Stroud District Council

Strategic Flood Risk Assessment for
Local Development Framework
Level 1
Volume 1 - FINAL
September 2008

Halcrow Group Limited

Stroud District Council

Strategic Flood Risk Assessment for Local Development Framework Level 1 - FINAL Volume 1

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Executive Summary

In December 2007 Gloucestershire County Council, in partnership with its Local Authorities, commissioned Halcrow to produce a Level 1 Strategic Flood Risk Assessment (SFRA) in accordance with Planning Policy Statement 25 (PPS25). The purpose of the SFRA is to assess and map all forms of flood risk from groundwater, surface water, impounded water bodies, sewer, river and tidal sources, taking into account future climate change predictions, to allow the Councils to use this as an evidence base to locate future development primarily in low flood risk areas. The outputs from the SFRA will also help the Councils to prepare sustainable policies for the long-term management of flood risk.

Flooding is a natural process which shapes the natural environment, but also threatens life and can cause substantial distress and damage to property. The effects of weather events can be increased in severity as a consequence of past decisions about the location, design and nature of development and as a consequence of climate change. While flooding cannot be wholly prevented, its impacts can be avoided and reduced through good planning and management. The SFRA aims to ensure that flood risk forms one of the material planning considerations to help deliver sustainable development.

Stroud District drains into the River Severn. The onset of flooding in the District, particularly in the steeper upland catchments, can be rapid, resulting in flashy flows which can be conveyed to downstream locations at the valley bottoms. Under capacity culverts can also exacerbate flooding. As a result of climate change, the depth of flooding is likely to increase in well-defined floodplains, notably in the River Frome catchment, while the extent of flooding is likely to affect the Little Avon and Cam catchments, especially in Dursley, as well as along the Severn Estuary, which will be subject to increased storm surges and wave height in the future.

The SFRA is a tool which will inform the Council of the nature of flood risk in the District. It will provide an important part of the evidence base for the preparation of the Local Development Framework (LDF), in particular the Core Strategy. Furthermore the SFRA will provide useful information for the Sustainability Appraisal (SA) and will assist in the development of flood risk management policies. The suggested policies in the SFRA take direction from PPS25, Making Space for Water, the Water Framework Directive and Catchment Flood Management Plans (CFMPs).

In accordance with PPS25 and its Practice Guide, areas of ‘low’, ‘medium’ and ‘high’ risk have been mapped using data from the Environment Agency, Gloucestershire County Council and its Local Authorities, water companies, the Highways Agency and British Waterways. This has included information on flooding from all sources and provides the basis for the Sequential Test to be applied. The Councils must apply the Sequential Test to all sites within the ‘high’ and ‘medium’ risk Flood Zones. Where there is an area of overlap between the site boundary and flood risk area this should be used as an opportunity to reduce flood risk within the site by using the flood risk areas as open space. It is important that policies recognise the positive contribution that avoidance and management of flood risk can make to the development of sustainable communities. Where the need to apply the Exception Test is identified the scope of the SFRA should be widened to a Level 2 SFRA. It is recommended that this is undertaken by a suitably qualified technical expert.

The SFRA has been reviewed and approved by the Environment Agency, and a letter which signs off the SFRA can be found in Appendix A

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1 Introduction

1.1 Terms of Reference

1.1.1 In December 2007 Gloucestershire County Council, in partnership with its Local Authorities, commissioned Halcrow to produce a Level 1 Strategic Flood Risk Assessment (SFRA) in accordance with Planning Policy Statement 25 (PPS25). This report presents the findings of the SFRA for Stroud District Council.

1.2 Project Aims

1.2.1 The aims of PPS25 planning policy on development and flood risk are to ensure that flood risk is taken into account at all stages of the planning process to avoid inappropriate development in areas at risk of flooding, and to direct development away from areas at highest risk. Where new development is necessary in such areas, exceptionally, the policy aims to make it safe without increasing flood risk elsewhere and where possible, reducing flood risk overall. 'Safe' in the context of this study means that dry pedestrian access to and from the development is possible without passing through the 1% AEP (1 in 100 year) plus climate change floodplain; emergency vehicular access is possible during times of flood; and the development includes flood resistance and resilience measures to ensure it is safe.

1.2.2 The aim of the SFRA therefore is to map all forms of flood risk and use this as an evidence base to locate new development primarily in low flood risk areas (Zone 1). Where development cannot be located in Flood Zone 1 the planning authority will need to apply the Sequential Test to land use allocations and, where necessary, the Exception Test (requiring a Level 2 SFRA). In addition, the SFRA allows the planning authority to:

- Prepare appropriate policies for the management of flood risk
- Inform the Sustainability Appraisal (SA) so that flood risk is taken account of, when considering options and in the preparation of strategic land use policies
- Identify the level of detail required for site-specific Flood Risk Assessments (FRAs)
- Determine the acceptability of flood risk in relation to emergency planning capability

1.2.3 The SFRA will inform the site selection process for future development sites and provide recommendations for policies to deal with non-allocated sites. The SFRA will feed into the Local Authority's SA of the Local Development Documents (LDDs) and will enable informed decisions to be made relating to land use and development allocation within the respective Development Plan Documents (DPDs).

1.3 Project Objectives

1.3.1 Halcrow has carried out this project in accordance with the Project Brief, dated October 2007, though the methodology and deliverables have been aligned to the document "Development and Flood Risk: A Practice Guide Companion to PPS25" (2006). The SFRA has also followed advice from the Environment Agency.

1.3.2 For this study, a Level 1 SFRA approach has been agreed with the Council and the Environment Agency. A Level 1 SFRA is defined in the Practice Guide Companion to PPS25 (2006) as principally being a desk-based study using existing information to allow application of the Sequential Test on the

basis of Table D1 of PPS25 and to identify whether application of the Exception Test is likely to be necessary.

1.3.3 The best available data within the study timescale has been collected for use in this study, and the nature of the data used has been agreed with the Environment Agency, specifically Flood Zone information. It is, however, important to recognise that the SFRA is a 'living' document. As new information becomes available (such as improved river models) updates will be made to the Flood Zone maps and this should be reflected in the SFRA document, to ensure that the best information is used to guide the site selection process for future developments.

1.4 Project Deliverables

1.4.1 The project outputs for a Level 1 SFRA have been adopted for this study. The deliverables of this assessment are: a technical report; a summary document and a series of maps (a map index can be found in Appendix B).

1.4.2 Following the advice from Section 2.34 of the Practice Guide Companion to PPS25 (2006), the key project outputs are as follows:

1) Plans showing the administrative boundaries of the study area, watercourse centrelines, modelled watercourses, canals, defences, Areas Benefiting from Defences (ABDs) and culverted watercourse sections (Volume 2, Tiles A1-A6)

2) Strategic flood risk maps showing flooding from all sources, including fluvial Flood Zones, and areas at risk of flooding from other sources (Volume 2, Tiles B1–B29)

3) An assessment of the implications of climate change for flood risk in the study area over an appropriate time period (Volume 2, Tiles C1-C6)

4) The location of any flood risk management measures, including both infrastructure (Volume 2, Tiles A1-A6) and the coverage of flood warning systems (Volume 2, Tile F1)

5) Guidance on the application of the Sequential Test (see Chapter 8)

6) Guidance on the preparation of FRAs for development sites (see Chapter 9).

7) Guidance on the likely applicability of different Sustainable Drainage System (SUDS) techniques for managing surface water run-off at key development sites (see Chapter 10)

1.5 Outcomes of the SFRA Process

1.5.1 The Level 1 SFRA provides sufficient data and information to enable the planning authority to apply the Sequential Test to land use allocations to therefore identify where the Exception Test needs to be applied (see sections 1.5.4 and 1.5.5 respectively).

1.5.2 PPS25 also indicates that SAs should be informed by the SFRA for their area. Under the Town and Country Planning (Local Development - England) Regulations 2004, a SA is required for all LDFs. The purpose is to promote sustainable development through better integration of sustainability considerations in the preparation and adoption of plans. The Regulations stipulate that SAs for LDFs should meet the requirements of the Strategic Environmental Assessment (SEA) Directive. An SFRA is used as a tool by a planning authority for the production of development briefs, setting constraints, identifying locations of emergency planning measures and requirements for FRAs.

1.5.3 It is important to reiterate that PPS25 should not be applied in isolation, but as part of the planning process. The formulation of Council policy and the allocation of land for future development must also meet the requirements of other planning policy. Clearly a careful balance must be sought in these instances, and the SFRA aims to assist in this process through the provision of a clear and robust evidence base upon which informed decisions can be made. Importantly, policies should recognise the positive contribution that avoidance and management of flood risk can make to the development of sustainable communities.

The Sequential Test

1.5.4 The primary objective of PPS25 is to steer development towards areas of lowest flood risk. PPS25 therefore advocates a sequential approach to guide the planning decision making process (i.e. the allocation of sites). In simple terms, this requires planners to seek to allocate sites for future development within areas of lowest flood risk in the first instance. Preference should therefore be given to locating new development in Flood Zone 1, Low Probability (see section 2.3). If there is no reasonably available site in Flood Zone 1, the flood vulnerability (see table D3 of PPS25, below) of the proposed development can be taken into account in locating development in Flood Zone 2 (Medium Probability) and then Flood Zone 3 (High Probability). Within each Flood Zone new development should be directed away from 'other sources' of flood risk and towards the area of lowest probability of flooding, as indicated by the SFRA. Appendix C shows the Sequential Test process as advocated in PPS25.

1.5.5 As an integral part of the sequential approach, PPS25 stipulates permissible development types in Table D3 (flood risk vulnerability and Flood Zone 'compatibility'). This considers both the degree of flood risk posed to the site, and the likely vulnerability of the proposed development to damage (and indeed the risk to the lives of the site tenants) should a flood occur. Provided the Sequential Test is carried out and it can be demonstrated that there are no sites available fully in Flood Zone 1, a site can be developed in accordance with Table D3 of PPS25. It is important to note that where a 'tick' is shown in Table D3 of PPS25, this does not imply that development may immediately proceed; the Sequential Test must still be applied and passed.

Table 1.1: Flood Risk Vulnerability and Flood Zone 'Compatibility' (Table D3 of PPS25)

Flood Risk Vulnerability classification (see Table D2)		Essential Infrastructure	Water compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone (see Table D.1)	Zone 1	✔	✔	✔	✔	✔
	Zone 2	✔	✔	Exception Test required	✔	✔
	Zone 3a	Exception Test required	✔	✗	Exception Test required	✔
	Zone 3b 'Functional Floodplain'	Exception Test required	✔	✗	✗	✗

Key:

✔ Development is appropriate

✗ Development should not be permitted

1.5.6 Table D2 of PPS25 (Table 1.2) classifies different types of development under different flood risk vulnerabilities, and should be used with Tables D1 and D3 in allocating development as part of the Sequential Test.

Table 1.2: Flood Risk Vulnerability Classification (Table D2 of PPS25)

Essential Infrastructure	• Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk, and strategic utility infrastructure, including electricity generating power stations and grid and primary substations and chemical tank facilities
Highly Vulnerable	• Police stations, Ambulance stations and Fire stations and Command Centres and telecommunications installations required to be operational during flooding • Emergency dispersal points • Basement dwellings • Caravans, mobile homes and park homes intended for permanent residential use • Installations requiring hazardous substances consent[1]
More Vulnerable	• Hospitals • Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels • Buildings used for: dwelling houses; student halls of residence; drinking establishments; nightclubs; and hotels • Non-residential uses for health services, nurseries and educational establishments • Landfill and sites used for waste management facilities for hazardous waste[2] • Sites used for holiday or short-let caravans and camping, subject to specific warning and evacuation plan
Less Vulnerable	• Buildings used for: shops; financial, professional and other services; restaurants and cafes; hot food takeaways; offices; general industry; storage and distribution; non-residential institutions not included in 'more vulnerable'; and assembly and leisure • Land and buildings used for agriculture and forestry • Waste treatment (except landfill and hazardous waste facilities) • Minerals working and processing (except for sand and gravel working) • Water treatment plants • Sewage treatment plants (if adequate pollution control measures are in place)
Water-compatible Development	• Flood control infrastructure • Water transmission infrastructure and pumping stations • Sewage transmission infrastructure and pumping stations • Sand and gravel workings • Docks, marinas and wharves • Navigation facilities • MOD defence installations • Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location • Water-based recreation (excluding sleeping accommodation) • Lifeguard and coastguard stations • Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms • Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan

1 DETR Circular 04/00 – Para 18: Planning controls for hazardous substances.
www.communities.gov.uk/index.asp?id=1144377

2 See Planning for Sustainable Waste Management: Companion Guide to Planning Policy Statement 10 for definition.
www.communities.gov.uk/index.asp?id=1500757

Notes:

1) This classification is based partly on Defra/Environment Agency research on Flood risks to people (FD2321/TR2)21 also on the need to keep some uses to keep functioning during flooding

2) Buildings that combine a mixture of uses should be placed into the higher of the relevant classes of flood risk sensitivity. Developments that allow uses to be distributed over the site may fall within several classes of flood risk sensitivity.

3) The impact of a flood on the particular uses identified within this flood risk vulnerability classification will vary within each vulnerability class. Therefore, the flood risk management infrastructure and other risk mitigation measures needed to ensure the development is safe may differ between uses within a particular classification

The Exception Test

1.5.7 If, following application of the Sequential Test, it is not possible, or consistent with wider sustainability objectives, for the development to be located in zones of lower probability of flooding, the Exception Test can be applied as indicated by Table D.3 of PPS25. This test provides a method of managing flood risk while still allowing necessary development to occur.

1.5.8 The Exception Test is only appropriate for use when there are large areas in Flood Zones 2 and 3, where the Sequential Test alone cannot deliver acceptable sites, but where some continuing development is necessary for wider sustainable development reasons (the need to avoid social or economic blight and the need for essential civil infrastructure to remain operational during floods). It may also be appropriate to use it where restrictive national designations such as landscape, heritage and nature conservation designations, e.g. Areas of Outstanding Natural Beauty (AONBs), Sites of Special Scientific Interest (SSSIs) and World Heritage Sites (WHS), prevent the availability of unconstrained sites in lower risk areas.

1.5.9 For the Exception Test to be passed:

a) It must be demonstrated that the development provides wider sustainability benefits to the community which outweigh flood risk, informed by an SFRA where one has been prepared. If the DPD has reached the 'submission' stage (see Figure 4 of PPS12: Local Development Frameworks) the benefits of the development should contribute to the DPDs SA process;

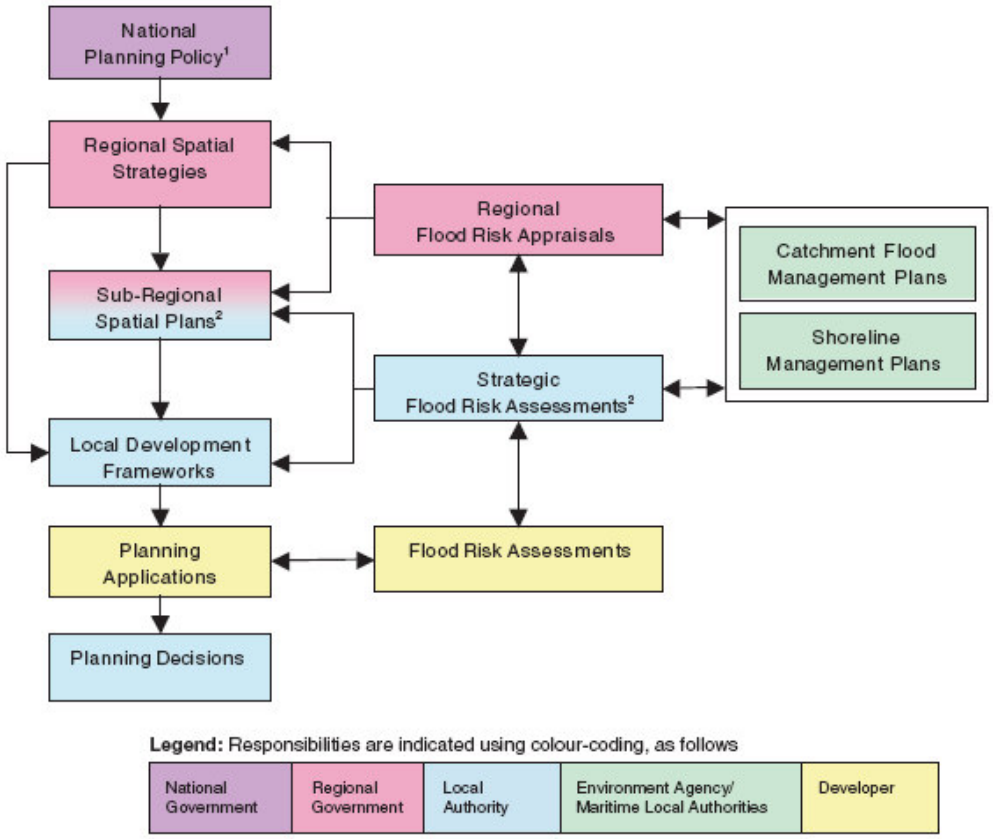
b) The development should be on developable previously-developed land or, if it is not on previously developed land, that there are no reasonable alternative sites on developable previously-developed land; and,

c) A flood risk assessment must demonstrate that the development will be safe, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

1.5.10 It is possible that the Council will need to apply the Exception Test if sites fall within Flood Zone 2 and 3, although it is not possible to fully determine this until the Sequential Test process has been undertaken.

1.6 SFRA Context

1.6.1 Figure 1.1 taken from the PPS25 Practice Guide (2006), illustrates the responsibilities for the production of key documents required to effectively manage flood risk through each stage of the spatial planning process, and, importantly, shows the link with other strategic documents.



Notes

1 Including Planning Policy Statement 25 *'Development and Flood Risk'* and the other flooding-related national planning policy listed in Appendix B of this Practice Guide.

2 SFRAs may cover more than one local planning authority region, and the adoption of a catchment-based approach by a number of LPAs working in partnership could be highly beneficial.

3 This diagram has been developed from the original within the Defra/EA 2005 report FD2320.

Figure 1.1: Development planning process for flood risk

1.7 The Study Area

1.7.1 Stroud is a local government District covering an area of some 460km^2. The District borders the Gloucestershire Districts of the Forest of Dean to the west, Gloucester City and Tewkesbury Borough to the north, Cotswold to the east, and the Unitary Authority, South Gloucestershire, to the south. The District is predominantly rural in nature, with approximately half of the District lying within the Cotswolds AONB and the flat, fertile valley of the River Severn located along the western extent of the District. The town of Stroud is the largest in the District, with the southern extent of the District served by its own market towns, namely Cam/Dursley and Wotton-under-Edge. Other small towns and villages within the District include Nailsworth, Minchinhampton, Stonehouse, and Chalford. The total estimated population in 2006 was 110,300.

1.7.2 Stroud District encompasses a high quality natural environment of very diverse character. Wide areas and a large number of sites are covered by designations related to their special attributes. The Severn Estuary is internationally recognised under the Convention on Wetlands of International Importance (or RAMSAR Convention) and is a Special Protection Area site (SPA). It is also a

proposed Special Area of Conservation site (pSAC) with two further confirmed Special Areas of Conservation (SAC) at Cotswold Beechwoods and Rodborough Common. The District also contains 29 Sites of Special Scientific Interest (SSSI) and a number of National Nature Reserves. There are also many locally recognised sites of nature conservation and geological importance.

1.7.3 The District contains a large number of listed buildings, conservation areas, scheduled ancient monuments, archaeological sites and Historic Parks and Gardens set predominantly within the Cotswold AONB.

1.8 Main Rivers, Hydrology, Geology and Topography

1.8.1 Stroud District Council occupies an area of diverse landscape character ranging from the steeper upland catchments of the Cotswold escarpment to the flat, extensive floodplains of the Lower Severn Estuary. All catchments in the District drain into the River Severn. In terms of contribution to flood risk, a distinction can be made between the Severn, which has a large upstream catchment, and small catchments originating within, or in the vicinity of, the Stroud District.

1.8.2 The Severn, at the point of entry into Stroud, derives from a very large catchment of almost 10,000km^2, and is consequently subject to a great variability in flow. The topography of the western part of the District is relatively flat. Drainage within this flat, low lying area is relatively complex and slow. The artificial and much modified channels and drainage networks are, at times, tide locked by high water levels in the River Severn, and often spill into the floodplain after prolonged heavy rainfall. The risk of the Severn coming out of bank and flooding areas during periods of high flows has, however, been substantially mitigated by the presence of defences along the estuary. Nonetheless, the Environment Agency's 'undefended' Flood Zones show that a significant area, some of which is developed, falls within flood zone 3.

1.8.3 The onset of flooding in the District, particularly in the steeper, upland catchments can be rapid, resulting in flashy flows which can be conveyed to downstream settlements at the bottom of river valleys. Such fast flowing water can be particularly hazardous and pose a risk to existing development areas and Brownfield sites located in the valley bottoms. Consultation with the Council has indicated that floods resulting from out of bank flows for higher flows can be exacerbated by local channel restrictions, in particular, under capacity culverts which are not of sufficient capacity to adequately convey flows. This can result in the backing-up of river flows and the overtopping of culverts, leading to further flooding.

1.8.4 Table 1.3 demonstrates catchment descriptors from the Flood Estimation Handbook (FEH) Version 2 for the river catchments within the District. The baseflow (BFIHOST) and runoff (SPRHOST) values for different watercourses reflect the varied geology. The Oolitic rocks making up the hills to the east of the district are largely permeable whereas the Lias clay in the plains to the west of the district are largely impermeable. Topography is mixed, giving rise to a variety of drainage path slope (DPS) values. Relatively low lying, gently sloping land in the east of the District near the Severn is contrasted with steep hills in the west of the District bordering the Cotswold District. The varied DPS values are discussed for each catchment.

1.8.5 While the Flood Zone maps indicate how the probability of flooding is, in general, greatest near to River Severn due to its tributaries 'backing up', the greatest flood risk in the District in terms of both the probability and consequences of occurrence lies in the more built-up areas of Dursley and Stroud. In Stroud, the confluence of the River Frome, Painswick Stream and Slad Brook, as well as the

Nailsworth Stream a little further west, complicated by the interaction of the Stroudwater Canal, pose a significant flood risk in the relatively steep-sided valleys through which the rivers flow. Although the catchments upstream of this region are small and the underlying Oolitic rock largely permeable, the topography is such that intense localised storms on already wet catchments would bring about significant increases in river levels over a short space of time. The situation is similar in Dursley, with the River Cam flowing from the hills to the east, although its tributaries arise in less steep locations. The river corridor through Dursley, however, is relatively flat so the extent of inundation will be more sensitive to rises in river levels. The villages of Draycott and Cambridge, downstream of Dursley, are also subject to flood risk from the River Cam.

1.8.6 Main rivers within the District are listed in Table 1.3 along with brief watercourse descriptions and eight figure grid references for clarification on locations (using standard Ordnance Survey (OS) notation). Main Rivers are watercourses shown on the statutory main river maps held by the Environment Agency and the Department for Environment, Food and Rural Affairs (also shown in Volume 2, Tiles A1-A6). The Environment Agency has permissive powers to carry out works necessary for flood defence purposes on these rivers. The overall responsibility for maintenance, however, lies with the riparian owner. Minor rivers cover every river, stream, ditch, drain, cut, dyke, sluice, sewer (other than a public sewer) and passage through which water flows and which does not form part of a main river. The local authority or Internal Drainage Board (IDB), where relevant, has powers for ordinary watercourses.

1.8.7 Solid geology and drift maps are shown in Volume 2, Tiles D1 and D2 respectively.

1.8.8 The Lower Severn IDB operates within the Stroud District. The IDB manages water levels using numerous rhynes, pills and control structures on the Little Avon catchment as it approaches the Severn estuary. Consultation with the IDB has indicated that the lower catchment of the River Cam and Wickster's Brook is flat and numerous drainage ditches exist which contain water. Due to the flat topography of the area these are largely stagnant, with the embankments preventing interaction with the river in this area under normal flow conditions. Discussions with the IDB have revealed that the only locations of known interaction between the river and drainage ditches are a ditch near Newhouse farm which drains into the River Cam (SO 7464 0413) and sluices on the Wickster's Brook which allow flow both into and out of the watercourse (SO 7482 0489 and SO 7509 0497). In flood conditions there is one siphon within the study area that is controlled by hydraulic head and operates to drain flood water under the canal.

Table 1.3: Main Rivers in Stroud District and associated catchment descriptors (from north to south) as per FEH Version 2

River Name	Enters District	Exits District	Upstream Catchment Descriptors* (from FEH CD ROM)					
			Downstream point of catchment	Upstream Catchment Area (km^2)	BFIHOST	SPRHOST	DPSBAR (m/km)	Watercourse Description
River Severn	SO 7920 1480	ST 6290 9830	SO 8215 2160	9969.94 (very large)	0.512 (medium)	35.93 (medium)	73 (medium)	The River Severn is by far the largest watercourse in the Stroud District and forms the eastern boundary of the District, running 40km from SO 7590 1658 to ST 5490 8830. All other main rivers in the District drain in a northern or western direction toward the Severn. The River Severn, throughout Stroud District, is considered as a tidal estuary and, therefore, does not have any catchment descriptors attached to it. The catchment descriptors given here are therefore those of the fluvial river at the downstream point of the fluvial catchment at SO 8215 2160. Tidal influence along the River Severn through the District is significant, especially the high spring tide (the famous 'Severn Bore') when a sudden increase in tidal water level downstream is funnelled quickly and sometimes dramatically up the watercourse.

* Underneath each of the numerical parameters are written approximate classifications ('low', 'medium' or 'high' for example) derived from a comparison with the 943 gauged catchments which were used to produce these catchment descriptors – see Flood Estimation Handbook, Volume 5, pp.73 ff.

River Name	Enters District	Exits District	Upstream Catchment Descriptors* (from FEH CD ROM)					
			Downstream point of catchment	Upstream Catchment Area (km^2)	BFIHOST	SPRHOST	DPSBAR (m/km)	Watercourse Description
Dimore Brook	SO 8069 1306 (from Gloucester district)	-	SO 7934 1508	5.95 (small)	0.37 (low)	45.3 (high)	18.1 (low)	Dimore Brook originates as a main river in Gloucester at SO 8154 1259. It joins the Stroud/Gloucester boundary at SO 8069 1306, and flows along the boundary through the Quedgeley area for 1.5km, then crosses the Gloucester and Sharpness canal at SO 7953 1406. It then flows along the District boundary for a further 0.7km until SO 7933 1460, where it departs from the boundary to flow entirely in the Stroud District. It flows for around 0.5km before draining into the Severn at SO 7933 1507. The low DPSBAR value reflects the fact that Dimore Brook is located largely on the flatter part of the District adjacent to the Severn, which can cause a fairly slow catchment response to rainfall, though the low BFI value indicates a fairly impermeable catchment, which can speed the catchment's response to rainfall, as reflected by the high runoff value.
Slad Brook	-	SO 8476 0512	SO 8476 0512	14.96 (small)	0.769 (high)	16.1 (low)	169.5 (high)	The Slad Brook rises in the District to the west of Knapp Farm (SO 8724 0686) and flows in a predominantly south westerly direction for approximately 3.3km before it reaches the Stroudwater Canal.

River Name	Enters District	Exits District	Upstream Catchment Descriptors* (from FEH CD ROM)					
			Downstream point of catchment	Upstream Catchment Area (km^2)	BFIHOST	SPRHOST	DPSBAR (m/km)	Watercourse Description
River Frome / Stroudwater Canal	-	-	SO 7514 1045	227.4 (medium)	0.701 (high)	22.9 (low)	115.3 (high)	The River Frome is the largest watercourse in the District apart from the Severn. It drains most of the upland region in the west of the catchment, over an area including Nailsworth, Minchinhampton, Stroud, Chalford, Painswick and Cranham. This upland region results in the high DPSBAR value, though the catchment is permeable which can slow the catchment's response, as shown by the low runoff value. However, if the catchment is saturated it can respond very quickly to rainfall. Several main rivers are identified, starting at SO 8475 0574, SO 8724 0686, SO 9293 0299, ST 8544 9954, ST 8434 9831 and ST 8373 9970. The Frome interacts with the Stroudwater Canal for a distance while passing through Stroud and Stonehouse. The canal is identified as a main river, running alongside the Frome from SO 8482 0510, and joins the river at SO 8316 0467. Stroudwater Canal again diverges from the Frome at SO 8232 0445 before rejoining it at SO 7810 0572. It then flows in a north westerly direction for 4.5km before crossing the Gloucester and Sharpness canal. It then flows in the same direction for a further 1.25km before draining into the Severn.

River Name	Enters District	Exits District	Upstream Catchment Descriptors* (from FEH CD ROM)					
			Downstream point of catchment	Upstream Catchment Area (km^2)	BFIHOST	SPRHOST	DPSBAR (m/km)	Watercourse Description
Wickster's Brook	-	-	SO 7425 0499	29.97 (small)	0.612 (high)	30.3 (medium)	112.0 (high)	Wickster's Brook begins as a series of small westward flowing streams centred around the towns of Frocester, Eastington and Coaley. The topography in this region slopes relatively steeply towards the Severn, resulting in a high DPSBAR value, though the response to rainfall is slowed by the relatively permeable catchment. The brook is classified as a main river from SO 7669 0487, where it passes under the M5 motorway. It then flows westward for 2.5km, picking up a number of tributaries, before draining into the River Cam at SO 7425 0499, shortly before the River Cam itself drains into the Gloucester and Sharpness canal.
River Ewelme / River Cam	-	-	SO 7389 0509	44.92 (small)	0.542 (medium)	35.5 (medium)	92.4 (medium)	The River Ewelme is designated main river from Castle Stream at Ewelme Close to its confluence with the River Cam. The River Cam begins as several minor rivers in the steep hills around Uley, resulting in a medium/high DPS value. From ST 7668 9793 it is classified as a main river, and flows in a generally northern direction along the northern edge of Dursley and Cam. The Wickster's Brook flows into it at SO 7425 0499, and it flows into the Gloucester and Sharpness canal at SO 7389 0509.Geologically, the minor rivers of the upper part of the catchment lie on permeable limestone whereas the section classified as main river mostly lies on clay, with alluvium and river terrace deposits underlying the main channel. This results in average BFI and SPR values for the catchment.

River Name	Enters District	Exits District	Upstream Catchment Descriptors* (from FEH CD ROM)					
			Downstream point of catchment	Upstream Catchment Area (km^2)	BFIHOST	SPRHOST	DPSBAR (m/km)	Watercourse Description
Doverte Brook	-	-	ST 6766 9925	25 (small)	0.554 (medium)	31.2 (medium)	99.5 (medium)	The Doverte Brook is fed by a network of small streams centred around Berkeley, but extending beyond Dursley 10km to the east. It is only classified as a main river for around 0.8km, between ST 6835 9903 and ST 6766 9925 while it flows through Berkeley. It flows into the Little Avon at ST 6766 9925.
Little Avon	-	-	ST 66643 99961	169.52 (medium)	0.519 (medium)	33.6 (medium)	78.5 (medium)	The Little Avon begins as many small streams draining the entire southern part of the District. Main rivers are considered to begin at ST 7284 9017, ST 7662 9123 and ST 7594 9316. All main rivers are united by ST 7234 9296. Flowing in a north western direction, the Little Avon briefly leaves the Stroud district for 2km between ST 7234 9296 and ST 7091 9415, flowing instead in the South Gloucestershire District. From ST 7091 9415, it flows along the Stroud/South Gloucestershire boundary for around 2km, before fully rejoining the Stroud district at ST 6947 9493. It then flows in a general north westerly direction for 7km, being joined by the Doverte Brook at ST 6766 9925 as it flows through Berkeley. It drains into the Severn at ST 6664 9996.
Shorn Brook	-	-	SO 79160 12790	3.44 (small)	0.367 (low)	42.4 (high)	43.2 (low)	The Shorn Brook rises in the District by Harescombe (SO 8288 1031) and flows in a north westerly direction. Only a small section of the Shorn Brook is designated main river between Church House Farm (SO 7944 1257) and the point at which it enters the Gloucester and Sharpness Canal at SO 7916 1279.

River Name	Enters District	Exits District	Upstream Catchment Descriptors* (from FEH CD ROM)					
			Downstream point of catchment	Upstream Catchment Area (km^2)	BFIHOST	SPRHOST	DPSBAR (m/km)	Watercourse Description
Painswick Stream	SO 9036 1300	SO 8441 0505	SO 8441 0505	31.37 (small)	0.737 (high)	16.9 (low)	141.8 (high)	The Painswick Stream rises in the District at Cranham Wood (SO 9036 1300) and flows in a predominantly south westerly direction, passing through Cranham and around the eastern edge of Painswick. At Stroud, the watercourse becomes designated main river to the east of Stratford Park, before flowing into the Stroudwater Canal at SO 8441 0505.
Caphall Brook	-	-	SO 7556 0475	1.98 (very small)	0.272 (low)	52.7 (high)	20.4 (very low)	Caphall Brook rises within the District to the east of Coaley (SO 7701 0284). The watercourse flows in a north westerly direction joining the Wickster's Brook at SO 7556 0475. The relatively low BFI HOST value of 0.27 and the high SPR value of 52.7% are indicative of an impermeable catchment with a relatively high percentage of surface runoff.

River Name	Enters District	Exits District	Upstream Catchment Descriptors* (from FEH CD ROM)					
			Downstream point of catchment	Upstream Catchment Area (km^2)	BFIHOST	SPRHOST	DPSBAR (m/km)	Watercourse Description
Horsley Brook / Nailsworth Stream	-	-	SO 8343 0452	61.84 (small)	0.784 (high)	18.3 (low)	113.2 (high)	The Nailsworth Brook is designated main river from SO 8435 9831 at Horsley. It is thought that the watercourse is called the Horsley Brook at this point. The watercourse flows in a northerly direction, being joined by a left bank tributary at SO 8490 9947. This tributary is designated main river from SO 8373 9970; upstream of which the watercourse is referred to as Miry Brook. The Nailsworth Stream continues to flow in a northerly direction through the District, before joining the River Frome at SO 8343 0452.
Ozleworth Brook	-	-	ST 7611 9126	2.70 (small)	0.441 (medium)	40.2 (high)	63.8 (medium)	Ozleworth Brook is designated main river from Curtis Mill at Lower Kilcott (ST 7854 8930) to its confluence with Dyers Brook. The watercourse flows in a predominantly north westerly direction through the District and has a relatively small catchment area (2.70km^2) in comparison with other watercourses within the District.
Dyers Brook	-	-	ST 7495 9198	8.52 (small)	0.735 (high)	22.0 (low)	166.9 (high)	Dyers Brook is designated main river from Wortley Road at Wotton-under-Edge (ST 7594 9315) to its confluence with Little Avon River at ST 7495 9198.

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1.9 Key Recommendations: Chapter One

- The primary objective of PPS25 is to steer development towards areas of lowest flood risk (Flood Zone 1). Where development cannot be located in Flood Zone 1, the planning authority will need to apply the Sequential Test to land use allocations and, where necessary, the Exception Test (requiring a Level 2 SFRA).
- The Exception Test is only appropriate for use when there are large areas in Flood Zones 2 and 3, where some continuing development is necessary for wider sustainable development reasons or where restrictive national designations such as AONBs, SSSIs and WHSs prevent the availability of unconstrained sites in lower risk areas.
- To achieve safe development, dry pedestrian access to and from the development must be possible without passing through the 1% AEP (1 in 100 year) plus climate change floodplain; emergency vehicular access must be possible during times of flood; and the development must include flood resistance and resilience measures to ensure it is safe.
- The SFRA is a living document. As new flood risk information becomes available (such as updated Flood Zone information and more extensive information on flooding from other sources) it should be incorporated into the SFRA.
- The Sustainability Appraisal should be informed by the SFRA, to promote sustainable development.
- PPS25 should not be applied in isolation, but as part of the planning process. A careful balance must be struck between PPS25 and the requirements of other planning policy.
- Policies should recognise the positive contribution that avoidance and management of flood risk can make to the development of sustainable communities.

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2 Study Methodology

2.1 Level 1 SFRA Methodology

2.1.1 PPS25 recommends a staged approach to SFRAs, dependant on the development pressures and significance of flooding issues in the study area. The practice guide companion to PPS25 (2006) recommends that a Level 1 SFRA should principally be a desk-based study making use of existing information, to allow application of the Sequential Test and to identify where the Exception Test is likely to be necessary. The main tasks undertaken during the study were as follows:

a) Establishing relationships and understanding the planning context:

An Inception meeting was held to build relationships between the project team, the Councils and the Environment Agency. This allowed the partnering approach to form and allowed the free exchange of available information. Discussions were held on planning pressures and the status of the Councils' LDF, to gain a clear picture of the challenges faced by the planning teams, and the various opportunities and constraints guiding the site allocation process. The study area was also discussed in detail, giving an overview of local features and flooding experienced from all sources.

b) Gathering data and analysing it for suitability:

A quality review of flood risk information was carried out by an experienced core team, who reviewed the collated data, assessed its significance and quality and advised on which data would be needed to drive the SFRA. The main approach adopted for the SFRA was to build on previous studies and existing information, supplied during the data collection phase.

c) Producing strategic flood risk maps, GIS deliverables and a technical report

A series of GIS maps were produced using the data gathered in the early phases of the study. The main mapping output is the strategic flood risk maps of the entire study area, which shows Flood Zones 1, 2 and 3 and flooding from all other sources, and should be used to carry out the Sequential Test. Other maps include study area maps showing canals and fluvial features, climate change maps showing the impacts of climate change on flood probability, geological maps, historic flood outline maps, and maps showing flood watch and warning areas. Hardcopy maps are provided in Volume 2 of the SFRA report, while GIS layers can be found in the CD at the front of this report.

d) Providing suitable guidance

Sections have been written in the report providing guidance on policy considerations, the application of the Sequential Test, guidance for the preparation of FRAs and guidance for the application of SUDS in the study area. A planning workshop has also provided further guidance on the application of the Sequential Test. This established the principles of Sequential Test, provided mock Sequential Testing scenarios and helped to develop broad policy recommendations.

2.2 Need for a Level 2 SFRA

2.2.1 Where the need to apply the Exception Test is identified, due to there being an insufficient number of suitably available sites for development within zones of lower flood risk or due to possible increases in flood risk arising from climate change, the scope of the SFRA may need to be widened to a Level 2 assessment.

2.2.2 This increased scope involves a more detailed review of flood hazard (flood probability, flood depth, flood velocity, rate of onset of flooding) taking into account the presence of flood risk management measures such as flood defences. This could include 2D modelling and breach/overtopping analysis for certain locations.

2.2.3 Level 2 SFRA outputs include:

- An appraisal of the condition of flood defence infrastructure and likely future policy
- An appraisal of the probability and consequence of breach or overtopping of flood defence infrastructure
- Maps showing distribution of flood risk across zones
- Guidance on appropriate policies for making sites which satisfy parts a) and b) of the Exception Test safe; and the requirements for satisfying part c) of the Exception Test
- Guidance on the preparation of FRAs for sites with varying flood risk across the Flood Zone

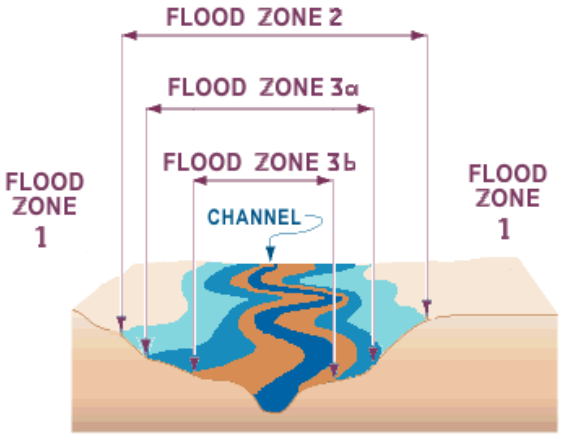
2.2.4 In general, the Level 2 SFRA should aim to provide clear guidance on appropriate risk management measures for adoption on sites within Flood Zone 3, which are protected by existing defences. This should minimise the extent to which individual developers need to undertake separate studies on the same problem. The scope of a Level 2 SFRA cannot be fully determined until the Sequential Test has been undertaken by the Council on all possible site allocations.

2.3 Technical Background

2.3.1 It is useful to gain a good understanding of Flood Zones and the approaches taken to satisfy the Level 1 SFRA requirements, using existing data.

Flood Zones

2.3.2 Flood Zones show the areas potentially at risk of flooding from rivers or the sea, ignoring the presence of defences (although areas benefiting from formal defences are identified).



2.3.3 PPS25 defines the Flood Zones as follows:

Zone 1: Low Probability

2.3.4 This zone comprises land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%).

Zone 2: Medium Probability

2.3.5 This zone comprises land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% – 0.1%) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% – 0.1%) in any year.

Zone 3a: High Probability

2.3.6 This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.

Zone 3b: The Functional Floodplain

2.3.7 This zone comprises land where water has to flow or be stored in times of flood (land which would flood with an annual probability of 1 in 20 (5%) or greater in any year, or is designed to flood in an extreme (0.1%) flood, including water conveyance routes). The SFRA maps Flood Zone 3b where it has been produced. Where no modelled outlines have been produced, Flood Zone 3b has been shown to equal Flood Zone 3a.

2.3.8 It should be noted that flooding from surface water, groundwater, sewers and impounded water bodies can occur in any zone, even Flood Zone 1.

2.3.9 Flood Zone maps in the SFRA have been produced from two sources: Environment Agency Flood map, published and updated quarterly on their website, and detailed local hydraulic modelled outlines (a list of these models can be found in Table 5.1).

2.4 Environment Agency Flood Zone Maps

2.4.1 A national flood map dataset has been produced by the Environment Agency. Most fluvial Flood Zones 2 and 3 are derived from the modelling package JFlow, which is a 'coarse' modelling approach (see Appendix D for further details). In many places the results of flood mapping studies have superseded the JFlow outlines. Generally these studies have included detailed hydrological research, surveyed river cross sections, and more precise digital modelling such as ISIS, TuFlow and HecRas.

2.4.2 It should be noted that not all minor watercourses have had Flood Zone maps produced for them. Only watercourses with a catchment area greater than 3km² have been modelled using JFlow software and, therefore, smaller watercourses as identified on the 10K or 25K OS maps within Flood Zone 1 may not be covered by the Environment Agency Flood Zone maps. As such, for any development site located adjacent to an unmapped watercourse within Flood Zone 1, it is recommended that an 8m development easement from the top of bank is applied, and a site specific FRA is undertaken. It should be noted that the Environment Agency is not the statutory consultee for ordinary watercourses and developers should refer to the Council's Land Drainage departments where they exist.

2.4.3 The Environment Agency Flood Map does not show the potential impact of climate change or the functional floodplain, Flood Zone 3b, which is a recent PPS25 requirement.

2.5 Key Recommendations: Chapter Two

- Not all minor watercourses have had Flood Zone maps produced for them, specifically, those with a catchment area of less than 3km². These watercourses may appear to be fully in Flood Zone 1, when in reality a degree of flood risk will be posed. For any development site located adjacent to an unmapped watercourse within Flood Zone 1, an 8m development easement from the top of bank must be applied and a site specific FRA undertaken.
- The Environment Agency is not the statutory consultee for ordinary watercourses and developers should refer to the Council's Land Drainage departments where they exist.

3 Planning Context

3.1 Introduction

3.1.1 This section provides an overview of the planning policy framework relevant to Stroud District Council.

3.1.2 This report has been prepared in accordance with the PPS25 and its Practice Guide companion (2006) and fulfils the requirements of PPS25: Development and Flood Risk. Information contained in the SFRA provides evidence to facilitate the preparation of robust policies for flood risk management, used to inform the SA of LDDs and enable informed decisions to be made relating to land use and development allocations within the respective DPDs.

3.1.3 The success of the SFRA is heavily dependent upon the Council's ability to implement the recommendations put forward for future sustainable flood risk management. It is ultimately the responsibility of the Council to establish robust policies that will ensure future sustainability with respect to flood risk.

3.2 Planning Policy Framework

3.2.1 The UK planning system has a comprehensive hierarchy of policies and plans, beginning with national guidance. This provides a policy basis for regional plans through to development plans at the local level. Development plans are intended to provide the framework for the future development of an area. They are prepared following public and stakeholder involvement and are intended to reconcile conflicts between the need for development and the need to protect the wider built and natural environment.

3.2.2 The Government is currently implementing reforms to the planning system, with Planning Policy Statements (PPS) replacing Planning Policy Guidance (PPG), Regional Spatial Strategies (RSS) replacing Regional Planning Guidance (RPG) and Local Development Frameworks (LDF) replacing Structure Plans, Local Plans and Unitary Development Plans.

3.2.3 The following paragraphs provide an overview of the relevant policy documents for the SFRA.

3.3 National Planning Policy

PPS1: Creating Sustainable Communities (2005)

3.3.1 PPS1 sets out the Government's objectives for the planning system. It confirms that good planning should deliver the development in the right place, at the right time, and protect the environment. It identifies sustainable development as the core principle underpinning planning and requires that development plans ensure it is pursued in an integrated manner.

Planning and Climate Change (Consultation Draft Supplement to PPS1)

3.3.2 Planning and Climate Change was published in December 2007 as a supplement to Planning Policy Statement 1. The Statement requires planning authorities to tackle both the causes of climate change (reduction of green house gas emissions) and the impacts of a changing climate (flooding, habitat migration).

PPS3: Housing (2006)

3.3.3 PPS3 has been developed in response to recommendations in the Barker Review of Housing Supply (March 2004). Its principal aim is to underpin the necessary step change in housing delivery, improving the supply and affordability of housing in all communities including rural areas.

3.3.4 PPS3 states that the Government's key housing policy goal is to ensure that everyone has the opportunity of living in a decent home, which they can afford, in a community where they want to live. The specific outcomes that the planning system should deliver in relation to housing are:

- Well designed, high quality housing that is built to a high standard
- A mix of market and affordable housing for all households in all areas
- A sufficient quantity of housing, taking into account need and demand and seeking to improve choice
- Housing developments in suitable locations offering a good range of community facilities and with good access to jobs, key services and infrastructure
- A flexible, responsive supply of land; which is used efficiently and effectively, including the use of previously developed land

3.3.5 Housing policies should help to deliver sustainable development objectives, in particular seeking to minimise environmental impact taking account of climate change and flood risk, and take into account market information, in particular housing need and demand.

PPS4: Planning for Sustainable Economic Development (Consultation Paper, 2007)

3.3.6 The new PPS on Planning for Sustainable Economic Development sets out how planning bodies should, in the wider context of delivering sustainable development, positively plan for sustainable economic growth and respond to the challenges of the global economy, in their plan policies and planning decisions.

PPS6: Planning for Town Centres (2005)

3.3.7 PPS6 sets out the Government's policy on planning for the future of town centres.

PPS7: Sustainable Development in Rural Areas (2004)

3.3.8 PPS7 sets out the Government's planning policies for rural areas, including country towns and villages and the wider, largely undeveloped countryside up to the fringes of larger urban areas.

PPS9: Biodiversity and Geological Conservation (2005)

3.3.9 PPS9 sets out policies on protection of biodiversity and geological conservation through the planning system. The broad aim is that development should have minimal impacts on biodiversity and geological conservation interests and enhance them where possible. Appropriate weight should be attached to the need to protect international and national designated sites.

PPS10: Planning for Sustainable Waste Management (2005)

3.3.10 PPS 10 gives criteria that must be considered in testing the suitability of sites for waste development, which includes protection of water resources; air emissions including dust; odours; and noise and vibration.

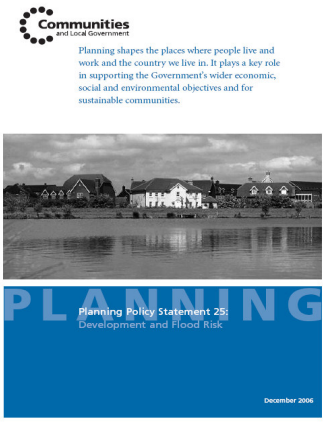
PPG15: Planning and the Historic Environment (1994)

3.3.11 PPG15 sets out policies on the protection of the historic environment and recognises that planning plays an important role in preserving built and natural heritage.

3.3.12 **PPG17: Planning for Open Space and Recreation (2002)**

PPG17 recognises the importance that public open spaces, green areas and recreational rights of way can play in supporting regeneration and contributing to local quality of life.

PPS25: Development and Flood Risk (2006)



3.3.13 PPS25 sets out a plan led approach to flood risk. It confirms that all forms of flooding and their impact on the natural and built environment are material planning considerations. It clarifies the sequential approach (a process that minimises risk by directing development to areas of lowest risk), matches types of development to degrees of flood risk and strengthens the requirement to include FRAs at all levels of the planning process. Regional planning bodies and local planning authorities (LPAs) should, amongst other things, reduce flood risk by safeguarding land from development that is required for current and future flood management e.g. conveyance and storage of flood water and flood defences.

Town and Country Planning Legislative Changes

3.3.14 Amendments to the Town and Country Planning (General Development Procedure) Order 1995 came into force on 1 October 2006 introducing further requirements for LPAs to consult the Environment Agency before determining applications for development in flood risk areas.

3.3.15 The Town and Country Planning (Flooding) (England) Direction 2007 (which came into force on 1st January 2007) seeks to safeguard against inappropriate development in flood risk areas. The Direction introduces a requirement for LPAs to notify the Secretary of State of any application for major development (e.g. 10 or more dwellings) in a flood risk area which it proposes to approve against Environment Agency advice.

3.4 Regional Planning Policy

3.4.1 Regional planning policies provide the overarching framework for the preparation of the LDFs. The Draft South West Regional Spatial Strategy (RSS) provides a broad development strategy for the South West Region up to 2026. The RSS will supersede RPG 10, which was prepared in the late 1990s. The new strategy for the region is more positive, more explicit and more prescriptive regarding matters that require a strategic approach.

3.4.2 The purpose of the RSS is to provide a long term land-use and transport planning framework for the Region. It influences the future planning of the region in a number of ways:

- As part of the development plan system it provides guidance on the location and scale of development for interpretation in LDFs
- It guides investment in transport and provides a framework for the preparation of Local Transport Plans (LTPs)

- It provides spatial context for the plans, programmes and investments of other agencies and organisations in the South West

3.4.3 When the RSS is published, countywide Structure Plans will be superseded, and their policies replaced by the RSS. Until that time, Structure Plan policies are 'saved' until adoption of the plan. The Gloucestershire Structure Plan Second Review policies (adopted November 1999) are currently saved.

3.4.4 The draft RSS was placed on deposit from 6th June 2006 to 30th August 2006 and following consultation period responses to the report were received from individuals, organisations, interest groups and local authorities. The South West RSS Panel team was appointed by the Secretary of State to conduct an Examination in Public (EiP) of selected issues arising out of the draft RSS. The report of the findings was published in January 2008 and recommendations of changes to the draft RSS were made. The panel stressed that as a result of their recommendations, there may be a further need to modify or delete policies and/or text throughout the Strategy as necessary. It is therefore recommended that reference to the findings of the panel report be made.

3.4.5 The Northern Sub-Region, of which Gloucestershire is part, will continue to be the main focus for growth in the South West. The area has the potential to continue as a major focus of growth and economic expansion here is likely to be above the national average. Development plans will need to identify strategic employment sites, and provision needs to be made to meet future development requirements at sustainable development locations.

3.4.6 Table 3.1 illustrates the housing requirements for the Gloucestershire put forward within the draft RSS along with the recommendations made by the South West RSS Panel team in their report:

Table 3. 1: Housing requirements for Stroud District

	Draft RSS Figures			Panel Modifications		
Gloucester and Cheltenham Housing Market Area	**2006-2026 Overall Annual Net Dwelling Requirement**	**2006-2016 Annual Average Net Dwelling Requirement**	**2016-2026 Annual Average Net Dwelling Requirement**	**2006-2026 Overall Annual Net Dwelling Requirement**	**2006-2016 Annual Average Net Dwelling Requirement**	**2016-2026 Annual Average Net Dwelling Requirement**
Cheltenham	425	425	425	405	405	405
Gloucester	575	575	575	575	575	575
Tewkesbury	525	525	525	730	730	730
Cotswold	300	340	260	345	345	345
Forest of Dean	270	300	240	310	310	310
Stroud	**335**	**435**	**235**	**455**	**455**	**455**
TOTAL	2430	2600	2260	2820	2820	2820

Relevant RSS Policies

3.4.7 Four high level Sustainable Development Policies (SD1 to SD4) are put forward in the RSS which set the broad sustainability context for the RSS, aiming to make future development and lifestyle choices in the region more sustainable. The points relevant to the SFRA are as follows:

- SD1 states that the region's Ecological Footprint will be stabilised and then reduced by ensuring that development respects environmental limits;
- SD2 states that the region will adapt to the anticipated changes of climate change by avoiding the need for development in flood risk areas and incorporating measures in design and construction to reduce the effects of flooding
- SD4 states that growth and development will be planned for and managed positively to create and maintain Sustainable Communities throughout the Region by providing networks of accessible green space for people to enjoy [these can also be utilised as flood storage areas which can provide a positive reduction to flood risk]

3.4.8 These policies, and an assessment of contextual evidence, leads to a Spatial Strategy for the region, which will provide the most sustainable way of dealing with change and pressure for development, while addressing some of the region's major challenges. The Spatial Strategy for the South West is based on recognition of the diverse needs and potential for change of different places and parts of the region. Development will be planned to meet the needs of all communities and to realise their potential within environmental limits.

3.4.9 What follows are sub-regional expressions of SD1 to SD4 in spatial policy and development terms. The varied characteristics of the region mean the Spatial Strategy has three distinct emphases. The RSS presents more locationally specific policies grouped within each of the three distinct Strategy Emphases. Gloucestershire falls in the 'north and centre of the region' grouping. SR1 states that:

"In the north and central part of the region, the strategic emphasis is to realise economic potential by enabling the Strategically Significant Cities and Towns (SSCTs) [Cheltenham and Gloucester in the SFRA study area] to develop, maintain and improve their roles as service and employment centres, with a view to enhancing regional prosperity and addressing regeneration. Sufficient housing will be provided to complement this role and to meet the needs of a growing population".

3.4.10 Chapter 7 of the RSS discusses 'enhancing distinctive environments and cultural life', in which it puts forward Policy F1 - Flood Risk:

"Taking account of climate change and the increasing risk of coastal and river flooding, the priority is to:

- *Defend existing properties and, where possible, locate new development in places with little or no risk of flooding*
- *Protect floodplains and land liable to tidal and coastal flooding from development*
- *Follow a sequential approach to development in flood risk areas*
- *Use development to reduce the risk of flooding through location, layout and design*

- *Relocate existing development from areas of the coast at risk, which cannot be realistically defended*
- *Identify areas of opportunity for managed realignment to reduce the risk of flooding and create new wildlife areas"*

3.4.11 The RSS states that in implementing Policy F1, LDDs will need to:

- Require SFRAs to guide development away from floodplains, areas at risk or likely to be at risk in the future from flooding, or where development would increase the risk of flooding elsewhere
- Ensure that the location of new development is compatible with relevant Shoreline Management Plans (SMPs) and River Basin Management Plans (RBMPs) and other existing relevant strategies, and takes account of the Environment Agency's Flood Map
- Seek to reduce the causes of flooding by requiring that all developments and, where subject to planning control, all land uses (including agricultural activities changes to drainage in existing settlements) should not add to the risk of flooding elsewhere and should reduce flooding pressures using appropriate SUDS techniques
- Require that all developments on the perimeter of towns and villages take account of local flooding risks from agricultural run-off
- Ensure that development proposals do not prejudice future coastal management or the capacity of the coast to form a natural sea defence, or to adjust to changes, without endangering life or property
- Include proposals which allow for the relocation of existing development from areas of the coast at risk, which cannot be realistically defended

3.4.12 Recommended flood risk management policies, to be developed as part of the LDF, are put forward in Chapter 7. These have been developed in accordance with the above core objectives.

3.4.13 Other policies in the Draft RSS of particular relevance to this study are:

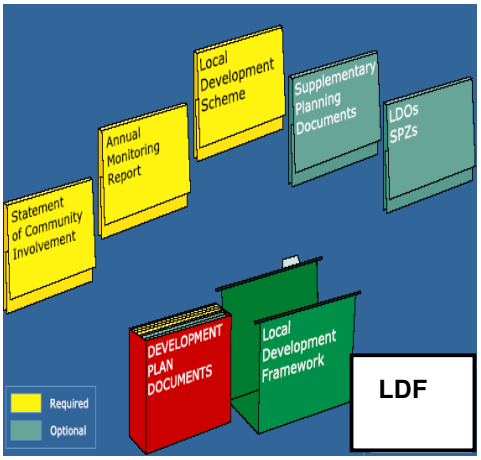
- **RE6: Water Resources.** This states that *"The Region's network of ground, surface and coastal waters and associated ecosystems will be protected and enhanced, taking account of the Environment Agency's 'Regional Water Resources Strategy', catchment abstraction management strategies, groundwater vulnerability maps, groundwater source protection zone maps and river basin management plans. Surface and groundwater pollution risks must be minimised so that environmental quality standards are achieved and where possible exceeded. LPAs, through their LDDs, must ensure that rates of planned development do not exceed the capacity of existing water supply and wastewater treatment systems and do not proceed ahead of essential planned improvements to these systems".* Information on groundwater source protection zones can be found in Chapter 10.
- **Development Policy G: Sustainable Construction.** This states that *"Developers, local authorities, regional agencies and others must ensure that their strategies, plans and programmes achieve best practice in sustainable construction".* This includes the point:

"Requiring the use of sustainable drainage systems to minimise flood risk associated with new developments". Information on the use of SUDS can be found in Chapter 10, as well as in the policy recommendations in Chapter 7.

3.5 Local Planning Policy

Local Development Framework

3.5.1 The reforms to the planning system mean that the LPA will gradually depart from the Local Plan and create new planning policies within the new planning system, known as the LDF. The LDF will deliver the vision of the RSS, at the local level. Unlike its predecessors such as the Local Plan or Structure Plan, the LDF is not a single document but rather a 'folder' into which a series of documents are placed. This flexible approach enables some aspects of the Framework to be revised quickly in response to changing circumstances, whilst leaving others to endure for the longer term. The composite documents (the LDDs) have different purposes, some used to guide and others to inform. The main documents involved are:



- The Statement of Community Involvement
- The Annual Monitoring Report
- The Local Development Scheme (LDS)
- Supplementary Planning Documents (SPDs)
- The Core strategy
- Site Specific Allocations
- Adopted Proposals map
- Generic Development Control Policies DPD

3.5.2 SPDs may be prepared to add further detail or guidance to DPDs.

3.5.3 Stroud District Local Plan forms part of the development plan for the area of Stroud District Council and runs until 2011. The development plan forms the basis for decisions on land use planning affecting the District. The Local Plan was adopted in November 2005 and the Council is currently looking to save the Local Plan Policies. In 2004, following the introduction of the Planning and Compulsory Purchase Act, Stroud District Council commenced the preparation of their LDF. This will eventually replace the Stroud District Local Plan.

3.5.4 In preparing the LDF, the Council is required to prepare a LDS. This is a three-year project plan setting out, in detail, how and when the Council intends to prepare the various components of its LDF. The LDS is reviewed regularly to take into account any changes in the process and to update the detail. The current LDS (October 2007 version) has been submitted to and agreed by the Secretary of State. The LDS and previous editions are available on the Council's website: http://www.stroud.gov.uk/docs/localplan/lds.asp.

3.5.5 The SCI sets out when and how the Council will undertake public and stakeholder consultation with regard to the LDF process and in determining significant planning applications. The SCI was adopted by the Council on 8th November 2007.

3.5.6 The Core Strategy is the most important part of the LDF, which will establish the planning objectives for Stroud District to 2026 and set out the overall context for future development and growth. Work on the Core Strategy is ongoing.

3.5.7 The Cotswold Canals Brimscombe Area Action Plan (AAP) replaces the previously proposed Cotswold Canals AAP and provides a planning framework for Thrupp. It will be used to manage any significant change associated with canal restoration and place emphasis on conservation in such a sensitive and historic location. The Cotswold Canals comprise the historic waterways of the Stroudwater Navigation and the Thames and Severn Canal. The canal has formed a historic link between the River Severn, the Gloucester and Sharpness Canal and the River Thames (via a tunnel at Sapperton). Complex interactions exist between the canal and River Frome for much of its length, which must be considered when assessing flood risk at individual sites. The Brimscombe AAP Issues and Options document was prepared in response to the complex planning issues and opportunities presented by the restoration of the Stroudwater and the Severn and Thames Canal at Brimscombe. The document identifies a variety of options for mixed use development including homes, employment uses and infrastructure. The Issues and Options stage of the Brimscombe AAP took place between 31st October and 12th December 2007.

3.5.8 The LDF will contain various policies and proposals that will influence the development of Stroud District in the period up to 2026. It is essential that these policies and proposals are based on robust, comprehensive and up-to-date evidence. Indeed, the SFRA forms part of this evidence base.

3.6 Key Recommendations: Chapter Three

- The success of the SFRA is heavily dependent upon the Council's ability to implement the recommendations put forward in the SFRA for future sustainable flood risk management.
- While policy recommendations are put forward in Chapter 7, it is ultimately the responsibility of the Council to establish robust policies that will ensure future sustainability with respect to flood risk.

4 Data Collection and Review

4.1 Overview of Flooding Sources

4.1.1 Flooding can come from a variety of sources, including rivers, rainfall on the ground surface (surface water), rising groundwater, overwhelmed sewer and drainage systems and breached or overtopped reservoirs and canals. This chapter gives a strategic assessment of the risk posed to the study area from these sources.

4.2 Approach to Data Gathering

4.2.1 Throughout the data collection and review process it has been critical to make best use of the significant amount of information which already exists with respect to flood risk (held by the Councils, Environment Agency, British Waterways, the Highways Agency, Severn Trent Water, Thames Water, Wessex Water, Welsh Water, Bristol Water and IDBs). The data gathering process has resulted in a review of:

- Strategically important documents including the Regional Flood Risk Appraisal and the Pitt Review
- Historical flooding information from Environment Agency historic flood outlines and various datasets from water companies, the Councils and British Waterways, detailing flooding experienced from 'other sources'
- Environment Agency Flood Zone maps and detailed flood risk mapping outputs, including fluvial climate change outputs
- Information on flood risk management infrastructure, including defences, culverts and structures (supported by information from the Councils and the Environment Agency's National Flood and Coastal Defence Database (NFCDD))
- Existing flood risk management reports including Catchment Flood Management Plans (CFMPs)
- Environment Agency flood warning and flood watch information

4.2.2 The team has been able to review the collected data, assess its significance and quality and advise on which part of the collected data should be used for the SFRA. The main approach to the SFRA has been to build on previous studies and gathered information.

4.2.3 Consultation has formed a key part of the data gathering stage of the SFRA. The aforementioned stakeholders were consulted during the SFRA and as part of the consultation process, an Inception meeting was held to allow key stakeholders to share their experience and knowledge of flooding issues across the study area. The benefits of adopting a partnering approach (as advocated by PPS25) are significant and have helped to ensure that the findings and recommendations of the SFRA are relevant and workable for the Council.

4.3 The Pitt Review

4.3.1 Following the summer 2007 floods an independent review of the flood-related emergencies which occurred was undertaken by Sir Michael Pitt on behalf of the Government. The final report has been published and should be reviewed by the Council with appropriate action taken where the report recommends it.

4.3.2 A summary of the summer 2007 June and July 2007 events, in terms of rainfall and subsequent flooding, is briefly summarised in Sections 4.5.5 to 4.5.18. In the main, the Pitt review has been guided by four key principles and conclusions reached, including:

- The needs of those individuals and communities who have suffered flood or are at risk
- That change will only happen with strong and more effective leadership across the board
- That we must be much clearer about who does what
- That we must be willing to work together and share information

4.3.3 These principles were translated into recommendations, which have been included in Appendix E of this report. Attention should be drawn specifically to recommendations 14, 15, 16, 17 and 19 which address the role of the Local Authority with regards to flood risk management and recommends that the Local Authority takes a lead role in the management of flood risk with the support of the relevant organisations.

4.4 Findings of the Regional Flood Risk Appraisal

4.4.1 The South West Regional Flood Risk Appraisal (RFRA) was completed in February 2007, to inform the Regional Sustainability Appraisal (RSA) as part of the RSS. It provides a broad overview of the source and significance of all types of flood risk across the region, and is used to assess and influence housing and employment as well as to identify where flood risk management measures may be functional at a regional level. The main aim of the RFRA is to direct development away from areas at highest risk of flooding.

4.4.2 The RFRA states that around 100,000 properties in the South West Region lie in Flood Zone 3. While flood defences do reduce the risk of flooding, the RFRA re-iterates that these do not eliminate the risk of flooding due to the residual risk of breach or overtopping. By their very nature, residual risks have a low probability of occurrence. However, consequences can vary from low (e.g. marginal overtopping of a flood defence wall) to high (e.g. sudden collapse of high flood defence bank, where property is close by). Residual risk tends to depend upon the extent and height of the flood defences in the locality and the density, and proximity of development relative to the defences (further details on residual risk can be found in Section 6.9). Flood risk also remains from sources including sewers, surface water and groundwater [and impounded water bodies].

4.4.3 The RFRA discusses the impact of climate change on flood risk in the South West region. This tends to focus on the concern over sea level rise and the effects this will have on the coast of the South West. This could potentially impact sea defences in the Stroud District (see Section 6.6 for further details on defences). The RFRA does not consider the impact of climate change on rivers as there is no data that considers these areas for the whole of the South West. The RFRA does, however, refer to Defra guidance on climate change (outlined in Table 5.2) and states that increases in river flows as a result of climate change should be assessed in site specific FRAs and detailed design. Further details of climate change within the District can be found in Section 5.5.

4.4.4 An appraisal of regionally significant flood risk was carried out as part of the study, and Gloucester and Cheltenham made up one of the 9 sub-regions covered by the South West RFRA. All other areas in Gloucestershire were not assessed, thought the RFRA does state that the Stroud Valleys have “significant flood risk challenges”, and that the River Frome and River Little Avon catchments

have significant fluvial and tidal flood risk issues and these areas contain a number of rural centres. Therefore the LPA should use the more detailed findings of the SFRA to locate future development and formulate appropriate flood risk management and development control policies.

4.5 Historical Flooding

4.5.1 Recent years have seen a number of large scale flood events throughout the UK including Easter and October 1998, autumn 2000, February 2002, New Year 2003, February 2004 and more recently summer 2007. The Environment Agency has produced a number of historic flood outlines within the Stroud District and the following events have been mapped: January 1939, March 1947, July 1968, December 1981, January 1990, December 2000 and summer 2007. The historic flood outlines can be found in Volume 2, Tiles E1-E4. Details of the main affected locations are in Table 4.1.

4.5.2 Sections 4.5.5 to 4.5.18 provide a detailed account of the summer 2007 floods and how the events affected the County of Gloucestershire as a whole. This event has been covered in detail because it is the most recent and memorable event to have affected the County. It should be stressed, however, that other historical events have affected the County which are just as important in obtaining an understanding of the flood risk posed to the District. All historical flood events should also therefore be considered as part of any assessment of flood risk within the District.

Table 4.1: Historical Flooding based on the Environment Agency Historic Flood Outlines within the Stroud District

Flood Event	Watercourse	Description of Affected Watercourses & Areas
January 1939	River Severn	Small area of rural floodplain towards the north eastern boundary of the District with Tewkesbury Borough Council. No properties shown to have been affected.
March 1947	River Severn	Flooding mainly to rural locations in the northern extent of the District. Some locations shown to be flooded including: Elmore Back Farm (SO 7675 1662), Severn Bank Farm (SO 7748 1671) and Weir Green Farm (SO 7909 1531)
July 1968	Various	Affected various isolated locations within the District including: rural floodplain adjacent to the River Severn at Elmore towards the northern extent of the District and Sharpness towards the south western extent of the District; properties at Stroud adjacent to the Stroud Water Canal and rural floodplain and properties along the River Frome at Stroud, Bridgend, Stanley Downton & Saul; residential and commercial properties along the River Cam through Dursley, Cam & Cambridge; rural floodplain adjacent to the Wickster's Brook; properties at Uley along the River Ewelme; properties along the Doverte Brook; a number of properties along the Little Avon at Wotton-under-Edge, Kingswood, Charfield Green and larger rural floodplain areas and a few properties by Berkley in the reaches of the watercourse.
December 1981	River Severn	Large areas of rural floodplain along the River Severn towards the western extent of the District.
January 1990	Dimore Brook	A small area of rural floodplain along the Dimore Brook at its confluence with the River Severn.
December 2000	River Severn	Rural floodplain adjacent to the River Severn at Elmore in the northern extent of the District.

4.5.3 Historic records for the District also indicate that extensive and prolonged flooding occurred along the River Frome in December 1965. This was a result of rapid snow melt and a number of properties and large areas of the floodplain of the River Frome were affected[6], though no historic flood outline exists for this event.

4.5.4 Historically flooding along the River Severn Estuary has occurred since Roman times. Records indicate that flood defences were constructed in Roman times to protect newly reclaimed land from high tides. More recently, in 1981 severe flooding occurred along the Severn Estuary as a result of high tides coinciding with heavy rainfall and a high surge, with the worst affected areas at Avonmouth and Severnside (outside of the District). Following the 1981 flooding, the Avonmouth to Worcester Improvement scheme was commissioned by Severn Trent Water and a series of embankments and flood walls were constructed along the estuary (Section 6.6). Following the construction of the

defences, the frequency and severity of flooding along the Severn Estuary has significantly reduced. The most recent floods occurred during Christmas 1999, affecting approximately 30 properties between Longney and Elmore Back. Further flooding was experienced along the estuary in November and December 2000, affecting mainly rural floodplain within the District. This flooding occurred primarily as a result of significant rainfall in the Severn catchment.

Summer 2007 Floods

4.5.5 This section provides an account of the summer 2007 floods including a timeline of events, the rainfall that was experienced and how this manifested itself as river flows and subsequent flooding. The historic flood outline of this event, which can be found in Volume 2, Tiles E1–E5, depicts the extent of the flooding. This was produced by the Environment Agency and involved the deployment of numerous survey teams to capture wrack marks and levels so that the extent of flooding could be captured. The outlines were then verified by the Environment Agency using aerial photography of the event, information from the public, ground photos and information from Gloucestershire County Council. Consultation with local authorities took place for further verification. The scale of the event was unprecedented and as much data as was realistically possible was gathered. While the majority of flood affected areas were captured, some minor omissions may remain.

4.5.6 It should be noted that at this stage, the Environment Agency does not intend to change the existing Flood Zone information (as presented in Volume 2, Tiles B1-B29) in light of the summer 2007 flood events. Liaison with the Environment Agency has confirmed that this may change in the future, but until such time the latest Flood Zone information should be used to enable the Sequential Test and therefore locate future development. However, historic flood events should be taken into account for all development sites. Where a historic flood event has affected a proposed development site, flood resistance and resilience should be incorporated into the site.

Timeline of Events[3]

4.5.7 The 15th June 2007 marked the beginning of extreme flood events in the UK. During June, North and East Yorkshire suffered severe thunderstorms with resultant flooding, causing the fire brigade to launch 'the biggest rescue effort in peacetime Britain'. In early July, forecasters warned of treacherous weather for the rest of July and in mid July, the Met Office issued severe weather warnings as strong winds and low pressure swept across England. On 20th July over 3 inches of rain fell in just 12 hours over much of south and south west England. Resultant severe flooding was experienced across Gloucestershire. Up to 10,000 people were left stranded on the M5 as drivers were forced to abandon cars, and 500 people were stranded at Gloucester railway station as the railway network failed. Rest centres were set up for some 2,000 people unable to travel home.

4.5.8 On 22nd July Mythe water treatment works flooded, leaving over 350,000 people without clean water for up to 17 days. Despite efforts to distribute bottled water and bowsers, the lack of water for basic daily use caused severe distress to thousands of people. Electricity supplies throughout the County were also threatened, with Walham switching station (which serves over half a million homes across Gloucestershire and South Wales) and Castle Meads electricity sub-station under threat from rising flood water. Walham switching station was protected following the mobilisation of temporary defences and temporary pumping equipment in a joint effort from the Environment Agency, British

3 Pitt, M. (2007) Learning Lessons from the 2007 floods – An independent review by Sir Michael Pitt

Waterways, Armed Forces, Fire and Rescue and Police Services. British Waterways lowered the Gloucester and Sharpness Canal which created sufficient capacity to enable the emergency services to pump water from the switching station in order to prevent it from flooding. However, Castle Meads sub-station had to be shut down on the 23rd July before it flooded, leaving approximately 42,000 people without power. The effects of the infrastructure failure were felt outside the flooded areas and resulted in an increase in demand for emergency responses.

4.5.9 The emergency response in the county of Gloucestershire was coordinated by the Gold Command. Rainfall, river levels and sea conditions were monitored by the Environment Agency with data used to issue flood warnings. On 27th July another heavy downpour of rain occurred, causing further localised flooding in Gloucestershire. The emotional and financial toll that the floods caused is undisputable.

How the summer 2007 Floods Affected Stroud District Council

4.5.10 Approximately 200 properties within the District of Stroud were affected by the summer 2007 floods.

Rainfall Data

4.5.11 The flooding followed unprecedented rainfall; the wettest-ever May to July period since national records began in 1766. The Centre for Ecology and Hydrology[4] states that May to July produced hydrological conditions with no close modern parallel for the summer period in England and Wales. Met Office records show that an average of 414mm of rain fell across England and Wales during a three month period - 228mm greater than the average May to July rainfall recorded. Table 4.1[5] confirms the outstanding character of the May to July rainfall in 2007.

Table 4. 2: Highest May-July rainfall totals for England and Wales

Rank	Year	mm	% of 1971 - 2000 average
1	**2007**	**415**	**223**
2	1789	349	187
3	1879	342	184
4	1828	330	177
5	1782	329	177
6	1797	324	174
7	1830	323	173
8	1766	319	171
9	1768	317	170
10	1860	315	169
11	1817	313	168
12	1777	312	167
13	1924	308	165
14	1779	307	165
15	1816	304	163

4 http://www.ceh.ac.uk/data/nrfa/index.html

5 Marsh, T.J. and Hannaford, J. (2007) The summer 2007 floods in England and Wales – a hydrological appraisal. Centre for Ecology and Hydrology

4.5.12 The heavy rainfall was a result of exceptional weather patterns across the UK and was linked to both the strength and location of the jet stream, and unusually high Atlantic Sea temperatures. The jet stream is a ribbon of strong winds that are concentrated in a narrow band in the atmosphere and are formed by temperature differences. At the boundary between cold polar air and warm tropical air weather fronts can develop which can bring heavy rainfall and strong winds. For much of summer 2007, the jet stream was further south and stronger than usual (Figure 4.2), resulting in more rain bearing depressions crossing southern and central parts of the UK, with the higher Atlantic sea temperatures leading to the creation of more rain clouds.

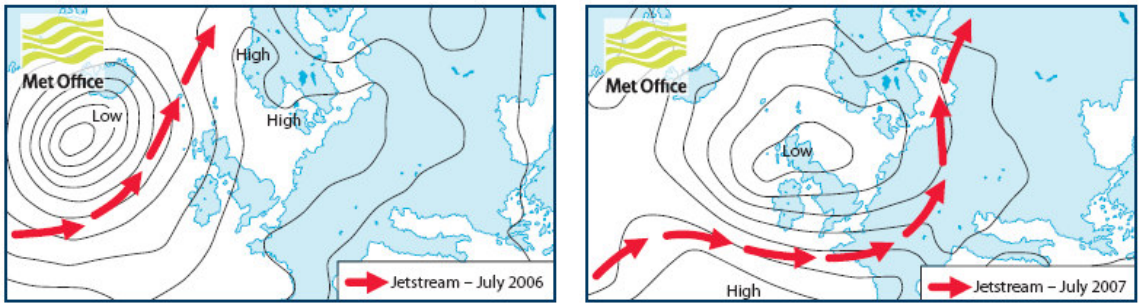


Figure 4. 1: Comparison of the position of the Jet Stream in July 2006 and July 2007 (Met Office 2007)

4.5.13 The first rainfall event occurred between 14th and 15th June, affecting areas in the Midlands, North East and South West. This generally did not result in serious flooding within Gloucestershire but a substantial quantity of rainfall was absorbed by the dry ground and produced waterlogged conditions. Further heavy, persistent and frequent rain fell across Gloucestershire between 24th and 25th June, with approximately one month's rainfall falling in two days. Some flooding from smaller watercourses, which responded quickly to local runoff, was experienced within Gloucestershire, however at this stage there was no significant flooding from the River Severn.

4.5.14 The third rainfall event substantially affected Gloucestershire and occurred on the 20th July, resulting in extensive flooding throughout the lower Severn catchment. This was a result of a slow-moving depression centred over south-east England moving slowly northwards. Embedded convective cells contributed to significant spatial variability but a defining characteristic of the storm was the large area (>30,000 km²) registering exceptional rainfall totals[4]. Gloucestershire was one of the worst affected, receiving 197mm of rainfall during July 2007. This is more than four times greater than the average monthly rainfall recorded since records began in 1766.

4.5.15 The rainfall fell onto already saturated ground resulting in quick, widespread flooding from a variety of sources, not just watercourses. It is important to note that surface water, sewer and groundwater flooding played a considerable role in the summer flood event, adding to the complications. Drains and sewers were overwhelmed by the intense and prolonged rainfall, rapidly causing flooding.

River Flow Data

4.5.16 The exceptional rainfall manifested itself as extremely high river flows. Peak river flows eclipsed previous recorded maxima in some (mostly central England) catchments, runoff patterns were more typical of a wet winter and summer flow regimes were redefined over wide areas.

4.5.17 Record flood flows were recorded in Gloucestershire as a result of the exceptional flows in the Rivers Teme and Avon and the heavy rainfall experienced across Gloucestershire and Worcestershire. River levels at the Gloucester Docks gauge reached a peak of 4.92m on 23rd July. This was only 1cm lower than the highest recorded level in 1947. Across Gloucestershire, sustained high levels in the major rivers hampered the drainage of floodwaters away from afflicted communities, particularly Tewkesbury.

4.6 Fluvial Flood Risk in Stroud District

4.6.1 Flood Zones show the areas potentially at risk of flooding from rivers, ignoring the presence of defences (although areas benefiting from formal defences are identified). This information has been used, in conjunction with other data, to give an account of flood risk in study area. This has focused primarily on the Main Rivers including the River Severn, Dimore Brook, River Frome, the Little Avon, Doverte Brook, River Cam and Wickster's Brook. In some places, small ditches and streams exist without Flood Zones. It is clear that many of these watercourses, though small, do pose local flood risk issues. The assessment of flood risk has also been enhanced using information from Flood Mapping Study Reports, the Severn Tidal Tributaries CFMP, the Tidal Severn Flood Risk Management Strategy and valuable local knowledge obtained from the Council.

4.6.2 Flood Zone maps exist for the main river catchments within the District and have been presented in Volume 2, Tiles B1 – B29. An initial assessment of the Flood Zone maps indicates that of the 49,951 properties within the District, 1,876 are located within Flood Zone 3 and 2,437 within Flood Zone 2 (Table 4.3).

Table 4. 3: Properties within Flood Zone maps within the Stroud District

Location	No. Properties	Percentage of Properties Located within Flood Zone (%)
Whole District	49,951	-
Flood Zone 3	1,876	3.8
Flood Zone 2	2,437	4.9

4.6.3 Within the Lower Severn Valley, flooding can occur from a combination of both tidal and fluvial processes. Many of the Main Rivers within the District discharge into the River Severn estuary and as such can be affected to some extent by the tide. Sea water from the Severn estuary is prevented from entering the tributaries by tidal flaps and a series of embankments along the River Severn. These control structures allow water to discharge into the estuary freely at low tide but prevent sea water from entering the tributary at high tide. This can lead to an increase in flooding on the tributaries when high river flows in the watercourses coincide with high tides in the estuary, preventing flood water from discharging into River Severn, thus backing up along the watercourse and overtopping river channels and embankments. This is referred to as 'tide locking.' Mechanisms of tidal flooding are investigated further within Section 4.7.

4.6.4 Towards the western extent of the District, Flood Zone maps for the River Severn form the boundary with the District of the Forest of Dean to the west and Tewkesbury Borough to the north. Flood risk from the River Severn can occur from a combination of both fluvial flooding and tidal flooding from the sea. Gloucester is the limit of fluvial dominance on the River Severn with the Llanthony and Maisemore weirs generally identified as marking the boundary between fluvial and tidal interaction.

4.6.5 Flood Zone maps for the River Severn extend across predominantly rural floodplain, with a number of farms and properties located within Flood Zones 2 and 3 at locations including: Longney, Epney, Upper Framilode, Saul, Arlingham, Frampton on Severn, Purton, Sharpness and Berkeley Technology Centre. Throughout the District, the Flood Zone maps for the River Severn are wide, reflecting the flat, broad nature of the Severn valley. A number of flood storage cells exist in the lower reaches of the River Severn which act as storage areas for flood water (Section 6.8).

4.6.6 The River Frome and the Little Avon River catchments have significant fluvial and tidal flood risk issues associated with them. The River Frome flows in a predominantly north westerly direction through the District, joining the River Severn on its left bank at Upper Framilode. The upper reaches of the catchment are steep and well defined and for this reason, Flood Zone maps extent only short distances onto the floodplain and do not increase significantly with increasing flows. Downstream of Stroud, the river widens as it approaches the flat rural topography of the River Severn, and Flood Zones 2 and 3 extend significant distances onto the floodplain. The watercourse itself has been highly modified and realigned to locations upland of the valley floor. As such, floodwaters follow the natural valley floor, which can be some distance from the location of the current channel. It should also be noted that there are complex interactions between the watercourse and the adjacent Stroudwater and Thames and Severn canals.

4.6.7 Flood Zone maps for the River Frome indicate that the main areas at risk from fluvial flooding within the District are Chalford, Brimscombe (mainly industrial properties at risk), Dudbridge, Nailsworth, Stroud and Stonehouse. River flooding has been recorded at these locations, however, there is a lack of good quality information on high flows making it difficult to predict the potential effect heavier rainfall or larger magnitude flooding could have[6]. Anecdotal evidence suggests that flooding occurs in Stroud, Chalford and Nailsworth when debris blocks historic structures and bypass channels during high river flows, which is exacerbated as it is difficult to get access to these structures to remove debris. Localised surface water flooding caused by small mesh trash screens becoming blocked has been recorded throughout the catchment, particularly during autumn due to fallen leaves. The effects of tide locking are also evident along the Frome. Under normal river flow conditions, water is drawn from the River Frome into the Gloucester to Sharpness canal. This outtake is closed during flood conditions to prevent sediment building up in the canal and water drawn from the canal for domestic supply becoming contaminated. The tidal flap at the mouth of the River Frome at Upper Framilode is closed for 1.5 hours during high tide, causing tide locking and water levels to back up around Saul. A flood alleviation scheme was built in the mid 1990s in Upper Framilode that took account of tide locking and defences along the Frome were raised in Framilode[6].

4.6.8 Nailsworth Stream forms a left bank tributary of the River Frome, flowing in a north-westerly direction through the District. Flood Zone maps exist for the extent of the watercourse and are relatively narrow due to the steeper, more confining topography of the catchment. In the upper reaches of the

6 Environment Agency (January 2007), Severn Tidal Tributaries CFMP

watercourse the Flood Zone maps extend only a short distance onto predominantly rural floodplain, however, as the watercourse approaches Nailsworth a number of properties are shown to be located within Flood Zones 2 and 3. Further locations shown to be at risk of flooding from the Nailsworth Stream include industrial and residential properties at Theescombe, Woodchester and Dudbridge. Assessment of the Flood Zone maps indicates that they are significantly misaligned at a number of locations with a number of culverted sections also evident through Nailsworth.

4.6.9 The Little River Avon forms part of the western boundary of the District with the Unitary Authority of South Gloucestershire. In the upstream reaches of the watercourse Flood Zone maps are relatively narrow extending onto mainly rural floodplain. Downstream of Charfield Green the watercourse exits the District before rejoining at Damery and once again forming the District boundary. Here the Flood Zone maps extend slightly further onto rural floodplain, with only a few isolated properties located within Flood Zones 2 and 3, before the Little River Avon becomes known as the Berkeley Pill.

4.6.10 Berkeley Pill forms the outfall for the Little River Avon and flows into the Severn estuary just upstream of Berkeley Power Station. A combination of high tides and high river flows has caused flooding in Berkeley and on agricultural land to the south of the town. The village of Berkeley itself lies on higher ground and few properties are shown to be at risk from flooding, however, there is a risk of flooding from tide-locking of the Little Avon, Doverte Brook and the Lynch Brook. It is thought that tide locking causes river flows to back up as far as Charfield, flooding agricultural land and some properties around Woodford. A series of earth embankments are located along the river bank and around Berkeley Pill which protect agricultural land from flooding up to the 10% AEP (1 in 10 year) event. Further earth embankments run from the Pill outfall to Severn House Farm and beyond which are thought to protect agricultural land and isolated farms from flooding up to a 0.5% AEP (1 in 200 year) event. A sewage works near Saniger Pill is also shown to be at risk from flooding. A nuclear power station exists at Berkeley which is shown to be at risk from flooding. It is thought that this is currently being decommissioned.

4.6.11 Flood Zone maps exist for a small unnamed watercourse which joins the right bank tributary of the Little Avon River at ST 7495 9198. A number of properties are located within Flood Zones 2 and 3 between Coombe and Wotton-under-Edge, however, the Flood Zone maps are misaligned at various locations (Section 4.8).

4.6.12 The Dimore Brook forms part of the north-eastern boundary of the District with Gloucester City Council. Flood Zone maps exist for a small stretch of the watercourse with a number of properties shown to be at risk from flooding at Quedgeley. The main flood risk issues along the Dimore Brook occur due to tide locking (Section 4.7) with river flows backing up as far as RAF Quedgeley. Localised flooding can also occur as a result of sediment building up in the channel and as a result of sediment blocking the siphon (and associated trash screen) under the canal near the A430, with flood flows known to back up beyond Quedgeley[7].

4.6.13 Flood Zone maps exist for the River Cam and are generally narrow in the upper reaches reflecting the steep topography at the headwaters of this watercourse. Flood risk appears to be confined to small localised areas through Dursley and Upper Cam. Significant development is known to have occurred along the River Cam in recent years including the redevelopment of a former industrial site into a

7 Environment Agency (1996), Tidal Severn Flood Risk Management Strategy

residential and business site (Lister Petter site). Here, the watercourse has been de culverted and converted to open channel. Flood Zone 3 at this location has been produced as part of a Flood Risk Mapping Study of the watercourse, however, consultation with the Environment Agency has indicated that the existing Environment Agency JFLOW flood outlines have been used for Flood Zone 2. It is evident that the maps depicting Flood Zone 2 are misaligned from the watercourse through the site and do not appear to follow the alignment of the new open channel. Should the Flood Zone maps be updated in the future these should be incorporated into the SFRA.

4.6.14 As the River Cam flows in a north westerly direction through the District it is joined by the Wickster's Brook on the right bank just upstream of its confluence with the Gloucester and Sharpness Canal. Flood Zone maps in the lower reaches of both the River Cam and Wickster's Brook widen significantly, extending large distances onto predominantly low lying rural floodplain. Steep embankments line both the left banks of the River Cam and Wickster's Brook in their lower reaches. These embankments elevate the river levels above that of the surrounding land. A flood storage area was constructed in the 1970s, designed to store flood water on the land in-between the River Cam and Wickster's Brook to protect the Gloucester and Sharpness Canal. The lower catchment is flat and there are numerous drainage ditches containing water, but due to the flat topography are largely stagnant, with the embankments preventing interaction with the river in this area under normal flow conditions. Discussions with the IDB have revealed that the only locations of known interaction between the river and drainage ditches are: a ditch near Newhouse farm which drains into the River Cam (SO 7464 0413) and sluices on the Wickster's Brook which allow flow both into and out of the Wickster's Brook (SO 7482 0489 and SO 7509 0497). In flood conditions there is one siphon within the study area that is controlled by hydraulic head and operates to drain flood water under the canal. Flood risk on the Wickster's Brook is restricted to rural floodplain with no properties are shown to lie within Flood Zones 2 and 3.

4.6.15 Under normal flow conditions the River Cam flows directly into the Gloucester to Sharpness canal. Excess water during high flows on the River Cam is managed using off-line storage ponds at Cambridge. Anecdotal evidence suggests that localised flooding has occurred at Charfield, Kingswood, Woodford and Dursley due to blockages and constrictions of small capacity watercourses (millraces and restricted channels) combined with excess surface water.

4.7 Tidal Flood risk within the Stroud District

4.7.1 The River Severn Estuary forms the boundary of the Stroud District with the Forest of Dean to the west and Tewkesbury Borough to the north. The main areas shown to be at risk from tidal flooding within the Stroud District include: Elmore Back, Epney, Upper Framilode, Saul, Priding, Arlingham, Frampton on Severn and Berkeley.

4.7.2 Flooding along the Severn Estuary can be caused by a combination of factors including high tides, tidal surges and waves overtopping defences. The funnel-shape of the Severn Estuary encourages tidal waters to propagate up the estuary, resulting in flooding to undefended areas at inland locations. Tidal flooding can affect areas on the River Severn as far up the Severn estuary as Gloucester and occasionally beyond as far as Tewkesbury. In general however, the weirs at Gloucester (Lanthony Weir on the East Channel, SO 8219 1820; and Maisemore Weir on the West Channel, SO 8183 2165) are considered to represent the boundary between the tidal and fluvial flows, and higher up the channel towards Gloucester the influence of fluvial flows becomes increasingly dominant in flooding.

The channel also becomes narrower providing a constriction to high tides moving upstream and river flows moving downstream.

4.7.3 Within the Severn Estuary, tide levels can increase by up to 2 metres during tidal surges. Tidal surges can occur when atmospheric pressure changes. When atmospheric pressure is low, a positive surge can occur, resulting in increased water levels. Low pressure weather systems are characterised by wet and windy weather, which can result in further increases in water levels. Particularly severe flooding can occur if a surge coincides with the peak of a high tide. Wave action can also have a significant effect on the overtopping of defences and flooding. Sea defence walls are designed to accommodate a degree of wave overtopping.

4.7.4 Flooding also occurs on a number of tributaries which feed into the River Severn and Estuary. The River Frome, together with a number of other watercourses and drainage systems along the estuary, have flapped outfall structures to prevent tidal inundation. Flooding can occur in these watercourses when outfalls are tide-locked (i.e. water levels in the estuary are high, preventing river flood flows progressing any further down the channel) leading to fluvial flows backing up and overtopping banks.

4.7.5 Flooding in the upstream sections of the Severn Estuary may be worsened by development on the floodplain. This can reduce the amount of floodplain storage and obstruct flow across the floodplain, which may result in additional flooding problems elsewhere. Studies undertaken as part of the Tidal Severn Flood Risk Management Strategy identified a number of strategically important flood storage areas within the floodplain of the River Severn (Section 6.8). These areas have been mapped and can be seen in Volume 2, Tiles A1-A6. Further demands for new development on the floodplain will inevitably occur, however, these should be carefully controlled, particularly as water levels are expected to rise due to the effects of climate change.

4.8 Issues With Existing Flood Maps

4.8.1 During the review of the existing flood map information, some inaccuracies were identified and these are detailed in Table 4.3. It should be noted that most of the Flood Zone information in the study area has been derived from the modelling package JFLOW, which is national broadscale model and as such has known limitations. The accuracy of the Flood Zones in some areas is poor, likely to be due to the upland fluvial setting and complex nature of drainage. The Flood Zones can be misaligned from the channel or follow a path which does not have a watercourse. The JFLOW flood extents also do not show the impact of flood defence structures or culverts.

4.8.2 When viewing the Flood Zone data with OS Tiles these inaccuracies are clear, and whilst the best available information has been used in the SFRA, appropriate judgement should be exercised when applying the Sequential Test. In the future, updates to the Flood Zone maps may be undertaken as part of the Environment Agency's ongoing Flood Map improvements. Updates to the Flood Zone maps should therefore be incorporated into the SFRA when they become available. It may be prudent for a suitably qualified flood risk management specialist to review and assess preliminary site allocations, to advise on local Flood map issues and areas where further investigation may be required (such as a Level 2 SFRA).

Table 4.4: Inaccuracies with Flood Maps within the Stroud District

Watercourse	Location	Problem
River Cam	Dursley	Through the Lister Petter development site Flood Zone 2 is misaligned from the new watercourse alignment through the development site. Should updated Flood Zone maps be produced upon completion of the construction work at this location the SFRA should be updated to incorporate this information
Nailsworth Stream	Dale Brook	Misalignments throughout extent of watercourse and adjoining tributaries including the Miry Brook. Culverted sections through Nailsworth, Theescombe & Dudbridge
Little Avon River	Wickwar, Michael Wood, Woodford	Misalignments along parts of the watercourse
Doverte Brook	Various	Flood Zone maps misaligned at a number of locations as watercourse flows through the District
Unnamed Tributary of Little Avon River	Coombe to confluence with Little Avon River	Misalignments and some culverted sections
Wash Brook	Various	JFlow generated Flood Zone maps with a number of misalignments
Painswick Stream	Painswick, Painswick Valley	Misalignments at a number of locations through Painswick and Painswick Valley

4.9 Flooding from Other Sources

4.9.1 Methodologies for recording flooding from sources other than fluvial or tidal were not standardised until 2006. Therefore records held of such flooding can be incomplete, or not to a uniform standard. Records of flooding from other sources also tend to show locations that have flooded in the past, rather than give an indication of flood risk areas based on probabilities, like the Flood Zone maps.

4.9.2 Information has been gathered on flooding experienced from sources other than rivers, and is described in this section.

4.10 Flooding from Artificial Drainage Systems (Sewers)

4.10.1 Sewer flooding occurs when urban drainage networks become overwhelmed and maximum capacity is reached. This can occur if there is a blockage in the network causing water to back up behind it or if the sheer volume of water draining into the system is too great to be handled.

4.10.2 Higher flows are likely to occur during periods of prolonged rainfall, common to the autumn and winter months. This is also when the capacity of the sewer systems is most likely to be reached. During periods of low flow, for example summer months, sewers become susceptible to blockage as the low flows are unable to transport solids. This leads to deposition and gradual build up of solid debris.

4.10.3 Two water companies cover the Stroud District: Severn Trent Water (STW) and Wessex Water. These companies have been consulted for information on flooding from surface water and artificial drainage sources and this has been provided where data exists.

4.10.4 All Water Companies have a statutory obligation to maintain a register of properties/areas which are at risk of flooding from the public sewerage system, and this is shown on the DG5 Flood Register. This includes records of flooding incidents from foul sewers, combined sewers and surface water sewers which are deemed to be public and therefore maintained by the Water Company. Flooding from land drainage, highway drainage, rivers/watercourses and private sewers is not recorded within the register.

4.10.5 The DG5 register tends to show, to a greater or lesser extent: the location of the incident, the date of the incident, a description of the incident, whether the incident occurred internally or externally and the register the incident has been recorded on. When an incident is reported, a decision chart is used to assess whether the properties/areas are 'at risk' and then the record is added to the appropriate register.

4.10.6 The recording of flood events by the authorities has often led to improvements intended to prevent reoccurrence, so historical flooding is not necessarily evidence of propensity for future flooding.

4.10.7 The DG5 data received from STW and Wessex Water has been provided at four-digit postcode level, hence no street level information on flooding was available. In summary it is evident that 21 postcode areas within the Stroud District are identified as having properties at risk of flooding from artificial drainage systems and surface water runoff. It is not possible to identify the exact location of the properties at risk within the postcode polygons and therefore caution should therefore be taken when interpreting this information, as it is at a course resolution. In general the level of flood risk from artificial drainage systems within the District is medium to low with the highest level of risk within postcode areas GL10 3, GL11 5, GL5 2, GL5 3, and GL5 4. The data for the District is illustrated in Volume 2, Tile B22.

Table 4.5: Flooding From Sewers as Recorded in the Severn Trent Water and Wessex Water DG5 Register

Postcode Area	No. Properties Affected	Level of Risk
GL10 3	12*	Medium
GL11 4	1	Low
GL11 5	15*	Medium
GL11 6	2*	Low
GL13 9	1*	Low
GL15 4	5*	Low
GL2 4	6*	Medium
GL2 7	6*	Medium
GL3 4	3*	Low
GL4 0	8*	Medium
GL4 5	1*	Low
GL4 6	9*	Medium
GL5 1	2	Low
GL5 2	11	Medium
GL5 3	10	Medium
GL5 4	11	Medium
GL5 5	1	Low
GL53 9	5*	Low
GL6 6	5	Low
GL6 7	1*	Low
GL6 8	1*	Low

∗ These numbers include properties within this postcode area which fall outside the Council Boundary

4.10.8 STW has stressed that Local Planning Authorities should adopt a planning policy requiring the use of SUDS as proposed in PPS25 and that the Sequential Test should be used to allocate land for development within low risk Flood Zones, so that the risk of fluvial flooding is minimised. This reduces the risk of fluvial flood waters entering public foul and surface water sewers and resultant widespread flooding and pollution. Individual developments should be designed so that natural flood pathways are left free of buildings. These recommendations are put forward as policy considerations, in Chapter 7. Guidance on the application of SUDS can be found in Chapter 10.

Flooding from Surface Water

4.10.9 Surface water flooding occurs when excess water runs off across the surface of the land and is usually the product of short duration but intense storms. This type of flooding usually occurs because

the ground is unable to absorb the high volume of water that falls on it in a short period of time, or because the amount of water arriving on a particular area is greater than the capacity of the drainage facilities that take it away. Surface water flooding can also occur from wet antecedent conditions. Where discharge is directly to a watercourse, locally high water levels can cause back-up and prevent drainage taking place. In each instance the water remains on the surface and flows along the easiest flow path towards a low spot in the landscape. The impermeability of concrete and tarmac is often responsible for reduced infiltration and resultant high runoff. Roads often make for easy flow paths, leading to situations where roads become impassable.

4.10.10 Surface water flooding is often short lived and localised. Several instances may result from a single storm throughout the catchment. Often there is limited notice as to the possibility of this type of flooding. This, combined with the high velocities achievable when water is flowing along a contained smooth surface such as a road, can cause surface water flooding to be devastating in nature. Suspended material can be carried into drains by overland flows or floodwaters and this can also lead to them becoming blocked, exacerbating the problem.

4.10.11 There is currently no dataset depicting predicted surface water flood risk areas, and time restraints have precluded surface water flood risk mapping for Gloucestershire as part of the SFRA. Through the duration of the Level 1 study, surface water modelling has come to the fore and methodologies are rapidly being developed. The Pitt Review notes that the Environment Agency is assessing the feasibility of developing a rapid, national topographic screening technique to show areas which are susceptible to surface water flooding from heavy rainfall, which could be used to inform future updates of the SFRA. In the interim, data on surface water flooding hotspots included in the SFRA (Volume 2, B Tiles) will be of use to local emergency responders and for planning purposes. It should be noted, however, that through the duration of the study the Environment Agency has firmed its requirement for surface water modelling as part of SFRAs, and has requested that surface water modelling is carried out as part of a Level 2 SFRA.

4.10.12 The Highways Agency and the County Council provided extensive databases of surface water flooding locations and these have been mapped as GIS points in Volume 2, Tiles B1-B29. The area around Stroud is particularly affected by surface water flooding due to the combination of steep catchments, combined urban drainage networks, older style properties and an abundance of woodland debris which blocks the urban drainage network[6].

4.10.13 The geology and topography of the District contribute to the rainfall response within the District and therefore the likelihood and nature of surface water flooding (see Section 1.8). In addition, areas with an abundance of impervious surfaces means these areas are also at risk of surface water flooding, especially when local intense rainstorms occur. Locations around Stroud are known to be affected by surface water flooding due to the combination of steep catchments, combined urban drainage networks, older style properties and an abundance of woodland debris which blocks the urban drainage network. In addition, incidents of surface water flooding have occurred throughout the River Frome catchment mainly due to the steep topography. All FRAs for proposed developments should assess this form of flood risk and the effect of the proposed development on existing surface water runoff rates.

4.10.14 A change in the way surface water is managed is required to alleviate the risk of flooding from this source. Management of surface water through the overland system is generally considered more effective than relying solely on the capacity of underground systems. Slowing down the water and

storing it before it reaches the piped system can greatly reduce the potential impact of surface water flooding. In less extreme circumstances than summer 2007, this approach should be able to prevent flooding. This approach is set out in the Government's new Water Strategy, Future Water[8]. It states that by 2030 surface water will be managed more sustainably by allowing for the increased capture and reuse of water, slow absorption through the ground, and more above-ground storage and routing of surface water separate from the foul sewer, where appropriate. There will be less reliance on the upgrading of the sewer system to higher design standards and rather that water will be increasingly managed on the surface.

4.10.15 The Pitt Review recommends the production of Local Authority Surface Water Management Plans (SWMPs), a first step in realising the sustainable management of surface water. SWMPs should focus on risk management and optimising the provision of sustainable surface water drainage infrastructure (i.e. SUDS). They should also take account of the risks of surface water and sewer flooding and how these might affect an area in combination with flooding from rivers and (where relevant) canals, reservoirs, the sea or groundwater. SWMP guidance may be developed as a supplementary planning document within the LDF to address flooding and water management issues. Further details on SWMPs can be found in paragraph 4.23 of the PPS25 Practice Guide (2008), which became available during the course of this study.

4.10.16 It is recommended that the Council considers the production of a SWMP for the District.

4.11 Flooding from Impounded Water Bodies

4.11.1 As part of the SFRA it is necessary to consider the risk of overtopping or breach of reservoirs and canals. British Waterways (BW) was consulted to gain information on past reservoir breach and overtopping incidents of canals, while the Environment Agency was consulted to gain a comprehensive overview of reservoirs currently held under the Reservoirs Act, and any breach and overtopping information of these reservoirs. Where reservoirs and canals impound water above the natural ground level, there may be a risk of failure of the embankment resulting in rapid inundation of the surrounding area.

Canals

4.11.2 It is important that canals are included in an SFRA as canals can form a vital land drainage function. Occasionally, canals can overtop due to high inflows from natural catchments and if overtopping occurs from adjacent water courses. This additional water can be routed/conveyed by the canal which may cause issues elsewhere, not only within the catchment of interest but also in neighbouring catchments where the canal might cross a catchment boundary.

4.11.3 There are three canals in the District: Stroudwater Navigation Canal, Thames and Severn Canal and the Gloucester and Sharpness Canal.

4.11.4 The Gloucester and Sharpness Canal is located in the north western extent of the District. Consultation with British Waterways (BW) indicated that there is one recorded incident of breach/overtopping associated with this canal. This occurred in June 1990 at Parkend (SO 7746 1055) as a result of culvert collapse (Saul Junction). The Gloucester and Sharpness Canal acts a line of defence but is not under the Environment Agency's responsibility to operate or maintain. Any

8 Defra – Water Strategy, Future Water (2008)

failure of the canal could potentially cause or exacerbate flooding problems within the District. Water from watercourses within the Stroud District and Gloucester City Council area is pumped into the Gloucester and Sharpness canal to manage water levels. This could be seen as a flood defence role. The River Cam also joins the Gloucester and Sharpness Canal at SO 7389 0509. A series of flood defences were constructed along the River Cam and Wickster's Brook to protect the Gloucester and Sharpness Canal from flood waters within these watercourses. In addition, consultation with the Environment Agency has indicated that flooding has occurred at Hope Mills and at Chalford due to canal overtopping.

4.11.5 The Stroudwater Canal runs parallel to the River Frome for much of its length. Upstream of Thrupp, the canal is known as the Thames and Severn Canal. The canal has formed a historic link between the River Severn, the Gloucester and Sharpness Canal and the River Thames (via a tunnel at Sapperton). Complex interactions exist between the canal and the River Frome for much of its length, which must be considered when assessing flood risk at individual sites. There are large-scale plans to reinstate the River Frome canal in the next few years. The impact of any proposals to reinstate the canal must be considered in relation to future development within the District[9].

4.11.6 Consultation with BW has indicated that there are a number of raised sections of canals within the Stroud District. There is a residual risk of breach or overtopping from these canals and therefore, residual risk areas have been mapped and can be viewed in Volume 2, Tiles A1-A6. Development should be avoided within these residual risk locations.

4.11.7 At present canals do not have a level of service for flood recurrence (i.e. there is no requirement for canals to be used in flood mitigation). It is important, however, that any development proposed adjacent to a canal be investigated on an individual basis regarding flooding issues and should be considered as part of any FRA.

Reservoirs

4.11.8 Many reservoirs in the UK lie immediately upstream of, or adjacent to, heavily populated areas. The rapid, uncontrolled discharge of water from such reservoirs could have catastrophic consequences on life and property (though the risk of this occurrence is very low). Reservoirs with an impounded volume in excess of 25,000 cubic metres (measured above natural ground level) are governed by the Reservoirs Act 1975 and are listed on a register held by the Environment Agency. The reservoir register for Stroud District Council is detailed in Table 4.6.

9 Capita Symonds (November 2006), Strategic Flood Risk Assessment of the River Frome, Gloucestershire, Volume 1, Baseline SFRA Summary Document

Table 4.6: Reservoir Register for Stroud District Council

Reservoir	Physical Status	Situation	NGR	Category	Year Built	Dam Type	Maximum Height	Capacity	Surface Area (m^2)
Parkmill Pond, Woodchester	In Operation	Near Nailsworth	SO 83000 00900	Impounding	1782	Gravity and Earthfill	16	125000	31000
Kennel Pond, Woodchester	In Operation	Near Nailsworth	SO 82600 01100	Impounding	1782	Gravity and Earthfill	6	50000	21000
Middle Pond, Woodchester	In Operation	Near Nailsworth	SO 82100 01300	Impounding	1850	Gravity and Earthfill	11	135000	39000
Purton No 1	In Operation	Near Bristol	SO 69500 04100	Non-impounding	1972	Gravity and Earthfill	4.3	55000	12000
Purton No 2	In Operation	Near Bristol	SO 69500 04100	Non-impounding	1972	Gravity and Earthfill	4.3	55000	12000
Cam and Wicksters Brook FSA	In Operation	Near Slimbridge	SO 75000 04500	Non-impounding	1982	Unknown	1	140000	53000

4.11.9 Due to high standards of inspection and maintenance required by legislation, normally flood risk from registered reservoirs is moderately low. Whilst the reservoir register, and indeed the SFRA, has identified impounded water bodies with a storage volume greater the 25,000m^3, it should be stressed that a number of smaller impounded water bodies are located within the District, all of which pose a flood risk. Therefore development immediately downstream of any reservoir or impounded water body (not just those contained within the reservoirs database) should be discouraged and will be subject to a Level 2 SFRA if the development is deemed necessary.

4.11.10 Consultation with the Environment Agency has indicated that there are no records of breaching/overtopping within the Stroud District area. Reporting of dam incidents to the Environment Agency is a voluntary process and the system has only been in place since 2007. Prior to that reports of incidents were collected on an ad hoc basis by the Building Research Establishment, from published papers and questionnaires. Due to the voluntary nature of incident reporting the records held by the Environment Agency are not complete and the incidents provided only represent those overtopping incidents or breaches that the Environment Agency have been informed of. It should be noted that when referring to 'overtopping' the records held by the Environment Agency are referring to the overtopping of an embankment and are not referring to water flowing down a reservoir spillway. A spillway operating in the way that it was designed is not a reportable reservoir incident under the post-incident reporting system.

4.11.11 Defra's 'Making Space for Water' project 'Flooding from Other Sources HA4a' refers to the need for flood risk mapping for all sources of flooding. The study concluded that flood risk mapping is feasible for many sources of flooding that are not currently covered by the Environment Agency Flood Map, using existing flow modelling and GIS tools. However, there are significant constraints in terms of the need to undertake extensive data collection to ensure the production of flood maps that will be useful and are not dominated by modelling uncertainties. The outcome of the HA4a project is to produce a report on the feasibility of mapping possible flooding from other sources; it will not produce the actual

maps that show these risks. The intention is that these requirements can be built into the Environment Agency's next Flood Mapping Strategy 2008-13. The project is also considering means of making this information available to interested parties, both internal and external.

Recommendations put forward by the Pitt Review further highlight the need for inundation maps of reservoir breaches which provide a spatial indication of flood risk from impounded water bodies. Guidance put forward by Defra in their Research and Development Technical Report FD2320/TR2 FRA Guidance for New Development refers to the CIRIA Report C542 Risk Management for UK Reservoirs. The report was prepared following extensive consultation with the UK reservoir community and is aimed chiefly at reservoir owners, engineers, regulators, insurers and safety personnel concerned with reservoirs in the UK. The document provides an examination of past reservoir failure and provides an assessment procedure to determine potential floodwater levels and their impact following a failure. As noted by the Pitt Review, once inundation maps of reservoir breaches have been produced by reservoir undertakers, the Council should incorporate this information into the Community Risk Register and emergency planning procedures and indeed the SFRA. The Defra document FD2321/TR2[10] also provides further guidance on the mapping of reservoir flood plans.

4.12 Flooding from Groundwater

4.12.1 Groundwater flooding is most likely to occur in low-lying areas underlain by permeable rocks (aquifers). These may be extensive regional aquifers (e.g. Chalk or Sandstone) or localised sands or river gravels in valley bottoms underlain by less permeable rocks. Groundwater flooding occurs as a result of water rising from the underlying rocks or from water flowing from abnormal springs. This tends to occur after long periods of sustained high rainfall. Higher rainfall means more water will infiltrate into the ground and cause the water table to rise above normal levels. Groundwater tends to flow from areas where the ground level is high, to areas where the ground level is low. In low-lying areas the water table is usually at shallower depths anyway, so during very wet periods, all the additional groundwater flowing towards these areas can cause the water table to rise to the surface causing groundwater flooding.

4.12.2 Different geological aquifers can react in different ways to high rainfall intensity events. For example, limestone aquifers can readily transmit groundwater as they are fractured in nature and thus may exacerbate flooding issues in watercourses when combined with other hydrological factors. In comparison, the effects and impacts of groundwater flooding in sandstone aquifers can take long periods of time to dissipate due to the high storage potential of the aquifer. Groundwater flooding differs from fluvial flooding and surface water flooding in that it may take weeks or months to dissipate, because groundwater flow is very slow and water levels take much longer to fall, therefore groundwater flooding effects can still be evident a long time river levels have subsided.

4.12.3 In recent times the decline in industry has led to an increase in groundwater levels due to a reduction of abstraction, though there is no record of this problem in the study area.

4.12.4 In comparison to fluvial and tidal flooding, the understanding of the risks posed by groundwater flooding is limited and mapping of areas susceptible to groundwater flooding is in its infancy. There is

10 Defra/Environment Agency Flood and Coastal Defence R&D Programme; R&D Outputs: Flood Risk To People, Phase 2, FD2321/TR2 Guidance Document, March 2006

currently no one organisation with responsibility to respond to groundwater flooding, therefore the risks and mechanisms of groundwater flooding are poorly reported. Groundwater level monitoring records are available for areas on Major Aquifers, however, at lower lying valley areas, which can be susceptible to groundwater flooding such as mudstones, clays and superficial alluvial deposits, very few records are available. This gap is currently being addressed as part of Defra's Making Space for Water (MSfW) consultation on Groundwater flooding records collation, monitoring and risk assessment (Reference HA5). The need for a national co-ordination of groundwater flooding risk management within the overall flood and coastal erosion risk management framework has been recognised, and Reference Document HA5 has put forward recommendations for the effective monitoring and collation of groundwater flooding information along with further recommendations for organisational and funding changes to implement this and direction for the strategic overview role of the Environment Agency.

Historical Groundwater Flooding

4.12.5 The most widespread and recent incident of groundwater flooding throughout the UK occurred during the winter of 2000/2001 (with some further locations affected during 2002/2003) and followed a period of exceptionally heavy rainfall. During an eight month period from September 2000, rainfall in England and Wales was 166% of the long term average with the highest rainfall coinciding with areas of Chalk outcrop. Summer groundwater flooding is relatively rare as dry soil conditions normally preclude widespread aquifer recharge during the summer months (exceptions include 1879, 1912 and 2007).

4.12.6 Following the widespread floods of winter 2000/2001 Defra commissioned a study investigating the occurrence of groundwater flooding throughout England. Provisional maps of areas vulnerable to groundwater emergence from consolidated aquifers (Groundwater Emergence Maps, GEMs) were produced to asses the geographical extent and severity of the groundwater flooding in 2000/01[11]. Analysis of the GEMs indicated that the problem of groundwater flooding within England is largely confined to Chalk aquifers, particularly in the southeast of England[12].

Groundwater Flooding within Stroud District

4.12.7 As discussed, records of groundwater flooding are generally limited and methods of mapping areas susceptible to groundwater flooding are in their infancy. Consultation with the Environment Agency has indicated the GEMs do not cover the Stroud District and there are no recorded incidents of groundwater flooding within the Council area. However, consultation with the District Council has indicated that there are known groundwater issues within the District but these are not very well known.

11 Morris, S.E, Cobby, D and Parkes A (2007) Towards Groundwater Flood Risk Mapping, Quarterly Journal of Geology and Hydrogeology

12 Jacobs (2004), Strategy for Flood and Erosion Risk Management: Groundwater Flooding Scoping Study (LDS 23). Jacobs, Reading

4.12.8 In conclusion, areas at risk from groundwater flooding are largely unknown. Although data collected for the SFRA has not uncovered specific areas potentially at risk, the assessment undertaken as part of this SFRA is not exhaustive and the risk of flooding from groundwater flooding must be considered as part of any further FRA.

4.13 Key Recommendations: Chapter Four

- In the Pitt Review, attention should be drawn to recommendations 14, 15, 16, 17 and 19, which address the role of the Local Authority with regards to flood risk management. It recommends that the Local Authority takes a lead role in the management of flood risk with the support of the relevant organisations.
- All historical events, including summer 2007, are important in obtaining an understanding of the flood risk posed to the District, and should all be considered in the location of new development and as part of any assessment of flood risk.
- The accuracy of the Flood Zones in some areas of the District is poor; they can be misaligned from the channel or follow a path which does not have a watercourse. When viewing the Flood Zone data with OS Tiles these inaccuracies are clear, therefore appropriate judgement should be exercised when applying the Sequential Test. It may be prudent for a suitably qualified flood risk management specialist to review and assess preliminary site allocations, to advise on local Flood map issues and areas where further investigation may be required (such as a Level 2 SFRA).
- The Environment Agency will require further surface water investigation and mapping to be carried out as part of a Level 2 SFRA.
- There should be less reliance on the upgrading of the sewer system to higher design standards to accommodate new developments; rather, water should be managed on the surface through the appropriate application of SUDS.
- The Council should produce a Surface Water Management Plan, in line with Pitt Review recommendations, which should provide the basis for managing all local flood risk.
- New development adjacent to raised sections of canals will require breach analysis to be carried out as part of a Level 2 SFRA.
- Whilst the SFRA has identified reservoirs with a storage volume greater the 25,000m^3, there are smaller reservoirs are located within the District which also pose flood risk. Development immediately downstream of any reservoir or impounded water body should be discouraged and will be subject to a Level 2 SFRA if the development is deemed necessary.
- Specific areas susceptible to groundwater flooding within the District are largely unknown. The assessment undertaken as part of this SFRA is not exhaustive and the susceptibility to flooding from groundwater must be considered as part of any further FRA.

5 Strategic Flood Risk Mapping

5.1 Strategic Flood Risk Maps

5.1.1 This chapter provides a clear description of the data that has been used for the purpose of strategic flood risk mapping. These maps, which can be found in Volume 2, Tiles B1-B29, show flood risk from sources including fluvial, surface water, foul and combined sewers, groundwater and impounded water bodies including reservoirs and canals. This information is based on the findings in Chapter 4, which has included an assessment of suitability. The Sequential Test process primarily uses the Flood Zone maps to locate developments in low fluvial flood risk areas. The point of mapping flooding from other sources is to ensure new developments are also located away from areas which have experienced flooding from 'other sources'.

5.1.2 The strategic flood risk information is also presented as GIS layers, and can be interrogated to gain the associated descriptive information. These can be found in the CD attached to this report.

5.1.3 In accordance with the PPS25 Practice Guide (2006), the Level 1 SFRA has used Flood Zone outlines which have been produced using detailed modelling techniques in preference to the Environment Agency's Flood Zone maps, wherever possible. Flood Zone outlines used within the SFRA are undefended and should be used to carry out the Sequential Test. When representing the Flood Zones, Level 1 SFRAs should also show the functional floodplain, Flood Zone 3b, where such outlines exist. If Flood Zone 3b has not been produced as part of a detailed modelling project, similar outlines, such as the 1 in 25 year outline can be used, upon agreement with the Environment Agency. In the absence of such detailed information, the PPS25 Practice Guide (2006) recommends that all areas within Flood Zone 3a should be considered as Flood Zone 3b unless, or until, an appropriate FRA shows to the satisfaction of the Environment Agency that it can be considered as falling within Flood Zone 3a. Therefore, as part of this SFRA, modelled outlines have been used to represent Flood Zone 3b where they exist. Where no modelled outlines exist, Flood Zone 3a has been used to represent Flood Zone 3b.

5.2 Hydraulic (River) Models

5.2.1 River models have been collected and used for the production of the SFRA flood maps. Within the study area, Environment Agency hydraulic models exist for the River Severn (Tidal), River Frome and River Cam and Wickster's Brook. The table overleaf gives details of the modelled Flood Zone outlines and the outlines are presented in Volume 2, Tiles B1-B29. In all cases the approach has been discussed and agreed with the Environment Agency.

5.2.2 For the remainder of watercourses in the study area, the Environment Agency's Flood Zone information has been used and is also presented in Volume 2, Tiles B1-B29. It should be noted that some smaller watercourses do not have Flood Zones produced for them.

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Table 5.1: Environment Agency Hydraulic Models and Modelled Flood Zones within Stroud District

Model	Watercourse	Derived From	Modelled Extents within District		Modelled Flood Zones			Notes
			Upstream	Downstream	3b	3a	2	
River Severn Tidal	River Severn	Environment Agency Strategy & SFRM models	SO 7940 1480	SO 6270 9820		✓	✓	The model extends along the western District boundary with Tewkesbury Borough and Forest of Dean District. Analysis of the existing Flood Zone maps and modelled flood outlines indicated differences. Following consultation with the Environment Agency it was recommended that the existing Flood Zones were used for Flood Zones 3a and 2 as the current planning system is based on the Flood Zone outline
River Cam & Wickster's Brook	River Cam	Environment Agency SFRM	ST 7679 9798	SO 7385 0509	✓	✓		4% AEP (1 in 25 year) outline used for Flood Zone 3b. 1% AEP (1 in 100 year) outline used for Flood Zone 3a. Environment Agency recommended using existing Flood Zones for Flood Zone 2.
	Wickster's Brook	Environment Agency SFRM	SO 7703 0478	SO 7425 0490	✓	✓		As above
River Frome	River Frome	Council Owned	SO 9293 0298	SO 7518 1061	✓	✓	✓	Model produced as part of River Frome SFRA and extends from Whitehall Bridge to the confluence with the River Severn. 4% AEP (1 in 25 year) outline used for Flood Zone 3b. 1% AEP (1 in 100 year) outline used for Flood Zone 3a. 0.1% AEP (1 in 1000 year) outline used for Flood Zone 2.

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5.3 Sewer Flooding

5.3.1 Due to the Data Protection Act, it is not possible to specify the exact locations of past incidents. Instead, data has been received at four-digit postcode level. These postcode polygons outline a series of large geographical areas. Within each postcode area it has been indicated how many incidents have occurred. This information is presented in a separate high-level historical flooding map in Volume 2, Tile B30. This information has also been digitised as a GIS layer.

5.3.2 Sewer flood risk has been classified according to the number of properties flooded from overloaded sewers within each postcode area. The categorisation is as follows:

- Low sewer flood risk: 1 to 5 properties Denoted by a yellow polygon
- Medium sewer flood risk: 6 to 15 properties Denoted by an orange polygon
- High sewer flood risk: >15 properties Denoted by a red polygon

5.3.3 The colour system is designed to indicate that even though a whole postcode area might be shown as at risk, only a few incidents might have been recorded in that area.

5.3.4 Future updates to the DG5 flood register should be fed into future updates of the SFRA. At present, the relatively course resolution of data limits its use for the purpose of spatial planning. In future updates to the SFRA, water companies may provide full location information. In the meantime there is an onus on developers to assess sewer flood risk as fully as possible as part of site-specific FRAs.

5.4 Flooding from Surface Water, Impounded Water Bodies and Groundwater

5.4.1 Flooding from surface water, canals, reservoirs and groundwater has been mapped using the historical data collected in Chapter 4. GIS 'points' have been used to indicate where flooding from these sources has occurred. This is not considered to be exhaustive since the data are based on historical events rather than predictive modelling (and therefore may not represent very rare events) so the full extent of these flooding mechanisms may not have been captured. It is therefore recommended that during future updates to the SFRA, reviews and consultations are undertaken to ensure that any new surface water, canal, reservoir and groundwater flooding locations and issues are fully taken into account.

5.5 Climate Change

5.5.1 In its October 2006 publication of the predicted effects of climate change on the UK[13], Defra described how short duration rainfall could increase by 30% and flows by 20% by the year 2085, and suggested that winters will become generally wetter whilst summers, although drier, will be characterised by more intense rainfall events. Changes in rainfall patterns could result in changes in the intensity, frequency and timescales of rainfall events. Such changes will affect catchment wetness, groundwater flows into rivers and peak flows in watercourses, as well as urban drainage. Changes in sea level could result in tide locking of watercourses draining to the sea and resultant coastal and tidal flooding. Within the District itself, the landform, constrained waterways (Mill impoundments) and underlying geology in Stroud escarpment s and valleys coupled with climate change may have significant implications to flood risk for a number of communities within the Stroud Valleys.

13 Defra, Flood and Coastal Defence Appraisal Guidance, FCDPAG3 Economic Appraisal; Supplementary Note to operating Authorities – Climate Change Impacts; October 2006

5.5.2 Overall, these effects will tend to increase both the size of Flood Zones and the depth of floodwater associated with rivers, and the amount of flooding experienced from 'other sources'. Sites that are currently within Flood Zones 2 and 3 will be subject to more frequent and potentially deeper flooding. PPS25 sets out current guidance for changes to flood risk as a result of climate change, shown in Table 5.2.

Table 5.2: PPS25 Guidance for Changes to Flood Risk as a Result of Climate Change

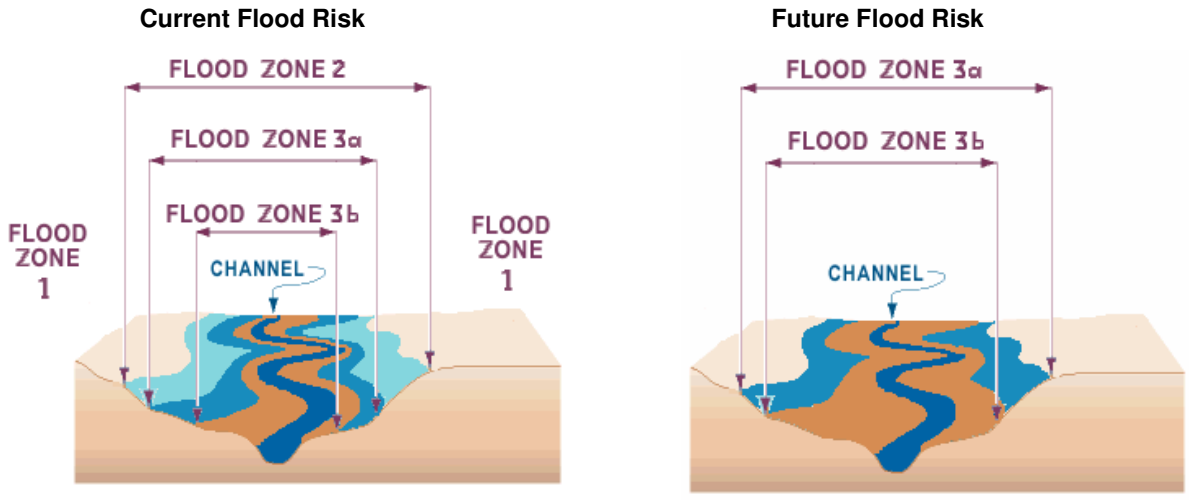
Parameter	1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115
Peak rainfall intensity	+5%	+10%	+20%	+30%
Peak river flow	+10%	+20%		
Offshore wind speed	+5%		+10%	
Extreme wave height	+5%		+10%	

5.6 Methods used to derive the Climate Change maps

5.6.1 Sensitivity testing of the national Flood Zone maps has been carried out by the Environment Agency, using the 20% increase in peak river flows expected between 2025 and 2115. In very flat areas, the extent of inundation becomes bigger, while in well-defined floodplains, the depth of the floodwaters increases. This means that areas currently located in a lower-risk zone (e.g. Flood Zone 2) could, in future, be re-classed as lying within a higher risk zone (e.g. Flood Zone 3). In line with these findings, and to represent fluvial climate change scenarios where no other information exists, the Environment Agency Flood Zone maps have been used to infer climate change scenarios. The current Flood Zones have been 'reassigned' to show the following:

- Over a period of 50 to 100 years areas currently indicated as being within Flood Zone 2 will become Flood Zone 3a
- Over a period of 50 to 100 years areas currently indicated as being within Flood Zone 3a will become Flood Zone 3b

5.6.2 This approach (see below) gives an indication of how Flood Zones and flood probabilities are likely to change over time. The technique adopted is precautionary but one which is suitable to infer possible climate change impacts on fluvial flood risk in the absence of modelled climate change outlines.



5.6.3 A number of watercourses in the study area have been modelled, detailed in the table below. Wherever possible, this study has sought to use modelled information for the 1% AEP (1 in 100 year) climate change scenario (i.e. 100 +20%) in preference to the technique outlined previously, by either:

- Using modelled climate change scenarios for the 1% AEP (1 in 100 year) event (Flood Zone 3a), or
- Where modelled climate change outlines do not exist, using the 0.5% AEP (1 in 200 year) or 1% AEP (1 in 100 year) modelled outlines as a climate change proxy for the 1% AEP (1 in 100 year) event (Flood Zone 3a). This method is supported by the fact that the 0.1% AEP (1 in 1000) or 0.5% AEP (1 in 200 year) outlines often show similar extents to the climate change scenarios of the 100 year event.

Table 5.3: Modelled Flood Outlines used for the 1 in 100 year Climate Change Scenario

Model	Watercourse	Modelled Flood Outlines				Notes
		1 in 100 year + 20%	1 in 150 year	1 in 200 year	1 in 1000 year	
River Severn Tidal	River Severn					No modelled flood outlines available. Current Flood Zone 2 used climate change outline
River Cam & Wickster's Brook	River Cam & Wickster's Brook	✓			✓	1% AEP (1 in 100 year) +20% used for climate change outline
River Frome	River Frome	✓				1% AEP (1 in 100 year) +20% used for climate change outline

5.6.4 The climate change outlines are provided in a series of maps covering the study area (Volume 2, Tiles C1-C6).

5.6.5 The strategic flood risk maps (Volume 2, B Tiles) show the present-day fluvial flood risk scenario. Where no modelled outlines exist for Flood Zone 3b, Flood Zone 3a has been used to represent Flood Zone 3b. This incorporates potential climate change into the Flood Zone maps and provides an effective method of incorporating climate change into the Sequential Test process.

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5.7 Likely Climate Change Impacts

5.7.1 As discussed in Section 5.6.1, climate change impacts on fluvial flood risk mean upland areas will be subject to deeper, faster flowing water, while in lowland areas the extent of flooding is likely to become greater. Levels of the Severn Estuary are likely to rise by 5mm per year[6]. This is a combined result of the southern England land mass sinking and rising sea levels due to global warming (continental ice sheets melting and thermal expansion of the oceans).

5.7.2 The floodplains in the south and east areas of the District are generally narrow and well defined, though they widen and flatten towards the Severn Estuary. Well-defined floodplains generally mean that the extent of flooding is negligible under climate change scenario. In areas where no detailed climate change modelling exists, this finding is supported by the relatively small difference in the aerial extents of Flood Zone 2 and Flood Zone 3a. However, it is important to note that as a result of climate change, the depth of flooding is likely to increase in well-defined floodplains, notably in the River Frome catchment. In particularly steep areas the velocity might also increase. This will have a significant impact on the flood hazard. A Level 2 SFRA, which assesses flood hazard, will therefore be required for site allocations which need to satisfy the Exception Test.

5.7.3 By contrast, the effect of climate change on flood risk in flat areas can be dramatic. Where climate change is expected to increase flood extents considerably, notably in the Little Avon and River Cam catchments, especially in the Cam/Dursley Principal Settlement, the LPA should consider using the climate change maps to carry out the Sequential Test, in order to give a particularly long-term risk-based approach to planning. Other locations where it might be prudent to do this are along the Severn Estuary and its tributaries, as well as within the main urban centres of the District including Nailsworth. The estuary will be subject to increased storm surges and wave height in the future, and the Environment Agency plans to implement managed retreat. Development proposals in this area should be treated with caution. The climate change maps do not show a climate change scenario for Flood Zone 2. For the purpose of spatial planning it is recommended that a buffer of 10m (measured from the edge of the existing Flood Zone 2) is added to represent future climate change.

5.7.4 The Severn Tidal Tributaries CFMP provides information on how climate change will affect the main catchments in Stroud (and support the findings above). These are as follows:

- **River Frome:** Flooding on the River Frome is expected to become deeper but generally stay within the existing flood extent with a few exceptions such as in the downstream part of the catchment around Saul. The current catchment damages for the 100 year event are around £22.4 million. These are expected to rise to approximately £31.2 million in the year 2056 and £28.3 million in the year 2106, a 39 per cent and 26 per cent increase respectively. There are currently 275 of 33,000 properties at risk of flooding; 42 of these are at risk of flooding between one to two metres deep and 17 are at risk of flooding deeper than two metres.

- **Little Avon:** For the 100 year event damages from the Little Avon are expected to increase by 51 per cent from £0.8 million to approximately £1.2 million in 2106. Increases in flood extents here are associated with climate change. A significant increase in flood extent can be seen in Dursley, with a slight increase in Coaly.

- **River Cam:** For the 100 year event damages from the River Cam catchment are expected to rise from £0.005 million to £0.4 million by the year 2106, an increase of 8,000 per cent.

Increases in flood extents here are associated mainly with climate change. Differences in flood extent can be seen in Charfield and Berkley and flood depth increases by up to 150mm throughout the catchment.

5.7.5 It is expected that flood risk from surface water, sewers, groundwater and impounded water bodies will generally increase due to the expected wetter winters (causing more frequent groundwater flooding) and incidence of short-duration high-intensity rainfall events associated with summer convective storms (causing more frequent surface water and sewer flooding). However, if surface water can be better managed at the surface rather than the immediate discharge to sewers (i.e. by the implementation of SUDS) this risk can be reduced.

5.7.6 Should the need to apply the Exception Test be identified, a Level 2 SFRA will be required which should include a detailed investigation into the impacts of climate change on flood risk.

5.8 Key Recommendations: Chapter Five

- Flood Zone outlines used within the SFRA are undefended and should be used to carry out the Sequential Test.
- Modelled outlines have been used to represent Flood Zone 3b where they exist. Where no modelled outlines exist, Flood Zone 3a has been used to represent Flood Zone 3b. This incorporates potential climate change into the Flood Zone maps and provides an effective method of incorporating climate change into the Sequential Test process. 3a should be taken to equal 3b unless, or until, further work is carried out to prove otherwise (e.g. Level 2 SFRA, FRA).
- Future updates to the DG5 flood register (depicting sewer flood incidents) should be fed into future updates of the SFRA. At present, the relatively course resolution of data limits its use for the purpose of spatial planning. In the meantime there is an onus on developers to assess sewer flood risk as fully as possible as part of site-specific FRAs.

6 Flood Warning Systems and Flood Risk Management Measures

6.1 Flood Risk Management

6.1.1 Flood risk management can reduce the probability of flooding occurrence though the management of land, river systems and flood defences, and reduce the impact though influencing development in flood risk areas, flood warning and emergency response.

6.2 Catchment Flood Management Plans

6.2.1 A Catchment Flood Management Plan (CFMP) is a high-level strategic plan through which the Environment Agency seeks to work with other key-decision makers within a river catchment to identify and agree long-term policies for sustainable flood risk management (in contrast to flood risk management strategies overleaf, which provide strategic options for flood risk management). It is produced in discussion with other key decision makers within a river catchment. CFMPs are being developed for the whole of England and Wales and are intended to define appropriate policies for the management of flood risk over the next 50 to 100 years. They will not set specific flood risk reduction measures at defined areas within the catchment, but will promote a range of activities for managing flood risk across the whole catchment. Stroud District Council is covered entirely by the Severn Tidal Tributaries CFMP.

Severn Tidal Tributaries CFMP

6.2.2 The western, estuary length of Stroud District is covered by policy unit 2, while the majority of the centre of the District is covered by policy unit 6. Stroud itself, including Nailsworth, Rainswick and Stonehouse and a small surrounding area, is covered by policy unit 5. A summary of these areas and the recommended policies are as follows:

- **Policy Unit 2 – Western Estuary Length of the District (Severn Vale):** This area has extremely flat coastal floodplain and mudstones and clays which are frequently saturated with standing water across the floodplain. Rainfall is slow to drain away and may lead to localised flooding even when the River Severn is not in flood. Flooding occurs from tidal locking and tidal influences, and the area tends to flood extensively after prolonged periods of rainfall. Overall, the selected policy option is to 'continue with existing or alternative actions to manage flood risk at the current level (accepting that flood risk will increase over time from this baseline)'. This means that current maintenance will continue, and in some cases new defences might be introduced, though flooding will increase due to climate change in the long term.

- **Policy Unit 6 – Majority of District (River Cam, Little Avon and Thornbury):** The area is characterised by low-lying land adjacent to the Severn estuary (lowland meadows) and upland areas at the edge of the Cotswolds with steep sided valleys. The flood mechanisms include natural run-off, tide locking, blockage of culverts along rivers and surface water flooding, also stemming from the blockage of culverts. Affected areas include agricultural land and urban areas of Thornbury, Berkeley, Charfield, Wotton-under-Edge, Dursley, Almondsbury and Alverton. Overall, the same policy unit as above is selected for this area. Channel maintenance and unblocking of structures will continue, though flooding will increase due to climate change in the long term.

- **Policy Unit 5 – Stroud, Nailsworth, Rainswick and Stonehouse (Frome Catchment):** The area is characterised by the steep sided valleys of the Cotswolds. The rivers Frome and Leadon, together with a number of watercourses and drainage systems along the estuary, have flapped outfall structures to prevent tidal flooding. Flood mechanisms include tide locking, river flooding (including blockages to river flow) and surface water flooding, increased by blockages. Affected areas include the landscape character area of the Cotswolds, rural areas with market towns, the major urban areas of Stroud and Stonehouse and several conservation areas. Overall, the selected policy option is to 'take action to sustain the current level of flood risk into the future (responding to the potential increases in risk from urban development, land use change and climate change)'. The Environment Agency also aims to reduce flood risk here through actions taken in policy unit 6. This option includes maintaining the current standard of protection and increasing the standard in the future in response to climate change. This will prevent an increase in the risk to life and the economic damage of flooding.

6.3 Shoreline Management Plans

6.3.1 Shoreline Management Plans (SMPs) are very similar to CFMPs, but deal with the flood risk management of a shoreline rather than a river catchment. The Severn Estuary Shoreline Management Plan outlines strategic policies for coastal defence for the short and long term (50 years). The western boundary of the District is affected along its length by the Severn Estuary Shoreline.

6.3.2 In the short term, the Environment Agency's policy is to 'hold the line', that is, settlements and other features or assets will continue to be protected to an appropriate level by maintenance of the existing defences. In the long term, however, the policy is to retreat the line. This will involve moving defences away from their current position to a location further away from the riverbank. No substantial areas for retreat are specifically identified, although some proposals are made, particularly in agricultural areas away from settlements or major infrastructure. The policy of retreat will, however, be constrained by how much settlements, infrastructure or other interests can be defended locally.

6.4 Flood Risk Management Strategies

6.4.1 The Environment Agency also produces flood risk management strategies, which aim to deliver strategic options for flood risk management. Aims of strategies generally include the following:

- To identify a 100 year framework for sustainable management of flood risk
- To provide a five year plan for capital investment on a project level for flood risk management
- To identify measures to maximise the environmental /social enhancement opportunities

The Severn Tidal Strategy

6.4.2 The Environment Agency has produced a flood risk management strategy for the tidal section of the River Severn, that is, from the weirs at Gloucester. It provides a fifty-year framework to manage flood risk and provide a short-term plan for investment into flood risk management schemes. Flood risk management options for the length of the Severn Estuary in the District have been assessed in the Strategy.

6.4.3 Overall, the Environment Agency will continue to maintain existing estuary defences and provide flood warning. However in the longer term, options to 'retreat the line' will be appraised. Liaison with the Environment Agency has confirmed that a new Strategy will be progressed in the near future and this is likely to identify more explicit areas for managed retreat in the longer term. Climate modelling indicates that in future, sea levels might rise and storm surges and wave heights may also increase. This threat reinforces the need to consider options to retreat the line.

6.4.4 A clear recommendation is that future development should not be proposed in areas which are currently defended along the estuary, as these areas are likely to be subject to managed retreat in the future.

Severn Estuary Flood Risk Management Strategy

6.4.5 The Environment Agency has commenced work on a strategy for flood risk management for the Severn Estuary[14]. The strategy will cover the estuary from Gloucester to Lavernock point near Cardiff and from Gloucester to Hinkley Point in Somerset. The main objectives of the strategy are:

- To decide where to locate new intertidal habitats to compensate for coastal squeeze
- To define a 100 year plan of investment for flood defences by the Environment Agency and local authorities
- To prioritise all flood risk management measures such as advice to utilities, abandonment of defences, development control advice and flood warning investment

6.4.6 Once the strategy has been approved by the Environment Agency board, Defra and the Welsh Assembly Government (WAG), it will guide much of the work that is undertaken by the Environment Agency in the estuary. It is anticipated that the draft strategy will be submitted for external consultation in autumn 2009. It is recommended that the SFRA be updated to incorporate the findings of the draft and final strategy upon completion.

6.5 Summary of Environment Agency Policies and Options

6.5.1 In summary, in the short term, the Environment Agency's policy for the Severn Estuary is to continue to protect features or assets by maintenance of the existing defences. In the long term, however, the policy is to retreat the line. This will be confirmed by work planned for the near future. This will involve moving defences away from their current position to a location further away from the riverbank, particularly in agricultural areas away from settlements or major infrastructure. The policy of retreat will, however, be constrained by how much settlements, infrastructure or other interests can be defended locally. Again, this policy will have implications for future development in the District. Indeed, Council can help deliver this policy by ensuring new development does not take place in areas along the estuary which are shown to be at risk and/or are currently defended. Such areas are likely to be exposed to greater flood risk in the future (due to climate change) and may well be earmarked for long term retreat in the future. When buildings within defended areas reach the end of their natural life, the Council should consider the option of not re-developing the site.

14 Environment Agency Severn Estuary Flood Risk Management Strategy – Briefing note No 1: May 2008

6.5.2 In terms of flood risk in the remainder of the District, for the most part channel and defence maintenance and unblocking of structures will continue, though the District will be susceptible to the impacts of climate change. In light of the likely impacts of climate change (see Section 5.5) the Council should seek to ensure that Flood Zones 2 and 3 remain undeveloped, because climate change will increase the flood risk in these areas in the future. In Stroud, Nailsworth, Rainswick and Stonehouse (the Frome Catchment) the Environment Agency intends to maintain the current level of flood risk and respond to changes that may come about from climate change (this will include maintaining defences and improving them where necessary in response to flood risk). Development behind defences will require careful consideration as residual risks will remain, now and in the future.

6.6 Flood Defences

6.6.1 Flood defences are structures which affect flow in times of flooding and therefore prevent water from entering property. They generally fall into one of two categories: 'formal' or 'informal'. A 'formal' defence is a structure which has been specifically built to control floodwater. It is maintained by its owner (this is not necessarily the Environment Agency) so that it remains in the necessary condition to function. An 'informal' defence is a structure that has not necessarily been built to control floodwater and is not maintained for this purpose. This includes road and rail embankments and other linear infrastructure (buildings and boundary walls) which may act as water retaining structures or create enclosures to form flood storage areas in addition to their primary function. A study of informal defences is also included in this section. Should any changes be planned in the vicinity of road or railway crossings over rivers in the study, it would be necessary to assess the potential impact on flood risk to ensure that flooding is not made worse either upstream or downstream. Smaller scale informal defences should be identified as part of site-specific detailed FRAs and the residual risk of their failure assessed.

6.6.2 The reduction in flood risk that a defence provides depends on the standard of protection (SoP) (the return period against which a defence offers protection) and the performance and reliability of the defence. Flooding may still occur in defended areas if the defence is overtopped or breached, or if flooding occurs as a result of non-fluvial sources such as groundwater flooding, surface water flooding or poor drainage. Development behind defences should, therefore, be planned with due regard to the flood risk in the defended area. This will need to be facilitated by a Level 2 SFRA.

6.6.3 In accordance with the scope of a Level 1 SFRA, a high level review of formal flood defences has been carried out using data from the National Flood and Coastal Defence Database (NFCDD) and information from the Council. NFCDD is a good starting point for identifying significant flood defences and potential areas benefiting from defence, but the quantity and quality of information provided differs considerably between structures. The NFCDD is intended to give a reasonable indication of the condition of an asset and should not be considered to contain consistently detailed and accurate data (this would be undertaken as part of a Level 2 SFRA where the need arises).

6.6.4 There are a number of locations at risk of flooding that are currently protected by permanent defences within the Stroud District and these can be viewed in Volume 2, Tiles A1-A6. Table 6.1 provides details of the existing defences within the District that are contained within the Environment Agency's NFCDD database, with further details of defences described below.

6.6.5 Table 6.1 demonstrates that there are a number of coastal defences within the District. The tributaries of the River Severn would be at risk of tidal flooding every high tide if the extensive

embankments, defences and tidal outfall flaps and gates used to keep the tidal water were not there. Following the severe flooding of 1981, the Avonmouth to Worcester improvements scheme was commissioned by Severn Trent Water and consisted of a phased construction of defences including earth embankments and flood walls. Although the scheme was never completed, most of the Lower Severn catchment is now protected by some form of defence, whether it is a floodwall, earth embankment, infrastructure acting as a defence or high ground. Earth embankments run from Berkeley Pill outfall to Severn House Farm and beyond which are thought to protect agricultural land and isolated farms from flooding up to a 0.5% AEP (1 in 200 year) event.

6.6.6 A series of earth embankments are located along the river bank and around Berkeley Pill which protect agricultural land from flooding up to the 1 in 10 year event.

6.6.7 A tidal flap exists at the mouth of the River Frome at Upper Framilode. This is closed for 1.5 hours during high tide causing tide locking and water levels to back up around Saul. A flood alleviation scheme was also built in the mid 1990s in Upper Framilode that took account of tide locking and defences along the Frome were raised in Framilode[5].

6.6.8 Within the District, there are also a number of structures which act as a line of defence but are not under the Agency's responsibility to operate or maintain (e.g. sections of the Gloucester to Sharpness canal and the railway line). Any failure of these structures could potentially cause or exacerbate flooding problems. The standard of protection provided by Agency maintained defences varies from low (protection from floods that have a 20% chance of occurring, i.e. 1 in 5 years) to high (protection from floods that have a 1% chance of occurring, i.e. 1 in 100 years).

6.6.9 The Cambridge flood alleviation scheme (constructed in the 1970s) is located at the downstream extent of the River Cam and Wickster's Brook catchments immediately downstream of the A38 at Cambridge. As part of the scheme, a concrete channel through Cambridge was constructed (approximate 80m in length) along with a flood storage area designed to store flood water in the land between the River Cam and Wickster's Brook. Earth embankments were constructed along the watercourse which elevated the river levels above that of the surrounding land. The storage area is classified under the Reservoir Act.

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Table 6.1: Environment Agency NFCDD Defences within the Stroud District

Watercourse	Location	NGR		Type of Defence	Owner	SOP	Approx. Length (m)	Comments
		Upstream	Downstream					
River Severn	Weir Green	SO 7909 1521	SO 7918 1544	Raised defence	Environment Agency	1:100 years	318.1	Earth defence, flood Bank ties into high ground, on left bank
River Severn	Windmill Hill to U/S of Severn bank farm	SO 7911 1580	SO 7755 1671	Raised defence	Environment Agency	1:25 years	2119.8	Combination of earth embankments, on left bank.
River Severn	U/S of Severn bank farm to Elmore Bank Farm	SO 7755 1671	SO 7693 1683	Raised defence	Environment Agency	1:25 years	700.2	Combination of earth embankments, on left bank.
River Severn	Elmore Bank Farm, Hill Farm, D/S upper Framilode	SO 7693 1683	SO 7497 1044	Raised defence	Environment Agency	1:100 years	9526.2	Combination of earth embankments and concrete flood wall, on left bank.
River Severn	Embankment Framilode to Priding House Flood Wall	SO 7474 1037	SO 7374 1081	Raised defence	Environment Agency	1:100 years	1111.6	Combination of earth embankments, sheet pile walls and reinforced concrete walls, on left bank
River Severn	U/S of Barnesmarsh F/O/F to U/S of Hock Cliff	SO 7246 1136	SO 7223 0937	Raised defence	Environment Agency	1:100 years	8321.9	Combination of earth embankments, on left bank
River Severn	U/S of Hock Cliff	SO 7223 0937	SO7228 0938	Raised defence	unknown	1:100 years	51.2	High Ground to Earth Embankment Interface on left bank
River Severn	Hock Cliff	SO7228 0938	SO 7337 0881	Raised coastal defence	unknown	-	1219	Natural High Ground, on left bank

Watercourse	Location	NGR		Type of Defence	Owner	SOP	Approx. Length (m)	Comments
		Upstream	Downstream					
River Severn	Extends from in front of Severn Trent Water Frampton Sewage Works to Hock Cliff	SO 7337 0881	SO 7383 0852	Raised coastal defence	Environment Agency	1:100 years	591.8	Earth Embankment, on left bank
River Severn	U/S of Frampton Village	SO 7383 0852	SO 7437 0796	Raised coastal defence	unknown	-	749.7	Natural High Ground, on left bank
The Gloucester and Sharpness Canal	Frampton, U/S of Splatt Bridge (Jct of Old X bank Defence) to U/S of Frampton Village, where Sharpness Canal meets High Ground	SO 7437 0796	SO 7411 0659	Raised coastal defence	unknown	1:100 years	1424.8	Raised Canal Embankment, on left bank
River Severn	Slimbridge, Frampton Breakwater to End of embankment at Sharpness Canal (Fampton)	SO 7411 0659	SO 7060 0422	Raised coastal defence	Environment Agency	1:100 years	4597.8	Earth Embankment, on left bank
River Severn	Hinton	SO 6780 0340	SO 6678 0294	Coastal protection	unknown	1:99 years	1230	Wall, on left bank
River Severn	Sharpness Docks	SO 6674 0222	SO 6673 0211	Raised coastal defence	unknown	-	123.2	Shoreline & Dock pier/outer gate abutment interface, on left bank
River Severn	Sharpness, Severn Rd to U/S Club House	SO 6672 0205	SO 6672 0192	Raised coastal defence	unknown	-	135.8	Natural High Ground with erosion protection, on left bank
River Severn	Saniger O/F to Severn Rd, Sharpness	SO 6672 0192	SO 6665 0133	Raised coastal defence	Environment Agency	1:200 years	588.5	Earth Embankment Def', on left bank

Watercourse	Location	NGR		Type of Defence	Owner	SOP	Approx. Length (m)	Comments
		Upstream	Downstream					
River Severn	Panthurst Farm Drain to D/S Sewage Works	SO 6665 0133	SO 6659 0102	Raised coastal defence	Environment Agency	-	320.9	Earth Embankment Def', on left bank
River Severn	U/S Berkeley Pill, Adj Oakhunger Farm	SO 6659 0102	SO 6636 0042	Raised coastal defence	Environment Agency	1:200 years	655.6	Earth Embankment Def', on left bank
River Severn	U/S Berkeley Pill, Adj Pill Inlet	SO 6636 0042	SO 6636 0034	Raised coastal defence	Environment Agency	-	70.7	Earth Embankment Def', on left bank
River Severn	U/S Berkeley Pill, Adj Pill Inlet	SO 6636 0034	ST 6632 9999	Raised coastal defence	Environment Agency	1:200 years	1025.3	Earth Embankment Def', on left bank
River Severn	Adjacent to Berkeley Pill D/S Side	ST 6632 9999	SO 6612 0005	Raised coastal defence	Environment Agency	-	226.1	Earth Embankment Def', on left bank
River Severn	Berkeley Power St, U/S End	SO 6612 0005	ST 6588 9970	Raised coastal defence	Environment Agency	1:200 years	431	Earth Embankment Def', on left bank
River Severn	Berkeley Power St	ST 6588 9970	ST 6552 9925	Raised coastal defence	unknown	-	589.2	Combination of Natural high ground and made up high ground with some erosion protection, on left bank
River Severn	Berkeley Technology Centre	ST 6552 9925	ST 6547 9898	Raised coastal defence	Environment Agency	-	339.9	Earth Embankment Def', on left bank
River Severn	Berkeley Technology Centre, Severn House Farm	ST 6547 9898	ST 6437 9836	Raised coastal defence	Environment Agency	1:200 years	1274.8	Earth Embankment Def' on left bank
River Severn	Clapton, Severn House Farm	ST 6437 9836	ST 6410 9826	Raised coastal defence	Environment Agency	-	298.5	Earth Embankment Def' on left bank

Watercourse	Location	NGR		Type of Defence	Owner	SOP	Approx. Length (m)	Comments
		Upstream	Downstream					
River Severn	Nupdown, Worldsend	ST 6410 9826	ST 6349 9800	Raised coastal defence	Environment Agency	1:200 years	678.5	Earth Embankment Def' on left bank
River Severn	D/S, Severn House Farm Wall, Worldsend W	ST 6349 9800	ST 6339 9792	Raised coastal defence	Environment Agency	-	124.8	Earth Embankment Def' on left
River Severn	Nupdown, Hill Flats	ST 6339 9792	ST 6115 9769	Raised coastal defence	Environment Agency	1:200 years	336.3	Earth Embankment Def' on left (total length 2850.5m)
Berkeley Pill/Little Avon River	Berkeley Castle	ST 6855 9611	ST 6822 9876	Raised defence	Environment Agency	-	3004.3	Combination of concrete walls, concrete channel wall and side, earth embankment. Defences on right bank
Little Avon River	Matford Bridge	ST 6831 9386	ST 6829 9692	Raised defence	Unknown	-	95.6	Embankment
River Cam	Coaley Mill	SO 7598 0235	SO 7563 0223	Raised defence	Environment Agency	-	390.1	Earth embankment, no Berm, on left bank
River Cam	Coaley Mill	SO 7599 0235	SO 7599 0235	Raised defence	Environment Agency	-	21.5	Weir and training walls
Wickster's brook	Cambridge	SO 7562 0480	SO 7389 0507	Raised defence	Environment Agency	-	2026.1	Combination of earth embankments with no Berm/stone wall, on right bank.
Wickster's brook	Cambridge	SO 7562 0480	SO 7426 0489	Raised defence	Environment Agency	-	1519.4	Earth Embankment with no Berm, on left bank.

Watercourse	Location	NGR		Type of Defence	Owner	SOP	Approx. Length (m)	Comments
		Upstream	Downstream					
River Cam, Cambridge arm	Cambridge	SO 7492 0377	SO 7489 0384	Flood defence structure	Environment Agency	-	80.5	Concrete River Wall on left bank
River Cam, Cambridge arm	Cambridge	SO 7492 0377	SO 7489 0384	Flood defence structure	Environment Agency	-	80.7	Concrete Channel Wall on right bank
River Cam, Cambridge arm	Near Newhouse Farm	SO 7493 0379	SO 7454 0439	Flood defence structure	Environment Agency	-	752.2	Defended channel within FSA, on right bank.
River Cam, Cambridge arm	Newhouse Farm	SO 7484 0394	SO 7453 0437	Raised defence	Environment Agency	-	535.3	Earth Embankment on left bank.
River Cam, Cambridge arm	Cambridge, Hopehouse Farm	SO 7453 0437	SO 7386 0505	Raised defence	Environment Agency	-	964.6	Earth Embankment, no Berm/with sheet/stone wall piling, on left bank.
River Frome	M5 to Millend, Wheatenhurst, Wheatenhurst road bridge extending U/S to a point on field boundary on opposite bank	SO 7809 0572	SO 7597 0888	Raised defence	Environment Agency	-	4094	Combination of earth embankments en left bank.
River Frome	Between A38 Road Bridge & M5 Road Bridge, Near M5 Junction 13	SO 7809 0572	SO 7652 0832	Raised defence	Environment Agency	-	2345.4	Combination of earth embankments en right bank.
River Frome	Upper Framilode, Road bridge to Glos/Sharpness Canal	SO 7593 0898	SO 7517 1047	Raised defence	Environment Agency	-	1799.4	Combination of earth embankments and masonry flood wall on left bank

Watercourse	Location	NGR		Type of Defence	Owner	SOP	Approx. Length (m)	Comments
		Upstream	Downstream					
River Frome /bifurcation	Upper Framilode U/S, Inner bank from RB Bifurcation to Glos/Sharpness canal	SO 7588 0903	SO 7530 0963	Raised defence	Environment Agency	-	1040	Combination of earth embankments and masonry flood wall on left bank
River Frome /bifurcation	Upper Framilode U/S, Extends from Glos/Sharpness canal U/S towards Wheatenhurst	SO 7593 0921	SO 7530 0963	Raised defence	Environment Agency	-	1649	Combination of earth embankments on right bank
River Frome	Upper Framilode	SO 7522 1021	SO 7522 1021	Raised defence	Environment Agency	-	12.6	Concrete Weir
River Frome	Upper Framilode, High Ground U/S of Property adjacent to Saul O/F	SO 7520 1021	SO 7520 1025	Raised defence	Unknown	-	32.9	Channel side (Natural High Ground)
River Frome	Church end graveyard, upstream of road bridge	SO 7824 0572	SO 7820 0572	Raised defence	Unknown	-	38.8	Stone wall / retaining wall on right bank.
River Frome	Directly D/S of Bonds Mill	SO 7936 0516	SO 7910 0522	Raised defence	Unknown	-	163	Raised earth bank on left bank.
River Frome	D/S of splash cottage	SO 7954 0485	SO 7945 0491	Raised defence	Unknown	-	84	Low masonry wall on right bank.
River Frome	D/S of splash cottage	SO 7951 0487	SO 7947 0489	Raised defence	Unknown	-	52.4	Exterior brickwork wall on left bank
River Frome	U/S of culvert under railway embankment.	SO 7967 0497	SO 7967 0497	Raised coastal defence	Unknown	-	7.1	Brickwork wall, on left and right banks.
River Frome	Bliss Mills.	SO 8949 0246	SO 8935 0249	Raised defence	Unknown	-	149.7	Concrete wall, on right bank

Watercourse	Location	NGR		Type of Defence	Owner	SOP	Approx. Length (m)	Comments
		Upstream	Downstream					
River Frome	U/S of Bliss Mills culvert.	SO 8942 0246	SO 8935 0249	Raised defence	Unknown	-	71.9	Masonry wall on left bank
River Frome	D/S of Bliss Mills culvert.	SO 8924 0245	SO 8911 0243	Raised defence	Unknown	-	142.4	Blockwork wall on left bank (11m on right bank)
River Frome	U/S of Brimscombe railway embankment (Brookside).	SO 8883 0230	SO 8895 0235	Raised defence	Unknown	-	329.3	Combination of low masonry wall, low concrete wall and earth bank on left and right banks.
River Frome	St Marys Mill	SO 8863 0220	SO8854 0216	Raised defence	Unknown	-	88.4	Low rock / stone wall on right bank
River Frome	Directly U/S of Wimberly Mill Culvert and D/S of Knapp Lane Industrial Park Culvert	SO 8790 0214	SO 8732 0203	Raised defence	Unknown	-	230.8	Combination of Low concrete wall, turfed embankment, blockwork wall and earth bank on left and right banks.
River Frome	Kingfisher Business Park to U/S of Bath Rd culvert	SO 8630 0281	8669 0502	Raised defence	Unknown	-	5742	Combination of earth banks and berm / vegetated/stone revetment, Stonework/blockwork wall along left and right banks.

Watercourse	Location	NGR		Type of Defence	Owner	SOP	Approx. Length (m)	Comments
		Upstream	Downstream					
River Frome	u/s of Eberly mill weir	SO 8316 0467	SO 8299 0449	Raised defence	Unknown	-	565.6	Combination of natural earth bank, masonry wall, grouted stone revetment along left and right banks.
River Frome	Directly U/S of Snow Business buildings to Adjacent to Waters Edge landfill	SO 8261 0455	SO 8207 0454	Raised defence	Unknown	-	790.6	Combination of masonry wall, raised earth bank, blockwork wall, along left and right banks.
River Frome	D/S of A419 to Directly D/S of Downton road (road bridge)	SO 8193 0439	SO 8019 0438	Raised defence	Unknown	-	3277	Combination of raised earth defence, vegetated earth bank, blockwork wall, along left and right banks.
River Frome	Ryeford industrial estate to D/S of Bridgend works.	SO 8170 0458	SO 7998 0478	Raised defence	Unknown	-	2329.7	Combination of raised defence, vegetated earth bank, earth bank/ stone revetment, masonry/stone wall along left and right banks.

Informal Defences

6.6.10 Road and railway embankments and other linear infrastructure may act as informal defence and divert flood water elsewhere, hold back water or create enclosures to form flood storage areas. Raised embankments may also offer a degree of flood protection. An overview assessment of informal defences (primarily railways and major roads) within the District has been undertaken as part of this SFRA. Locations identified can be viewed in Volume 2, Tiles A1-A6.

6.6.11 Informal defences should only be relied upon to protect new development following an FRA as outlined within the PPS25 Practice Guide (Paragraph 6.17) (2006). This should investigate:

- The suitability of the embankment materials to prevent seepage of water, and whether it is physically strong enough to withstand the pressure of water on one side
- An assessment as to whether there are any culverts through the embankment or other gaps within the structure that may let water through
- The performance of the structure during recent historical flood events
- The long-term Asset Management Plan (AMP) provided by the owner of the embankment
- Whether by holding water back, the structure may fall under the regulation requirements of the Reservoirs Act (1975).

6.6.12 Only major structures such as motorways and railways acting as informal defences have been identified within this Level 1 SFRA. An assessment of all informal defences should be made as part of an FRA.

6.7 Culverts

6.7.1 Sections of culverted watercourse as identified within NFCDD are illustrated in Volume 2, Tiles A1-A6 and detailed in Table 6.2. It is still possible, however, that culverts exist which are not identified on NFCDD. Therefore when locating development, OS tiles should be analysed to identify any culverts in the vicinity of development sites. In some cases site visits may be required. Further details of the implications of culverts on new development can be found in Section 6.9.

6.7.2 Consultation with the Council has indicated that floods resulting from out of bank flows for higher flows can be exacerbated by local channel restrictions, in particular, under capacity culverts which are not able to adequately convey flows. This can result in the backing-up of river flows and the overtopping of culverts leading to further flooding and create a residual risk. Where development is located in the vicinity of a culvert, potential blockage to such structures will need to be considered as part of a Level 2 SFRA.

6.7.3 On any new development site and indeed on existing sites, further culverting and building over of culverts should be avoided. All new developments with culverts running through their site should seek to de-culvert rivers for flood risk management and conservation benefit.

Table 6.2: Culverted Watercourses as identified within NFCDD

Watercourse	Location	NGR	Owner	Approx. Length (m)	Comments
Little Avon River	Grindstone Mill	ST 7641 9122	Unknown	10.3	Culvert under road into Mill Pond. 2 sections of approx specified length on left and right banks.
River Cam	U/S of Station Road Bridge	SO 7524 0015	Unknown	161	Culverted channel. 2 sections of approx specified length on left and right banks.
River Cam	Under building u/s of Cam Mills	ST 7534 9993	Unknown	51.2	Culvert with corrugated roof. 2 sections of approx specified length on left and right banks.
River Cam	Under Church Road Bridge	ST 7553 9923	Unknown	15.6	Culverted section under bridge, right bank.
River Cam	U/s of Church Road Bridge to end of 1st large works unit (u/s)	ST 7553 9921	Unknown	490	Brick and concrete culvert on left bank.
River Cam	U/s of Church Road Bridge to culvert entrance at Water Street	ST 7568 9874	Unknown	557.8	Brick arch with brick wall. 2 sections of approx specified length on left and right banks.
River Cam	Culvert under road near Ferney Hill	ST 7614 9802	Unknown	72.6	Brick arch set into right bank.
River Cam	Confluence with River Ewelme to storage pond inlet	ST 7645 9795	Unknown	119.9	1.3m diameter brick and stone culvert. 2 sections of approx specified length on left and right banks.
Miry brook	Plumber's Lane, under works unit	ST 8419 9949	Unknown	130.7	Culvert with concrete pipe. 2 sections of approx specified length on left and right banks.
Miry brook	Under car park parallel with Newmarket Road	ST 8472 9946	Unknown	60.9	Good concrete headwall, no screen. 2 sections of approx specified length on left and right banks.
Miry brook	From confluence to Britannia Pub Car Park.	ST 8490 9947	Unknown	146.8	600 x 150 Concrete bolster. 2 sections of approx specified length on left and right banks.
Nailsworth stream	Under factory building u/s of pond	ST 8472 9926	Unknown	48	Preformed Concrete Culvert. 2 sections of approx specified length on left and right banks.
Nailsworth stream	Under buildings at end of Brewery Lane	ST 8480 9933	Unknown	21	2 sections of approx specified length on left and right banks.
Nailsworth stream	Under buildings u/s of Brewery Lane	ST 8486 9937	Unknown	56.3	2 sections of approx specified length on left and right banks.

Watercourse	Location	NGR	Owner	Approx. Length (m)	Comments
Nailsworth stream	Under house at end of Brewery Lane	ST 8485 9938	Unknown	26.5	2 sections of approx specified length on left and right banks.
Nailsworth stream	Exit adjacent to police Station	ST 8497 9959	Unknown	164.1	Corrugated iron culvert with brick headwall. 2 sections of approx specified length on left and right banks.
Nailsworth stream	Beneath Williams Kitchen, parallel and between Old Market and Fountain Street	ST 8501 9969	Unknown	56.3	2 sections of approx specified length on left and right banks.
Nailsworth stream	Confluence with Nailsworth Stream u/s under Bridge Street	ST 8502 9975	Unknown	51.3	2 sections of approx specified length on left and right banks.
Wickster's brook	Wickster's Bridge	SO 7562 0480	Environment Agency	23	2 sections of approx specified length on left and right banks.
River Cam, Cambridge arm	Cambridge, A38	SO 7492 0377	Environment Agency	38.5	2 sections of approx specified length on left and right banks.
River Cam, Cambridge arm	Cambridge, A38	SO 7494 0378	Unknown	41.2	Concrete side wall to road bridge
River Cam, Cambridge arm	Cambridge, A38	SO 7494 0376	Unknown	14.3	Road bridge, former dummy,
River Frome	Upper Framilode, LB Road bridge abutment	SO 7520 1021	Local Authority	15.9	Stone revetment against vertical wall
River Frome/ bifurcation	Under the Gloucester Sharpness Canal (Junction with Old Frome Canal, Upper Framilode)	SO 7585 0953	Local Authority	52.6	Culvert / Syphon, 2 sections of approx specified length on left and right banks.
River Frome/ bifurcation	Under the Gloucester Sharpness Canal (Junction with Old Frome Canal, Upper Framilode)	SO 7566 0937	Local Authority	40.6	Culvert / Syphon, 2 sections of approx specified length on left and right banks.
River Frome	Culverted channel beneath Mill End Mills.	SO 7811 0536	Unknown	32.1	2 sections of approx specified length on left and right banks.
River Frome	Bonds Mill culvert	SO 7919 0520	Unknown	63.9	2 sections of approx specified length on left and right banks.
River Frome	Beards Mill Lane	SO 7952 0487	Unknown	21.9	2 sections of approx specified length on left and right banks.
River Frome	Railway embankment	SO 7967 0497	Unknown	45.6	2 sections of approx specified length on left and right banks.

Watercourse	Location	NGR	Owner	Approx. Length (m)	Comments
River Frome	U/S of Bliss Mills.	SO 8949 0246	Unknown	66.6	Arched masonry culvert. 2 sections of approx specified length on left and right banks.
River Frome	U/S of Chalford Stone Merchants (Bliss Mill).	SO 8932 0247	Unknown	29.3	2 sections of approx specified length on left and right banks.
River Frome	D/S of Bliss Mills.	SO 8924 0245	Unknown	46.2	Culverted channel.2 sections of approx specified length on left and right banks.
River Frome	Old Mill House/pump room and Clayfields Mill Road Bridge.	SO 8882 0233	Unknown	51	2 sections of approx specified length on left and right banks.
River Frome	Railway bridge	SO 8874 0224	Unknown	186.1	Sections of approx specified length on left and right banks.
River Frome	Knapp Lane Industrial estate	SO 8767 0205	Unknown	146.6	Culverted Channel, Sections of approx specified length on left and right banks.
River Frome	U/S pond culvert - arch.	SO 8668 0241	Unknown	30.3	Sections of approx specified length on left and right banks.
River Frome	Burkert Offices.	SO 8681 0234	Unknown	74.5	Culverted Channel, Sections of approx specified length on left and right banks.
River Frome	Ham Mill Culvert	SO 8603 0319	Unknown	16	Masonry culvert, Sections of approx specified length on left and right banks.
River Frome	Griffin Mill	SO 8597 0353	Unknown	53	Culverted Channel, Sections of approx specified length on left and right banks.
River Frome	Second Bow bridge lock culvert.	SO 8587 0411	Unknown	15.8	Sections of approx specified length on left and right banks.
River Frome	Bow bridge lock and Butterrow Hill road bridge.	SO 8576 0427	Unknown	45.5	Sections of approx specified length on left and right banks.
River Frome	Eagle Mill Lane culvert.	SO 8567 0441	Unknown	35.8	Brickwork culvert. Sections of approx specified length on left and right banks.
River Frome	Arundell Mill Lane	SO 8545 0461	Unknown	24.2	Sections of approx specified length on left and right banks.
River Frome	Bath RD Road bridge / culvert	SO 8469 0502	Unknown	25.1	Mass concrete channel / culvert. Sections of approx specified length on left and right banks.

Watercourse	Location	NGR	Owner	Approx. Length (m)	Comments
Slad brook	Culvert At boundary of upper Batch Mill and from Gravel Hill to Road u/s	SO 8707 0659	Unknown	120.3	Sections of approx specified length on left and right banks.
Slad brook	Under Libby's Drive and u/s under building	SO 8593 0561	Unknown	120.3	Sections of approx specified length on left and right banks.
Slad brook	Under Lansdown (road) and u/s under building	SO 8558 0553	Unknown	127.1	Sections of approx specified length on left and right banks.
Slad brook	u/s of bus station to Stroud Water Canal to Rail Bridge	SO 8476 0512	Local authority	628.2	Sections of approx specified length on left and right banks.
Painswick stream	Culvert under Tesco Superstore and car park to A4171 Road Bridge	SO 8465 0534	Unknown	198.7	Sections of approx specified length on left and right banks.
Painswick stream	Under A419 Road Bridge (Cainscross Road)	SO 8449 0517	Unknown	19.4	Culvert / Road Bridge. Sections of approx specified length on left and right banks.
Nailsworth stream	Selsley Hill	SO 8352 0442	Unknown	106.5	Sections of approx specified length on left and right banks.
River Frome	Snow Business	SO 8255 0455	Unknown	17.3	Sections of approx specified length on left and right banks.
River Frome	A419 road culvert	SO 8203 0440	Unknown	61.5	Sections of approx specified length on left and right banks.
River Frome	Stanley Mills	SO 8115 0428	Unknown	83.3	Sections of approx specified length on left and right banks.
River Frome	Under Spring Cottages	SO 8144 0459	Unknown	109.5	Sections of approx specified length on left and right banks.
River Frome	A419 road culvert.	SO 8098 0465	Unknown	41.9	Sections of approx specified length on left and right banks.

6.8 Storage Areas

6.8.1 Storage in a catchment is often considered as an important flood management option. Storage can have the effect of delaying the time at which the peak of a hydrograph occurs. Delaying the peak of one hydrograph can alter the phasing of the other hydrographs in a system. Altering the phasing of peaks may mean that it is possible to stop the peak flow from one tributary combining with that of another. This can have the effect of reducing peak flow, and therefore flooding, in the main channel.

6.8.2 A number of flood storage areas are situated along the River Severn. These are areas of natural, low lying topography bounded by high ground, with earth embankments along the edge of the river. These earth embankments have a SoP of typically 5% AEP (1 in 20 years) or less. During a flood event, water from the River Severn spills into the storage areas and is contained by a series of high embankments. They function by removing large volumes of flood water, retaining it, and then

allowing it to drain back to the main channel via flapped outfalls and sluice gates after the peak of the flood event. Key storage cells located within the Stroud District include: Weir Green (SO 7926 1494), Longney (SO 7708 1621), Priding (SO 7654 1029) and Frampton (SO 7339 0577). These have been mapped in Volume 2, Tiles A1-A6.

6.8.3 A purpose built flood storage area is located between the River Cam and Wickster's Brook in the 1970s. Steep embankments line the edges of both the Wickster's Brook downstream of the A38 (SO 7435 0466) and the River Cam downstream of Hopehouse farm (SO 7562 0479). A flood storage area was constructed in the 1970s, designed to store flood water on the land in-between the River Cam and Wickster's Brook, to protect the Gloucester and Sharpness Canal. In addition, consultation with the Council has indicated that there is an on-line storage pond at Lawns Pond, Dudbridge (SO 8363 0499) which forms part of the Ruscombe Brook. As part of the canal restoration within the District, Lawns Pond was de-silted to provide a water storage area linked with the Canal.

6.8.4 It is imperative that any storage areas used as a means of attenuation of flood waters are safeguarded from development and maintained to ensure their efficient operation during a flood event. If the storage areas are not maintained this may lead to an increased risk of flooding at locations downstream.

6.9 Residual Risk

6.9.1 In producing Flood Zone maps the Environment Agency takes the presence of defences into account by showing the area that benefits from the defence (ABD). This area can also be deemed an area which is at risk of defence overtopping or failure. It can therefore also be described as a residual risk zone. Residual flood risks from defences can arise due to:

- The failure of flood management infrastructure such as a breach of a raised flood defence
- A severe flood event that exceeds a flood management design standard and results in, for example, overtopping
- Issues with deployment of flood defences and pump failure

6.9.2 ABDs have not been mapped by the Environment Agency within the District. This does not mean, however, that there are no areas of residual risk. An assessment of residual risk should therefore be made at the site-specific level. Actual levels of residual risk will vary spatially depending on flow routes, velocities, flood depths and proximity to the breach or overtopping location. In the event that development is located in or near a residual risk areas (e.g. behind a defence) the scope of the SFRA should be extended to a Level 2 assessment to refine information on the flood hazard in these locations. Known defence locations are mapped in Volume 2, Tiles A1-A21 to assist with this.

6.9.3 Residual risks can also arise from the following sources:

- Blockage or collapse of a culvert
- Blockage of a surface water conveyance system
- Overtopping of an upstream storage area
- Failure of a pumped drainage system

- Surcharging of surface water conveyance systems and SUDS systems drainage networks

6.9.4 There is currently no dataset which identifies precise residual risk areas from these sources, therefore again any development in the vicinity of culverts, surface water conveyance systems, storage areas and pumped drainage systems should assess residual risk through a Level 2 SFRA. Known culvert locations are mapped in Volume 2, Tiles A1-A6. These should be referenced by those proposing development to identify the possibility of localised residual risks as well as opportunities for de-culverting and restoring the natural channel. OS tiles should be analysed to identify any culverts in the vicinity of development sites which are not recognised in Volume 2, Tiles A1-A6. In some cases site visits may be required.

6.9.5 This study has found that flood mechanisms in the District include blockage of culverts which can cause residual flood risk areas, and surface water flooding also stemming from the blockage of culverts. Poorly maintained trash screens and rubbish inappropriately dumped in watercourses can reduce culvert and structure capacity, therefore presenting residual risk. This can be mitigated by regular inspection and clearance of culverts and trash screens.

6.9.6 It is recommended that any development in the vicinity of culverts should assess the potential of de-culverting. If this is not possible, an assessment of the state of the culvert should be made, and any remedial works carried out prior to the development of the site.

6.10 Existing Flood Warning System

6.10.1 One aspect of the Environment Agency's work is reducing risks to people and to the developed and natural environment from flooding through flood forecasting, flood warning and response. The Environment Agency is the lead organisation on flood warning and they work closely with Local Authorities and Emergency Services to plan for flooding emergencies and reduce the risk of flooding to people and properties. Stroud District falls within the Midlands Region of the Environment Agency.

6.10.2 When conditions suggest that floods are likely, it is the responsibility of the Environment Agency to issue flood warnings to the Police, Fire and Rescue Service, to the relevant local authorities, and to the public. It is the responsibility of individuals in the community to receive flood warnings via Floodline Warnings Direct (FWD) which passes messages over the telephone network, email, fax and text message.

6.10.3 A flood warning system is in operation for the main rivers within the Stroud District and is outlined below in four stages.

- **Flood Watch:** Flooding of low lying land and roads is expected. Be aware, be prepared, watch out! The following actions are recommended:
  - Watch water levels
  - Stay tuned to local radio or TV
  - Ring Floodline on 0845 988 1188
  - Make sure you have what you need to put your flood plan into action
  - Alert your neighbours, particularly the elderly

- Check pets and livestock
- Reconsider travel plans

6.10.4 Flood Watch Areas can be seen in Volume 2, Tile E1. Flood Watches are issued for expected flooding, which could occur anywhere within the Flood Watch Area but with low or minor impact. The trigger for Flood Watch is a forecast that flooding of low impact land is expected.

- **Flood Warning:** Flooding of homes and businesses is expected. A Flood Warning could be issued at any time, a Flood Watch may not necessarily be issued first. Act now! The following actions, in addition to those associated with Flood Watch, are recommended:
  - Move pets, vehicles, food, valuables and other items to safety
  - Put sandbags or floodboards in place
  - Prepare to turn off gas and electricity
  - Be prepared to evacuate your home
  - Protect yourself, your family and others that need your help
- **Severe Flood Warning:** Severe flooding is expected. A Severe Flood Warning could be issued at any time; a Flood Warning may not necessarily be issued first. There is extreme danger to life and property. Act now! The following actions, in addition to those associated with Flood Warning, are recommended:
  - Be prepared to lose power supplies - gas, electricity, water, telephone
  - Try to keep calm, and to reassure others, especially children
  - Co-operate with emergency services and local authorities
  - You may be evacuated
- **All Clear:** Flood Watches or Warnings are no longer in force. The following is recommended:
  - Flood water levels receding
  - Check all is safe to return
  - Seek advice

6.10.5 Table 6.3 details the flood warning coverage within the Stroud District.

Table 6.3: Flood Warning coverage within the Stroud District

Type of Warning	Coverage	EA Region
Flood Watch	Severn Vale including Cheltenham, Gloucester, Tewkesbury and the Forest of Dean	Midlands
Flood Watch	Severn Estuary including Severn Beach and Gloucester	Midlands
Flood Warning	River Cam at Cambridge	Midlands
Flood Warning	The River Severn at Gloucester including Sandhurst and Maisemore	Midlands
Flood Warning	The Severn Estuary between Gloucester and Westbury including Minsterworth, Elmore, Longney and Framilode	Midlands
Flood Warning	Severn Estuary between Sharpness and Aust	South West
Flood Warning	Severn Estuary from Westbury to Sharpness	Midlands

6.11 Flood Response Plan

County Council Flood Response Plan[15]

6.11.1 Gloucestershire County Council owns and operates a number of contingency plans, each detailing how local services will work together to respond to any type of emergency. Every plan is regularly updated and also thoroughly revised at regular intervals. The 'Major Flooding Emergency Plan' aims to detail the roles, responsibilities and actions to be taken by Category One responders in both the mitigation of and response to a major flooding emergency in Gloucestershire. It reflects the known risks of flooding within the County of Gloucestershire, details the response actions of Local Authorities to incidents of flooding and summarises the response of the emergency services and other agencies. Gloucestershire County Council has prepared the plan in close consultation with the Gloucestershire Local Resilience Forum (LRF), to comply with the statutory duties of the Civil Contingencies Act 2004 and the National Capabilities Programme guidance.

15 Gloucestershire County Council Emergency Management Service (2007), Major Flooding Emergency Plan (http://www.gloucestershire.gov.uk/index.cfm?articleid=3327)

6.11.2 The first section gives the background information to the plan. The Gloucestershire LRF Risk Assessment Subgroup has assessed the potential Impact and Likelihood of a Major Flooding Emergency affecting Gloucestershire as follows:

Table 6.4: Potential impact and Likelihood of a Major Flooding Emergency affecting Gloucestershire

Severe Weather	**(SW7) Localised coastal / tidal flooding**		
Outcome description	**Impact**	**Likelihood**	**Overall Risk**
Sea surge, high tides, gale force winds affecting the coastline, some defences overtopped. Localised impact with infrastructure affected and up to 1,000 properties flooded. Multi-agency response invoked with some local evacuation. Impact on infrastructure includes disruption to traffic for one-three days, impact on access to agricultural land and impact to infrastructure.	**Significant (4)**	**Unlikely (3)**	**VERY HIGH**
Severe Weather	**(SW8) Major local fluvial flooding**		
Outcome description	**Impact**	**Likelihood**	**Overall Risk**
A sustained period of heavy rainfall extending over two weeks, perhaps combined with snow melt, resulting in steadily rising river levels. Localised flooding of more than 100 but less than 1,000 properties. Some impact on minor roads and some A and trunk roads impassable. Some rail lines would be closed. Most waterways would be closed to traffic due to strong currents and water levels.	**Moderate (3)**	**Possible (4)**	**HIGH**
Severe Weather	**(SW8) Major local fluvial flooding**		
Outcome description	**Impact**	**Likelihood**	**Overall Risk**
A sustained period of heavy rainfall extending over two weeks, perhaps combined with snow melt, resulting in steadily rising river levels. Localised flooding of more than 1,000 and less than 10,000 properties. Major impact on minor roads and some A and trunk roads impassable. Some rail lines would be closed. Most waterways would be closed to traffic due to strong currents and water levels.	**Moderate (3)**	**Unlikely (3)**	**HIGH**
Severe Weather	**(SW9)Localised fluvial flooding (flash flooding)**		
Outcome description	**Impact**	**Likelihood**	**Overall Risk**
Heavy localised rainfall in steep valley catchment leading to flash flooding. Likely that no flood defences in place. Possibility no flood warning service available / suddenness of events means timely flood warnings not possible. Flooding of up to 200 properties.	**Moderate (3)**	**Possible (4)**	**HIGH**

Source: Gloucestershire LRF Community Risk Register

6.11.3 The plan goes on to give details of flood warning and mitigation (as presented in Section 6.10), then gives information on immediate response. This details the roles and responsibilities of the County Council, LPAs, Gloucestershire Constabulary, Gloucestershire Fire and Rescue Service, Great Western Ambulance Service, the Environment Agency, British Waterways, utility companies, Gloucestershire Primary Care Trust, the media and the general public are put forwards.

6.11.4 Of particular relevance is the LPA roles and responsibilities. The primary role of local authorities in responding to any emergency is to provide care and support for those affected. They deliver this through close working partnerships with the emergency services and other agencies involved in the combined response. In Gloucestershire both the District Councils and the County Council's involvement may be required in responding to a flooding emergency. The District Councils, as land drainage authorities, are primarily responsible for assisting with flooding to property, whereas the County Council is primarily responsible with flooding on the highway.

6.11.5 The Area Highways Managers within Gloucestershire Highways will deal with flooding of highways. Each of the Area Depots has a stockpile of sandbags and a supply of sand, which can be used to assist in preventing highway runoff entering houses, etc. District Councils provide different levels of out-of-hours service within the County in respect of the provision of sandbags to the public. The public are expected to take reasonable measures to protect their own property and to assist this public information has been disseminated. Response may be provided at a County and/or District level as summarised in the table below. In principle, Districts will provide the service and the County will support unless the incident severely affects more than one District such that County resources are required.

Table 6. 5: County and District Flood Response Responsibilities

Required Response	County Responsibility		District Responsibility
Co-ordination of the local authority response and liaison with other organisations, including provision if required of a representative to support Police arrangements for coordination	✓	Or	✓
Emergency care including feeding, accommodation and welfare for those who have been evacuated from their homes or those affected by flooding but remaining in their homes	✓	And	✓
Emergency transport for personnel, equipment, materials such as sandbags and, if necessary, evacuation	✓	And	✓
Information services for liaison with the media on the local authority response and for information to the public, relatives of evacuees etc.	✓	Or	✓
Flood alleviation – for flood prevention, such as issuing of sandbags, clearance of blocked culverts, for dealing with flooded roads and diversions and for other assistance to the public, such as drying-out facilities, and issuing of sandbags	✓	And	✓
Emergency environmental health advice for action relating to environmental problems caused by flooding			✓
Joint agency co-ordination of non-life threatening floods and of the recovery phase following a flooding incident	✓	Or	✓
Co-ordination of the voluntary response	✓		

6.11.6 As the emphasis moves from the immediate response to the recovery phase, the local authority will take the lead role to facilitate the rehabilitation of the community and the restoration of the environment. Involvement may include the provision of welfare needs and access to appropriate personal, social, psychological and financial support.

6.11.7 Where there is a need to evacuate people the District Council for the area concerned has the responsibility for providing Rest Centres and the provision of transport. It is recognised that during a

sudden onset emergency the public may be evacuated to any site deemed necessary by the emergency services. As such the County and District Councils will work together to provide what support is deemed necessary at that site and arrange transport to transfer to a designated Rest Centre.

Stroud District Council Flood Response Plan

6.11.8 The Council's website states that Stroud District Council's role is to assist the emergency services in the event of a major civil emergency. This assistance would mainly take the form of safely accommodating evacuees and help at the scene of the emergency. Three teams, Welfare, Operations and Emergency, exist to carry out these tasks.

6.11.9 Emergency Management is undertaken in close co-operation with Gloucestershire County Council, which has a dedicated Emergency Management unit. The Council's website provides details of the County Council's emergency planning information.

6.11.10 Following the summer 2007 flood events, the Council is currently updating the Emergency Plan.

Emergency Response Plan Recommendations

6.11.11 It is recommended that the Council's Emergency Response Plan is reviewed and updated in light of the findings of the SFRA to ensure that safe evacuation and access for emergency services is possible during times of flood both for existing developments and those being promoted as possible sites within the LDF process. It is further recommended that the Council works with the Environment Agency to promote the awareness of flood risk to maximise the number of people signed up to the FWD service (previously this has involved targeted mail shots to those identified as living within Flood Zone 3a). Within the study area particular attention should be given to vulnerable people including those with impaired hearing or sight and those with restricted mobility.

6.11.12 Following the summer 2007 flood events, it is recommended that a review of designated rest centres and other major facilities should be carried out to ensure that they have the necessary levels of resilience to enable them to be used in the response to flooding and other major emergencies, or that alternative arrangements are put in place. A review of current local arrangements for water rescue should also be carried out to consider whether they are adequate in light of the summer's events and the community risk register. Further, Local Resilience Forums should consider the vulnerability of motorways and trunk roads to flooding and consider the potential for warnings and strategic road clearance and closures to avoid people becoming stranded. Finally, the community risk register should reflect risks to critical infrastructure from flooding and other hazards.

6.11.13 With respect to new developments, those proposing the development should take advice from the Council's emergency planning officer and for large-scale developments, the emergency services, when producing an evacuation plan as part of a FRA. As a minimum these plans should include information on:

- How flood warning is to be provided:
  - Availability of existing warning systems
  - Rate of onset of flooding and available warning time and

- Method of dissemination of flood warning

- What will be done to protect the infrastructure and contents:
  - How more easily damaged items could be relocated
  - The potential time taken to respond to a flood warning
  - Ensuring safe occupancy and access to and from the development
  - Occupant awareness of the potential frequency and duration of flood events
  - Provision of safe (i.e. dry) access to and from the development
  - Ability to maintain key services during an event
  - Vulnerability of occupants and whether rescue by emergency services may be necessary and feasible
  - Expected time taken to re-establish normal practices following a flood event

6.11.14 In some areas, particularly for existing properties and proposed developments behind defences, it may be necessary to extend the scope of the SFRA to Level 2. The outputs from detailed overtopping and breach analysis of the key defences will provide refined hazard information on flood depths, velocities and flow paths, which could be used by the LPA emergency planning teams to define new or refine existing emergency plans for these areas.

6.12 Key Recommendations: Chapter Six

- The relevant CFMP policies, outlined in the SFRA, should be taken into account in the Council's own flood risk management policies.
- Development behind defences should be avoided. Where development behind defences is required, breach and overtopping scenarios will need to be assessed through a Level 2 SFRA.
- Informal defences (e.g. road and railway embankments) should only be relied upon to protect new development following an FRA, undertaken in accordance with paragraph 6.17 of the PPS25 Practice Guide (2006).
- Further culverting and building over of culverts should be avoided. All new developments with culverts running through their site should seek to de-culvert rivers.
- If de-culverting is not possible, an assessment of the state of the culvert should be made, and any remedial works carried out prior to the development of the site. In addition, the residual risk arising from a potential blockage of the culvert should be assessed through a Level 2 SFRA.
- Regular inspection and clearance of culverts and trash screens should be carried out to reduce the risk of blockage during a flood event, which can exacerbate flooding.
- Areas of extended floodplain, acting as natural storage areas, should be safeguarded from development and maintained to ensure their efficient operation during a flood event.
- Flood Zone 3b should be protected from development, the use of green corridors in flood risk areas should be promoted and the natural course of rivers should be restored. These will all act as a means of risk reduction and should be explored through the planning process.
- Any development in the vicinity of culverts, surface water conveyance systems, storage areas and pumped drainage systems should assess residual risk through a Level 2 SFRA.
- The Council's Emergency Response Plan should be reviewed and updated in light of the findings of the SFRA to ensure that safe evacuation and access for emergency services is possible during times of flood both for existing sites and those being promoted through the LDF.
- The Council should work with the Environment Agency to promote the awareness of flood risk to maximise the number of people signed up to the Flood Warnings Direct service (previously this has involved targeted mail shots to those identified as living within Flood Zone 3a). Particular attention should be given to vulnerable people including those with impaired hearing or sight and those with restricted mobility.

7 Flood Risk Management Policy Considerations

7.1 Overview

7.1.1 This chapter provides recommendations for what should be included in the Council's policy for flood risk management. Council policy is considered essential to ensure that the recommended development control conditions can be imposed consistently at the planning application stage. The suggested policies put forward in this section take a strong lead from PPS25, Making Space for Water, the Water Framework Directive and the Severn Tidal Tributaries CFMP.

7.1.2 The policy recommendations provided in this chapter are not exhaustive and it is therefore recommended that the Council refers to the following key flood risk management documents in order to fully inform their own flood risk management policies:

- **Planning Policy Statement 25: Development and Flood Risk** – sets out national policy for development and flood risk and supports the Government's objectives for sustainable communities.
- **Severn Tidal Tributaries CFMP** - strategic planning document through which the Environment Agency will work with other stakeholders to identify and agree policies for long-term flood risk management over the next 50 to 100 years.
- **Making Space for Water** - outlines the Government's proposals for forward planning of flood management over the next 20 years advocating a holistic approach to achieve sustainable development. The protection of the functional floodplain is central to the strategy.
- **Water Framework Directive** - European Community (EC) water legislation which requires all inland and coastal waters to reach good ecological status by 2015.

7.2 Policy Considerations

7.2.1 A key aim of an SFRA is to define flood risk management objectives and identify key policy considerations. It should be noted that it is ultimately the responsibility of the Council to formally formulate these policies and implement them.

7.2.2 It is recommended that the following flood risk objectives are taken into account during the policy making process and, where appropriate, used to strengthen or enhance the development control policies provided in Section 7.3.

7.2.3 **Flood Risk Objective 1: To Seek Flood Risk Reduction through Spatial Planning and Site Design:**

- Use the Sequential Test to locate new development in least risky areas, giving highest priority to Flood Zone 1
- Direct new development away from flood risk areas and areas that are currently defended along the Severn Estuary to enable the Environment Agency to achieve the long-term goal of 'retreating the line'
- Use the Sequential Test and approach within development sites to inform site layout by locating the most vulnerable elements of a development in the lowest risk areas. For example, the use of

low-lying ground in waterside areas for recreation, amenity and environmental purposes can provide an effective means of flood risk management as well as providing connected green spaces with consequent social and environmental benefits

- Ensure that a positive gain in floodplain storage capacity is provided on-site and ensure that there is no negative impact on flood conveyance routes
- Build resilience into a site's design (e.g. flood resistant of resilient design, raised floor levels)
- Identify long-term opportunities to remove development from the floodplain through land swapping, particularly along the Severn Estuary
- Ensure development is 'safe'. For residential developments to be classed as 'safe', dry pedestrian access to and from the development should be possible without passing through the 1% AEP (1 in 100 year) plus climate change floodplain; emergency vehicular access should be possible during times of flood; and the development should include flood resistance and resilience measures to ensure it is safe. Residual risk, i.e. the risks remaining after taking the sequential approach and taking mitigating actions, during the 1 in 1000 year event, should also be 'safe'.
- Avoid development immediately downstream/adjacent to reservoirs/impounded water bodies which will be at high hazard areas in the event of failure.

7.2.4 Flood Risk Objective 2: To Reduce Surface Water Runoff from New Developments and Agricultural Land:

- SUDS are required on all new development. Section 10.4 outlines appropriate SUDS techniques for the District and Chapter 9 provides further guidance for developers on the application of SUDS.
- As part of any ongoing or future development within the District, the treatment and control of surface water runoff should provide a level of betterment, incorporating the use of various SUDS techniques as outlined in section 10.4.
- All sites should meet the following criteria:
  - As a minimum there should be no increase in the peak discharges/volumes from any existing Greenfield site and at minimum a 20% reduction of peak discharges/volumes from any existing Brownfield site where an existing positive drainage system has been identified
  - Attenuation should be provided to a 1 in 100 year standard taking account of climate change
  - Space should be specifically set aside for SUDS and used to inform the overall site layout
  - Promote environmental stewardship schemes to reduce water and soil runoff from agricultural land

  However, a greater level of betterment may be required within specific locations or areas of the county where necessary due to local issues as identified by any local authority or other appropriate drainage authority.

- All sites require the following approach to be taken:
  - Application of a SUDS management train
  - A hierarchical approach should be applied to the SUDS used:
    1. Preventative measures to ensure that there are not unnecessary impermeable areas on-site
    2. Source control measures such as rainwater harvesting and infiltration systems provided site conditions are appropriate
    3. Site control measures where prevention and source control measures alone cannot deal with all on-site drainage. Above ground attenuation systems, such as balancing ponds and swales, should be considered in preference to below ground attenuation, due to the water quality, biodiversity and amenity benefits they offer
    4. Regional control measures should only be considered where none of the above preferred options can be achieved
- A hierarchical approach should also be applied to the disposal of surface water from the site taking the following order: rainwater harvesting systems, an adequate soakaway or other adequate infiltration system, a watercourse, a surface water sewer and, only as a last resort, a combined sewer
- Exceedance design measures should be applied to ensure that extreme events above the design standards of the system do not pose adverse impacts
- SUDS should be designed for the lifetime of the development, with suitable provisions for likely future permitted and minor development e.g. paving of front gardens or minor extensions (it may be possible to achieve this either through suitable planning or engineered solutions)

7.2.5 Flood Risk Objective 3: To Enhance and Restore the River Corridor:

- Those proposing development should look for opportunities to undertake river restoration and enhancement as part of a development to make space for water. Enhancement opportunities should be sought when renewing assets (e.g. de-culverting, the use of bioengineered river walls, raising bridge soffits to take into account climate change)
- An assessment of the condition of existing assets (e.g. bridges, culverts, river walls) should be made. Refurbishment or/and renewal should be made to ensure the lifetime is commensurate with lifetime of the development. Developer contributions should be sought for this purpose. When the structure is beyond its life, and/or no longer required, the first consideration should be to remove the structure. If it is identified that the structure is still required but still requires replacement, opportunities for further enhancement work should be sought.
- Avoid further culverting and building over of culverts. All new developments with culverts running through their site should seek to de-culvert rivers for flood risk management and conservation benefit

- Set development back from rivers, seeking a minimum 8 metre wide undeveloped buffer strip from the top of bank

7.2.6 Flood Risk Objective 4: To Protect and Promote Areas for Future Flood Alleviation Schemes

- Protect Greenfield functional floodplain from future development (our greatest flood risk management asset) and reinstate areas of functional floodplain which have been developed (e.g. reduce building footprints or relocate to lower flood risk zones)
- Develop appropriate flood risk management policies for the Brownfield functional floodplain, focusing on risk reduction
- Identify sites where developer contributions could be used to fund future flood risk management schemes or can reduce risk for surrounding areas
- Seek opportunities to make space for water to accommodate climate change

7.2.7 Flood Risk Objective 5: To Improve Flood Awareness and Emergency Planning

- Seek to improve the emergency planning process using the outputs from the SFRA
- Encourage all those within Flood Zone 3a and 3b (residential and commercial occupiers) to sign-up to Floodline Warnings Direct service operated by the Environment Agency, where this service can be provided
- Ensure robust emergency (evacuation) plans are implemented for new developments in areas at risk of flooding

7.3 Development Control Policies

7.3.1 For the purposes of development control, detailed policies will need to be set out to ensure that flood risk is taken account of appropriately for both allocated and non-allocated 'windfall' sites. In all Flood Zones, developers and local authorities should realise opportunities to reduce the overall level of flood risk in the area and beyond through the location, layout and design (in that order) of development.

7.3.2 The following reflects the minimum requirements under PPS25 (reference should be made to Tables D1-D3 in PPS25).

Future Development within Flood Zone 1

7.3.3 There is no significant flood risk constraint placed upon future developments within the Low Probability Flood Zone 1 (unless the issues outlined in Section 8.4 are identified), although the vulnerability from other sources of flooding should be considered as well as the effect of the new development on surface water runoff.

7.3.4 Typically, a Drainage Impact Assessment will be required to demonstrate that the treatment and control of surface water runoff can provide a level of betterment, incorporating the use of various SUDS techniques, which should take into account the local geological and groundwater conditions. As a minimum, there should be no increase in the peak discharges/volumes from any existing Greenfield site and at minimum a 20% reduction of peak discharges/volumes from any existing Brownfield site where an existing positive drainage system has been identified.

7.3.5 Consideration must be given to the effect of the new development in terms of off-site consequences from all sources of flooding.

7.3.6 For sites where the access and egress routes are within Flood Zone 3 or 2, the site should be considered as if being within that higher Flood Zone itself.

Future Development within Flood Zone 2

7.3.7 Land use within Medium Probability Flood Zone 2 should be restricted to the 'water compatible', 'less vulnerable' and 'more vulnerable' category, though it will be necessary to undertake the Sequential Test. Should the Exception Test be required a Level 2 SFRA should be carried out.

7.3.8 Where other planning pressures dictate that 'highly vulnerable' land uses should proceed, it will be necessary to ensure that the requirements of the Exception Test are satisfied.

7.3.9 The following is required:

- A detailed site-specific FRA should be prepared in accordance with PPS25 and Council Development Control policies
- Floor levels should be situated above the 100 year plus climate change predicted maximum level plus a minimum freeboard of 600mm
- Safe dry pedestrian access to and from the development should be possible above the 1% AEP (1 in 100 year) flood level with an appropriate allowance for climate change and emergency vehicular access should be possible during times of flood
- Flood resistance and resilience should be incorporated into the design
- People (including those with restricted mobility) should be able to remain safe inside the new development up to a 0.1% AEP (1 in 1000 year) event; and rescue and evacuation of people from a development (including those with restricted mobility) to a place of safety is practicable up to a 0.1% AEP (1 in 1000 year) event
- The treatment and control of surface water runoff should provide a level of betterment, incorporating the use of various SUDS techniques. As a minimum there should be no increase in the peak discharges/volumes from any existing Greenfield site and at minimum a 20% reduction of peak discharges/volumes from any existing Brownfield site where an existing positive drainage system has been identified
- The proposed development should be set-back from the watercourse with a minimum 8m wide undeveloped buffer zone from top of bank, to allow appropriate access for routine maintenance and emergency clearance.

Future development within High Probability Flood Zone 3a

7.3.10 Land use with High Probability Flood Zone 3a should be restricted to the 'less vulnerable' uses to satisfy the requirements of the Sequential Test. For 'more vulnerable' uses it is necessary to ensure that the requirements of the Exception Test are satisfied, which will require a Level 2 SFRA.

7.3.11 The following should be considered:

- A detailed site-specific FRA should be prepared in accordance with PPS25 and Council Development Control policies. Properties situated within close proximity to formal defences or water retaining structures (reservoirs/canals) will require a detailed breach and overtopping assessment to ensure that the potential risk to life can be safely managed throughout the lifetime of the development. The nature of any breach failure analysis should be agreed with the Council, the Environment Agency and/or the operating authority, as appropriate.

- The development should not increase flood risk elsewhere, and opportunities should be taken to decrease overall flood risk (such as use of SUDS and de-culverting). This should be optimised by developing land sequentially, with areas at risk of flooding favoured for green space. There should be a positive gain in the floodwater storage capacity provided and there should not be any detrimental impact on floodwater flow conveyance.

- Floor levels should be situated above the 100 year plus climate change predicted maximum level plus a minimum freeboard of 300mm. Within defended the areas the maximum water level should be assessed from a breach analysis. Where there is sufficient depth between the underside of the floor slab and the existing ground level, under-floor voids should be included with adequate void openings.

- The development should allow safe dry pedestrian access to and from the development above the 1% AEP (1 in 100 year) flood level with an appropriate allowance for climate change emergency vehicular access should be possible during times of flood.

- An evacuation plan should be prepared. With respect to new developments, those proposing the development should take advice from the LPAs emergency planning officer and for large-scale developments, the emergency services, when producing an evacuation plan as part of a FRA. All access requirements should be discussed and agreed with the Council and the Environment Agency.

- Basements should not be used for habitable purposes. Where basements are permitted for commercial use, it is necessary to ensure that the basement access points are situated 600 mm above the 1 in 100 year flood level plus climate change.

- The treatment and control of surface water runoff should provide a level of betterment, incorporating the use of various SUDS techniques. As a minimum there should be no increase in the peak discharges/volumes from any existing Greenfield site and at minimum a 20% reduction of peak discharges/volumes from any existing Brownfield site where an existing positive drainage system has been identified. Space should be set aside for SUDS.

- The proposed development should be set-back from the watercourse with a minimum 8m wide undeveloped buffer zone from top of bank, to allow appropriate access for routine maintenance and emergency clearance.

- For sites where the access and egress routes are within Flood Zone 3 or 2, the site should be considered as if being within that higher Flood Zone itself.

Future development within Functional Floodplain Zone 3b

7.3.12 This zone comprises land where water has to flow or be stored in times of flood (land which would flood with an annual probability of 5% (1 in 20 year) or greater in any year or is designed to flood in an extreme (0.1%) flood, including water conveyance routes. Where a modelled outline for Flood Zone 3b has not been produced, its extent is equal to Flood Zone 3a. Therefore for any development site falling in Flood Zone 3a with no 3b available, this section should be used to understand the requirements of development.

- Development in High Probability Flood Zone 3b should be restricted to 'water-compatible uses' only.
- PPS25 dictates that 'essential infrastructure' can be located in Flood Zone 3b if the Exception test is passed (this would require a Level 2 SFRA). However, appropriate judgement should be exercised when attempting the Exception Test for essential infrastructure in Flood Zone 3b. Essential infrastructure includes: essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk; and strategic utility infrastructure, including electricity generating power stations and grid and primary substations. Essential transport infrastructure may be appropriate if designed in such a way that flood flow routes and flood storage areas are not affected (e.g. designing a bridge to cross the flood risk area). However, utility infrastructure may be less appropriate due to the potential consequences that may occur should the utility site become flooded (as demonstrated by the flooding of Mythe Treatment Works, Castlemeads electricity sub-station and the near-flooding of the Walham electricity sub-station during the summer 2007 flood events).
- 'Essential infrastructure' in this zone must be designed and constructed to remain operational in times of flood and not impede water flow.
- Associated buildings, such as boathouses, should be situated outside 3b and should follow the guidance for development in the relevant Flood Zone (as outlined above)
- Building extensions proposed in 3b should be discouraged. Where permitted, they should follow the guidelines of 3a (as outlined above). The local authority should request and review an FRA for the extension. The FRA should demonstrate that the extension will minimise the impact on flow conveyance and lost storage.

7.4 Council Specific Policy Issues

7.4.1 The Severn Tidal Tributaries CFMP, which covers the entire District, has been reviewed so that relevant policies can be included in the SFRA. The below paragraphs outline the policies that are relevant to Stroud District Council.

7.4.2 In the short term, the Environment Agency's policy for the Severn Estuary is to continue to protect features or assets by maintenance of the existing defences. In the long term, however, the policy is to retreat the line. This will be confirmed by work planned for the near future. This will involve moving defences away from their current position to a location further away from the riverbank, particularly in agricultural areas away from settlements or major infrastructure. The policy of retreat will, however, be constrained by how much settlements, infrastructure or other interests can be defended locally. This policy will have implications for future development in the District. Indeed, Council can help deliver

this policy by ensuring new development does not take place in areas along the estuary which are shown to be at risk and/or are currently defended. Such areas are likely to be exposed to greater flood risk in the future (due to climate change) and may well be earmarked for long term retreat in the future. When buildings within defended areas reach the end of their natural life, the Council should consider the option of not re-developing the site.

7.4.3 In terms of flood risk in the remainder of the District, for the most part channel and defence maintenance and unblocking of structures will continue, though the District will be susceptible to the impacts of climate change. In light of the likely impacts of climate change (see Section 5.5) the Council should seek to ensure that Flood Zones 2 and 3 remain undeveloped, because climate change will increase the flood risk in these areas in the future. In Stroud, Nailsworth, Rainswick and Stonehouse (the Frome Catchment) the Environment Agency intends to maintain the current level of flood risk and respond to changes that may come about from climate change (this will include maintaining defences and improving them where necessary in response to flood risk). Development behind defences will require careful consideration as residual risks will remain, now and in the future.

7.5 Sensitive Development Locations

7.5.1 As discussed above, The Severn Estuary will be subject to increased storm surges and wave height in the future, and the Environment Agency plans to implement managed retreat. Development proposals in this area should be treated with caution; indeed, the Council should seek to ensure that development does not take place in areas along the Severn estuary which are currently defended or shown to be at risk.

7.5.2 In light of the District's susceptibility to climate change (deeper flooding in the Frome catchment, increase in flood extent in the Little Avon and Cam catchments especially in Dursley) developments in Flood Zones 2 and 3 should be discouraged, not least because of the detrimental impact this will have on flood storage and flood flows.

7.5.3 Therefore, assuming that future site allocations and windfall sites are guided by PPS25 and the recommendations provided in this report, there are few other locations in which development would significantly increase flood risk.

7.5.4 In general, any development (including developments in Low Probability Flood Zone 1) which does not incorporate appropriate SUDS methods may increase the risk of surface and/or fluvial flooding both on-site and off-site (downstream). As such effective development control policies to incorporate SUDS on all new development should be implemented. Site-specific assessments will be required to ensure the appropriate SUDS method is implemented in accordance with geological conditions.

7.5.5 Areas within the District are protected by defences, with resultant residual risk areas. Any development situated behind defences will need careful consideration. The following paragraph comes from the PPS25 Practice Guide Companion (2006):

"When proposing new development behind flood defences, the impact on residual flood risk to other properties should be considered. New development behind flood defences can increase the residual flood risk, should these defences breach or overtop, by disrupting conveyance routes (flow paths) and/or by displacing flood water. If conveyance routes that allow flood water to pass back into a river following failure of a flood defence are blocked this will potentially increase flood risk to existing properties. If there is a finite volume of water able to pass into a defended area following a failure of

the defences, then a new development, by displacing some of the flood water, will increase the risk to existing properties".

7.5.6 Therefore any development behind defences should be appropriately assessed through a Level 2 SFRA, to ensure no increased risk elsewhere in the event of a defence breach or overtopping.

7.5.7 The natural floodplain of watercourses in the study area is an important feature in terms of flood risk management. Future development sites should be guided away from these areas using the Sequential Test, and in line with recommended policies, should be safeguarded for the future. Any development in these areas would have detrimental effect on flood risk in the immediate vicinity and downstream, by the displacement of flood water.

7.5.8 Finally, it is clear that numerous culverts exist in the study area. Culverts pose a residual risk if river flows are greater than their capacity, if they become blocked, or if they collapse. Any development upstream of culverts should appropriately assess the structural integrity, clearance and maintenance regime and capacity, to ensure all residual risks to the development are minimised. All options for de-culverting should be explored.

7.6 Key Recommendations: Chapter Seven

- The suggested flood risk management policies outlined in Section 7.2 should be taken into account during the policy making process and, where appropriate, used to strengthen or enhance the development control policies provided in Section 7.3.
- For the purposes of development control, detailed policies will need to be set out to ensure that flood risk is taken account of appropriately for both allocated and non-allocated 'windfall' sites. Recommendations are outlined in Section 7.3, which should be followed.
- Sections 7.4 and 7.5 should be referred to when considering council-specific policies and sensitive development locations respectively.

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8 Guidance on Application of the Sequential Approach & Sequential Test

This section provides guidance on how to apply the Sequential Approach and Sequential Test. Guidance on how windfall sites should be dealt with is given in Section 7.3

8.1 The Sequential Approach

8.1.1 The Sequential Approach is a simple decision-making tool designed to ensure that areas at little or no risk of flooding are developed in preference to areas at higher risk. PPS25 (paragraphs 14-15) sets out the requirement to apply the Sequential Approach. The aim of the Sequential Approach should be to keep all new development out of medium and high risk areas (Flood Zones 2 and 3) and away from locations affected by other sources of flooding. Opportunities to locate new developments in reasonably available areas of little or no flood risk should be explored, prior to any decision to locate them in areas of higher risk.

8.2 The Sequential Test

8.2.1 The Sequential Test refers to the application of the Sequential Approach, by the Council. The Sequential Test is a key component of the hierarchical approach to avoiding and managing flood risk. The Sequential Test is outlined in PPS25, paragraphs 16-17, as well as Annex D, paragraphs D1-D8 and tables D1-D3.

8.2.2 When allocating land for development, the LPA must demonstrate that it has applied the Sequential Test and has attempted to place all new development in Flood Zone 1 (and away from other sources of flooding). Guidance as to how to apply the Sequential Test is outlined herein.

8.3 Step One: Strategic Overview of flood risk across all potential development areas

8.3.1 The recommended initial step is to determine the extents of potential land allocations on a GIS system. GIS layers of the most up-to-date Flood Zones, main and minor watercourses, canals, flooding from other sources data, defences, culverts and ABDs (located in the CD attached to the front of this report) should then be superimposed on the site layers. Summary tables of flood risk issues should then be prepared for each location, indicating if the potential sites overlap Flood Zones 2, 3, localised flooding areas or if there are records of historic fluvial flood incidents shown in the maps (a template to assist with this process is provided in Appendix F). This can be carried out by a consultant to ensure all issues are fully captured. For the site allocations process, as part of the LDF, it is then recommended that the summary tables and proposed locations are sent to the Environment Agency for verification. Particular care should be taken by identifying allocations that could increase flood risk elsewhere (flood incident points, localised flooding areas, Flood Zones) and lack of dry access.

8.4 Step Two: Flood Risk Issues in Zone 1

8.4.1 The next step should be to analyse all potential sites within Zone 1 by identifying those that:

- Have watercourses without Flood Zone information
- Are affected by flooding from sources other than rivers or have been affected by historic flood events

- Do not have safe dry access routes during flood events (i.e. a site with its access and egress route being within Flood Zone 3 would be sequentially considered as being within Flood Zone 3 itself)

Each of these points is addressed below.

8.4.2 For any development site containing or located adjacent to a watercourse without Flood Zone information, it is recommended that a minimum 8m development easement from the top of bank is applied, and a site specific FRA is undertaken.

8.4.3 For sites with evidence of flooding from other sources, or have been affected by historic flood events (where the source may be unknown), the Sequential Approach should be used to steer new development away from these areas. An assessment of likely significance of flood risk should be carried out in terms of likely probability of flooding and potential consequences/flood damages (advice from a drainage specialist may be required, such as the SFRA consultant, the Environment Agency, a highways drainage engineer and/or the planning authority drainage specialist). The purpose is to identify sites with significant flood risk, which may need to be facilitated by a Level 2 SFRA. If a site with significant flood risk is identified within Zone 1, this should be considered as if it was in the High Probability Zone 3a, for further application of the Sequential Test in Zone 3a (see Section 8.5), bearing in mind that if a more vulnerable land use is required for the site, it will have to pass the Exception Test. Where these tests are passed, the development must include flood resilience and resistance measures. The potential site owners/residents must also be made aware that they live/work in a localised flood risk area.

8.4.4 Sites without safe dry access routes during flood events are not likely to be able to proceed unless road raising works could be identified that would not impede flood flows or cause a loss in the floodplain storage capacity of the floodplain. This may not always be possible.

8.4.5 It is important to note that most potential sites that pass the Sequential Test in Zone 1 will still require site-specific FRAs. The vulnerability to flooding from other sources (as well as from river flooding) and the potential to increase flood risk elsewhere through the addition of hard surfaces and the effect of the new development on surface water runoff, with appropriate mitigating action, should be incorporated in an FRA. This need only be brief unless the factors above or other local considerations require particular attention. It is recommended that FRAs are produced for Zone 1 sites of less than one hectare, at locations where there are records of previous flood incidents.

8.5 Step Three: Sequential Test in Zones 2 and 3

8.5.1 The third step is to sequentially allocate sites as part of a SA. It is recommended that prior to incorporating the Sequential Test within the SA, the following actions take place:

a) Apply the measure of avoidance/prevention by moving the boundaries of the potential sites away from Zones 2, 3a and 3b, ensuring flood risk areas remain as open space and river enhancements are undertaken (such as the removal of culverts) as part of the regeneration process.

b) Provisionally adopt land uses that are fully compatible with the vulnerability classification of PPS25, to try to avoid the need to apply the Exception Test where possible.

8.5.2 Once this has all been carried out, the need to apply the Exception Test might be identified. It is important to note that the Exception Test should only be carried out when it is not possible, or consistent with wider sustainability objectives, for the development to be located in zones of lower probability of flooding. The Exception Test is also only appropriate for use when there are large areas in Flood Zones 2 and 3, where the Sequential Test alone cannot deliver acceptable sites, but where some continuing development is necessary for wider sustainable development reasons (the need to avoid social or economic blight and the need for essential civil infrastructure to remain operational during floods). It may also be appropriate to use it where restrictive national designations such as landscape, heritage and nature conservation designations, e.g. Areas of Outstanding Natural Beauty (AONBs), Sites of Special Scientific Interest (SSSIs) and World Heritage Sites (WHS), prevent the availability of unconstrained sites in lower risk areas.

8.5.3 The need to apply the Exception Test should always prompt the production of a Level 2 SFRA.

8.6 Application of the Sequential Approach to Other Sources of Flooding

8.6.1 Development proposals in any location (Flood Zones 1, 2, 3a and 3b) must take into account the likelihood of flooding from sources other than rivers and the sea (where applicable). The principle of locating development in lower risk areas should therefore be applied to other sources of flooding.

8.6.2 The information collated within the SFRA has identified areas in which risk from other sources of flooding is likely to be an important consideration. The Council should therefore use the Sequential Approach to steer new development away from areas at risk from other sources of flooding, as well as fluvial.

8.6.3 The SFRA has highlighted areas where information of flooding from other sources is currently poorly understood or will require further refinement in the future. Of particular relevance is the fact that the Environment Agency now requires further investigation/mapping of surface water flooding to be carried out as part of a Level 2 SFRA, to ensure that potential allocations can be Sequentially Tested against this source of flooding.

8.7 Dealing with Windfall Sites

8.7.1 Any proposal for development on a 'windfall' site will by definition differ to a site allocated in a development plan that has been sequentially tested. Following the completion of the SFRA, the LPA should develop policies in the LDDs on how windfall sites should be treated in flood risk terms (refer to Section 7.3 for suggested policies). LPAs should, through application of the Sequential Test, identify areas where windfall development would be considered as appropriate i.e. defining the type of windfall development which would be acceptable in certain flood risk areas and what the broad criteria should be for submitting a planning application under these circumstances. PPS3 outlines that LPAs should not make allowances for windfall sites for the first ten years of land supply, unless they can demonstrate genuine local circumstances that prevent specific sites being identified. Windfall sites should be subject to the same consideration of flood risk as other housing development.

8.7.2 The Sequential Test should be applied to windfall sites, unless the area and the flood risk vulnerability proposed in which they occur has been sequentially tested on the basis of a SFRA. Where the Sequential Test has not been applied to the area, proposals will need to provide evidence to the LPA that they have adequately considered other reasonably available sites. This will involve considering windfall sites against other sites allocated as suitable for housing in plans.

8.7.3 It should also be noted that paragraphs 4.33-4.39 of the PPS25 Practice Guide (2008) give guidance on applying the Sequential Test to areas requiring redevelopment or regeneration; redevelopment of an existing property and change of use.

8.8 Key Recommendations: Chapter Eight

- The Sequential Test must be carried out on all potential development sites. The aim is to keep all new development out of medium and high risk areas (Flood Zones 2 and 3) and away from locations affected by other sources of flooding.
- GIS layers of all the data depicted on the maps in Volume 2 have been provided with the SFRA. Using a GIS system to superimpose this information on to potential development sites provides an effective means of assessing sites in regard to the Sequential Approach. Using the GIS information, summary tables of flood risk issues should be prepared for each site, indicating if the potential sites overlap Flood Zones 2, 3, localised flooding areas or if there are records of historic fluvial flood incidents shown in the maps (a template to assist with this process in provided in Appendix F). Particular attention should be paid to identifying flood risk issues in Flood Zone 1 (Section 8.4).
- Prior to incorporating the Sequential Test and Exception Test within the Sustainability Appraisal, the following actions must take place:

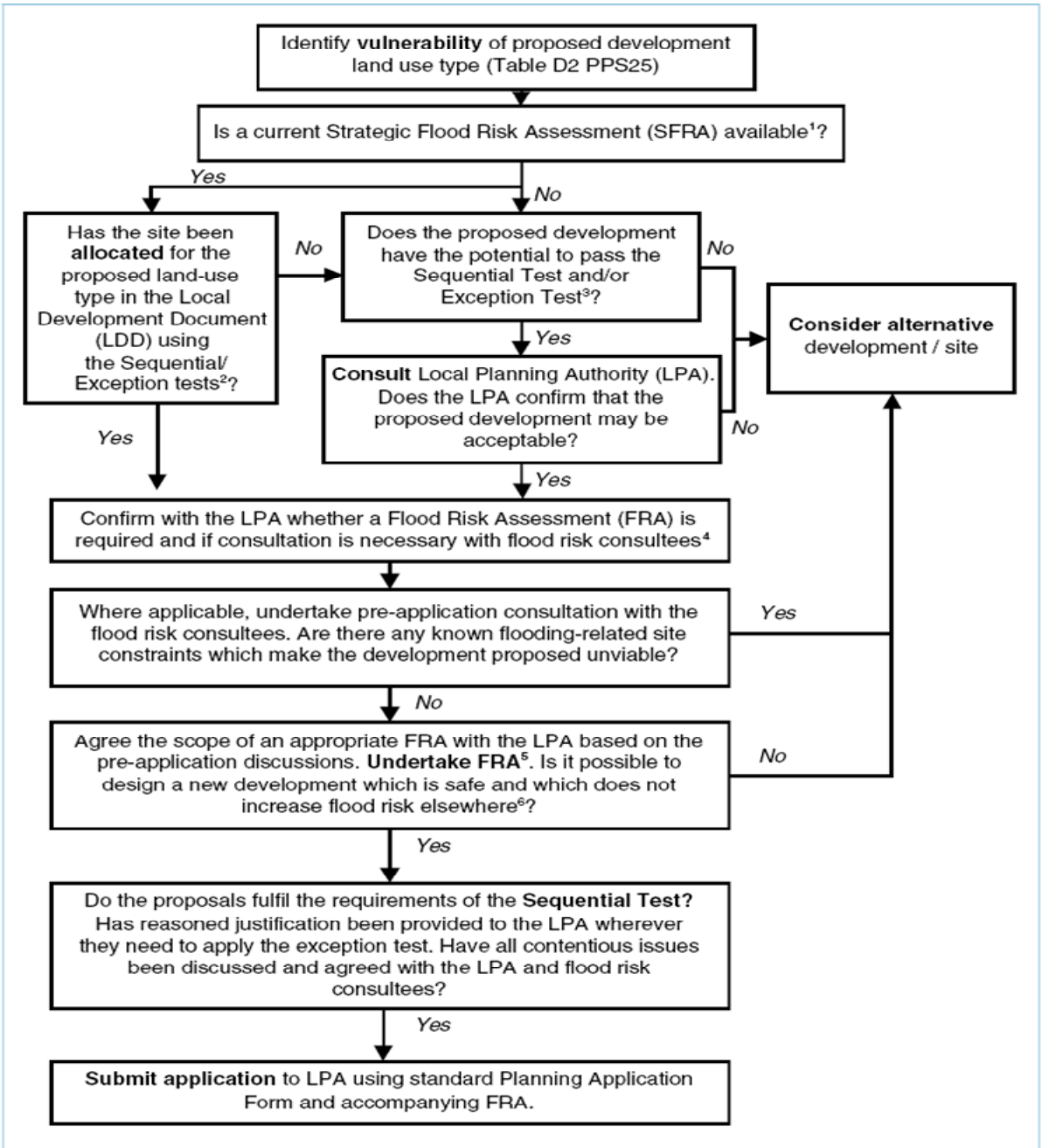
  a) Apply the measure of avoidance/prevention by moving the boundaries of the potential sites away from Zones 2, 3a and 3b, ensuring flood risk areas remain as open space and river enhancements are undertaken (such as the removal of culverts) as part of the regeneration process.

  b) Provisionally adopt land uses that are fully compatible with the vulnerability classification of PPS25, to try to avoid the need to apply the Exception Test where possible.
- Following application of the Sequential Test, if any sites are identified for application of the Exception Test a Level 2 SFRA should be progressed.
- Most potential sites that pass the Sequential Test in Zone 1 will require site-specific FRAs.
- It is recommended that FRAs are produced for Zone 1 sites of less than one hectare, at locations where there are records of previous flood incidents.
- The Sequential Test should be applied to windfall sites, unless the area and the flood risk vulnerability proposed in which they occur has been sequentially tested on the basis of a SFRA.
- Paragraphs 4.33-4.39 of the PPS25 Practice Guide (2008) give guidance on applying the Sequential Test to areas requiring redevelopment or regeneration; redevelopment of an existing property and change of use.

9 Guidance for Developers

9.1.1 Site-specific FRAs will be required for most proposed developments and the level of detail will depend on the level of flood risk at the site (see general details about FRA requirements in Appendix E in PPS25). A FRA should assess flooding from other sources at the site-specific level and offer mitigating options for the management of the risk, without increasing flood risk elsewhere. The onus is on the developer to provide this information in support of a planning application. Prior to undertaking a FRA, developers should ensure that the Sequential Test has been passed at the site to ensure that a site-specific FRA is required and unnecessary time and expenditure is avoided.

9.1.2 Since the release of PPS25 in December 2006, the Environment Agency has power of direction over the determination of planning applications, which can be refused on the grounds of flood risk. Should the Council wish to disregard the advice of the Environment Agency then the planning application could be put before the Secretary of State (as indicated by PPS25 paragraphs 25-29).. It is therefore imperative that developers hold discussions over the need for FRAs early on within the planning process. Consultation should be undertaken with the Environment Agency and the relevant Council to ensure that the Council's policies on flood risk management are respected and taken account of, and that the scope of the FRA is commensurate with the level of flood risk. The following reflects best practice on what should be addressed within a detailed FRA. Those proposing development should also be directed towards Annex F of PPS25 (the figure overleaf shows the recommended process of undertaking an FRA as part of an individual planning application).



Notes

1 A SFRA can be defined as current if it has been prepared in accordance with PPS25.
2 If the site has been allocated in this way then subsequent steps in the process are likely to be significantly more straightforward.
3 If a site has not been allocated in the LDD because it was considered that the flood risk is unacceptable, it is unlikely that a proposed development at the site will be accepted by the LPA.
4 See pages 30-31 for key consultees to the planning process with regard to flood risk.
5 Guidance on undertaking a FRA can be found in Chapter 2.
6 Including surface water management.

Figure 9.1: Guidance for developers for individual planning applications

Note: the footnotes refer to pages in the PPS25 Practice Guide (2006).

9.2 Proposed Development within Flood Zone 1

9.2.1 The risk of other sources of flooding (surface water drainage, sewers, impounded water bodies, groundwater) must be considered, and SUDS techniques must be employed to ensure no worsening of existing flooding problems elsewhere within the area.

9.2.2 The SFRA provides specific recommendations with respect to the provision of sustainable flood risk mitigation opportunities that will address both the risk to life and the residual risk of flooding to development within particular 'zones' of the area. These recommendations should form the basis for the site-based FRA.

9.3 Proposed Development within Medium Probability Zone 2

9.3.1 For all sites within Medium Probability Zone 2, a scoping level FRA should be prepared based upon readily available existing flooding information, sourced from the Environment Agency. If there is a significant flood risk from other sources (surface water drainage, sewers, impounded water bodies, groundwater) identified then a more detailed FRA should be prepared. It will be necessary to demonstrate that the residual risk of flooding to the property is effectively managed throughout, for example, the provision of raised floor levels and the provision of planned evacuation routes or safe havens.

9.4 Proposed Developments within High Probability Flood Zone 3a

9.4.1 All FRAs supporting proposed development within High Probability Zone 3a should assess the proposed development against all elements of the Council's flood policy, and include an assessment of the following:

- The risk of flooding to and from the development from other sources (e.g. surface water, sewers, impounded water bodies, groundwater) as well as from river flooding. This will involve discussion with the Council, Environment Agency and/or operating authority to confirm whether a localised risk of flooding exists at the proposed site. Localised flooding may also occur, typically associated with local catchment runoff following intense rainfall passing directly over the area. This localised risk of flooding must also be considered as an integral part of the detailed FRA.

- The risk of flooding to and from the development over its lifetime (including the potential impacts of climate change as well as changes that may occur, such as permitted development), i.e. maximum water levels and depths, flow paths and flood extents within the property and surrounding area. The Environment Agency may have carried out detailed flood risk mapping within localised areas that could be used to underpin this assessment. Where available, this will be provided at a cost to the developer. Where detailed modelling is not available, hydraulic modelling by suitably qualified engineers will be required to determine the risk of flooding to the site.

- The potential of the development to increase flood risk elsewhere through the addition of impermeable surfaces, the effect of the new development on surface water runoff, and the effect of the new development on depth and speed of flooding to adjacent and surrounding property. This will require a detailed assessment to be carried out by a suitably qualified engineer.

- A demonstration that residual risks of flooding (after existing and proposed flood management and mitigation measures are taken into account) are acceptable. Measures may include flood

defences, flood resistant and resilient design, escape/evacuation, effective flood warning and emergency planning.

- Details of existing site levels, proposed site levels and proposed ground floor levels should be provided on maps. A topographic survey and flood extents must be shown on maps to show the full extent of the 1% AEP (1 in 100 year) flood with and without an appropriate allowance for climate change and, where relevant, the extent of the functional floodplain. In addition, where safe access and egress is required, it must be demonstrated on the maps that it can be provided from the property to an area wholly outside of the floodplain.

- Demonstration that a positive gain in floodplain storage capacity is provided. This should be provided through 'level for level' floodplain compensation. Further guidance can be found in the CIRIA document C624 Development and Flood Risk (the use of under-floor voids will not normally, by itself be considered as mitigation).

- Demonstration that the layout and design of the development will not have a detrimental impact upon floodwater flow conveyance.

- Demonstration that opportunities to reduce flood risk and enhance river corridors have been maximised, for example, through the removal of unnecessary obstructions such as culverts or low bridges (subject to these works not causing in themselves an unacceptable increase in flood risk).

- Demonstration that the development is consistent with the relevant CFMP and its policy units

9.4.2 It is essential that developers thoroughly review the existing and future structural integrity of informal defences, if present, upon which the development will rely (i.e. over the lifetime of the development), and ensure that emergency planning measures are in place to minimise risk to life in the unlikely event of a defence failure. This would be particularly important for development that could potentially be affected as a result of a breach of any canals in the study area.

9.5 Proposed Developments within Functional Floodplain Flood Zone 3b

9.5.1 In line with PPS25, after having applied the Sequential Test, development will not normally be allowed in the Functional Floodplain unless it is classified as a 'water compatible' or 'essential infrastructure' use. Table D2 from PPS 25 details the type of developments classified as 'water compatible' or 'essential Infrastructure.' Refer to Section 7.3 for further guidance on compatible uses.

9.6 SUDS Requirements

9.6.1 Annex F of PPS25 outlines a range of SUDS options which could be applied to new development sites. Although not all will be appropriate for individual development sites, a suitable drainage approach should be possible on almost every site. All new development sites will require the following:

- To obtain the most benefit, SUDS must be considered as early as possible in the planning process

- The drainage system to be designed to accommodate all storm events up to and including the 1% AEP (1 in 100 year) event, with an appropriate allowance for climate change

- Application of a SUDS management train
- As outlined in section 10.4, which outlines appropriate SUDS techniques for the District, a hierarchical approach should be applied to the SUDS used, in order of priority:

    1. Preventative measures should be the preferred option i.e. ensuring there are not unnecessary impermeable areas on-site,
    2. Source control measures such as rainwater harvesting and infiltration systems should be the next preferred option, provided the site conditions are appropriate,
    3. Site control measures should be the next preferred option, where prevention and source control measures alone cannot deal with all on-site drainage. Above ground site control attenuation systems, such as balancing ponds and swales, should be considered in preference to below ground attenuation, due to the water quality, biodiversity and amenity benefits they offer.
    4. Regional control measures should only be considered where none of the above preferred options can be achieved.

- A hierarchical approach should be applied to the disposal of surface water from the site referencing in order of priority:

    1. Rainwater harvesting systems
    2. An adequate soakaway or other adequate infiltration system
    3. A watercourse
    4. A surface water sewer
    5. A combined sewer, only as a last resort

- Where prevention, source control/infiltration cannot deal with all on-site site drainage, as a minimum there should be no increase in the peak discharges/volumes from any existing Greenfield site and at minimum a 20% reduction of peak discharges/volumes from any existing Brownfield site where an existing positive drainage system has been identified
- Exceedance design measures to be applied to ensure that extreme events above the design standards of the system do not pose adverse impacts
- A sequential approach should be applied to the site layout to specifically set aside space for SUDS
- They should be designed for the lifetime of the development, with suitable provisions for likely future permitted and minor development e.g. paving of front gardens or minor extensions (it may be possible to achieve this either through suitable planning or engineered solutions).

9.7 Raised Floor Levels and Basements (Freeboard)

9.7.1 The raising of floor levels above the 1% AEP (1 in 100 year) peak flood level will ensure that the damage to property is minimised. Given the anticipated increase in flood levels due to climate change, the adopted floor level should be raised above the 1% AEP (1 in 100 year) flood level with an appropriate allowance for the potential impacts of climate change (refer to Section 5.5).

9.7.2 It is highlighted that many of those areas currently situated within Medium Probability Zone 2 could become part of the High Probability Zone 3. This is important as it means that properties that are today at relatively low risk will, in 20 to 100 years, be within High Probability Zone 3a. It is imperative therefore that planning and development control decisions take due consideration of the potential risk of flooding in future years.

9.7.3 Wherever possible, floor levels should be situated a minimum of 600 mm above the 1% AEP (1 in 100 year) flood level with an appropriate allowance for the potential impacts of climate change, determined as an outcome of the site-based FRA. Additional freeboard may be required because of the risk of blockages to the channel, culverts or bridges. The height that the floor level is raised above the flood level is referred to as the 'freeboard', and is determined as a measure of residual risks. Where the depth between the underside of the floor slab and the existing ground level will allow, under-floor voids should be included with openings. In these instances the voids and openings should reach between the existing ground level and the 1% annual probability (1 in 100 year) flood level with an appropriate allowance for the potential impacts of climate change.

9.7.4 The use of basements within flood risk areas should be discouraged. Where basements are permitted however, it is necessary to ensure that the basement access points are situated a minimum of 600 mm above the 1% AEP (1 in 100 year) plus climate change flood level plus climate change. The basement must have unimpeded access and waterproof construction to avoid seepage during flooding conditions. Habitable uses of basements within Flood Zone 3 should not be permitted, while basement dwellings can be allowed in Flood Zone 2 provided they pass the Sequential and Exception Tests.

Development Behind Defences

9.7.5 Prior to the development of areas behind defences, the Sequential and Exception Tests must be undertaken in the first instance. Where the need to apply the Exception Test is identified, this should be supported by a Level 2 SFRA.

9.7.6 Areas behind defences are at particular risk due to breach or overtopping, resulting in the rapid on-set of fast-flowing, deep water flooding with little or no warning. Risks will therefore be highest closest to these defences and as such it is recommended that the LPAs should set back developments and ensure that those proposing developments develop robust evacuation plans as part of their FRA in consultation with the Environment Agency.

9.7.7 Consideration of flood risk behind defences should be made as part of detailed FRAs. Developers should review Volume 2, Tiles A1-A21 to determine the location of structures and defences in proximity to the site and therefore identify the possibility of localised residual flood risk. The FRA should take into account:

- The potential mechanisms of failure of flood defence infrastructure

- The standard of protection and design freeboard
- The asset condition of the flood defence
- The height of the flood defence infrastructure and retained water levels compared to ground levels
- The potential location, width and invert level of breach(es) in the flood defences
- The duration of water levels during a flood event or tidal cycle
- The period it would take the operating authority to close the breach
- The period it would take for water to drain from the flooded area following a breach or overtopping event
- The residual risk from failure through demountable defences or pumps not being in position / operation when they are used

9.7.8 In addition to this it is recommended that should any development be proposed in a defended flood area, the potential cumulative impact of loss of storage on flood risk elsewhere should be considered.

Car Parks

9.7.9 Car parking may be appropriate in areas subject to shallow, low velocity flooding where there is not a risk of the vehicles being washed away or the surrounding transport network becoming unsafe to drive through (e.g. in High Probability Zone 3a), provided sufficient flood warning is available, and appropriately located and worded signs are in place. However, this would still need to consider the sequential approach and be discussed and agreed with the LPA and/or the Environment Agency.. As part of an FRA, the developer should consider the likelihood of people being able to move their cars within the flood warning time.

9.8 Developer Contributions

9.8.1 If new developments are placed on Flood Zones 2 or 3, it might be necessary for local infrastructure to be increased. With regards to flood risk, it might also be necessary to extend flood warning system coverage where appropriate, or increase the maintenance of flood defences. The LPA and other authorities might wish to request developer contributions to cover the cost of this, and if so this should be achieved through a Section 106 Legal Agreement. The LPA and the Environment Agency may wish to work in conjunction with each other to formulate a consistent process for obtaining developer contribution.

9.9 Key Recommendations: Chapter Nine

- FRAs will be required for most proposed developments (general details about FRA requirements are in Appendix E of PPS25).
- The onus is on the developer to provide an FRA in support of a planning application.
- Prior to undertaking a FRA, developers should ensure that the Sequential Test has been passed at the site.
- Developers should consult with the Environment Agency and the Council to ensure that the Council's policies on flood risk management are respected and taken account of, and that the scope of the FRA is commensurate with the level of flood risk.
- Section 9.2-9.5 of the SFRA reflects best practice on what should be addressed within a detailed FRA.
- A suitable drainage approach should be possible on almost every site. All new development sites must follow the guidance outlined in Section 9.6. The FRA must demonstrate that these requirements have been achieved.
- Floor levels for developments in flood risk areas must be situated a minimum of 300mm above the 1% AEP (1 in 100 year) plus climate change flood level, determined as an outcome of the site-based FRA.
- The use of basements within flood risk areas should be discouraged. Where basements are permitted however, it is necessary to ensure that the basement access points are situated a minimum of 600 mm above the 100 year plus climate change flood level.

10 Guidance for the Application of Sustainable Drainage Systems

10.1 Introduction

10.1.1 PPS1: Delivering sustainable development; PPS23: Planning and Pollution Control; and PPS25 requires that LPAs should promote SUDS. LPAs should therefore ensure policies encourage sustainable drainage practices in their LDDs. SUDS is a term used to describe the various approaches that can be used to manage surface water drainage in a way that mimics the natural environment. The management of rainfall (surface water) is considered an essential element of reducing future flood risk to both the site and its surroundings. Indeed, reducing the rate of discharge from urban sites to Greenfield runoff rates is one of the most effective ways of reducing and managing flood risk within the area.

10.1.2 SUDS systems need to be considered at and early stage, prior to defining the layout of a proposed site, in accordance with the Sequential Approach. This is likely to lead to a reduction in the overall cost of draining the site as it is much more difficult and expensive to retrofit SUDS to a site that has a development layout already designed. For major development schemes proposed where there are likely to be many competing issues, SUDS should ideally be discussed pre-application to maximise the on-site opportunities. This in return should result in a reduced cost to the developer for the system.

10.2 Effective application of SUDS techniques

10.2.1 A hierarchical approach is recommended for selection of SUDS techniques to dispose of surface runoff. The SUDS Manual (CIRIA 697) states that 'wherever possible, stormwater should be managed in small, cost-effective landscape features located within small sub-catchments rather than being conveyed to and managed in large systems at the bottom of drainage areas'. This is illustrated by the SUDS Management Train (see Figure 10.1).

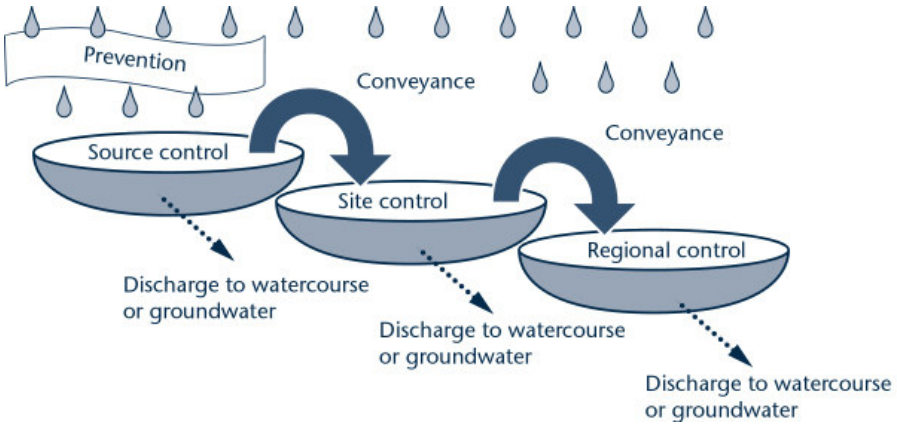


Figure 10.1: SUDS Management Train (from the Environment Agency website)

10.2.2 The first stage, 'prevention' stresses the benefit of avoiding runoff in the first place, and also refers to the need to prevent pollution. Prevention of runoff can be achieved by maintaining a permeable area. This can be achieved by avoiding paving a surface, instead using permeable materials which allow rainfall to soak directly into the ground. It may also be possible to allow roof water to discharge straight onto a lawn in order to soak into the ground, but infiltration must avoid pollution of the soil and

groundwater. This includes ensuring minimal use of herbicides on lawns, secure storage of oils and chemicals to avoid leakage and dog litter policies.

10.2.3 If prevention methods are not sufficient to avoid runoff, the next preferred option is to store and dispose of it on site. This includes measures such as permeable paving or rainwater harvesting, which has the added benefit of reducing demand on public water supply, and reduces costs for the user of the rainwater (if they purchase water using a water meter). Where water cannot be directly infiltrated into the ground, it may be conveyed some distance before infiltration or, alternatively, discharged into a watercourse. As the runoff is conveyed further, it moves from source control to site control and then regional control.

10.2.4 Infiltration is preferred over disposal to a watercourse or the public sewer system as this more commonly deals with runoff nearer to source and serves to replenish groundwater. This recommendation is reinforced by the requirements of the Building Regulations Part H3. If infiltration is not viable (due to a high water table, local impermeable soils, contamination issues including source protection zones etc.), then the next option of preference is for the runoff to be discharged into a nearby watercourse. Only if neither of these options is possible should the water be discharged into the public sewer system.

10.3 Types of SUDS Systems

10.3.1 SUDS may improve the sustainable management of water for a site by:

- Reducing peak flows to watercourses or sewers and potentially reducing the risk of flooding downstream
- Reducing volumes of water flowing directly to watercourses or sewers from developed sites
- Improving water quality compared with conventional surface water sewers by removing pollutants from diffuse pollutant sources
- Reducing potable water demand through rainwater harvesting
- Improving amenity through the provision of public open space and wildlife habitat
- Replicating natural drainage patterns, including the recharge of groundwater so that base flows are maintained

10.3.2 Any reduction in the amount of water that originates from any given site is likely to be small however if applied across the catchment, the cumulative effect from a number sites could be significant.

10.3.3 There are numerous different ways that SUDS can be incorporated into a development. The appropriate application of a SUDS scheme to a specific development is heavily dependent upon the topography and geology of the site and the surrounding areas. Careful consideration of the site characteristics is necessary to ensure the future sustainability of the adopted drainage system. When designing surface water drainage systems, PPS25 states that climate change should be taken into account appropriate to the predicted lifetime of the development, and designed to account for the predicted increases in rainfall intensity, as outlined in Table 5.2.

10.3.4 The most commonly found components of a SUDS system are described below:

- Pervious surfaces: Surfaces that allow inflow of rainwater into the underlying construction or soil.
- Green roofs: Vegetated roofs that reduce the volume and rate of runoff and remove pollution. They comprise a multi-layered system that covers the roof of a building or podium structure with vegetation cover/ landscaping/ permeable car parking, over a drainage layer. They are designed to intercept and retain precipitation, reduce the volume of runoff and attenuate peak flow.
- Filter drains: Linear drains consisting of trenches filled with a permeable material, often with a perforated pipe in the base of the trench to assist drainage, to store and conduct water; they may also permit infiltration.
- Filter strips: Vegetated areas of gently sloping ground designed to drain water evenly off impermeable areas and to filter out silt and other particulates.
- Swales: Shallow vegetated channels that conduct and retain water, and may also permit infiltration; the vegetation filters particulate matter.
- Basins: Ponds and wetlands areas that may be utilised for surface runoff storage.
- Infiltration Devices: Sub-surface structures to promote the infiltration of surface water to ground. They can be trenches, basins or soakaways.
- Bioretention areas: Vegetated areas designed to collect and treat water before discharge via a piped system or infiltration to the ground.
- Pipes and accessories: A series of conduits and their accessories normally laid underground, that convey surface water to a suitable location for treatment and/or disposal (although sustainable, these techniques should be considered where other SUDS techniques are not practicable).

10.3.5 The treatment and control of surface water runoff should provide a level of betterment, incorporating the use of various SUDS techniques. As a minimum there should be no increase in the peak discharges/volumes from any existing Greenfield site and at minimum a 20% reduction of peak discharges/volumes from any existing Brownfield site where an existing positive drainage system has been identified.

10.3.6 For more guidance on SUDS, the following documents and websites are recommended as a starting point:

- Planning Policy Statement 25 (PPS25) Development and flood risk (Department for Communities and Local Government, 2006 – Free download from CLG web site http://www.communities.com)
- Development and flood risk: A practice Guide Companion to PPS25 (Department for Communities and Local Government, 2006 – Free download from CLG web site http://www.communities.com)
- The SUDS Manual – CIRIA C697 (2007) (Woods Ballard B; Kellagher R et al, 2007). Free download from CIRIA bookshop (www.ciria.org). Provides the best practice guidance on the planning, design, construction, operation and maintenance of SUDS and facilitates their effective implementation within developments.

- CIRIA c644 – Green Roofs (2007) provides guidance on the design, construction and operation of Green Roofs. The guidance also describes how 'quick wins' for biodiversity can be achieved in the built environment by incorporating nesting and roosting boxes for birds, bats and other animals.

- Interim Code of Practice for Sustainable Drainage Systems (National SUDS Working Group, 2004). Free download from CIRIA web site www.ciria.org or Environment Agency web site www.environment-agency.gov.uk

- Preliminary rainfall runoff management for developments (DEFRA/Environment Agency R&D Technical Report W5-074/A/TR/1 Revision D) – Free download from Environment Agency web site www.environment-agency.gov.uk

- C625 Model agreements for sustainable drainage systems (Shaffer et al, 2004 – available from CIRIA bookshop www.ciria.org)

- C539 Rainwater and grey water use in buildings – best practice guide – available from CIRIA bookshop www.ciria.org

- C582 Source control using constructed pervious surface: hydraulic, structural and water quality performance issues (Pratt et al, 2002 – available from CIRIA bookshop www.ciria.org)

- C635 Designing for exceedance in urban drainage – good practice – free download from CIRIA bookshop www.ciria.org

- Report 156 Infiltration drainage – manual of good practice (Bettess R, 1996 – available from CIRIA bookshop www.ciria.org)

- Harvesting rainwater for domestic uses: an information guide (Environment Agency, 2003 – Free download from Environment Agency web site www.environment-agency.gov.uk)

- Defra FD2320: Development and Flooding

- www.ciria.org.uk/suds/

10.4 Application of SUDS for Stroud District Council

10.4.1 The District has a mixture of lime-rich soils, slightly acid loamy and clayey soils with impeded drainage and some floodplain soils with naturally high groundwater. The more permeable sites should have priority given to infiltration drainage techniques, as opposed to discharging surface water to watercourses. Where less permeability is found and infiltration techniques that rely on discharge into the existing soils are not viable (also due to a high water table, source protection zones, contamination etc), discharging site runoff to watercourses is preferable to the use of sewers. Integrated urban drainage should also be used throughout the design process.

10.4.2 Approximately two thirds of the district has been highlighted by DEFRA as a Nitrate Vulnerable Zone (NVZ) and several areas in the south and east have been classified as Ground Water Source Protection Zones (GSPZ) by the EA. Any boreholes, water wells or other extraction points should also be identified and taken into account in the design process.

10.4.3 NVZs are generally indicative of the agricultural nature of the surrounding land and the use of fertilisers. Nitrate levels in many English waters are increasing principally due to surface water runoff from agricultural land entering receiving water bodies. The level of nitrate contamination will have an impact on the choice of SUDS and will have to be assessed for specific sites.

10.4.4 The GSPZs are situated over the Jurassic Limestone Aquifer and are designated as inner, outer and total catchment areas. The Inner Zones of the GSPZ are the most sensitive areas and vary in diameter from 0.3 to 2.5km. The Outer Zones are also sensitive to contamination and vary in diameter from 0.7 to 5.3km. The GSPZ requires attenuated storage of runoff to prevent infiltration and contamination.

10.4.5 Five GSPZ Inner Zones have been identified by the EA in the Stroud District and they are situated in the following areas:

- Southern area of the district: Charlford
- Western area of the district: Four in Dursley

These are depicted in Figure 10.2[16].

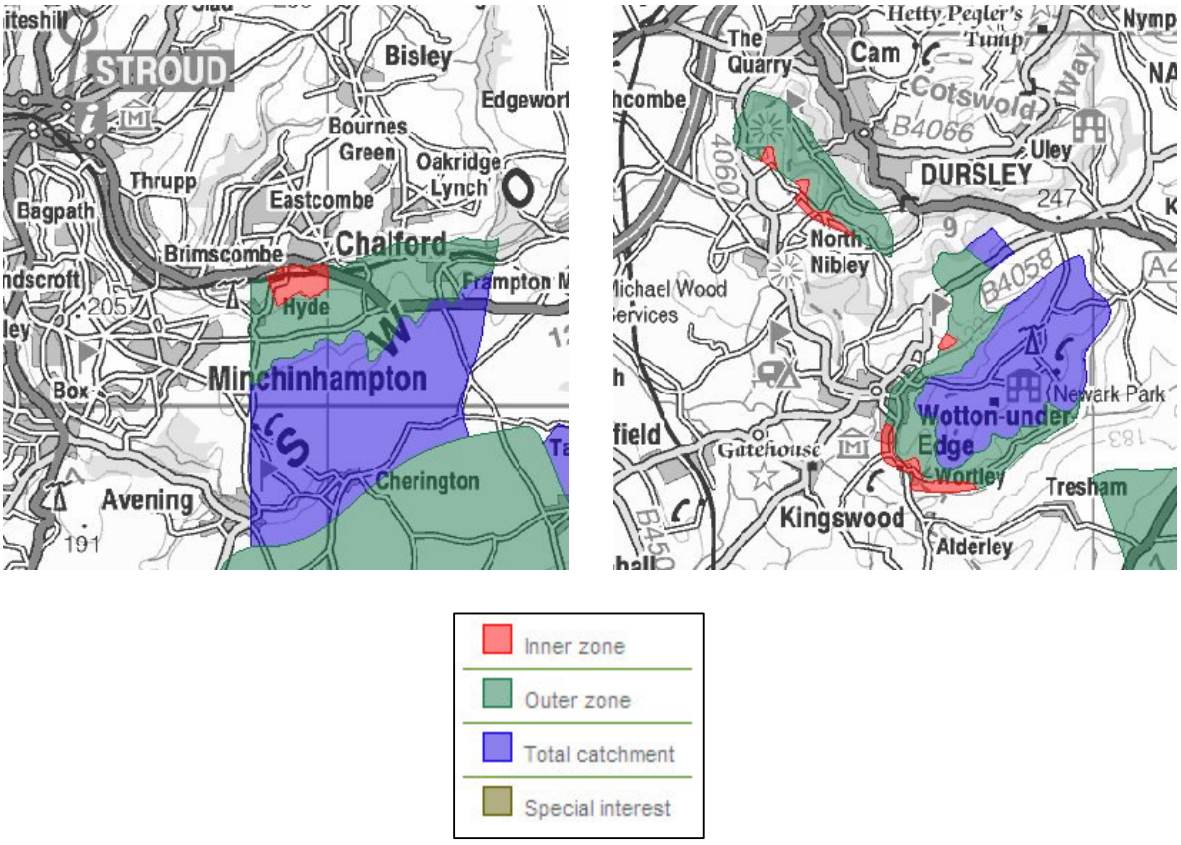


Figure 10.2: GSPZ Inner Zones identified by the Environment Agency

16 http://www.environment-agency.gov.uk/maps/info/groundwater/

10.4.6 Runoff which is likely to be heavily contaminated must be treated by a proprietary device, which should be carefully considered to ensure the correct system is selected to remove pollutants. PPS 3 (2006) states that source control SUDS must be considered and incorporated where suitable. For example; surface water drained from a car park should implement a filter bed wherever possible before considering an interceptor device to remove contaminants.

10.4.7 If the local soil is contaminated then a lined system is generally required. This may include a drainage design which allows infiltration in the upper layer, but should incorporate an impermeable layer at its base to prevent contamination. In such cases lined underground attenuation storage is used to store a 1% AEP (1 in 100 year) +20% (for climate change) storm event and discharges into a nearby watercourse.

10.4.8 Regardless of the underlying geology identified in the SFRA, where there are no reasons why infiltration is not possible (e.g. contaminated land), soakage tests must be undertaken on site in accordance with either CIRIA Report 156 or BRE365. The SFRA will only provide an early indicator to enable decisions as to the best way forward to be formulated for the design site.

10.5 Adoption and Maintenance of SUDS

10.5.1 PPS25 states that when planning SUDS, it is important that developers carefully consider maintenance to ensure that SUDS continue to function over time. Poorly maintained SUDS could lead to an increase in flood risk rather than a reduction.

10.5.2 The future ownership and management of all elements of the SUDS system will need to be addressed at an early stage as the maintenance responsibility must be given to durable and accountable bodies which have the resources to meet the long term needs of the system.

10.5.3 Ensuring developers make a full contribution to the costs of both building and maintaining such systems is vital to their long term effectiveness. The costs of maintaining SUDS devices will be dependant on the types of system used and this should be considered by the developer at an early stage.

10.5.4 Traditional drainage systems are criticised that problems are often hidden underground and take time to eventually be discovered. The majority of SUDS devices are at the surface and pollution or silt build up can be observed as it happens. This means that any issues can be dealt with as they occur, but requires a regular monitoring regime and suitable body to provide the maintenance support.

10.5.5 As the majority of SUDS are at the surface elements, they are best incorporated into local landscape maintenance regimes where possible. An advantage of this is that the site managers and landscape contractors will have a good knowledge of the site through regular maintenance operations such as grass cutting and litter removal. This should also ensure regular monitoring and a quick response to any maintenance needs.

10.5.6 Water companies such as Severn Trent Water Ltd are currently only willing to adopt hard structures and not softer SUDS systems, such as swales or ponds, which provide a break between pipe networks. Until this process changes there will be issues with adoption and developers will have to consult with local authorities to establish the best long term maintenance plan.

10.5.7 SUDS in new developments are usually constructed by the developer and offered for adoption to the responsible organisation. There are currently four main options for determining who might take responsibility for adoption and maintenance of SUDS for a site: Local Planning Authorities, Sewerage Undertakers, Highway Authority or Specialist SUDS undertakers or companies.

10.5.8 Existing legislation (e.g. Section 38 of the Highways Act, 1980 and Section 106 of the Town and Country Planning Act, 1990) can provide a mechanism for SUDS adoption. PPS25 recommends that early consultation with the relevant stakeholders is made to establish and agree responsibilities for long-term maintenance. In addition, the National SUDS Working Group (NSWG) has developed an Interim Code of Practice for SUDS (NSWG, 2004) which provides a set of planning model agreements for use between those public organisations with statutory or regulatory responsibilities relating to SUDS. The model agreements are based on current legislation and the current planning system. This code of practice is complemented by CIRIA publication C625 Model agreements for SUDS.

10.6 Key Recommendations: Chapter Ten

- The Council should endeavour to ensure that SUDS are applied for all new developments, and retro-fitted wherever possible.
- The treatment and control of surface water runoff should provide a level of betterment, incorporating the use of various SUDS techniques. As a minimum there should be no increase in the peak discharges/volumes from any existing Greenfield site and at minimum a 20% reduction of peak discharges/volumes from any existing Brownfield site where an existing positive drainage system has been identified.
- SUDS systems need to be considered at and early stage, prior to defining the layout of a proposed site, in accordance with the Sequential Approach. For major development proposals where there are likely to be many competing issues, SUDS should be discussed pre-application to maximise the on-site opportunities.
- The SUDS management train should be followed (Section 10.2).
- The future ownership and management of all elements of the SUDS system will need to be addressed at an early stage as the maintenance responsibility must be given to durable and accountable bodies which have the resources to meet the long term needs of the system. Ensuring developers make a full contribution to the costs of both building and maintaining such systems is vital to their long term effectiveness.

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11 Summary and Recommendations

11.1.1 This section summarises the findings of the SFRA, recommendations and further work. Key recommendations are summarised at the end of each chapter and should also be reviewed by the reader.

11.2 Summary: Flood Risk Issues

11.2.1 Based on the findings of the SFRA, flood risk issues within the District can be summarised as follows:

- Within the Lower Severn Valley, flooding can occur from a combination of both tidal and fluvial processes. Many of the Main Rivers within the District discharge into the River Severn estuary and as such can be affected to some extent by the tide
- The onset of flooding in the District, particularly in the steeper upland catchments, can be rapid, resulting in flashy flows which can be conveyed to downstream locations at the valley bottoms. Under capacity culverts can also exacerbate flooding.
- Flood Zone maps indicate that the risk of flooding along the other six main rivers in the District is greatest near their confluence with the Severn, due to high water levels causing the tributaries to 'back up'. This particularly happens on the River Frome and Little Avon.
- The topography of the eastern part of the District is relatively flat, but the risk of the Severn coming out of bank and flooding some areas during periods of high flows has been substantially mitigated by the presence of defences along the estuary. Nonetheless, the Environment Agency's 'undefended' Flood Zones show that a significant area, some of which is developed, falls within Flood Zone 3.
- The main areas shown to be at risk from tidal flooding within the Stroud District include: Elmore Back, Epney, Upper Framilode, Saul, Priding, Arlingham, Frampton on Severn and Berkeley.
- In general the level of flood risk from artificial drainage systems within the District is medium to low.
- Flooding from surface water is a problem within the District, particularly around Stroud. This is due to the combination of steep catchments, combined urban drainage networks, older style properties and an abundance of woodland debris which blocks the urban drainage network. Surface water flooding has also been identified along the River Frome catchment, mainly due to the steep topography.
- An assessment of flooding from impounded water bodies indicated that only one incident of canal breach has been recorded within the District in June 1990 at Parkend (SO 7746 1055) as a result of culvert collapse (Saul Junction). There are no records of breaching/overtopping from reservoirs within the Stroud District.
- It is evident that the Gloucester and Sharpness Canal acts a line of defence, although this is not considered under the Environment Agency's responsibility to operate or maintain. Any failure of the canal could potentially cause or exacerbate flooding problems within the District.

- No records of groundwater flooding were identified within the District. However, some valleys in the Cotswold escarpment may show potential vulnerability to groundwater flooding due to the underlying limestone geology and a relatively high water table. The catchment area of the River Severn contains numerous groundwater springs which can respond to prolonged periods of rainfall and seasonal variations in climate, impacting on the contribution to flow in adjacent watercourses and the clays and mudstones of the Severn Valley lie close to the groundwater table for much of the year and as such, are frequently saturated with standing water across the floodplain increasing the risk of surface runoff and localised flooding.

- There are a number of locations at risk of flooding that are currently protected by permanent defences within the Stroud District as identified on the Environment Agency's NFCDD database. Most of the Lower Severn catchment is now protected by some form of defence, whether it is a floodwall, earth embankment, infrastructure acting as a defence or high ground.

- A number of flood storage areas are situated along the River Severn in Gloucestershire. These are areas of natural, low lying topography bounded by high ground, with earth embankments along the edge of the river. Key storage cells located within the District include: Weir Green (SO 7926 1494), Longney (SO 7708 1621), Priding (SO 7654 1029) and Frampton (SO 7339 0577). A purpose built flood storage area is also located between the River Cam and Wickster's Brook in the 1970s designed to store flood water on the land in-between the River Cam and Wickster's Brook, to protect the Gloucester and Sharpness Canal.

11.3 Summary: Flood Zone Data Issues

11.3.1 During the review of the Flood Zone information, some inaccuracies were identified. The accuracy of the Flood Zones in some areas is poor; they can be misaligned from the channel, show flood risk when a culvert is present, or follow a path which does not have a watercourse. Appropriate judgement should be exercised when applying the Sequential Test. It may be prudent for a suitably qualified flood risk management specialist to review and assess preliminary site allocations, to advise on local Flood Zone issues and areas where modelling, or alternative solutions, might have to be carried out to adequately assist the Sequential Test process.

11.4 Summary: Climate Change Impacts

11.4.1 The floodplains in the south and east areas of the District are generally narrow and well defined, though they widen and flatten towards the Severn Estuary. However, it is important to note that as a result of climate change, the depth of flooding is likely to increase in well-defined floodplains, notably in the River Frome catchment. In particularly steep areas the velocity might also increase. This will have a significant impact on the flood hazard. A Level 2 SFRA, which assesses flood hazard, will therefore be required for site allocations which need to satisfy the Exception Test.

11.4.2 By contrast, the effect of climate change on flood risk in flat areas can be dramatic. Where climate change is expected to increase the flood extent, notably in the Little Avon and Cam catchments, especially in Dursley, the LPA should consider using the climate change maps to carry out the Sequential Test, in order to give a particularly long-term risk-based approach to planning. Other locations where it might be prudent to do this are along the Severn Estuary and its tributaries, as well as within the main urban centres of the District. The estuary will be subject to increased storm surges and wave height in the future, and the Environment Agency plans to implement managed retreat. Development proposals in this area should therefore be treated with caution. The climate change

maps do not show a climate change scenario for Flood Zone 2. For the purpose of spatial planning it is recommended that a buffer of 10m (measured from the edge of the existing Flood Zone 2) is added to represent future climate change. A Level 2 SFRA should assess climate change impacts in detail.

11.5 Recommendations: Site Allocation Process

11.5.1 It is recommended that the outputs from this study are used as an evidence base from which to direct new development to areas of low flood risk (Flood Zone 1). Where development cannot be located in Flood Zone 1, the Council should use the flood maps to apply the Sequential Test to their remaining land use allocations. The following should be considered:

- Flood Zone 3b has been mapped where it exists. Where it does not exist, Flood Zone 3a has been used to represent Flood Zone 3b.
- The Council should take note of Section 4.7 which outlines areas where the existing Flood Zones outlines are deemed to be of poor resolution. Where emerging site allocations are located in these areas, the Sequential Test process should be verified by a technical expert.
- Following application of the Sequential Test, a detailed interrogation of emerging allocations should be carried out, using the template in Appendix F. This will ensure that that all potential flood risk issues to the site are identified, such as incorrect Flood Zones, residual risk areas and so on. The review should identify resultant required works if necessary (Level 2 SFRA, FRA etc.)

11.5.2 The Sequential Approach should also be applied within development sites to inform site layout, by locating the most vulnerable elements of a development in the lowest risk areas (in accordance with Table D3 of PPS25). The use of Flood Zones 2 and 3 for recreation, amenity and environmental purposes can provide an effective means of flood risk management as well as providing connected green spaces with consequent social and environmental benefits.

11.5.3 The Environment Agency will require a Level 2 SFRA to be carried out in order to provide a detailed assessment of the risk of flooding from non-fluvial sources, in areas where new development is proposed.

11.5.4 With regard to fluvial sources of flood risk, a Level 2 SFRA will be required where the need to apply the Exception Test is identified (as outlined in Table D3 of PPS25). This cannot be determined until the Sequential Test has been carried out on all proposed development sites. It is recommended that as soon the need for the Exception Test is established, the Level 2 SFRA is undertaken by a suitably qualified expert so as to provide timely input to the overall LDF process. The following should be noted:

- Breach and overtopping assessments will be required for development situated behind defences and immediately adjacent to raised canals
- The effects of structures in the vicinity of development sites (culverts etc.) might need to be assessed to determine the capacity and identify residual risk areas that might result from blockage. This will inform the appropriate placement of development and ensure appropriate mitigation is put in place. This could also address any mitigation works that might be deemed appropriate.

11.6 Recommendations: Council Policy

11.6.1 It is recommended that for the purpose of clarity, a Supplementary Planning Document should be developed in light of the suggested policies and guidance notes, outlining the minimum requirement of the Environment Agency in response to PPS25.

11.6.2 It is recommended that the following core considerations should be included within the Council's flood risk management policy documents:

- Use the Sequential Test to locate new development in least risky areas, giving highest priority to Flood Zone 1
- Direct new development away from flood risk areas and areas that are currently defended along the Severn Estuary to enable the Environment Agency to achieve the long-term goal of 'retreating the line'
- Seek to ensure Flood Zones 2 and 3 remain undeveloped
- Use the Sequential Approach within development sites to inform site layout by locating the most vulnerable elements of a development in the lowest risk areas, in accordance with Table D3 of PPS25
- Protect the functional floodplain from development, promote the use of green corridors in flood risk areas and restore the natural course of rivers. These will all act as a means of risk reduction
- Seek to reinstate functional floodplain wherever possible (e.g. reduce building footprints or relocate to lower flood risk zones)
- Ensure all new development is 'safe', meaning that dry pedestrian access to and from the development is possible without passing through the 1% AEP (1 in 100 year) plus climate change floodplain, emergency vehicular access is possible, and flood resistance and resilience is incorporated
- No new building should be allowed in a flood risk area that is not flood resilient
- The treatment and control of surface water runoff should provide a level of betterment, incorporating the use of various SUDS techniques. As a minimum there should be no increase in the peak discharges/volumes from any existing Greenfield site and at minimum a 20% reduction of peak discharges/volumes from any existing Brownfield site where an existing positive drainage system has been identified
- Further culverting and building over of culverts should be avoided. All new developments with culverts running through their site should seek to de-culvert rivers for flood risk management and conservation benefit.
- Seek developer contributions (to be determined in consultation with the Environment Agency) via S106 planning obligations to fund (or part fund) strategic flood risk management facilities (such as storage areas) and bring benefit to the wider community.

11.7 Recommendations: Environment Agency Policies Relevant to the Council

11.7.1 In the short term, the Environment Agency's policy for the Severn Estuary is to continue to protect features or assets by maintenance of the existing defences. In the long term, however, the policy is to retreat the line. This will be confirmed by work planned for the near future. This will involve moving defences away from their current position to a location further away from the riverbank, particularly in agricultural areas away from settlements or major infrastructure. The policy of retreat will, however, be constrained by how much settlements, infrastructure or other interests can be defended locally. Again, this policy will have implications for future development in the District. Indeed, Council can help deliver this policy by ensuring new development does not take place in areas along the estuary which are shown to be at risk and/or are currently defended. Such areas are likely to be exposed to greater flood risk in the future (due to climate change) and may well be earmarked for long term retreat in the future. When buildings within defended areas reach the end of their natural life, the Council should consider the option of not re-developing the site.

11.7.2 In terms of flood risk in the remainder of the District, for the most part channel and defence maintenance and unblocking of structures will continue, though the District will be susceptible to the impacts of climate change. In light of the likely impacts of climate change the Council should seek to ensure that Flood Zones 2 and 3 remain undeveloped, because climate change will increase the flood risk in these areas in the future. In Stroud, Nailsworth, Rainswick and Stonehouse (the Frome Catchment) the Environment Agency intends to maintain the current level of flood risk and respond to changes that may come about from climate change (this will include maintaining defences and improving them where necessary in response to flood risk). Development behind defences will require careful consideration as residual risks will remain, now and in the future.

11.8 Recommendations: Emergency Planning

11.8.1 It is recommended that the Council's Emergency Response Plan is reviewed and updated in light of the findings of the SFRA to ensure that safe evacuation and access for emergency services is possible during times of flood both for existing developments and those being promoted as possible sites within the LDF process. It is further recommended that the Council works with the Environment Agency to promote the awareness of flood risk, especially to those living in flood risk areas, and encourage communities at risk to sign-up to the Environment Agency Flood Warning Direct service. In line with the Pitt Review, this should be achieved through 'door knocking' by local authorities.

11.8.2 In line with the Pitt Review it is recommended that a review of designated rest centres and other major facilities should be carried out to ensure that they have the necessary levels of resilience to enable them to be used in the response to flooding and other major emergencies, or that alternative arrangements are put in place. A review of current local arrangements for water rescue should also be carried out to consider whether they are adequate in light of the summer's events and the community risk register. Further, Local Resilience Forums should consider the vulnerability of motorways and trunk roads to flooding and consider the potential for warnings and strategic road clearance and closures to avoid people becoming stranded. Finally, the community risk register should reflect risks to critical infrastructure from flooding and other hazards.

11.8.3 Recommendations: General

11.8.4 A number of general issues and resultant recommendations have come forward through the SFRA process, and should be taken into account by the Council. These are:

- Not all minor watercourses have had Flood Zone maps produced for them, specifically, those with a catchment area of less than 3km^2. Any development site located adjacent to an unmapped watercourse within Flood Zone 1 should apply an 8m development easement from the top of bank, and a site specific FRA undertaken.
- In the future it is likely that the Environment Agency will take strategic direction over managing inland flood risks. The Local Authority should adopt a leadership and scrutiny role, overseeing flood risk management within the local area.
- Although the flood proofing of utilities should be carried out by the service provider, the Council should review the vulnerability of critical infrastructure in the local area and take steps to work with service providers to initiate retrospective FRAs and subsequent flood proofing works if required.
- Incorporate requirements for flood resistant and resilient refurbishment of flooded properties in high flood risk areas.
- In line with the recommendations of the Pitt Review, it is recommended that the Council produces a Surface Water Management Plan as a tool to improve co-ordination of activities between stakeholders involved in surface water drainage.

11.9 Recommendations: Future Updates to the SFRA

11.9.1 The SFRA should be retained as a 'living' document and reviewed on a regular basis in light of better flood risk information and emerging policy guidance. It is recommended that outputs from the following studies are used to update future versions of the SFRA report and associated maps:

- Future Flood Risk Mapping Studies
- Future Flood Risk Management Strategies
- Future groundwater flood risk maps, surface water flood risk maps and reservoir inundations maps. These should also feed into emergency planning documents

11.10 Recommendations: Next Stage of Work

11.10.1 It is recommended that a detailed interrogation of emerging allocations is carried out using the SFRA data and the table supplied in Appendix F. The flood risk posed to each site should be assessed, as well as the presence of defences and culverts. Any issues with the Flood Zones in each development site (mis-alignments etc.) should be identified. The Sequential Test should then be carried out for sites in Flood Zones 2 and 3, or where sites in Flood Zone 1 are affected by other sources of flooding. Where the resolution of flood risk data is poor, appropriate development easements, or further modelling work, should be put identified in consultation with the Environment Agency, to assist the Sequential Test process.

11.10.2 The Environment Agency will require a Level 2 SFRA to be carried out in order to provide a detailed assessment of the risk of flooding from non-fluvial sources, in areas where new development is proposed.

11.10.3 With regard to fluvial sources of flood risk, a Level 2 SFRA will be required where the need to apply the Exception Test is identified (as outlined in Table D3 of PPS25). This cannot be determined until the Sequential Test has been carried out on all proposed development sites. It is recommended that the Level 2 SFRA approach is agreed with the Environment Agency.

11.11 Recommendations: Level 2 SFRA

11.11.1 A Level 2 SFRA should be viewed as rather more site specific than a Level 1 SFRA, addressing flood risk to potential development sites which have gone through the Sequential Test and have been located in Flood Zones 2 or 3, or behind existing defences. The data required for a Level 2 SFRA will therefore depend upon which, if any, of the Council's final list of preferred sites remain in Flood Zones 2 and 3 following application of the Sequential Test and hence where the Exception Test needs to be applied.

11.11.2 In addition, The Environment Agency will require a Level 2 SFRA to be carried out in order to provide a detailed assessment of the risk of flooding from non-fluvial sources, in areas where new development is proposed.

11.11.3 It is important that a Level 2 SFRA considers the variation of flood risk in a Flood Zone. This increased scope involves a more detailed review of flood hazard (flood probability, flood depth, flood velocity, rate of onset of flooding). If development is to be located behind defences, it would be necessary to model constructional failure of the defence (breach) and water levels rising to exceed the level of the defence (overtopping). In some instances improvements to existing flood defences may be required to manage residual flood risks. Here, the SFRA should include an appraisal of the extent of works to provide or raise the flood defence to appropriate standard.

Level 2 SFRA outputs would include:

- Maps showing distribution of flood risk across zones (depth, velocity, rate and onset of flooding)
- An appraisal of the probability and consequence of breach or overtopping of flood defence infrastructure
- An appraisal of the condition of flood defence infrastructure and likely future policy
- Guidance on appropriate policies for making sites which satisfy parts a) and b) of the Exception Test, and the requirements for satisfying part c) of the Exception Test
- Guidance on the preparation of FRAs for sites with varying flood risk across the Flood Zone

11.11.4 As soon as the need to apply the Exception Test is identified, a Level 2 SFRA should be initiated.

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12 Glossary

1) **ABD -** Area Benefiting from Defences. Such areas are defined as areas benefiting from formal flood defences specifically in the event of flooding from rivers with a 1% (1 in100 year) chance in a given year, or flooding from the sea with a 0.5% (1 in200 year) chance in any given year. If the defences were not there these areas would be flooded. An area of land may benefit from the presence of a flood defence even if the defence has overtopped, if the presence of the defence means that the flood water does not extend as far as it would if the defence were not there (Source: Environment Agency Policy Number 132_06)

2) **AONB** - Area of Outstanding Natural Beauty. These are areas of countryside with significant landscape value.

3) **BFIHOST** – Base Flow Index derived from the Hydrology Of Soil Types classification as described in the Flood Estimation Handbook

4) **Breach Hazard** – Hazard attributed to flooding caused by the constructional failure of a flood defences or other structure that is acting as a flood defence.

5) **CFMP** – Catchment Flood Management Plan. A CFMP is a high-level strategic plan through which the Environment Agency seeks to work with other key-decision makers within a river catchment to identify and agree long-term policies for sustainable flood risk management.

6) **Core Strategy -** The Development Plan Document which sets the long-term vision and objectives for the area. It contains a set of strategic policies that are required to deliver the vision including the broad approach to development.

7) **Culvert** - A closed conduit used for the conveyance of surface drainage water under a roadway, railroad, canal, or other impediment

8) **Defra -** Department of Environment, Food and Rural Affairs Development

9) **DG5 Register -** A register of properties at risk from sewer flooding maintained by UK water companies.

10) **DPD -** Development Plan Document. A DPD is a spatial planning document within the Council's Local Development Framework which set out policies for development and the use of land. Together with the Regional Spatial Strategy they form the development plan for the area. They are subject to independent examination.

11) **DPSBAR** – Mean drainage path slope

12) **Dry pedestrian egress -** Routes to and from buildings that will remain dry and allow pedestrian/wheelchair evacuation to dry land in times of flood.

13) **Environment Agency -** The leading public body for protecting and improving the environment in England and Wales.

14) **Environmental Stewardship** - Environmental Stewardship is a new agri-environment scheme which provides funding to farmers and other land managers in England who deliver

effective environmental management on their land. The scheme is intended to build on the recognised success of the Environmental Sensitive Areas scheme and the countryside Stewardship Scheme. Flood risk management is among its secondary objectives.

15) **Exception Test -** If, following application of the Sequential Test, it is not possible (consistent with wider sustainability objectives) to demonstrate that there are no reasonably available sites in areas with less risk of flooding that would be appropriate to the type of development or land use proposed, the Exception Test may apply. PPS25 sets out strict requirements for the application of the Test.

16) **Flood Estimation Handbook (FEH) -** The latest hydrological approach for the estimate of flood flows in UK.

17) **Flood Defence** – Natural or man-made infrastructure used to reduce the risk of flooding

18) **Flood Risk –** Flood risk is a combination of two components: the chance (or probability) of a particular flood event and the impact (or consequence) that the event would cause if it occurred

19) **FRA –** Flood Risk Assessment. Assessment of **flood risk** posed to a defined area (usually a new development site) as defined above.

20) **Flood Risk Management –** Flood risk management can reduce the probability of occurrence through the management of land, river systems and flood defences and reduce the impact through influencing development on flood risk areas, flood warning and emergency response.

21) **FWD –** Floodline Warnings Direct. FWD is a system maintained by the Environment Agency which sends out warning messages to homeowners and businesses over the telephone network when floods are likely.

22) **Flood Risk Vulnerability -** PPS25 provides a vulnerability classification to assess which uses of land maybe appropriate in each flood risk zone.

23) **Formal Flood Defence -** A structure built and maintained specifically for flood defence purposes.

24) **Flood Zones -** Nationally consistent delineation of 'high' and 'medium' flood risk, published on a quarterly basis by the Environment Agency.

25) **Functional Floodplain Zone 3b -** Defined as areas at risk of flooding in the 5% AEP (1 in 20 year) design event. In any one year the chance of a 1 in 20 year event occurring is 5%.

26) **GIS –** Geographic Information System. GIS is any system which stores geographical data, such as elevations, location of buildings and extent of flood outlines.

27) **High probability Zone 3a -** Defined as areas at risk of flooding in the 1% AEP (1 in 100 year) design event. In any one year the chance of a 1% AEP (1 in 100 year) event occurring is 1%.

28) **Informal Flood Defence -** A structure that provides a flood defence function however has not been built and/or maintained for this purpose (e.g. boundary wall).

29) **Integrated urban drainage** – An integrated approach to surface water management

30) **JFLOW -** A computer river model based on routeing a flood calculated by Flood Estimation Handbook methodology along a river corridor the levels of which are derived from a Side Aperture Radar (SAR) remote sensed Digital Terrain Model.

31) **Land Swapping** - looking for long term opportunities to remove development from areas that flood at present and relocate in lower risk locations which is essentially restoration of the floodplain.

32) **LDD** – Local Development Documents

33) **LiDAR -** Light Detection and Ranging. LiDAR is an airborne terrain mapping technique which uses a laser to measure the distance between the aircraft and the ground.

34) **LDF -** Local Development Framework. The LDF consists of a number of documents which together form the spatial strategy for development and the use of land.

35) **LDS –** Local Development Scheme. A schedule and timetable for production of LDF documents.

36) **Low Probability Zone 1 –** The area outside Zone 2. Defined as an area with less that 0.1% AEP (1 in 1000 year) chance of flooding. In any one year the chance of a 0.1% AEP (1 in 100 year) event occurring is less than 0.1%.

37) **LPA –** Local Planning Authority

38) **Main River –** All watercourses shown on the statutory main river maps held by the Environment Agency and the Department for Environment, Food and Rural Affairs. This can include any structure or appliance for controlling or regulating the flow of water into, in or out of the channel. The Environment Agency has permissive power to carry out works of maintenance and improvement on these rivers.

39) **'Making Space for Water' (Defra 2004) -** The Government's new evolving strategy to manage the risks from flooding and coastal erosion by employing an integrated portfolio of approaches, so as: a) to reduce the threat to people and their property; b) to deliver the greatest environmental, social and economic benefit, consistent with the Government's sustainable development principles, c) to secure efficient and reliable funding mechanisms that deliver the levels of investment required.

40) **Medium probability Zone 2 -** Defined as an area at risk of flooding from flood events that are greater than the 1% AEP (1 in 100 year), and less than the 0.1% AEP (1 in 1000 year) design event. The probability of flooding occurring in this area in any one year is between 1% and 0.1%.

41) **Minor River -** Every river, stream, ditch, drain, cut, dyke, sluice, sewer (other than a public sewer) and passage through which water flows and which does not form part of a main river. The local authority or Internal Drainage Board (IDB) where relevant, has powers for ordinary watercourses.

42) **mAOD –** Metres Above Ordnance Datum

43) **NGR –** National Grid Reference

44) **NFCDD –** National Flood and Coastal Defence Database. Owned by the Environment Agency, NFCDD containing details of the location, standard and condition of all Environment Agency maintained defences.

45) **OS** - Ordnance Survey

46) **Ordinary Watercourse (non-main river, minor watercourse)** – Any section of watercourse not designated as a Main River.

47) **PPG** – Policy Planning Guidance. PPG notes are statements of the Government's national policy and principles towards certain aspects of the town planning framework, and have been superseded by Planning Policy Statements in many cases (below).

48) **PPS -** Planning Policy Statements. The Government has updated its planning advice contained within Planning Policy Guidance Notes with the publication of new style Planning Policy Statements.

49) **PPS 25 -** Planning Policy Statement 25: Development and Flood Risk. PPS 25 reflects the general direction set out in 'Making Space for Water'.

50) **Previously Developed (Brownfield) Land -** Land which is or was occupied by a building (excluding those used for agriculture and forestry). It also includes land within the curtilage of the building, for example a house and its garden would be considered to be previously developed land.

51) **Residual Risk -** The risk which remains after all risk avoidance, reduction and mitigation measures have been implemented.

52) **Return Period –** The probability of a flood of a given magnitude occurring within any one year e.g. a 1% AEP (1 in 100 year) event has a probability of occurring once in 100 years, or a 1% chance in any one year. However, a 1% AEP (1 in 100 year) event could occur twice or more within 100 years, or not at all.

53) **RFRA –** Regional Flood Risk Assessment

54) **RSS** - Regional Spatial Strategy. The RSS for Gloucestershire is the South West RRS, a regional planning policy providing the overarching framework for the preparation of LDFs. It provides a broad development strategy for the South West region up to 2026.

55) **Sequential Test -** Informed by a SFRA, a planning authority applies the Sequential Test to demonstrate that there are no reasonably available sites in areas with less risk of flooding that would be appropriate to the type of development or land use proposed.

56) **SEA -** Strategic Environmental Assessment.

57) **SFRA -** Strategic Flood Risk Assessment. An SFRA is used as a tool by a planning authority to assess flood risk for spatial planning, producing development briefs, setting constraints, informing sustainability appraisals and identifying locations of emergency planning measures and requirements for flood risk assessments.

58) **SFRM** – Strategic Flood Risk Management. An Environment Agency Framework which facilitates the implementation of **Flood Risk Management**.

59) **SPD** - Supplementary Planning Document. An SPD provides supplementary guidance to policies and proposals contained within Development Plan Documents. They do not form part of the development plan, nor are they subject to independent examination.

60) **SPR** – Standard percentage runoff from the Hydrology Of Soil Types classification.

61) **SA -** Sustainability Appraisal. An SA is an appraisal of plans, strategies and proposals to test them against broad sustainability objectives.

62) **SoP –** Standard of Protection. The return period against which a defence offers protection.

63) **SSSI** – Site of Special Scientific Interest. SSSIs are designated protected areas in the UK. NNRs and SACs are both SSSIs.

64) **SUDS –** Sustainable Urban Drainage Systems. SUDS are drainage systems which are designed to reduce the impact of urbanisation on the hydrology of a river system.

65) **Sustainable Development –** "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (The World Commission on Environment and Development, 1987)

66) **Wrack Mark** – a recorded level following a flood event

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APPENDIX A

Environment Agency Sign-off Letter

APPENDIX B

Map Index

APPENDIX C

Sequential Test Process

APPENDIX D

Flood Zone Information

APPENDIX E

Pitt Report Recommendations

APPENDIX F

Teplate to Assist with Sequential Test