide states that;

> *'The definition of the functional floodplain allows flexibility to make allowance for local circumstances and should not be defined on rigid probability parameters.'*

The maximum flood storage volume at the recreation and cricket grounds is estimated to be in the region of 148,000m^3, which equates to approximately 1% of the total flood volume during a 5% AEP event at this location. Whilst the maximum flood depth is relatively deep in this area (2m), the velocity is slow and does not provide a significant flood flow route.

The guidance suggests that developed areas are not generally part of the functional floodplain, unless they provide an important flood storage and conveyance function. The recreation and cricket grounds at North Parade Road are pre-developed and do not provide significant flood storage or conveyance during a 5% AEP flood event. In accordance with the guidance outlined in PPS25 Practice Guide and in agreement with the Environment Agency, this area has been removed from the Functional Floodplain.

There was no suitable model data available to define Flood Zone 3b on the tributaries of the River Avon or Newton Brook. In the absence of more detailed model data a precautionary approach should be adopted whereby Flood Zone 3a is used as an indication of functional floodplain. A site specific flood risk assessment for any development in these areas will require more detailed flood risk data (see Recommendation 2 in Section 5).

Climate Change

Map C1 in the annex to this document shows the predicted 1% AEP flood outline in a 100 years time, taking into account the potential climate change effects. Flood extents are expected to increase, although due to the defined nature of the valleys and development up to the riverbank, flood depths are expected to increase more than flood extents.

Flood extents are expected to increase between the A36 and A3039 around Henrietta Park are expected to spread southwards, flooding the A36 Rossiter Road either side of the junction with Prior Park Road, making this area most affected by climate change.

Flood Hazard

Map A2 shows the flood depth expected during a 1% AEP flood event in Bath. The deepest floodwaters are shown in the floodplain upstream of the city centre (south of Ringswell Gardens) and in the Bath Recreation Grounds, including the Henrietta Street and St John's Road. As per the latest Environment Agency/Defra guidance[1] on assessing flood risk to people, all flood waters deeper than 1.25m which are still and free of debris are considered dangerous for some. In times of flooding the watercourses in the study area will not be still or free of debris and as such velocity and debris need to be considered when assessing flood hazard.

Velocity information which is detailed enough for mapping is available in areas where detailed 2D hydraulic models have been prepared. The maximum modelled velocities for 1% AEP event on the River Avon are shown on Map A3. Velocities are highest in channel and decrease towards the outer limits of the floodplain.

The highest velocities in the floodplain (>1m/s) are expected where flood defences overtop (into the Bath Recreation Ground) and where floodwaters flow unobstructed along streets (including Lower Bristol Road). The flood risk to people guidance[1] indicates that for a velocity of 0.5m/s, the depth of flood water only needs to be 0.75m for it to be considered "dangerous for some".

In the Bath Recreation Ground fast flowing water (>1m/s) is expected to coincide with deep water (>1.75m). This combination is considered "dangerous for all." Flow within the main channel of the River Avon is also considered "dangerous for all". This type of flooding is symptomatic of the channel improvement works that have been undertaken to enhance conveyance.

In addition to hazardous reaches of open channel, floodwater is expected to be accelerated through a number of structures including the bridges on Bathwick Street and the A46. Here maximum velocities may reach more than 1.5m/s, and combined with deep channel depths, floodwater is considered "dangerous for all".

Site specific flood risk assessments should use this or more detailed flood depth and velocity information to assess flood hazard at potential development sites within the floodplain of Bath.

Flood risk from the sea (tidal)

The assessments in the Level 1 SFRA indicated that Bath is not expected to be at risk of flooding from the sea (or tides) now or in the future due to the current climate change predictions.

Flood risk from land (surface water)

Flooding from land (surface water flooding), occurs when intense, often short duration rainfall is unable to soak into the ground or enter drainage systems. It is made worse when soils are saturated so that they cannot accept any more water. The excess water then ponds in low points, overflows or concentrates in minor drainage lines that are usually dry. This type of flooding is usually short lived, localised and associated with heavy downpours of rain. Often there is limited warning before this type of flooding occurs.

Urban areas usually have extensive drainage or sewer systems. In urban areas it is complicated to determine whether flooding has been caused by surface water or sewers. For the purpose of the SFRA, any flood risk associated with direct runoff from surrounding land onto the urban area has been considered as flooding from land (surface water). Any flooding within the urban area itself where a comprehensive sewer system exists has been considered flooding from sewers.

[1] Defra/Environment Agency (2006) "Flood Risks to People Guidance Document" Technical Report FD2321/TR1

The spatial analysis undertaken during the Level 1 SFRA indicated that much of the urban area may be affected by flooding from land (surface water flooding). This analysis did not consider the impacts of the sewer system in the area and as such may have over-estimated this source of flooding. Map L1 shows the results of the analysis of surface water flooding which was carried out for the Level 1 SFRA for B&NES. The map shows that the areas with a higher likelihood of flooding are on flatter land in the urban areas of Bath. Overall, Bath has a mostly high and medium risk of flooding from land.

The Environment Agency hold few records of flooding from land within Bath, and those identified may also have been contributed to by river flooding. A more detailed study would be necessary to precisely understand the extent and frequency of such flooding (see Recommendation 1 in Setion 5).

The data provided by Wessex Water for sewer flooding indicates that there have been a number of incidents of sewer flooding within the urban area (as described in the flood risk from sewers section of this report). It is probable that some of these flood incidents could have been attributed to both flooding from land (surface water) in combination with flooding from sewers. Given the extensive urban drainage system within Bath all flooding within the urban area has been addressed as sewer flooding.

Surface Water Management Plans should be prepared where a more strategic approach is required to effectively manage surface water disposal and flood risk. The requirement for SWMPs within Bath is discussed further in Chapter 4.

Flood risk from sewers

Flooding from sewers occurs when rainfall exceeds the capacity of networks or when there is an infrastructure failure. For the purposes of this SFRA sewer flooding is defined as any flooding which occurs in an urban area with a comprehensive sewer network. This includes combined and surface water sewers, culverted minor watercourses (lost watercourses), sewer pumping stations and water treatment facilities. It does not include flooding from over land drainage systems in rural areas.

A probabilistic assessment of the risk of flooding from sewers is not within the scope of this document. Instead the likelihood of flooding from sewers has been assessed using historic flooding information and consultation with relevant stakeholders.

The Environment Agency Flood Reconnaissance Information System (FRIS) does not contain any records of flooding from sewers, however Wessex Waters ‘Flood Properties Register’ contained 19 incidents of flooding in Bath (note: Wessex Waters’ register is a live document, a property is added to the register when a problem is encountered, and it is removed from the register when the problem is resolved).

Map S in the annex to this document provides a grid of areas in Bath that have recently had a high, medium or low number of incidents of sewer flooding. Any new development within a medium or high area may be required to undertake a more detailed assessment of the sewer system. Areas where there have been a high number of sewer flooding incidents are located north of the River Avon, which is an area identified for further development and regeneration in the Bath Vision (Central zone).

Results from analyses of sewerage systems using hydraulic models provided by Wessex Water has also been used to assess areas more susceptible to sewer flooding. These were available for foul and combined sewer systems only, therefore do not provide full information on the capacity and flood risk from surface water sewers. Sewer systems which rely on pumps can also be more susceptible to flooding, so the assessment has included consideration of the location of these pumping stations.

The assessment of hydraulic models and the location of sewerage pumping stations indicated that the majority of sewers within Bath do not have spare capacity to accept additional runoff from new

development and/or climate change. Any new development will need to demonstrate that they will not increase runoff and will contribute to surface water flood risk reduction (see Recommendation 10 in Secion 5).

The sewers that are more likely to flood are concentrated in the city centre, along the River Avon and in the South Twerton and Kingsway areas. Along the River Avon the system is also reliant on a number of pumping stations. The mechanism for flooding in this area is likely to result from the lack of capacity in the existing sewer system in conjunction with 'locked' outlets when water levels on the River Avon are high. Floodwater is likely to follow major flow paths such as roads towards low-lying areas and flood depths may be relatively high. Flood risk assessments should consider failure of the surface water pumping systems (see Recommendation 4 in Section 5).

As well as along the River Avon, the topography of Bath indicates preferential flow paths from the Southdown & Kingsway area, running in a northerly direction following Ivy Avenue / Millmead Road. And from the Moorlands area, running along Oldfield Lane and Third Avenue (see map T2). In the north of the city, a preferential flow path is indicated from Weston, running south to the River Avon along High Street, Westin lane, Gainsborough Gardens and Audley Grove. These paths are likely to have conveyed surface water runoff towards the River Avon before the urban sewer system was installed. With the urban sewer system now in place, the flow path is only likely to convey water if the capacity of the urban sewer system or inlets to the system was exceeded due to very intense rainfall. The hydraulic model results provided by Wessex Water do not suggest that the sewer system has a particularly high probability of flooding due to lack of capacity, so flooding in this area is more likely to occur due to exceedance of the inlet capacity. Properties near these flow paths may be at risk of this type of flooding.

Climate change is expected to impact sewer flooding with increases in rainfall intensity. This will require new infrastructure to be designed with inlet capacities and existing infrastructure may require upgrading to maintain the same level of service. The sewer system in Bath is aging and as such it is likely to require considerable upgrade in the medium term.

Flood risk from artificial sources

The Kennet and Avon canal is the only canal in B&NES and contributes to the transportation link between Reading and Bristol. It runs parallel to the Lower Avon in the eastern side of B&NES until it joins the Avon in Bath. There are three principal mechanisms which could cause flooding:

- Leakage may occur through bed and bank linings or through structures designed to drain and manage water levels in the canal. This form of flooding is often of limited extent and low hazard, but may be prolonged in duration.
- Breach is a catastrophic failure of a water retaining structure, normally leading to rapid loss of all impounded water unless emergency measures are taken. Breach is considered to be of low probability but of high consequence and for this reason is identified as a most significant flood mechanism.
- Overtopping of canal banks either into or from the canal may lead to property flooding. Overtopping also puts more pressure on canal embankments which can lead to a breach. A canal may act as a conduit for flooding to low lying areas some distance away from the nearest watercourse. Overtopping in general is a low consequence event and so is often not reported.

Flood risk from the Kennet and Avon Canal is relatively low as the canal is perched on the slope of the Avon Valley, rather than on a raised embankment. As such the risk of overtopping is higher than the risk of breach. A railway line runs parallel and downstream of the canal for much of its length through the east of Bath. It is likely that the extent of any flooding from the canal would be limited due to the presence of the railway embankment.

Upstream of Bath there are few properties adjacent to the canal. Combined with the relatively small floodplain, their risk is considered low.

Within Bath there are properties adjacent to the canal which would be inundated if the canal banks failed or overtopped. Given that the canal is not raised on an embankment, the risk of bank failure is reduced. Likewise, water levels are well managed in the canal and thus the risk of overtopping is reduced. The flood risk from the canal in Bath is also considered low.

Flood risk from groundwater

For the purpose of the SFRA, groundwater flooding has been defined as flooding from sub-surface water. There are a number of mechanisms that can cause this type of flooding including regional groundwater rise and underground barriers to flow.

The spatial analysis undertaken for the whole of B&NES in the Level 1 SFRA (Map G3) indicated that the eastern side of the B&NES area is at an elevated risk due to its slightly more permeable geology and lower topography, but overall, the risk in Bath is low to medium. The risk primarily relates to the number of springs and issues in and around the city.

The Environment Agency does not hold any records of groundwater flooding in this area and does not consider it a significant issue in Bath.

3. Managing flood risk today

Introduction

Structures and defences are built to help reduce the occurrence, and therefore consequences of flooding. These assets can be owned, operated and maintained by the Environment Agency, Local Authorities, private business and/or local residents.

In some instances, river processes have been modified over time by these defences (such as river walls, flood storage areas, flood alleviation channels and embankments) and by undertaking maintenance activities (such as river dredging, drain clearance and debris removal from trash screen).

The Environment Agency manages flood defences as groups of structures, rather than individual assets. These groups are termed 'management units' and will be identified and managed through System Asset Management Plans (SAMPs). The SAMPs covering Bath are shown on Map D1 in Annex A and include:

ID and map reference	Name	Description	Draft FRM Systems Standard
FR/14/S083 Map D1d	Lower Bristol Avon E	The River Avon from Hilperton (beyond the boundary of B&NES) to Batheastern.	Medium
FR/14/S081 Map D1e	Lower Bristol Avon D	The River Avon through Bath, St Catherines Brook and Lam Brook	High
FR/14/S079 Map D1f	Lower Bristol Avon C	The River Avon (between Bath and Keynsham), Newton Brook, Corston Brook, and Broadmead Brook	Medium
FR/14/S082 Map D1i	By Brook Burton Broadmead	Covers By Brook in the north eastern corner of B&NES, which is a tributary of the River Avon entering the river at Batheaston.	High

The formal flood defences influencing in Bath have been identified through interrogation of the Environment Agency National Flood and Coastal Defence Database (NFCDD) and are shown on Map D2 in the annex to this report.

The formal flood alleviation scheme in Bath protects the city against flooding from rivers. The scheme is made up of a series of raised "formal[2]" and "defacto[3]" defences along the River Avon as it flows through the city.

Bath Flood Defence Scheme

Following the floods in 1960s, the Bath Flood Defence Scheme was constructed to improve conveyance through the city and several options were discussed.

The final scheme focused on channel widening, deepening and strengthening from Pulteney to Twerton, to increase conveyance. Modifications were made to Pulteney Weir, which was previously a simple straight weir which spanned the entire width of the channel. The new horseshoe shaped weir maximised the amount of flow that could pass over the weir, reducing flood risk upstream[4].

Adjacent to Pulteney Weir is a radial gate (sluice gate). As the water level rises upstream of Pulteney Weir, a corresponding rise of water level in the sluice structure causes large floats on either side of the sluice to rise.

[2] Infrastructure that was built for flood defence purposes

[3] Infrastructure that serves a flood defence purpose, but was not constructed for that reason (i.e. road embankment, property boundary wall)

[4] Bath and North East Somerset Council, (2006), River Avon Regeneration Pre-Feasibility, Final Report (9R80038), Haskoning UK Ltd

At the downstream end of the scheme at Twerton, there is a large structure which spans the Avon. This structure houses two sluice gates which replaced the original weir in 1967. During low flows, these sluice gates maintain water levels in Bath. The structure would have been important for the old mills in the city but is now essential for continued navigational use of the river (as a link to the Kennet & Avon Canal). Even when these gates are fully open, these structures influence water levels during flood events due to the head losses caused by the gate training walls and central pier[5].

In addition to the river modification works, the Bath Flood Defence Scheme also includes a series of earth embankments and walls throughout the City Centre. Only a small length of rasied defence is considered "formal", providing protection for events with a 20% to 0.5% AEP.

Maintained River Channels

In addition to the formal flood defences, sections of the River Avon are maintained. The maintained channel and steel piling through Bath and are identified in NFCDD as having a standard of protection which ranges between 20% AEP and 1% AEP.

Sections of maintained channel and sheet piling are not considered defences by the Environment Agency when assessing areas benefiting from defences. This approach was adopted when assessing the impact of flood defences in the B&NES Level 1 SFRA. Thus these assets were not removed when modelling the 'without defences' scenario.

Current condition and upkeep of flood defences

The Environment Agency and Local Authority carry out annual inspections of flood defence assets and update NFCDD. The data from these inspections is used to inform the owner of their duty to maintain assets to an appropriate level.

The management of the river defences and assets within B&NES is divided between a number of different parties. The Environment Agency is responsible for the majority of the river defences and has a supervisory duty over all flood defences under the Environment Act 1995. B&NES Council maintain and manage assets on watercourses designated as "non-main" river.

The Environment Agency has permissive powers to maintain and improve watercourses designated as 'Main River' and associated structures for the efficient passage of river flow and the management of water levels. The Environment Agency also has a general supervisory duty for all flood risk management activities.

As the operating authority, Councils have the regulatory and supervisory role for flood defences on all ordinary watercourses which are not within the area of an internal drainage board (IDB).

The Environment Agency operates the formal flood defence scheme (FDS) in Bath. There have been few operational problems associated with Pulteney Gate since its construction in the 1960s. The Gate is maintained and operated in accordance with the maintenance manual. B&NES carried out remedial works at Pulteney Weir to repair scour damage and stabilise the structure in 2003.

Following a feasibility study carried out by Halcrow[6], the Twerton sluices were refurbished in 2000 and 2001. The gates were fitted with electrical actuation but can still be operated manually.

Probability and consequences of overtopping or failure

Failure of the Twerton sluice gates could occur through a malfunction of the closure mechanism. Failure in the open position would cause serious structural damage to upstream river walls and bankside

[5] *Lewin, Fryer / Black & Veatch (for the Environment Agency), Bath Flood Defence Scheme - Option Identification Appraisal, August 2004*

[6] *Twerton and Pulteney Gates, Feasibility Study, Halcrow UK, February 1999*

property in the long-term. If the gates failed in the closed position, flood water levels upstream would increase. Any major development proposals along the river frontage in Bath should be accompanied by a site specific FRA that considers any increased flood risk to the site from failure or blockage of the Twerton Sluice gates (see Recommendation 3 in Section 5).

The failure of Pulteney radial gate could occur in either in the open or closed position. Upstream water levels trigger the gate to open. The most likely reason for the gates to fail would be if debris became lodged beneath the gate, preventing the gate from closing. Such a failure could significantly reduce water levels upstream of the structure, but have limited impact on flood risk.

Erosion and failure of the river sheet piling and walls could reduce conveyance of the river system through Bath, increasing flood levels locally. An inspection of the existing sheet piled river walls at a number of locations between Thimble Mill and Windsor Bridge was carried out in 2004 by CORUS estimated the residual life of the piles to be in excess of 90 years, indicating that the risk of this failure mechanism is low.

Residual risk from overtopping of defences in Bath was modelled for the B&NES Level 1 SFRA using an extreme event (0.1% AEP event). The flood defences in Bath have a standard of protection considerably lower than this event and as such the flood extents for the defended and undefended model runs are similar. Map F in Appendix A shows the predicted flood extent of a residual risk (0.1% AEP) flood event in Bath.

The potential impact of blockage upon flood risk (residual risk)

With the exception of Pulteney Bridge, it is unlikely that bridges will become blocked or prone to siltation as they are of sufficient size. Blockage of Pulteney Bridge was assessed in a previous study[7] which found that whilst the risk of a blockage occurring was low, the consequences of a blockage would result in significant increases in upstream water level.

Any major developments occurring along the River Avon in Bath should undertake a flood risk assessment that considers the impacts of blockage (see Recommendation 3 in Section 5).

Summary of flood warning and emergency planning

PPS25 states, 'the receipt of and response to warnings of floods is an essential element in the management of the residual risk of flooding'. Thus it recognises that flood warning and emergency planning is an important measure for managing flood risk from extreme events.

The Environment Agency is responsible for monitoring flood events and to issue warnings to people in properties and businesses at risk of flooding. Forecasting uses a combination of Meteorological Office weather forecasts and real-time data (rainfall, flow, level and soil moisture).

[7] Risk Assessment & Physical Model Study of Debris Blockage at Pulteney Bridge, Bath, Lewin, Fryer and Partners, November 2002

The Environment Agency provides flood warning services for Bath, as shown on Map W. The codes for the Environment Agency Flood Warning Services are:

Area code	Flood warning area
112FWF3F0C	Bristol Avon (middle) from Melksham to Bathford
112FWF3H0A	Bristol Avon (lower) from Bathford to Twerton
112FWF3F0H	Bristol Avon (lower) at Bath Centre
112FWF3H1A	Bristol Avon (lower) from Twerton to Bristol

B&NES are encouraged to work with the Environment Agency to ensure that as many homeowners as possible as signed up to this service, and that any new properties are also aware of the service.

The Civil Contingencies Act 2004 classifies Local Authorities as Category 1 responders along with other organisations such as the Police, Fire, Ambulance services. The role and responsibilities for emergency planning is set out by legislation following the implementation of the Civil Contingencies Act 2004. The Act defines the term 'emergency' as:

- *'an event or situation which threatens serious damage to human welfare;*
- *an event or situation which threatens serious damage to the environment, or*
- *war, or terrorism, which threatens serious damage to security'.*

During flood incidents the Environment Agency issues warnings to those likely to be affected, operates flood defences on certain rivers and advises the emergency services on the expected level of flooding. The Environment Agency and Local Authority also liaise closely during a flood incident, and B&NES will implement a range of contingency plans which detail how local services will work together to respond to any type of incident or disaster. These plans include but are not limited to a Civil Emergency Manual, Flood Plan, and Emergency Communications plan.[8]

Further details on the Flood Warning and Emergency Planning procedures are contained in the Technical Report of the Level 1 SFRA.

[8] *Lewin, Fryer / Black & Veatch (for the Environment Agency), Bath Flood Defence Scheme - Option Identification Appraisal, August 2004*

4. Managing flood risk in the future

Flood defences

Likely future flood management policy regarding maintenance and upgrade

In 2005, an Option Identification Appraisal was carried out in Bath to estimate the existing standard of protection and identify options for improvement. Three options were considered: do nothing, do the minimum or improve the standard of protection to a 1% or 0.5% AEP event. The favourable option aimed to formalise and improve flood defences to a 1% AEP standard, but was not considered economically viable at the time. In March 2005, the Bristol Avon Local Flood Defence Committee decided to postpone the flood defence works and instead work with Bath & North East Somerset Council (B&NES) to produce a "Master Plan" for Bath, which links the flood defence requirements with river corridor regeneration and development opportunities.

All strategic options to manage flood risk to existing properties in Bath are now being guided by the Bristol Avon Catchment Flood Management Plan (CFMP). The CFMP is divided into management units which have a policy assigned to provide an overall direction in the way flood risk should be managed in each unit. The urban area of Bath is defined as its own policy unit, and six policy options were appraised for the City:

CFMP policy	CFMP
P1	Defences on the Bristol Avon are not maintained and become ineffective over time. The frequency of flooding will increase, as will the depth and extent, though this will be a gradual process. Lack of maintenance of flood defence control structures at Twerton and Pulteney may result in their failure, which in itself may potentially cause or exacerbate flooding. The flood warning service will be stopped, as will the MIP.
P2	SoP gradually reduces to approximately 10% AEP as a result of reduced maintenance of defences through the city. Flooding will become more frequent and severe as defences deteriorate and possibly fail.
P3	Defences and maintenance activities are maintained at their current level, but increased fluvial flows will gradually reduce the SoP to approximately 2% AEP. Flooding will become more frequent and the associated extents and depths will increase.
P4	The existing SoP through Bath is sustained at 0.7% AEP. by increasing flood risk management activities. Damages are likely to increase for events exceeding the SoP.
P5	The SoP is improved through Bath or brought in line with the overall SoP of 0.7% in those areas where the standard of protection is currently lower.
P6	Increasing flooding would not be acceptable in this urban area, causing an increase in damages and putting many more people at risk. This policy has therefore not been appraised further.

The CFMP Appraisal found identified a policy 5 of 'take further action to reduce flood risk' as the most suitable option.

Improvements to existing assets identified as below standard will be made through development opportunities. Flood risk management in the past has been concentrated upstream of Bath. The CFMP identifies the need to increase flood storage in the more rural catchment upstream and future measures are also expected to combine recreational and environmental enhancement.

The CFMP identified the following actions for the EA which relate to improvements to existing flood defences:

- Improvements to existing assets through development opportunities on those lengths identified as below standard;
- Identify an overall strategy for the future protection of Bath and for its existing defences; and
- Increase awareness of risk and response to flood warnings, and discourage inappropriate development.

The Flood Risk Management (FRM) Strategy for Bath and North East Somerset will be appraising these options in greater detail.

Managing surface water flood risk

Identifying the scope and need for a surface water management plan

The responsibilities for surface water management fall to a number of bodies including the Environment Agency, B&NES, Wessex Water and the highways authority. Management of surface water is therefore a complex issue, best dealt with using a strategic and co-ordinated approach. SWMPs therefore have an important role in developing a coordinated strategic approach to managing surface water drainage and reducing flood risk and provide a platform so that climate change effects do not give rise to exacerbation of urban flooding.

The PPS25 Practice Guide outlines the key purposes of Surface Water Management Plans (SWMP) as:

- ensuring that allocations within an area are properly supported by adequate surface water management;
- providing a common framework for stakeholders to agree responsibilities for tackling existing drainage problems and preventing future problems;
- where development pressures are high it can be part of a Water Cycle Strategy; and
- demonstrating how capital investment, infrastructure and maintenance can deliver the required surface water management.

SWMPs are required for a number of reasons including:

- to identify locations where there is evidence of existing problems with the drainage infrastructure and therefore a requirement for upgrade to deal with surface water now and into the future;
- consideration of the implications of potential large-scale development where surface water may be best managed with a strategic approach, rather than on an individual development scale; and
- the evaluation of the potential opportunities to implement a coordinated approach by several bodies to plan infrastructure improvements.

The preparation of the SWMP should be specific to the location and nature of the drainage surface water infrastructure and flooding mechanisms.

We have identified critical drainage areas in a number of ways, including;

- An analysis of historic flooding information and existing capacity assessments;
- An assessment of potential allocation sites; and

- Consultation with key stakeholders including Wessex Water, Highways Authority, Bristol Water, the Environment Agency and B&NES technical specialists.

The following specific drivers for SWMPs have been identified in Bath, which should be addressed through the preparation of SWMPs and subsequent drainage strategies:

- The majority of the existing sewer infrastructure throughout Bath is unlikely to have sufficient capacity to cope with additional runoff resulting from climate change and future developments. A SWMP for the town is recommended, which should consider appropriate policies and strategies to prevent additional load on the existing system and a co-ordinated investment strategy for future improvements. The SWMP should consider appropriate policies for encouraging water cycling at existing properties and any new infill properties. Separate SWMPs and / or drainage strategies may be required for the city centre along the River Avon, South Twerton / Kingsway areas where the likelihood of flooding is greater and a more comprehensive upgrade may be required and in the Newton Brook area of planned urban extension. The historic flow paths from Southdown / Kingsway, Moorlands and Weston should also be considered.

- Future development for Bath is likely to consist mainly of development along the River Avon and infill development in other areas within the existing urban boundary. It is recommended the SWMP for the city examine the potential impacts of future development. The SWMP should aim to ensure that different land owners and land managers can contribute to the system to ensure that the new development as a whole is safe from flooding and would not exacerbate surface water flooding elsewhere. Where possible the SWMP should include appropriate policies and strategies to prevent surface water runoff from new developments contributing to the existing drainage system, and if possible use the new development to reduce the existing load on the system. The SWMP should also consider options for managing water onsite which could be used to reduce the requirement for other water resources within the area.

- There are more than 40 flapped outfalls from the Bath sewer system into the River Avon in Bath. When water levels are high in the River Avon these flapped outfalls prevent water from encroaching into the sewer system. During this time, the sewer system is 'locked' and must store surface water until water levels on the River Avon reside, allowing discharge. Climate change is expected to increase the frequency of the sewer outfalls becoming 'locked'. A SWMP is required to determine an appropriate form of action to prevent surface water flood risk from increasing to an unacceptable level.

There are a number of mechanisms for delivering the SWMPs, including through the location and design of new development, preparing for emergencies, and investment in capital infrastructure and maintenance.

Using the planning process to reduce flood risk

Policies for sites which will need to satisfy Part C of the Exception Test

Proposals which are required to satisfy Parts a) and b) of the Exception Test have, by definition, been located in an area which is not generally considered to be appropriate for development. Part c) of the Exception Test requires that these developments are safe, do not increase flood risk elsewhere and, where possible, reduce flood risk overall.

A Flood Risk Assessment (FRA) will be required to demonstrate that Part c) of the Test has been passed. The specific requirements will depend on the development and location in question, however general items to consider are outlined below.

'Safe' development requires that development is designed such that the likelihood of flooding at the development, and the consequences of flooding that does occur are not too severe and in particular are unlikely to lead to loss of life and disruption to normal living. The flood hazard, related to flood depths and flood velocities is one of the most important considerations for safe development with respect to access and egress during a flood for the public or attendance of emergencies by the Fire Rescue Service. Guidance and advice on acceptable flood hazard for different circumstances is regularly updated and therefore it is advisable that B&NES set policies that refer to using up to date guidance rather than setting fixed policies within the LDF. B&NES may wish to consider policies for the following items:

- Development layout – the development layout should be designed so that where possible more vulnerable (e.g. residential) land uses are located at the lower risk areas of the site.

- Basement dwellings within a flood risk area can be at particular risk and therefore should be avoided where possible.

- Development and floor levels may need to be raised for safety. Development levels set above the estimated flood level (to remain dry during an event) are the safest however developments that flood can still be considered safe. FRAs should refer to the latest guidance when assessing acceptable flood depths, velocities and freeboard allowances.

- Safe access is a requirement stated in PPS25. Dry vehicular access is preferable, although pedestrian and flooded access may also be acceptable provided it is safe. FRAs should refer to the latest guidance when assessing acceptable flood depths, velocities and freeboard allowances.

- Consideration should be given to the capacity of the emergency services to operate effectively in the light of anticipated level of flood hazard (most influential being flood depth and flood velocity).

- The requirement to ensure that all proposed critical civil infrastructure is implemented so that it remains operational during flood events.

- The potential impact of residual risk events (high intensity rainfall events) should be analysed and proposed development should be designed so that it is not harmed by surface water or land flooding episodes.

Developments can increase flood risk elsewhere through three main flood mechanisms:

- Increase in surface water runoff

- Loss of flood plain storage

- Impacts on flood flow routes

FRAs should demonstrate that the development will not adversely impact on flood plain storage or flood flow routes, and that where necessary competent mitigation measures are provided. SuDS systems should be employed to manage surface water runoff, according to the system priority as set out in the User Guide. Alternatively, surface water management should be in accordance with a relevant SWMP.

FRAs should provide evidence that the possibility of reducing flood risk through the development has been considered. This could be by providing additional flood plain storage to enhance the existing capacity, reducing surface water runoff below existing levels and replacing more vulnerable land uses with less vulnerable land uses. The FRA should provide justification why it is not possible to reduce flood risk if this is the case.

Flooding from sewers (and the 'backing up' of the sewer network when the river is in flood) should be managed by the development control process. Further collation of all relevant data, such as sewer capacity, past events and consultation with water companies and operating authorities should be undertaken when preparing site specific flood risk assessments, particularly for extensive development.

Guidance on the preparation of Flood Risk Assessments (FRAs)

The FRA will be required to demonstrate that flood risk to the development and from the development can be managed now and in the future. Planning applications for development proposals of 1 hectare or greater in Flood Zone 1 and all proposals for new development located in Flood Zones 2 and 3 require a FRA.

The FRA is required whether the site is a windfall site or an allocated site (i.e. in the Local Plan). Furthermore, a FRA is still required if a site has been subject to a sequential test and, if necessary, an exception test.

FRAs should consider all sources of flooding and where appropriate, mitigation measures and should evaluate conditions for the proposed lifetime of the development so that climate change effects are considered. Where risk of flooding from sources other than the sea or rivers has been identified such as groundwater or surface water flooding the FRA needs to consider the risk of flooding at the site. FRAs should also consider the impact of the development on flood risk elsewhere. Residual risks should also be assessed.

The SFRA User Guide (Volume II of the Level 1 SFRA) contains detailed advice on the scope of the FRA (section 5.3) and advice for developers in undertaking the FRA (section 5.2).

The scope of the FRA should always be consummate with the scope and scale of flood risk, the scope should be determined in consultation with the Environment Agency and B&NES at the earliest opportunity. The scope must always include a statement of the existing flood risk, details of the proposed development, a statement on the flood risk management measures and their effects upon the baseline risk and finally a statement of residual risk. Consideration must always be given to both the site, and potential off site impacts.

PPS25 advocates a three tiered approach to undertaking a FRA (Table 2.3, 2.4) that is presented in CIRIA publication C624 Development and Flood Risk – guidance for the construction industry. The three tiers are;

- Screening study
- Scoping study
- Detailed study

More details of the scope of each study can be found in the PPS25 Practice Guide.

Screening study in Bath

The screening study for Bath is captured in the content of this document, and the Level 1 SFRA for B&NES. These documents define the Flood Zones, and in doing so the areas where there are further flooding or surface water issues that warrant further consideration. Furthermore, the site specific assessments presented in the annex to the User Guide (Volume I of the Level 1 SFRA) include screening studies for specific sites identified in the B&NES adopted local plan.

All sites greater than 1.0ha in size, even if located in an area with a low probability of flooding, are required to prepare a flood risk assessment that considers the implications of increased runoff rates from the site.

Scoping studies in Bath

According to Table 3.5 in the PPS25 Practice guide, the Scoping study is to be undertaken if the Level 1 FRA indicates that the site may lie within an area that is at risk of flooding or that the site may increase flood risk due to increased run-off.

The scoping study should explore and assess whether there is sufficient existing quantitative information to undertake an appropriate FRA. The assessment should be based on the existing information presented in the full Level 1 SFRA for B&NES, and other documents listed in Table 3.6 of the PPS25 Practice Guide.

Preparing a FRA at this stage assumes that no new data is required. FRAs prepared for Bath, should pay particular attention to;

- the source and certainty of information as outlined in the Technical Report.
- variation of river flood depth, velocity and climate change information (Maps A2 and A3).
- design flood levels (as advised by the Environment Agency)
- the availability of a safe and dry access routes (safe) (Maps F and A1)
- whether the site may be at risk from failure of flood management infrastructure
- consideration of which SuDS features may be used in the development.

In any case, statements on the proposed development type and vulnerability of the intended residents and any flood risk mitigation / management measures will be required.

Detailed studies in Bath

According to Table 3.5 in the PP25 practice guide, a detailed study is to be undertaken if the Level 2 FRA concludes that further quantitative analysis is required to assess flood risk issues related to the development site. Usually this quantitative analysis will be based on extending or improving an existing flood risk model or by producing a new flood risk model where the development:

- is located in an area where the source and certainty of information is considered low.
- is located within 50m of an area already identified with a higher probability of flooding (following an assessment of the local topography).
- lies within the area at risk of flooding from failure of existing flood defences and infrastructure (Bath Flood Defence Scheme);
- is located within 100m upstream or downstream of a sluice gate; and
- is located in an area identified as a critical drainage area, and in particular if it falls under a surface water management plan (SWMP).

A detailed study would usually be required if any form of flood risk mitigation / management were required (even for sites in Flood Zone 1, where a Greenfield runoff calculation is usually made in preparation for the design of suitable sustainable urban drainage and / or compensatory storage).

Guidance on the use of Sustainable Drainage Systems (SuDS)

Flooding from rivers, sewers, and surface water is likely to increase throughout Bath in the future as a result of climate change. However in addition to this the impact of new development on flood risk needs to be considered, both at the new development site and existing developments within the catchment. SuDS aim to control surface water runoff as close to its origin as possible, before it is discharged to run over the surface, into a watercourse or sewer. This involves moving away from traditional piped drainage systems towards softer engineering solutions which seek to mimic natural drainage regimes.

Section 2-15 to 2-18 of the technical report in the Level 1 SFRA contains detailed documentation on what SuDS are, what options exist and their relative sustainability in terms of flood reduction, pollution reduction and wildlife / landscape benefit. A methodology for appraising the strategic suitability for SuDS as also been applied and a series of Maps (Map L2a to L2f) produced to accompany guidance on the capacity for using SuDS in B&NES, as outlined in the Level 1 assessment.

It is thought that potential for SuDS in Bath is limited due to the existing urban development and underlying soil and geology. However areas to the east of the city could benefit from SuDS where the ground is relatively permeable. There may also be some benefit to be realised in managing sustainable urban drainage using economies of scale, particularly for any new developments, by designing in larger community scale SuDS at the outline planning application stage.

5. Recommendations

Introduction

The long term management of flood risk, from all sources of flooding, will require a multi-lateral, multi-agency approach. The following recommendations are made on the basis of the findings of this SFRA.

Understanding the sources of flood risk

1. Further assessment is required of the potential of sewer / surface water flooding in Bath. This should consider the potential impacts of increased runoff from new development in the town, the impacts of locked-outfalls in the development sites adjacent to the River Avon and its tributaries, and the failure of surface water pumping systems.

2. Prior to any new development being considered near to the tributaries of the River Avon, a detailed hydraulic model should be developed to improve Flood Zones in the area.

3. Site specific FRAs should include an assessment of the probability and consequences of blockage or failure of critical infrastructure (including Twerton Sluice Gates) on the River Avon in Bath.

4. Site specific FRAs should include an assessment of the probability and consequences of failure of surface water pumping systems within the vicinity of the proposed development sites.

5. B&NES to prepare/commission a 'Sequential Test' report which provides an assessment of food risk at potential allocation sites, site-specific policy recommendations, and site-specific flood risk assessment guidance.

6. B&NES to prepare/commission a 'Scoping Report' for flood risk management to identify potential options for managing flood risk in key areas, and provide an outline assessment of these options.

Managing flood risk today

7. B&NES and the Environment Agency should continue to work together so that all properties at risk of flooding in Bath are "signed up" to the Environment Agency Flood Warning Service.

8. A new flood risk/drainage officer to be appointed in B&NES and funded by new development.

Managing flood risk in the future

9. Prepare a surface water management plan for Bath, considering flood risk from existing sewer systems and land surrounding the towns, as well as the additional pressures placed due to new development. This should consider the potential impacts of climate change and be incorporated with the water cycle strategies. In particular the SWMP should cover infrastructure improvements in the areas highlighted in chapter 4.

10. All new development within Bath must contribute to the reduction of surface water flood risk.

11. Review the capacity of the Fire Rescue Services to respond to residual risk events.

12. Ensure that any critical civil infrastructure that is implemented remains operational during residual risk events.