

Cotswold District Council

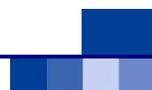
Strategic Flood Risk Assessment for
Local Development Framework

Level 1

Volume 1 - FINAL

September 2008

Halcrow Group Limited



Cotswold District Council

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

Contents Amendment Record

This report has been issued and amended as follows:

Issue	Revision	Description	Date	Signed
1		Draft Report	25/04/08	RD
2		Final Report	22/08/08	RD
2	A	Final Report	22/09/08	RD

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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 and river 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.

Cotswold District occupies the western end of the Upper Thames catchment. The majority of the District drains south east toward the River Thames, with small areas to the west draining toward the Severn. The steep topography can facilitate flash flooding, while the limestone geology can cause groundwater flooding. The greatest area at risk of fluvial flooding is in the south near the River Thames and the Cotswold Water Park. Smaller areas in towns such as Bourton-on-the-Water and Cirencester are also at risk. The effects of climate change mean that flood risk areas are likely to flood more frequently, and in the south of the District the extent of flooding might also increase.

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 appropriate 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). The Thames CFMP states that within the Upper Thames area, flood risk should be managed by taking opportunities to maximise the potential of the floodplain to store water. The Council can assist with this by safeguarding the natural floodplain from inappropriate development.

In accordance with PPS25 and its Practice Guide (2006), 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. In instances where there is an area of overlap between the site boundary and flood risk area, this should be utilised 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 Cotswold 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 access' 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-A13)
 - 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-B63)
 - 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-C13)
 - 4) The location of any flood risk management measures, including both infrastructure (Volume 2, Tiles A1-A13) 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 (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 and to 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, an 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 (Table 1.1) 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	✓	x	Exception Test required	✓
	Zone 3b ‘Functional Floodplain’	Exception Test required	✓	x	x	x

Key:

✓ Development is appropriate

x 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	<ul style="list-style-type: none"> • Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk, and strategic utility infrastructure, including electricity generating power stations, grid and primary substations and chemical tank facilities
Highly Vulnerable	<ul style="list-style-type: none"> • 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 consent¹
More Vulnerable	<ul style="list-style-type: none"> • 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 waste² • Sites used for holiday or short-let caravans and camping, subject to specific warning and evacuation plan
Less Vulnerable	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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:

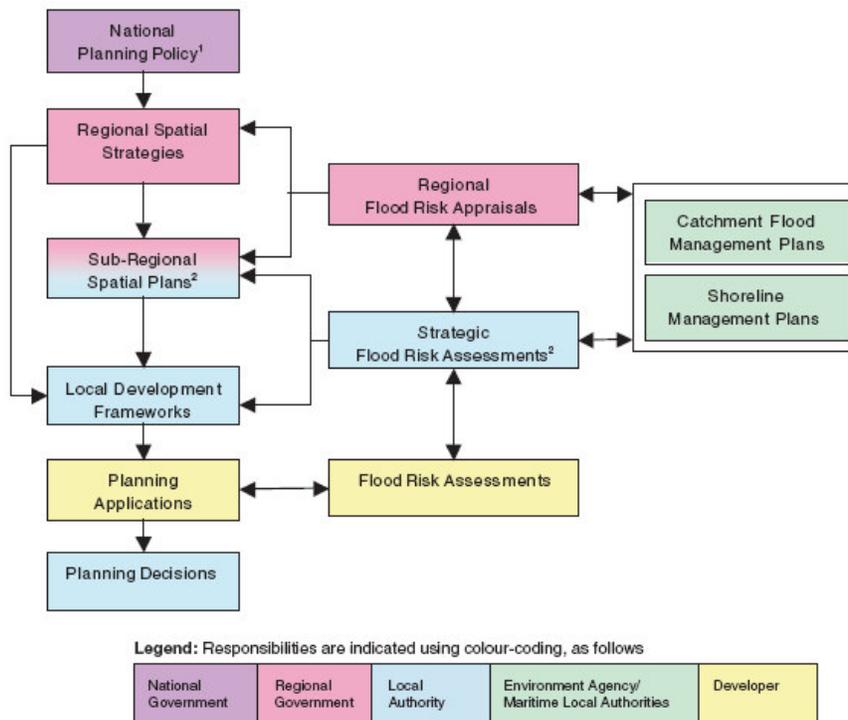
- 1) This classification is based partly on Defra/Environment Agency research on Flood risks to people (FD2321/TR2)²¹ also on the need to keep some uses to keep functioning during flooding
- 2) Buildings that combine a mixture of uses should be placed into the higher of the relevant classes of flood 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 D3 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 Zones 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 SFRAAs 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 Cotswold District Council is a local government district covering an area of some 1,161km². The District borders the Gloucestershire Districts of Tewkesbury, Cheltenham and Stroud to the west. To the north the Districts of Wychavon and Stratford-on-Avon are found, with the Districts of West Oxfordshire to the east and the Vale of the White Horse, Swindon, North Wiltshire and South Gloucestershire to the south. The District is predominantly rural in nature and is characterised by open wolds, dry-stone walls, ancient beech woods, shelter belts and deep river valleys, with historic market towns and villages constructed from the underlying Cotswold stone. The main urban areas include Cirencester and the market towns of Tetbury, Moreton-in-Marsh and Chipping Campden. A number of smaller typical Cotswold villages including Bourton-on-the-Water and Stow-on-the-Wold are located within the District. The total estimated population in 2006 was 83,200.
- 1.7.2 Cotswold District has the largest area designated as an AONB, with the greatest number of conservation areas and listed buildings of any local authority in England. There are also numerous scheduled ancient monuments, historic parks and gardens and sites of SSSI. The District has excellent communications to many parts of the UK, with Evesham, Stratford-on-Avon, Oxford, Witney, Swindon, Bristol, Cheltenham and Gloucester providing places of work for many people living within the District and vice versa. Lying within close vicinity to the M4, M5 and M40 motorways and other 'A' class roads, the District enables good access to the motorway network to adjacent towns and cities

within the Midlands and South East. Good rail access from Moreton-in-Marsh and Kemble to London and the Midlands make the area an attractive place to both retire and for those commuting to work in neighbouring urban areas such as Swindon, Cheltenham and Gloucester. This has resulted in the District experiencing pressures for growth in recent years.

1.8 Main Rivers and Hydrology

- 1.8.1 Cotswold District occupies the western end of the Upper Thames catchment, with 15 of its 16 main rivers originating from within the District and draining into the Thames. The highest of the Cotswold Hills, which run along the north western boundary of the District, forms the boundary between the River Thames and River Severn catchments and their tributaries. The vast majority of the District drains south east toward the River Thames (which itself arises within the District boundary) with only small areas to the west draining west toward the River Severn.
- 1.8.2 The underlying bedrock of the majority of the area comprises oolitic limestone. Since limestone is soluble in water (being largely made up of calcium carbonate) fissures have appeared in the rock over thousands of years. Consequently limestone catchments are highly permeable and are therefore excellent aquifers. Percolation of precipitation through to the water table is therefore significant and corresponding runoff in limestone catchments can be relatively slow. However, if the groundwater level is already high and soil moisture deficit very low due to previous rainfall events or prolonged wet weather, then limestone catchments have the potential to respond very rapidly to rainfall, which can result in both fluvial and groundwater flooding.
- 1.8.3 The catchment descriptors for the various river catchments in the District are shown in Table 1.3 as taken from the Flood Estimation Handbook (FEH). It is notable that the catchments show a relatively high BFIHOST (Base Flow Index derived using Hydrology of Soil Types classification) and relatively low SPRHOST (Standard Percentage Runoff derived using Hydrology of Soil Types classification) as would be expected from catchments underlain by largely permeable rock. This would indicate a slow response to precipitation in general, except in the case of prolonged wet weather as already discussed. The comparatively high values for DPSBAR (average Drainage Path Slope – an index of catchment steepness) for catchments in the south of England, however, would indicate the contrary; the steeper topography increases the speed with which the catchments respond to rainfall and can correspondingly increase the risk of flash flooding. Nevertheless, the permeable underlying rock and the comparatively small degree of urbanisation in the Cotswold District indicates that the greatest flood risk in the area would be during periods of prolonged wet weather more common during winter months than in the summer.
- 1.8.4 Inspection of the Environment Agency's Flood Zone Maps in the study area indicates that the greatest extent of flood risk in the District is in the south, near the River Thames and the Cotswold Water Park. Towns such as Bourton-on-the-Water and Cirencester also fall within Flood Zones 2 and 3. Although the extent of flooding at these locations is small, a large number of properties are located within the Flood Zones as the areas at risk are densely populated.
- 1.8.5 All sixteen main rivers within Cotswold 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). A Main River is a section of watercourse (including the structures and devices on it used to regulate flow) which the Environment Agency has the power to carry out flood defence works. Most of the minor rivers (or ordinary watercourses) in the District form upstream portions of named main rivers with the same name, therefore a detailed breakdown would not be very beneficial.

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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.

Table 1. 3: Main Rivers in Cotswold District and associated catchment descriptors as per FEH Version 2 (from north to south)

			Upstream Catchment Descriptors* (from FEH CD ROM)					Watercourse Description
River Name	Enters District	Exits District	Downstream point of catchment	Upstream Catchment Area (km ²)	BFI HOST	SPR HOST	DPSBAR (m/km)	
River Evenlode	-	SP 2537 2241	SP 2530 2240	86.18 (average)	0.474 (medium)	39.89 (medium)	40.9 (low)	The River Evenlode rises in Moreton-in-Marsh near SP 2077 3260 and winds its way southward collecting a number of drainage paths <i>en route</i> . Just south of the lakes of Adlestrop Park the river splits into two for 700 metres and rejoins near SP 2424 2540. The river reaches the District boundary around 600 metres downstream and forms the District boundary for the next 3km. At around SP 2514 2323 the river once again ducks inside the boundary collecting flows from the Bledington Brook, Westcote Brook and an unnamed main river to the east before leaving the district and continuing toward the Thames.
Bledington Brook	-	-						The Bledington Brook begins as a minor river south of Stow-on-the-Wold with two arms at SP 1954 2425 and SP 2088 2360. The confluence of the two arms is at SP 2173 2448. The Brook is classed as a main river from SP 2309 2393 near Bledington grounds and continues south east through the village of Bledington where it receives flow from another arm of the Brook before flowing into the River Evenlode at SP 2505 2290.
Westcote Brook	-	-	SP 2530 2230	13.11 (small)	0.347 (low)	46.57 (high)	56.9 (medium)	The Westcote Brook rises in multiple locations on Icomb Hill near the village of Icomb (SP 2129 2260). Four of these become a main river at SP 2290 2218. Two further tributaries, also classed as main rivers, enter the Brook at SP 2365 2211 and SP 2448 2186 as it continues eastward along the district boundary for nearly 2 km before flowing into the River Evenlode at SP 2537 2241.

* 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. Note that catchment descriptors for very small catchments are less reliable as any inaccuracies in the FEH CD ROM data can be exacerbated.

			Upstream Catchment Descriptors* (from FEH CD ROM)					Watercourse Description
River Name	Enters District	Exits District	Downstream point of catchment	Upstream Catchment Area (km ²)	BFI HOST	SPR HOST	DPSBAR (m/km)	
River Dikler	-	-	SP 2200 1300 244.82	244.82 (average)	0.803 (high)	16.11 (low)	69.2 (medium)	The River Dikler rises as a minor river at SP 1725 2776 at the base of a hill and flows southward around the hill and past Stow-on-the-Wold. The river separates into two arms for 500m at SP 1793 2451 and reforms into a major river at SP 1788 2422. The Dikler receives flow from the River Eye just north of Bourton-on-the-Water at SP 1802 2087 and briefly separates into three arms just east of Bourton-on-the-Water before continuing south and reaching its confluence with the River Windrush at SP 1791 1867.
River Eye	-	-						The River Eye rises as a minor river at Chalk Hill (SP 1308 2594) and flows south east for around 7km before becoming a main river at Lower Slaughter (SP 1708 2215). The River then runs southward for 2km parallel to the Dikler into which it flows at SP 1802 2087.
River Windrush	-	SP 2210 1311						The River Windrush rises in multiple locations near (and beyond) the western district boundary and is classed as a main river from SP 1603 2096 onward, near Bourton-on-the-Water. The river flows through the village, collecting a minor tributary on the right bank and merges with the River Dikler at SP 1791 1867. From here it winds its way southward collecting other minor tributaries, as well as a main river (the Sherborne Brook) near SP 1908 1447. A kilometre downstream the river turns eastward and separates for 1.5km into two or three channels near Little Barrington before leaving the district.

* 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. Note that catchment descriptors for very small catchments are less reliable as any inaccuracies in the FEH CD ROM data can be exacerbated.

			Upstream Catchment Descriptors* (from FEH CD ROM)					Watercourse Description
River Name	Enters District	Exits District	Downstream point of catchment	Upstream Catchment Area (km ²)	BFI HOST	SPR HOST	DPSBAR (m/km)	
Sherborne Brook	-	-	SP 2200 1300 244.82	244.82 (average)	0.803 (high)	16.11 (low)	69.2 (medium)	Like the River Windrush to the north, the Sherborne Brook rises in multiple locations near the western district boundary but is only classed as a main river from SP 1637 1517 onward. From here it continues to flow eastward for a further 3 km before its confluence with the River Windrush at SP 1908 1447.
River Coln	-	-	SU 2015 9885	146.11 (average)	0.831 (high)	14.42 (low)	64.4 (medium)	The River Coln rises as several minor rivers in the hills north of Withington (SP 0309 1557). It is classed as a main river from Chedworth Woods onwards (SP 0504 1499). From here it winds its way south eastwards through Bibury, Coln St Aldwyns and Fairford and past the Cotswold Water Park before flowing into the River Thames (or Isis) at SU 2100 9917 at the district boundary. The Coln is unusual in the frequency with which it splits temporarily into two or more parallel channels – no fewer than 14 times in its 25 km route to the Thames. The Coln receives one (unnamed) main river tributary at SU 1855 9834.
River Leach	-	SU 2422 9890	SU 2310 9990	76.93 (average)	0.866 (high)	12.11 (low)	36.8 (low)	The River Leach rises with two arms just north of the village of Northleach (SP 1149 1450) as a minor river and flows southward, being classed as a main river from SP 2021 0525 onward. It continues southward for 3km (separating into separate channels at three locations) before reaching the district boundary at around SP 2111 0281 and then forming the district boundary for a further 5.5km past Horseshoe Lake and Lechlade on Thames. The river reaches its confluence with the Thames just outside the district boundary.

* 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. Note that catchment descriptors for very small catchments are less reliable as any inaccuracies in the FEH CD ROM data can be exacerbated.

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			Upstream Catchment Descriptors* (from FEH CD ROM)					Watercourse Description
River Name	Enters District	Exits District	Downstream point of catchment	Upstream Catchment Area (km ²)	BFI HOST	SPR HOST	DPSBAR (m/km)	
Ampney Brook	-	SU 1045 9526	SU 1045 9525	70.08 (average)	0.743 (high)	20.56 (low)	29.4 (low)	The Ampney Brook, another tributary of the River Thames, begins as a main river at Ampney Park (SP 0625 0194) just 3km east of Cirencester. From here it flows southward down a gentle slope to the district boundary at SU 0882 9821 and along the boundary for a further 3.5km before leaving the district. The Brook separates into two parallel channels for 2km at SU 0946 9687.
River Churn	-	SU 0866 9491	SU 0795 9560	127.04 (average)	0.824 (high)	14.62 (low)	73.4 (medium)	The River Churn rises near the district boundary with Cheltenham as several minor rivers before being classed as a main river from SP 0232 0433 onward, just north of Cirencester. Within Cirencester the River Churn receives flows from the Gumstool Brook from where it continues south east through the Cotswold Water Park and reaching its confluence with the Thames at the district boundary (SU 0865 9476). The Churn runs along the district boundary prior to this for nearly 2km.
Gumstool Brook	-	-						The Gumstool Brook is a short tributary of the River Churn which rises as a minor river at Duntisbourne Abbots (SO 9714 0778), only becoming a main river 5.5km downstream just north of Cirencester (SP 0050 0400). The Brook then runs through the centre of the town parallel to the River Churn which it joins at SP 0323 0106 to the south of the town centre.

			Upstream Catchment Descriptors* (from FEH CD ROM)					Watercourse Description
River Name	Enters District	Exits District	Downstream point of catchment	Upstream Catchment Area (km ²)	BFI HOST	SPR HOST	DPSBAR (m/km)	
Marston Mersey Brook	-	SU 1287 9609		-	-	-	-	Marston Mersey Brook, another tributary of the Thames, is a main river along nearly the whole of its length. It becomes a main river at the point where it forms the district boundary at SP 1263 0040. It then flows southward for 5km along the district boundary, leaving the district at around SU 1287 9609.
River Thames or Isis	SU 0339 9631 SU 1400 9596	SU 0319 9403 SU 0863 9475 SU 2439 9840	SU 0315 9400	68.05 (average)	0.821 (high)	15.04 (low)	30.9 (low)	The River Thames originates as a minor river in the Cotswold District at Thames Head (ST 9804 9947), very soon being classed as a main river less than 1km downstream. It winds its way south eastwards through the lakes of Neigh Bridge Country Park (SU 0166 9482) at the western end of the Cotswold Water Park and then it runs eastwards out of the district at SU 0319 9403. It splits into a number of branches at the water park, one of which runs along the district boundary for over 6km (from SU 0339 9631 to SU 0863 9475). The Thames rejoins the district boundary at SU 1400 9596 and forms this boundary for a further 13.5km before finally leaving at SU 2439 9840. The Thames has many tributaries even at this upstream phase, some from within the Cotswold District (such as the Churn and Coln) and some also from other areas to the south.
Flagham Brook	-	SU 0173 9382						Flagham Brook main river rises on the district boundary at ST 9962 9448 and forms the boundary almost to its confluence with the Swill Brook at SU 0229 9346 just under 4km downstream.
Swill Brook	SU 0168 9324	SU 0348 9315						Swill Brook crosses the district boundary for under 2km between SU 0168 9324 and SU 0348 9315, receiving flow from the Flagham Brook before leaving the district.

The portion of the Marston Mersey Brook catchment which falls within the Cotswold District is only around 20km² in area. FEH CD ROM catchment descriptors become less reliable for catchments less than 20km² so the catchment descriptors have not been included for the Marston Mersey Brook in this study.

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1.9 Geology and Topography

- 1.9.1 The topography, geology and soil are all important in influencing the way the catchment responds to a rainfall event. The degree to which a material allows water to percolate through it, the permeability, affects the extent of overland flow and therefore the amount of run-off reaching the watercourse. Clay rich (low permeability) soils will promote rapid surface runoff, whereas more permeable rock such as limestone and sandstone may result in a more subdued response.
- 1.9.2 Topography has a direct impact on flood risk through its influence on catchment response to rainfall. Steeper slopes tend to cause a faster speed of flow, both below and over the ground surface. Topography also influences the extent of flooding as in flat areas floodwaters can spread over much larger extents than in narrow valleys.
- 1.9.3 The geology of the Cotswold District is complex and is dominated by limestones of the Jurassic age. The limestones within the Great Oolite Group and Inferior Oolite Group cover the majority of the District towards the north-western and central extents and have a significant influence on the topography, drainage and soils of the Cotswolds.
- 1.9.4 Much of the upland areas of the Cotswolds comprise the Great Oolite Group and demonstrate a greater variety in formations than the Inferior Oolite Group. Towards the south and east of the District in the Upper Thames Valley, the Jurassic limestones of the Great Oolite Group are succeeded by a succession of mudstones including the Oxford clay. These form the broad valleys around the main rivers and streams which flow eastwards.
- 1.9.5 There are relatively few drift deposits within the District, with the most prominent comprising the sand and gravel drift deposits found within the Cotswold Water Park towards the south. The deposits are mainly associated with the tributaries of the River Thames including the Rivers Churn, Coln, Leach, Windrush and Evenlode. Here, superficial deposits are thick and extensive.
- 1.9.6 Further drift deposits can be found towards the north east of the District, overlying the Lias deposits. These deposits tend to have a shallow water table and are drained by the surface watercourses running through them. When water levels in these watercourses are high, less groundwater is able to drain away. The drift deposits lie on top of the Oxford Clays or Lias Clays. The clays tend to act as a barrier to the downward movement of groundwater through the sands and gravels. This results in the sands and gravels being poorly drained leading to water-logging and surface water flooding.
- 1.9.7 Away from the escarpment the drainage is almost entirely south eastwards via the tributaries of the Thames; namely the Rivers Churn, Coln, Leach, Windrush and Evenlode. Where they join the Thames, superficial deposits are thick and extensive. The valleys of the Churn, Coln, Leach and their tributaries tend to be narrow and meandering because they are incised into the limestones of the Inferior Oolite and Great Oolite. They contain narrow tracts of superficial deposits. In contrast, the Windrush (and its main tributary the Dikler) and the Evenlode lie in broader shallow valleys cut into soft Lias mudstones, and may be flanked by more substantial expanses of terrace deposits and alluvium. In addition, in the case of the Evenlode, which drains the Vale of Moreton, there are broad tracts of till and associated sand and gravel deposits left behind by an ice sheet during the last Ice Age.

- 1.9.8 There are aquifers within the District that are confined by overlying geology. Groundwater levels within these confined aquifers may be artesian (above ground level) however the groundwater is prevented from reaching the surface by the overlying geology.
- 1.9.9 The topography of the District is influenced by the interbedded nature of the limestones and clays of the Inferior and Great Oolite Group. Towards the western extent of the District the landscape is characterised by a steep scarp face with incised valleys marking the edge of the Cotswold Hills. Here, elevations are in excess of 300m AOD with the Inferior Oolite rocks forming the main upland area. To the east and south west of the escarpment, the topography of the District becomes rather more undulating, reflecting the regional dip of the Inferior and Great Oolite beds. Towards the south and south eastern extents of the District, valleys of those such as the Evenlode, Windrush and Coln are typically much broader and shallower cut into the underlying softer Lias mudstones. Here, elevations ranging from approximately 165m AOD in the headwaters to 82m AOD as the watercourses approach the flatter, wider floodplains of the River Thames.
- 1.9.10 Solid geology and drift layers are shown in Volume 2, Tiles D1 and D2 respectively.

1.10 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.

2 Study Methodology

2.1 Level 1 SFRA Methodology

2.1.1 PPS25 recommends a staged approach to SFRA, 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

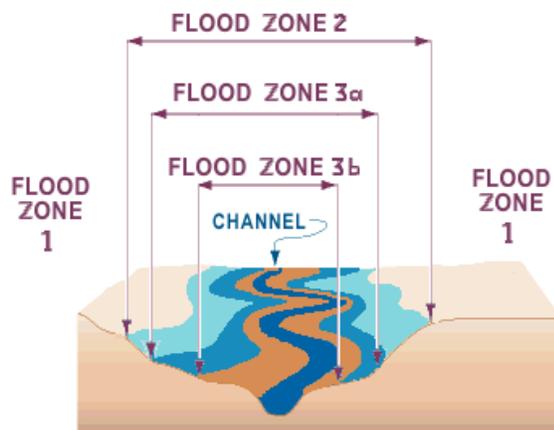
- 2.3.1 It is useful to gain a good understanding of Flood Zones and the approaches taken to satisfy the Level 1 SFRA requirements, using existing data.

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 In accordance with PPS25 within this SFRA the Flood Zones are defined as:

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). Within this Cotswold District Level 1 SFRA, where approved modelled flood extents exist to identify a 5% or greater annual probability of river flooding, they have been adopted as the functional floodplain (In the case of the River Frome the 4% [1 in 25 year] has been adopted as there is likely to be a minimal difference in extent between the 4% [1 in 25 year] and 5% [1 in 20 year] events). Where approved modelling of the 5% flood extent has not been undertaken, a conservative approach has been applied in defining the functional floodplain as being to equivalent to land assessed as having a 1% or greater annual probability of river flooding.

- 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 Cotswold District Council.
- 3.1.2 This report has been prepared in accordance with 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.

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 (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).

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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.

PPG17: Planning for Open Space and Recreation (2002)

- 3.3.12 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:

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- 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 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 the Cotswold area

Gloucester and Cheltenham Housing Market Area	Draft RSS Figures			Panel Modifications		
	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 SFRA 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:

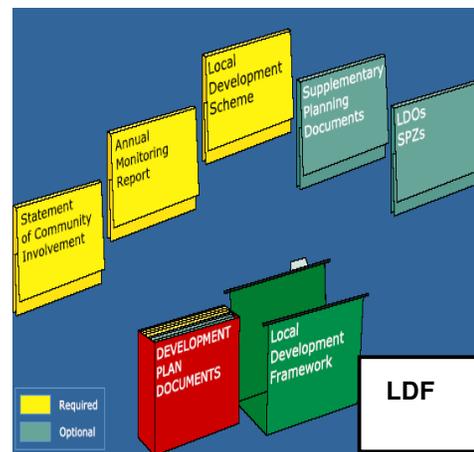
“Requiring the use of sustainable drainage systems to minimise flood risk associated with new developments”. Information on the use of SUDS can be found in Chapter 10, as well as in the policy recommendations in Chapter 7.

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
- 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 The Local Plan for the Cotswold District was adopted in April 2006. In 2004, following the introduction of the Planning and Compulsory Purchase Act, Cotswold District Council commenced preparation of their LDF. This will eventually replace the Cotswold District Local Plan 2001-2011. In the interim, the Local Plan is automatically 'saved' for a minimum of three years (to April 2009).

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 current LDS covers the period from March 2006 to March 2009.

3.5.5 The SCI sets out when and how the District Council will undertake public and stakeholder consultation with regard to the LDF process and in determining significant planning applications. Cotswold District's SCI was formally adopted on the 19th January 2007.

3.5.6 The Core Strategy is the most important part of the LDF, which will establish the planning objectives for Cotswold District to 2026 and set out the overall context for future development and growth in the District. The Issues and Options paper is the first major stage in the production of a LDF Core Strategy for the District. It is expected that further progress on the Core Strategy may slip in light of

the growing requirements surrounding the evidence base. Remaining milestones for the Core Strategy (including preferred options, previously programmed for March 2008) are therefore due to be reviewed in the next LDS (March 2008). Progress on the Site Allocations DPD and Generic Policies DPD are also dependent on the Core Strategy.

- 3.5.7 The LDF will contain various policies and proposals that will influence the development of the Cotswold District 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 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 6.8). 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. 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 (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, therefore the LPA should use the 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. Local historical flooding is explained more fully in Section 4.6, to compliment the information on fluvial flood risk. The Environment Agency has produced a number of historic flood outlines within the District and the following events have been mapped: March 1947, July 1968, August 1977, September 1992, October 1993, April 1998, December 2000, July 2007 and January 2008. These historic fluvial flood outlines can be found in Volume 2, Tiles E1-E7. Further historic information on flooding from no-fluvial sources can be found in Volume 2, Tiles B1-B63.
- 4.5.2 Sections 4.5.3 to 4.5.17 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.

Summer 2007 Floods

- 4.5.3 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–E7, 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.
- 4.5.4 It should be noted that potential changes to the Flood Map following the Environment Agency's July 2007 Flood Reviews, the Cotswold July 2007 Flood Review (Hyder Consulting, 2008) and any public map challenges are expected as part of an on-going project. This SFRA should be updated to include any updates to the Environment Agency Flood Map as they occur. Historic flood events should also 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 Events³

- 4.5.5 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

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

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.

- 4.5.6 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 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.
- 4.5.7 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 Cotswold District Council⁴

- 4.5.8 Following the heavy rainfall on 20 July 2007, Cotswold District Council received over 1,150 reports of flooded homes and businesses. Approximately 40% of these properties were located in Moreton-In-Marsh, Bourton-on-the-Water and Chipping Campden to the north of the district. In total, 79 towns and villages across the Cotswold District are known to have been affected by the floods in summer 2007.
- 4.5.9 Rivers were reported as a source of flooding in 42 of the 79 (53%) locations affected. The River Windrush flooded over 100 homes and businesses in Naunton and Bourton-on-the-Water, while the River Churn flooded parts of Cirencester. The River Thames at Lechlade reached record levels and there were over 100 reports of property flooding at the confluence of the Thames and River Leach. The northernmost part of the District is located within the Avon catchment. The River Cam, a sub-catchment of the Avon, caused severe flooding to a number of residential properties and businesses in Chipping Campden.
- 4.5.10 Some of the areas worst-affected by surface water flooding included Moreton-In-Marsh, Fairford and Whelford. Additionally, Thames Water has identified nine areas where properties were flooded internally by sewers (Fairford, South Cerney, Ampney St Peter, Ampney St Mary, Upper and Lower Slaughter, Moreton-in-Marsh, Bourton-on-the-Water, Quenington). However, it recognises that there were many other areas where sewers caused flooding to gardens and open spaces. Further, groundwater was reported as a source of flooding in nine locations.

⁴ Hyder Consulting (2008) Review of the Summer 2007 Floods in Cotswold District

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 Hydrology⁵ 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 4.1⁶ confirms the outstanding character of the May to July rainfall in 2007.

Table 4. 1: 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

- 4.5.12 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 4.1), 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.

⁵ <http://www.ceh.ac.uk/data/nrfa/index.html>

⁶ Marsh, T.J. and Hannaford, J. (2007) The summer 2007 floods in England and Wales – a hydrological appraisal. Centre for Ecology and Hydrology

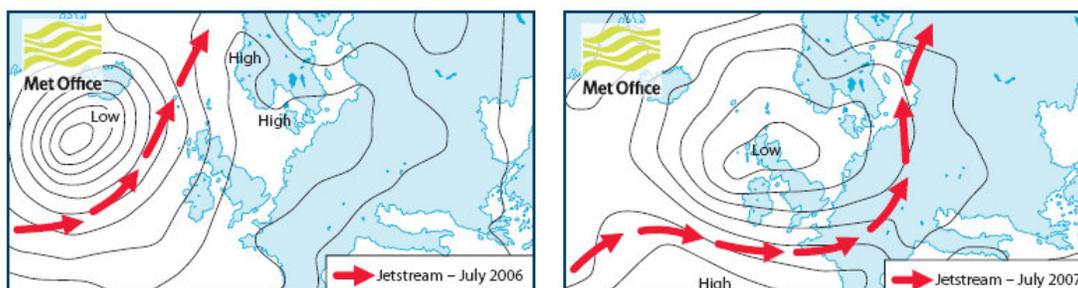


Figure 4. 1: Comparison of the position of the Jet Stream in July 2006 and July 2007 (Source: Met Office 2007)

- 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 totals⁵. 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.

March 1947

- 4.5.18 The March 1947 flood event that occurred on the River Thames, Flagham Brook, Swill Brook and River Churn flooded parts of the District in both rural and urban locations affecting a number of residential and commercial properties. The main locations affected include properties along the River

Cotswold District Council

Thames through Ewen, Somerford Keynes, the Caravan Park by Ashton Keynes, Kempsford and Lechlade on Thames. Along the River Churn a Water Sports Centre and residential properties at Cerney Wick were also affected.

July 1968

- 4.5.19 The July 1968 event occurred on the Knee Brook affecting a number of commercial and residential properties and a sewage works at Chipping Campden. A number of properties were also affected along an unnamed watercourse at Weston-sub-Edge.

August 1977

- 4.5.20 The August 1977 event also affected locations along the River Thames, but was smaller in magnitude than the March 1947 flood event. The historic flood outlines indicate that flooding was predominantly experienced in rural locations with some flooding to the Mobile Home Park to the east of Lechlade on Thames. The primary cause of the August 1977 flooding was thought to be local drainage problems and surface water.

September 1992

- 4.5.21 The September 1992 flood event mainly affected locations along the River Thames, River Leach, River Churn and Ampney Brook. Along the River Thames, the historic flood outlines extend predominantly onto rural floodplain with some properties located within the historic flood outline at Somerford Keynes and Kempsford. To the East of Southrop, Baxters Farm is located within the historic flood outline for the River Leach; some rural areas along the Ampney Brook by Ampney St Peter and along the River Windrush and a supermarket adjacent to the River Churn are all shown to lie within the September 1992 flood outline.

October 1993

- 4.5.22 The October 1993 flood event affected small rural areas along the River Evenlode to the east of Sydenham Farm, west of Daylesford and along the District boundary to the west of Kingham.

April 1998

- 4.5.23 The April 1998 flood event affected small rural areas along the River Evenlode to the west of Kingham.

4.6 Fluvial Flood Risk in Cotswold 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 Thames, River Churn, River Evenlode, River Dikler and River Windrush. In general, the Non Main Rivers have narrow Flood Zones, constrained by the local steep gradients.
- 4.6.2 The assessment of flood risk has also been enhanced using information from the River Thames Catchment Flood Management Plan (CFMP) and valuable local knowledge obtained from the Council and the Environment Agency. In general, the headwaters of the Thames catchment in Cotswold District cover relatively narrow, undeveloped floodplain with relatively small levels of flood risk. The main source of flooding in this area is predominantly fluvial; however, this often occurs in combination with high groundwater levels, with complex interactions existing between the rivers, lakes and

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aquifers within the District. This is particularly true towards the southern extent of the District within the Cotswold Water Park.

- 4.6.3 An initial assessment of the Flood Zone maps within the District indicates that of the 40,508 properties within the District, 2,156 are located within Flood Zone 3 and 3,029 are located within Flood Zone 2 (Table 4.2). Many of the watercourses within the District flow through rural areas and in general, the Flood Zone maps are relatively narrow for the smaller watercourses.

Table 4. 2: Properties located within Flood Zones 2 and 3 within Cotswold District

	No. Properties	Percentage of Properties Located within Flood Zone (%)
Whole District	40508	-
Flood Zone 3	2156	5.3
Flood Zone 2	3029	7.5

- 4.6.4 Starting towards the south of the District, Flood Zone maps exist for the River Thames and its main tributaries of the River Leach, River Coln, River Churn, Ampney Brook, and Marston Meysey Brook. As with the other watercourses within the District, the Flood Zone maps for the upper reaches of the tributaries of the River Thames are generally narrow with only a few locations shown to lie within Flood Zones 2 and 3. However, as these watercourses approach their confluence with the River Thames, Flood Zones 2 and 3 widen and vast areas are shown to be at risk from fluvial flooding. In general, locations shown within the Flood Zone maps correspond to locations reported within the anecdotal evidence and the Environment Agency Historic Flood Maps (Section 4.5). The main locations shown to be at risk from flooding include: Ewen, Somerford Keynes, a caravan park by Ashton Keynes, Kempsford and Lechlade on Thames on the River Thames; Northleach and Baxter's Farm on the River Leach; Andoversford, Bibury, Quenington, Fairford, and Whelford on the River Coln; Ampney Circus on the Ampney Brook; Cirencester, Siddington and South Cerney on the River Coln and Gumstool Brook. It should be noted that Flood Zones 2 and 3 for many of these watercourses are significantly misaligned, in particular, the River Thames through the Cotswold Water Park. Consultation with the Environment Agency has indicated that the existing hydraulic models for the River Thames and River Churn (built in 1996) do not incorporate recent development and structures that have been constructed within the floodplain. In addition, the complex interactions between the rivers, lakes and aquifers within the District have not been represented within the existing modelling. It has therefore been recommended by the Environment Agency that further detailed modelling is undertaken in this area to improve the quality and accuracy of the Flood Zone maps should development be planned for this area.
- 4.6.5 The River Evenlode flows in a south easterly direction through the District. Flood Zones 2 and 3 extend onto predominantly rural floodplain; however, a number of commercial and residential properties are located within Flood Zones 2 and 3 at Moreton-in-Marsh. This corresponds with anecdotal evidence from the summer 2007 floods, although the flooding experienced was thought to be from a combination of fluvial and surface water flooding. At Bledington, the Bledington Brook joins

the River Evenlode on the right bank. Flood Zone maps for the Bledington Brook show that a number of properties are located within Flood Zones 2 and 3 through the village. A number of misalignments can be seen in the Flood Zone maps for these watercourses which have been detailed in Section 4.7.

- 4.6.6 Towards the eastern extent of the District the River Dikler flows in a southerly direction, with Flood Zone maps extending onto predominantly rural floodplain with only a few isolated properties located within the Flood Zones. Flood Zones 2 and 3 are generally narrow, widening slightly when the River Eye joins on the right bank to the east of Lower Slaughter and again at the confluence with the River Windrush. Here a number of misalignments can be seen within Flood Zones 2 and 3 to the east of Bourton-on-the-Water, where a number of smaller drains and a series of lakes are located. Flood Zone maps for the River Eye indicate that a number of properties are located within the floodplain through Upper and Lower Slaughter, however, a number of misalignments can be seen within Flood Zones 2 and 3 along this watercourse.
- 4.6.7 The River Windrush initially forms the western boundary of the District, flowing in a predominantly south easterly direction. In the upper reaches of the catchment, Flood Zones 2 and 3 for the River Windrush are narrow reflecting the steep, confining nature of the surrounding topography; only a few isolated properties and farms are located within Flood Zones 2 and 3. However, at Bourton-on-the-Water, Flood Zones 2 and 3 widen as the watercourse nears its confluence with the River Dickler and a significant number of properties through the village are shown to be at risk.
- 4.6.8 Flood Zone maps for smaller watercourses within the District are generally narrow and extend onto predominantly rural floodplain with only a small number of isolated properties within Flood Zones 2 and 3. There are a number of locations where properties are located within Flood Zones 2 and 3 for smaller watercourses. As The Cam flows through the District in a westerly direction, a number of properties and a sewage works (SP 1632 3926) are located within Flood Zones 2 and 3 at Chipping Campden. A number of properties are shown to be at risk along the Knee Brook at Paxford. As with a number of the Flood Zone maps for watercourses within the District, misalignments are apparent in a number of places.
- 4.6.9 Towards the northern extent of the District, Flood Zone maps exist for a small unnamed watercourse which flows in a northerly direction before exiting the District to the north of Weston-sub-Edge. A number of both residential and commercial properties are located within Flood Zones 2 and 3 through Weston-sub-Edge, however, it is evident the Flood Zones are misaligned and therefore caution should be taken when interpreting this information.

4.7 Issues With Existing Flood Maps

- 4.7.1 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 extent 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 extents in some areas is poor, likely to be due to the limited data, upland fluvial setting and complex nature of drainage. The flood extents 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.
- 4.7.2 When viewing the Flood Zone data with OS Tiles these inaccuracies are clear, and whilst the best available information has been used, 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

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Environment Agency's ongoing Flood Map improvements. Updates to the Flood Zone maps should 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. 3: Inaccuracies with Flood Maps within Cotswold District

Watercourse	Location	Problem
River Thames	Cotswold Water Park	A number of inaccuracies are associated with Flood Zone maps for River Thames in upper reaches through Cotswold Water Park. Environment Agency staff have indicated that modelling undertaken as part of 1996 mapping study did not include recent development and a number of structures. In addition the models are not deemed suitable for Flood Zones as the area has complex groundwater interactions, as well as interactions between the lakes and watercourses in high flows which are not currently appropriately represented.
The Cam	Westington & Chipping Campden	Misalignments along much of watercourse including through Chipping Campden
Knee Brook	Paxford & Ditchford Mill	Flood Zone misaligned at Paxford where there are a number of small watercourses interacting. Further misalignments along watercourse until exits District
Blockley Brook	Blockley	Misalignments along watercourse between Blockley and confluence with Knee Brook
River Evenlode	Moreton-in-Marsh	Misalignments along watercourse through Moreton-in-Marsh. Downstream of town watercourse follows drain rather than watercourse. Further misalignments along watercourse and adjoining tributaries as flows through District
Westcote Brook	Various	Culverted sections, some misalignments
River Dickler	Upper Swell, Lower Slaughter & Bourton-on-the-Water	Misalignments along the watercourse including locations at Upper Swell. To the east of Bourton-on-the-Water in the lower reaches upstream of the confluence with the River Windrush where there are a number of drains and a series of lakes
River Eye	Upper Slaughter	Misalignments through village and along watercourse as flows through District
River Windrush	Cutsdean, Temple Guiting, Kington, Barton, Naunton & Lansdown	Misalignments along watercourse and joining tributaries that flow through the District. Misalignments evident in lower reaches around confluence with River Dickler where Flood Zone maps follow a series of smaller drains through the water meadow on the right bank rather than the watercourse
Sherbourne Brook	Various	JFlow generated Flood Zone maps with a number of misalignments in mainly rural locations
Unnamed Watercourse	Various	JFlow generated Flood Zone maps for small watercourse at Hatherop (SP 1718 0543) with a number of misalignments

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Watercourse	Location	Problem
River Coln	Various	Flood Zone maps misaligned throughout length of watercourse including locations at: Brockhampton, Sevenhampton, Syreford, Andoversford, Frogmill Inn, Withington, Cassey Compton, Saw Mills, Winson, Ablington, Arlington & Bibury. Consultation with EA staff has indicated that there is a complex relationship between the River Coln, Court Brook (draining from Fairford) and existing gravel pits. This is an area where development is underway and is also proposed. It should be highlighted that there is a need for further modelling work in this area.
Ampney Brook	Various	Misalignments throughout extent of watercourse
River Churn	Upper reaches including Coberley, Colesbourne	Misalignments in upper reaches of watercourse
Unnamed watercourse	Weston-sub-Edge	Misalignments through Weston-sub-Edge

4.7.3 Consultation with the Environment Agency has shown that the Flood Zone information is particularly erroneous around the Cotswold Water Park where there are complex interactions between the watercourses, lakes and groundwater (further details are given in Section 4.6). The existing model does not include development and structures that have subsequently been constructed. These issues spread uncertainty in the River Thames/River Churn model as a whole. The modelled Flood Zone outlines are therefore not deemed suitable by the Environment Agency. Should development be proposed in this area, further detailed modelling will need to be considered as part of a Level 2 SFRA. The watercourses in question are linked politically with North Wiltshire and Swindon and when the Thames floods it extends across the political boundaries. It is recommended that further modelling is undertaken as one combined project involving all the relevant stakeholders (i.e. Cotswold, North Wiltshire, Swindon etc). This will prevent unnecessary repetition of work.

4.8 Flooding from Other Sources

- 4.8.1 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.
- 4.8.2 Information has been gathered on flooding experienced from sources other than rivers, and is described in this section.

4.9 Flooding from Artificial Drainage Systems (Sewers)

- 4.9.1 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.
- 4.9.2 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.

- 4.9.3 Four water companies cover the Cotswold District: Severn Trent Water (STW), Wessex Water, Bristol Water and Thames Water. These companies have been consulted for information on flooding from surface water and artificial drainage sources and this has been provided where data has been made available.
- 4.9.4 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.
- 4.9.5 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.
- 4.9.6 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.
- 4.9.7 The data received has been provided at four-digit postcode level, hence no street level information on flooding was available. In summary it is evident that sixteen postcode areas within Cotswold 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 coarse resolution. In general the level of flood risk from artificial drainage systems within the District is medium to low with the exception of postcode area GL7 5 (located towards the south-eastern extent of the District) where there is a high level of risk (Table 4.4). The data for District is illustrated in Volume 2, Tile B64.

Table 4. 4: Flooding from Sewers as Recorded in the Severn Trent Water, Wessex Water and Thames Water DG5 Register

Postcode Area	No. Properties Affected	Level of Risk
GL10 3	12*	Medium
GL11 5	15*	Medium
GL3 4	3*	Low
GL51 4	3*	Low
GL53 9	5*	Low
GL54 2	3	Low
GL54 4	1*	Low
GL54 5	6*	Medium
GL55 6	1	Low
GL6 7	1*	Low
GL6 8	1*	Low
GL7 1	1	Low
GL7 4	1	Low
GL7 5	39	High
WR11 7	1*	Low
WR12 7	2*	Low

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

- 4.9.8 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.

4.10 Flooding from Surface Water

- 4.10.1 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.

- 4.10.2 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.
- 4.10.3 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 possibly be used to inform the production of 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.
- 4.10.4 The Highways Agency, County Council and Cotswold District Council provided extensive databases of surface water flooding locations and these have been mapped as GIS points in Volume 2, Tiles B1-B63.
- 4.10.5 It is evident that surface water flooding is a problem throughout the District with reported incidents referring to runoff from hills and drains being unable to cope with storm water. A detailed account of surface water flooding was received from RAF Fairford and is summarised below.
- 4.10.6 During the summer 2007 floods exceptional rainfall was experienced at RAF Fairford resulting in flooding to the airfield and surrounding villages of Whelford, Dunfield and Marston Meysey. A report produced by Defence Estates⁷ indicates that approximately 142mm of rain fell on the airfield and adjacent land over a six hour period on 20th July 2007. The most significant flooding was reported towards the eastern extent of the airfield (SU 1619 9815) which drains into the Dudgrove Brook. The intensity and duration of the rainfall event resulted in overland flow of storm water from adjacent land to the north of the airfield site, contributing to the localised flooding at the North East Jet Fuel Storage Installation (NE JFSI) and the Community Centre. In the area adjacent to the Community Centre, overland flow of storm water became a downhill watercourse, which led to flooding of the Base operations Building and Transportation Area.
- 4.10.7 The area towards the eastern end of the runway by Gate 7 provided an overflow area for the airfield drainage system. The Gate 7 Interceptor is the main outfall for the airfield and receives water from the runway, taxiways and aprons to the north and south. In addition to the airfield catchment, drainage is provided to adjacent land along Horcott Road and land to the north west of the airfield. It was reported that the drainage of the south taxiway to the Dunfield culvert was not surcharged during this storm event and overland flow of storm water to adjacent land was prevented by flood protection measures constructed in September 2004.

⁷ Defence Estates (2007), RAF Fairford Airfield Drainage Systems: Report on Flooding of Airfield 20 July 2007

- 4.10.8 Defence Estates identified four drainage routes within the airfield that convey drainage water to main rivers:
- River Coln – to the northern extent of Area 13
 - Dudgrove Brook – the Main Airfield and land along Horcott Road
 - Dunfield Culvert – part of the couth taxiway and south west parking aprons / South West Jet Fuel Storage Installation (SW JFSI)
 - Marston Meysey ditches – the west end of the runway and SW spur apron
- 4.10.9 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 light of this, surface water flooding is a significant problem, posing risk to Flood Zone 1 in addition to high and medium fluvial flood risk areas. 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. Any site-specific FRA would need to adequately assess the risk from surface water flooding.
- 4.10.10 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 Water⁸. 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.
- 4.10.11 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.
- 4.10.12 It is recommended that the Council considers the production of a SWMP for the District, though the exact location of where the SWMP should be targeted should be identified through future work.

8 Defra – Water Strategy, Future Water (2008)

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. Any FRA should also take account of canals. 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. It should be noted that there is a residual risk of breach from all raised canals and development should be avoided adjacent to these locations.
- 4.11.3 There is one canal located within the District. The Thames and Severn Canal is located at the northern extent of the District and runs parallel to the River Frome for much of its length. There are no records of breach or overtopping of this canal in the District. In addition, consultation with BW has indicated that there are no raised sections of canals within the Cotswold District.
- 4.11.4 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), although BW, as part of its function, will endeavour to maintain water levels to control the risk of flooding from canals to adjacent properties. 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

- 4.11.5 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 Cotswold District Council is detailed in Table 4.5.

Table 4.5: Reservoir Register for Cotswold District Council

Reservoir	Physical Status	Situation	NGR	Category	Year Built	Dam Type	Maximum Height (m)	Capacity (m ³)	Surface Area (m ²)
Dowdeswell	In Operation	Near Cheltenham	SO 99000 19700	Impounding	1886	Gravity and Earthfill	12	454600	77905
Cirencester Park - The Mansion Lake	In Operation	Cirencester	SP 01750 01750	Impounding	1736	Unknown	2	38326	34200
Gatcombe Water	In Operation	Near Stroud	ST 87000 99200	Impounding	1900	Impounding	5.8	60000	45000

- 4.11.6 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 than 25,000m³, 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. A simple assessment should be undertaken to identify if the area may be at risk and whether any policy recommendations are therefore necessary as a result.
- 4.11.7 Consultation with the Environment Agency has indicated that there are no records of breaching/overtopping of reservoirs within the Cotswold District. 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.
- 4.11.8 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. These are only recommendations and may not be adopted to inform future policy. The project is also considering means of making this information available to interested parties, both internal and external.

- 4.11.9 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. The Defra document FD2321/TR2⁹ 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, in the Cotswold District, the 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 flood risk from groundwater sources is in its infancy. There is 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

⁹ 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

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, including locations within the Cotswold District. 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 Although groundwater levels and river flows were very high in the Cotswolds during 2000/2001, no incidents, which could be strictly defined as groundwater flooding, were reported. Groundwater levels did not exceed previous levels by very much and were maintained for only a few days.
- 4.12.7 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 assess the geographical extent and severity of the groundwater flooding in 2000/01¹⁰. Analysis of the GEMs indicated that the problem of groundwater flooding within England is largely confined to Chalk aquifers, particularly in the southeast of England¹¹.
- 4.12.8 Also following the 2000/2001 event a groundwater monitoring network was set up, with trigger levels set on key boreholes to provide warning of a similar event occurring in the future. There are two groundwater flooding trigger level boreholes within the Cotswolds SFRA, these being Coln St. Aldwyn (SP10/96) and Hare Bushes (SP00/144). When groundwater levels exceed the set trigger level the Environment Agency will endeavour to inform its professional partners of this. These trigger level boreholes were successfully used in 2003 and 2007 to alert authorities and other external parties of high groundwater levels.

Groundwater Flooding within the Cotswold District

- 4.12.9 As discussed, records of groundwater flooding are generally limited and methods of mapping areas at risk from groundwater flooding are in their infancy. However, consultation with the Environment Agency and analysis of the GEMs produced by Defra has indicated that groundwater flooding has been reported within the District.

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

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

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- 4.12.10 GEMs extend into the south eastern extent of the Cotswold area have been mapped and can be viewed in Appendix F. The GEMs indicate that areas towards the southern extent of the District by Cirencester and along the river catchments of the Sherborne Brook, River Leach, River Coln, Ampney Brook, River Churn and River Thames may be susceptible to groundwater emergence (i.e. groundwater may be expected to be at or near to the ground surface in an extreme event). Research has indicated that a number of limitations are apparent with the GEMs therefore, where a development site is shown to be located within or adjacent to a groundwater emergence area, further investigation will be required as part of a site specific FRA.
- 4.12.11 Consultation with the Environment Agency has indicated that groundwater flooding has been reported within the District at a number of locations. Records of telephone calls or enquiries from residents who suspect that they have experienced groundwater flooding are held on a database by the Environment Agency and have been mapped as point locations (Volume 2, Tiles B1-B63). It should be noted that in some instances, reports have not been confirmed as groundwater flooding and therefore there are inherent limitations with the dataset. Table 4.6 details locations where groundwater flooding has been reported within the Cotswold District.

Table 4.6: Reported incidents of groundwater flooding within the Cotswold District (Source: Environment Agency)

Location	NGR	Date	Comments
Elm Bank View, Chapel Road, Cold Aston	SO 1280 1970	25/07/2007	Reports of occasional flooding following heavy rainfall
Shipton Oliffe, Cheltenham	SO 0400 1860	25/06/2007	Three inches of water reported in the lounge of property at lowest point of road. Significant heavy rain over last few days. Flooding thought to be groundwater or spring
Lower End, Daglingworth, Cirencester	SO 9960 0480	16/01/2008	Reports of water coming through kitchen floor fairly rapidly. Possibly groundwater but brook very close to property. Has been occurring over last 5 years.
Cirencester	SO 0160 0310	13/01/2004	Water appears in cellar every year
Whitelands Wood, near Cirencester	SO 0349 0345	27/04/2004	Water table as risen 3 times in last 3 years (twice in Nov/Dec 2000 and again in January 2003) flooding garden and rendering septic tank system inoperable. Fear that new development at property boundary may exacerbate situation.
Bledington, Chipping Norton	SO 2456 2251	30/07/2007	Reports of water collecting in the garden, lasting four weeks

- 4.12.12 A number of the reported groundwater flooding incidents occurred in summer 2007. During summer 2007, soil moisture deficits were recorded as the lowest on record (for July) across much of England and Wales; however the exceptional summer rainfall produced very substantial infiltration in some areas. As a consequence, previous maximum summer groundwater levels were exceeded by wide margins in some major aquifers throughout the UK¹². In the Jurassic Limestone of the Cotswolds, groundwater levels recorded at Ampney Circus in late July substantially exceeded the previous highest recorded level in a 50-year series for that time of year. The seasonally extreme groundwater levels were reflected in greatly increased summer outflows from springs and seepages, which contributed to major lowland flood peaks, and, particularly, to the extended period of record-breaking late-summer river flows in permeable catchments.
- 4.12.13 The underlying geology of the Cotswold District contributes significantly to the potential for groundwater flooding to occur. Drift deposits within the District can be found within the Cotswold Water Park towards the south of the District (predominantly sands and gravels associated with the River Thames) and towards the north-east of the District (overlying the Lias deposits). Drift deposits tend to have shallow water tables and are drained by the watercourses running through them. When the levels in these watercourses are high less groundwater can drain away. The drift deposits overlying the Oxford Clays or Lias Clays act as a barrier to the downward movement of groundwater through the sands and gravels, and as such, the sands and gravels may be poorly drained leading to water-logging and surface flooding. Within the study area there are also aquifers that are confined by the overlying geology. Groundwater within these confined aquifers may be artesian (above ground level) however; the groundwater is prevented from reaching the surface by the overlying geology. Groundwater levels recorded in these artesian boreholes may appear to be above groundwater but in reality are not. The aquifer hydraulic properties, groundwater regime and the nature of groundwater flow through the geological materials related to watercourses within the District will require further investigation should development be proposed in potential susceptibility areas.
- 4.12.14 In addition, consideration should also be given to groundwater springs which can be re-activated during high rainfall events. This was demonstrated in the Cotswold District during the summer 2007 event. Springs can begin to flow again and possibly emerge and lead to damage of property much higher up the hydraulic gradient as water levels rise in the regional aquifer.
- 4.12.15 Land drainage in agricultural fields and development schemes can affect shallow aquifer systems contributing flows directly to watercourses. Also engineering schemes, such as piling and road-cuttings, can interrupt and divert groundwater flows. Inappropriately designed surface water drainage infiltration systems can have an impact on groundwater when the water levels are high in the underlying aquifer. In these situations poorly designed schemes can have a negative effect by adding to the problems. This could also lead to a back-up and flooding of the drainage system as the soil / ground which it normally freely drains to may be fully saturated with no further capacity. All these factors can have an impact on groundwater flooding and consideration should be given to all these possible influences when considering new development.
- 4.12.16 In conclusion, areas at risk from groundwater flooding are largely unknown. Although data collected for the SFRA has provided an indication of areas potentially susceptible, the assessment undertaken as part of this SFRA is not exhaustive and the risk and impact of groundwater to all development must

¹² Centre for Ecology & Hydrology, http://www.nwl.ac.uk/ih/nrfa/water_watch/hs_browser_frame.html

be considered. Further to this a specific groundwater FRA should be submitted for sites within and adjacent the areas identified as susceptible.

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 River Thames through the Cotswold Water Park has particular Flood Zone issues. Detailed modelling should be undertaken in this area to improve the quality and accuracy of the Flood Zone maps, should development be planned for this area (through a Level 2 SFRA). As the watercourses in question are linked politically with North Wiltshire and Swindon, further modelling should be undertaken as one combined project involving all relevant stakeholders.
- 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.
- Whilst the SFRA has identified reservoirs with a storage volume greater than 25,000m³, there are smaller reservoirs 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.
- Groundwater Emergence Maps indicate that areas towards the southern extent of the District by Cirencester are susceptible to groundwater emergence. Where a development site is shown to be located within or adjacent to a groundwater emergence area, further investigation will be required as part of a site specific 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-B64, 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), to create the Flood Zones in this Level 1 SFRA flood outlines have been used which have been produced using detailed modelling techniques in preference to the Environment Agency's national JFLOW model wherever possible. Flood Zone outlines used within the SFRA are undefended and should be used to carry out the Sequential Test. This Level 1 SFRA also shows the functional floodplain (Flood Zone 3b). The SFRA defines Flood Zone 3b in paragraph 2.3.7. However, due to the existing modelling currently available, for the River Frome, the modelled 4% AEP (1 in 25 year) flood extent has been adopted as Flood Zone 3b (see Table 5.1). For all other watercourses in the District, following a precautionary approach (as there are known limitations with the modelling, as discussed in section 4.7 and tables 5.1 and 5.3) Flood Zone 3b has been shown to equal all of Flood Zone 3 (1% AEP [1 in 100 year] or greater flood extent). The PPS25 Practice Guide (2006) recommends this approach, 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.
- 5.1.4 It is recommended that the functional floodplain should be further reviewed in the Level 2 SFRA when more information is available as to the development needs of Cotswold District.

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, three Environment Agency 'detailed' hydraulic model exists. These are for the River Thames between its upstream Main River Limits and St John's Lock in Lechlade, the River Churn and the River Frome. The table overleaf discusses these modelled flood extents available for this SFRA, and also identifies where they have been included within the Flood Zones. The Flood Zones are presented in Volume 2, Tiles B1-B63. In all cases the approach has been discussed and agreed with the Environment Agency.
- 5.2.2 A hydraulic model for the River Thames has been constructed however, it should be noted that there are a number of inaccuracies associated with the modelled Flood Zone maps for the River Thames, particularly around the Cotswold Water Park. At this location there are complex interactions between groundwater, lakes and watercourses in high flows which are currently not appropriately represented within the existing hydraulic models (refer to Section 4.6). Following consultation with the Environment Agency, the existing Flood Zone maps have been used as opposed to model outputs. It has been

recommended by the Environment Agency that further detailed modelling is undertaken in this area to improve the quality and accuracy of the Flood Zone maps.

- 5.2.3 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-B63. It should be noted that some smaller watercourses do not have Flood Zones produced for them.

Table 5. 1: Environment Agency Hydraulic Models and Modelled Flood Zones within Cotswold District

Model	Watercourse Modelled	Derived From	Modelled Extents through District		Modelled Flood Zones			Notes
			Upstream	Downstream	3b	3a	2	
Thames between Main River upstream limits and St John's Lock in Lechlade	River Thames (Isis)	Environment Agency	SU 0058 98736	SU 0321 9404	✓	✓		Hydraulic model of main River Thames channel extends from Ewen within the District. Model coverage intermittently extends along the southern boundary and leaves the District at its downstream extent at SU 0058 9737. The model forms part of the boundary with the North Wiltshire, Swindon and Vale of White Horse Districts. A number of adjoining tributaries are included within the model. Environment Agency agreed to the use of their Flood Map to define Flood Zones for this watercourse as there is a lower confidence in the modelled outlines.
	Swill Brook	Environment Agency	ST 0167 9324	SU 0352 9314	✓	✓		Model forms part of the boundary with North Wiltshire District Council. Environment Agency agreed to the use of their Flood Map to define Flood Zones for this watercourse as there is a lower confidence in the modelled outlines.
	Flagham Brook	Environment Agency	ST 9962 9448	SU 0229 9344	✓	✓		As above
	Ampney Brook	Environment Agency	SU 0991 9599	SU 1043 9528	✓	✓		As above

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Model	Watercourse	Derived From	Modelled Extents through District		Modelled Flood Zones			Notes
			Upstream	Downstream	3b	3a	2	
Thames between Main River upstream limits and St John's Lock in Lechlade (cont'd)	Unnamed tributary to west of Marston Mesey	Environment Agency	SU 1249 9766	SU 1287 9609	✓	✓		As above
	Dalingworth Stream	Environment Agency	SP 0182 0229	SP 0324 0108	✓	✓		As above
River Churn	River Churn (including Daglingworth Stream & Gumstool Brook)	Environment Agency	SP 0230 0436	SU 0795 9562	✓	✓		Environment Agency agreed to the use of their Flood Map to define Flood Zones for this watercourse as there is a low confidence in the modelled outlines south of where the Churn crosses the disused railway line north of South Cerney (SU 040,984).
River Frome	River Frome	Stroud District Council	SO 92934 02983	SO 90813 02710	✓	✓	✓	4% AEP (1 in 25 year) outline used for Flood Zone 3b

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 B64. 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 coarse 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. Further assessment of risk from these sources may also be required as part of a Level 2 SFRA for key development areas.

5.5 Climate Change

- 5.5.1 In its October 2006 publication of the predicted effects of climate change on the UK¹³, 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.

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

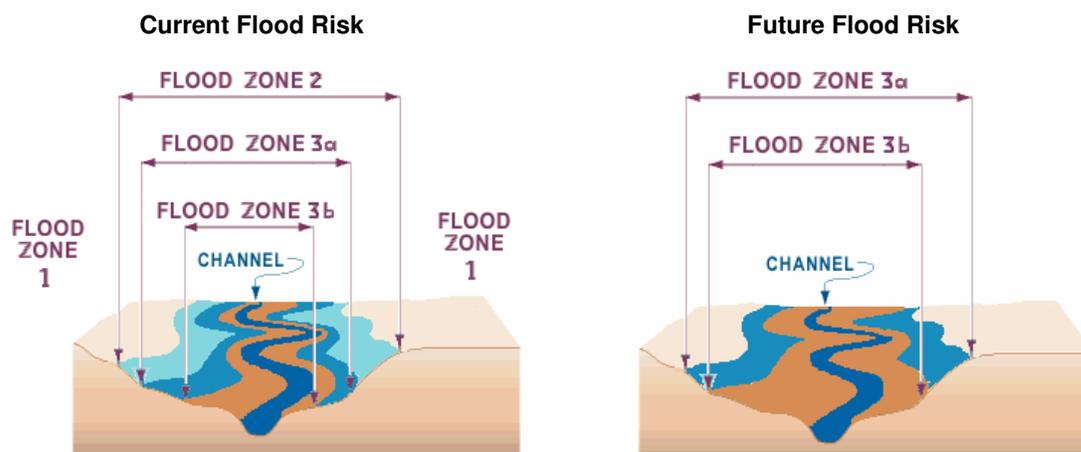
Parameter	1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115
Peak rainfall intensity	+5%	+10%	+20%	+30%
Peak river flow	+10%	+20%		
Offshore wind speed	+5%		+10%	
Extreme wave height	+5%		+10%	

Methods used to derive the Climate Change maps

5.5.3 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

5.5.4 This approach 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 any modelled climate change outlines. This approach is explained in the images below.



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5.5.5 A number of watercourses in the study area have been modelled, detailed in Table 5.3. Wherever possible, this study has sought to use modelled information for the 1% AEP (1 in 100 year) climate change scenario (i.e. 1 in 100 year + a 20% increase to peak flows) in preference to the technique outlined previously, outlines by either:

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

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

Model	Modelled Flood Outlines				Notes
	1 in 100 year + 20%	1 in 150 year	1 in 200 year	1 in 1000 year	
Thames between Main River upstream limits and St John's Lock in Lechlade					No modelled flood extents available indicating the potential impact of climate change.
River Churn	✓				1% AEP (1 in 100 year) + 20% increase to peak flows modelled.
River Frome	✓				While a modelled climate change outline does exist, it was not available for use in this study

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The climate change outlines are provided in a series of maps covering the study area (Volume 2, Tiles C1-C13).

- 5.5.6 The strategic flood risk maps (Volume 2, B Tiles) show the present-day fluvial flood risk scenario. This incorporates potential climate change into the Flood Zone maps and provides an effective method of incorporating climate change into the Sequential Test process.

Likely Climate Change Impacts

- 5.5.7 As discussed in Section 5.5.3, climate change impacts mean upland areas will be subject to deeper, faster flowing water, while in lowland areas the extent of flooding is likely to become greater.
- 5.5.8 The floodplains in the District are generally narrow and well defined in the upland areas, though they widen and flatter to the south of the District. Narrow 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 narrow floodplains. 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.
- 5.5.9 By contrast, the effect of climate change on fluvial flood risk in flat areas can be dramatic. Where climate change is expected to increase flood risk considerably, for example, where current Flood Zones are large (usually on wider, flatter floodplains), 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. Locations where it might be prudent to do so are at the south of the District along the Thames corridor and its tributaries. 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.
- 5.5.10 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.
- 5.5.11 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.

5.6 **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 (the River Frome only). 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 coarse 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 through the management of land, river systems and flood defences, and reduce the impact through 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. Cotswold District Council is covered by four CFMPs: The Thames CFMP covers the majority of the District; the Severn CFMP covers the northern tip of the District, the Bristol Avon CFMP covers the southern tip of the District and a small section of the south western border is covered by the Severn Tidal Tributaries CFMP. Figure 6.1 shows the coverage of CFMPs across the Cotswold District and how the District fits in the wider CFMP catchments.



Figure 6.1: Coverage of CFMPs across Cotswold District Council, and how the District fits in the wider CFMP Catchments

Severn CFMP

- 6.2.2 The first Severn CFMP was undertaken as a pilot study in 2004/2005 and during the course of the production of the SFRA, the updated draft Severn CFMP became available. The Severn CFMP covers the northern extent of the District and is affected mainly by Policy Unit 16: Avon Tributaries. While the Avon does not run through the District, the northern extent forms part of its wider catchment, though there are no Main Rivers in this area. The main centres of population are Chipping Campden, Willersey, Blockley and Mickleton, though the area is generally rural.
- 6.2.3 The selected option for this unit is to 'continue with existing or alternative actions to manage flood risk at its current level, accepting that flood risk will increase over time from this baseline'. Specifically, the level of flood preparedness (flood warning, flood proofing and flood resilience) should be increased and promoted in this area, and promotion of Environmental Stewardship Schemes will have the beneficial effects of decreasing run-off. Close communication between the Environment Agency Development Control and Local Planning Authority is required to ensure that development does not occur in areas of flood risk. The application of the Sequential Test to new development is therefore vital.

Thames CFMP

- 6.2.4 The Thames CFMP is available for use as a finalised document. The majority of Cotswold District falls into the Upper Thames CFMP Policy Unit which covers a large area of the River Thames and its main tributaries, from its source to Oxford. The Upper Thames Policy Unit is characterised by mainly undeveloped natural floodplain, with market towns and villages where there are clusters of properties at risk from flooding. The approach of the CFMPs to managing flood risk within such catchments is outlined below:
- The floodplain is our most important asset in managing flood risk
 - Maintaining the capacity of the natural floodplain to retain water and maintain the conveyance of watercourses in the towns and villages. Together this reduces the impacts of the more frequently experienced floods and has benefits for the natural environment
 - Redevelopment rates are often quite low. The natural floodplain should be safeguarded from inappropriate development. Refurbishment of buildings and redevelopment of industrial areas in the floodplain offers the opportunity to increase the resilience of these areas
 - Flood storage schemes will be complementary to wider objectives. However, the scale of intervention is likely to be moderate so other types of scheme can be progressed. There are some places where we will be able to reduce risk, but this will not be possible everywhere because of technical and economic constraints
 - Individual action will play an increasingly important role in these areas
- 6.2.5 Based on the findings of the CFMP, the preferred policy for the Upper Thames Policy Unit is: 'take action with others to store water or manage runoff in locations that provide overall flood risk reduction or environmental benefits, locally or elsewhere in the catchment. The Environment Agency's proposed approach for managing flood risk within the Upper Thames catchment is based on maintaining the function of the floodplain to retain water. Most of the floodplain of the Upper Thames

provides natural storage of water during times of flood. This leads to a reduction in the impact of flooding to property locally within this flood risk area and at locations downstream. For the Upper Thames Policy Unit, the key messages are therefore to:

- Maintain the capacity and function of the undeveloped natural floodplain to retain water so that it can continue to reduce the impact of low order flood events to people and property
- Seek to enhance the capacity of the undeveloped natural floodplain, recognising that this will require structural measures. This is more likely to be achievable upstream of sizeable communities at risk from flooding where the social, economic benefits are more clear-cut. Further refinement of the Upper Thames policy unit may be required to reflect the outcomes from these investigations
- Align the objective of maintaining or enhancing floodplain capacity with expansion and enhancement of floodplain environments, particularly Biodiversity Action Plan (BAP) habitat.
- Continue to reduce the impact of low order flooding in urban areas (up to a 20% AEP (1 in 5 year) event and 10% AEP (1 in 10 year) event) by maintaining conveyance where it is both effective and sustainable to do so
- Reduce the consequences of flooding through continued action to raise public awareness of flooding, tailoring the advice and approach (e.g. community based) to ensure those 'at risks' take appropriate action to respond to flooding
- Safeguard the existing undeveloped natural floodplain through the appropriate application of the Sequential Test within PPS25
- Maintain, or in some cases re-establish, river corridors so that urban areas can better accommodate flooding (location and layout) and the buildings are more resilient to flooding (design). In the long term this should be achievable through re-development. This is a long-term objective

6.2.6 The Environment Agency's adopted policy of accommodating more flooding in the undeveloped floodplain recognises the current value of the existing watercourses and floodplain as a flood defence; and how with further intervention its value can be maintained or enhanced. It recognises that flood defences cannot be built to protect everything. There may be the potential to deliver this policy so that it contributes to flood risk management at downstream areas. This will require a close collaboration between land and water management. Although the majority of benefits are likely to be local, there could be a cumulative benefit to the reduction of flood risk throughout the wider catchment area, particularly in the long term.

6.2.7 Most of the towns and villages where there are properties at risk from flooding are well established. The CFMP stresses the need to focus on the application of the Sequential Test to avoid inappropriate development in the floodplain and ensure that policies do lead to risk reduction where redevelopment does occur. This is further reinforced by the message that new flood defences are highly unlikely in most places. Any planning decisions that affect buildings or infrastructure at risk should therefore reduce the likelihood and consequences of flooding.

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- 6.2.8 An important element of flood risk management in the Upper Thames is to prepare for and to address the consequences of flooding. For example, increasing public awareness and improving flood warning systems. It is important to ensure that local drainage functions effectively and that vulnerable assets are resistant or resilient to water from any source. These actions could be pursued independently however in many cases it is suggested that a community based collective approach may be more effective. The CFMP also states that there are questions to be resolved associated with adaptation of vulnerable assets; in particular the role of the individual, private sector (e.g. insurance industry, Water Companies) and public sector (Local Authority and Environment Agency) in planning, funding and implementing these responses.
- 6.2.9 The CFMP Upper Thames Policy Unit also identifies the need to progress existing improvement options and strategies that complement the key messages of the policy unit such as the River Churn Strategy, in particular the consideration of flood storage upstream of Cirencester and reactivation of water meadows.
- 6.2.10 In conclusion, the overriding message of the Upper Thames Policy Unit is that flood risk should be managed by taking opportunities to maximise the potential of the floodplain to store water. It is therefore recommended that the Council seeks to safeguard the natural floodplain from inappropriate development. In addition, it should develop policies, strategies and initiatives that seek to increase the resistance and resilience of existing development at risk of flooding. This is because a large proportion of the properties at risk are dispersed across the local authority area and cannot be protected by flood defences.

Severn Tidal Tributaries CFMP

- 6.2.11 The recommendation of the Severn Tidal Tributaries CFMP for the area that affects the Cotswolds is in line with the recommendations of the Thames CFMP. PPS25 provides the policy framework to make sure that flood risk is considered in new developments, and opportunities to reduce flood risk by utilising natural processes to reduce surface water run-off, increase flow attenuation within channels and opportunities for flood storage should be realised. Improvements in river management including the restoration of river channels, functioning floodplains, sympathetic maintenance regimes, and the creation of buffer zones adjacent to rivers will all help manage flood risk in the area.

Bristol Avon CFMP

- 6.2.12 The policy unit for the area of the Cotswolds that falls in the Bristol Avon CFMP is as above.

6.3 Flood Risk Management Strategies

- 6.3.1 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
- 6.3.2 There are no Strategies known to exist within the Cotswold District Council area. However, the Upper Thames Policy Unit identifies the need to progress the River Churn Strategy.

6.4 Summary of Environment Agency Policies

- 6.4.1 The Environment Agency's proposed approach for managing flood risk within the majority of the District is based on maintaining the function of the floodplain to retain water and maximising this function wherever possible. The Environment Agency's priority will be to prevent development that works against this objective and adapt the maintenance activity to improve the capacity of the natural floodplain. The Council can help manage flood risk by seeking to ensure that the remaining floodplain is retained for flood risk management compatible uses by using the Sequential Test, using redevelopment opportunities to reduce flood risk (e.g. reduce building footprints or relocate to lower flood risk zones) identifying land for formal flood storage areas (ideally upstream of existing urban areas) and promoting the use of flood resilience measures. Within existing urban areas, efforts to reduce the impact of low order flooding by maintaining conveyance where it is both effective and sustainable to do so should be explored. Developer contributions could be sought for this purpose.
- 6.4.2 Towards the north of the District, including Chipping Campden, the level of flood preparedness (flood warning, flood proofing and flood resilience) should be increased and promoted in this area, and promotion of Environmental Stewardship Schemes will have the beneficial effects of decreasing run-off. Close communication between the Environment Agency Development Control and Local Planning Authority is required to ensure that inappropriate development does not occur in areas of flood risk. The application of the Sequential Test to new development is therefore vital.

6.5 Flood Defences

- 6.5.1 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.
- 6.5.2 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.
- 6.5.3 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

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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).

- 6.5.4 There are a number of locations at risk of flooding that are currently protected by permanent defences within the Cotswold District and these can be viewed in Volume 2, Tiles A1-A13. Table 6.1 provides details of the existing defences within the plan area that are contained within the Environment Agency's NFCDD database.

Table 6.1: Environment Agency NFCDD Defences within Cotswold District

Watercourse	Location	NGR		Type of Defence	Owner	SOP	Approx. Length (m)	Comments
		Upstream	Downstream					
River Evenlode	Queen Victoria Park to other side of railway lines, running under food store car park, Morton - in- Marsh.	SP 2053 3278	SP 2068 3275	Flood defence structure	Local authority	-	159	Stone built culvert, with stone headwalls /wingwalls/parapet us. On right bank.
River Evenlode	North of Oxford Street. Morton -in -Marsh.	SP 2074 3264	SP 2077 3260	Flood defence structure	Local authority	-	60	Flood Storage Area, with a raised earth embankment.
River Evenlode	Bledington Mill.	SP 2512 2257	SP 2518 2240	Raised defence	Unknown	1:5 Year	192	Raised soil bank in mill race. On left bank.
Dowdeswell Reservoir	Dowdeswell Cheltenham	SO 9878 1985	SO 9863 1974	Flood defence structure	Environment Agency	1:25 Year	192	
Dowdeswell Reservoir	Dowdeswell FSA	SO 9937 1981	SO 9872 1962	Flood defence structure	Environment Agency	1:25 1:100 Year	1458	Combination of Wave wall, gabion basket Wall, 2 stage Wall, gabion path, gabion wall, earth bank.
River Coln	Between Hathrop & St Aldwyn	SP 1468 0489	SP 1508 0511	Raised defence	Unknown	1:5 Year	537	Grassed raised bank - soil/earth, man made. On Left and right banks.
River Leach	U/S of Baxter's farm	SP 2021 0436	SP 2027 0419	Raised defence	Unknown	1:5 Year	180	Raised earth road embankment. On left bank.

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Watercourse	Location	NGR		Type of Defence	Owner	SOP	Approx. Length (m)	Comments
		Upstream	Downstream					
River Leach	Southrop	SP 2019 0378	SP 2020 0351	Raised defence	Unknown	1:5 Year	293	Bank retaining mill stream up to 2m above surrounding land. On left bank.
River Leach	Southrop	SP 2021 0348	SP 2030 0350	Raised defence	Unknown	1:5 Year	92	Stone revetment and wall. On right bank.
River Leach	Manor House, Southrop	SP 2031 0350	SP 2047 0354	Raised defence	Unknown	1:5 Year	177	Small raised road embankment, vegetated and stable. On left bank.
River Leach	U/S of Lechlade mill	SU 2313 0001	SU 2294 9969	Raised defence	Unknown	1:5 Year	375	Earth embankment On Left and right banks.
River Leach	Lechlade mill	SU 2293 9969	SU 2294 9968	Flood defence structure	Unknown	-	15	Concrete bank protection around property with main mill sluice in centre, on right bank.
River Leach	D/S of Lechlade mill	SU 2286 9963	SU 2283 9956	Raised defence	Unknown	1:5 Year	77	Raised earth embankment. Vegetated, stable, 2 sections on right bank.
River Leach	Mill Cottage	SU 2289 9961	SU 2288 9960	Raised defence	Unknown	1:5 Year	18	Shallow raised earth embankment. Vegetated, stable, on left bank.
River Coln	Whelford Mill	SU 1696 9946	SU 1702 9925	Raised defence	Unknown	1:25 Year	216	Grass topped bank, on right bank.
River Coln	D/S of Welford Mill. Welford	SU 1713 9917	SU 1720 9915	Raised defence	Unknown	1:5 Year	79	Masonry wall constructed of local stone and grassed earth bank.

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Watercourse	Location	NGR		Type of Defence	Owner	SOP	Approx. Length (m)	Comments
		Upstream	Downstream					
Daglingworth stream	Hereward Rd. Cirencester.	SP 0230 0246	SP 0232 0247	Flood defence structure	Local authority	1:50 Year	26	Raised bank with concrete masonry wall with raised parapet.
River Churn	Orchard House development. London Rd, Ciren.	SP 0275 0200	SP 0277 0199	Flood defence structure	Unknown	1:25 Year	26	Wall built from channel bed level, at risk of collapse. On right bank.
River Churn	Adjacent to lorry park	SP 0314 0102	SP 0327 0100	Raised defence	Unknown	1:5 Year	152	Earth embankment with level crest. On right bank.
River Churn	Tallot House Drive. School Rd: U/S of Clarks Hay Bridge. South Cerney.	SU 0467 9720	SU 0482 9723	Raised defence	Unknown	1:5 Year	139	Stone wall built from channel bed level. Varying Height, on left bank.
River Churn	Upper Mill, South Cerney.	SU 0465 9716	SU 0471 9718	Flood defence structure	Unknown	-	57	Raised earth/masonry embankment and culvert.
River Churn	U/S of Clarks Hay Bridge. South Cerney	SU 0474 9720	SU 0484 9723	Raised defence	Local authority	1:5 Year	102	Stone river wall.
River Churn	Bow-Wow Rd. South Cerney	SU 0484 9723	SU 0521 9729	Raised defence	Unknown	1:5 Year	479	Embankment between channels and stone wall with concrete foundation below water level. 6 sections on left bank.
River Churn	Chapter Manor Grounds	SU 0531 9737	SU 0532 9737	Raised defence	Unknown	1:5 Year	17	Stone bank protection. On left bank.

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Watercourse	Location	NGR		Type of Defence	Owner	SOP	Approx. Length (m)	Comments
		Upstream	Downstream					
Drain to River Thames or Isis	Somerford Keynes	SU 0184 9507	SU 0196 9466	Raised defence	Environment Agency	1:50 Year	483	Raised clay/earth embankment with conc. blocks inset into crest. On left bank.
Drain to River Thames or Isis	South of Somerford Keynes	SU 0194 9459	SU 0196 9461	Raised defence	Unknown	1:5 Year	74	Embankment leading to FSA. 2 sections on right bank.

6.5.5 Consultation has indicated that Cotswold District Council is working in partnership with the Environment Agency to undertake modelling work to investigate the potential for alleviation to Bourton-on-the-Water and Moreton-in-Marsh. In addition, there is a flood routing scheme from the River Thames through the lakes at Somerford Keynes.

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6.5.6 In addition to this information, the Council has supplied details of council-owned defences and flood alleviation schemes detailed below (Table 6.2). These have been mapped and can be viewed in Volume 2, Tiles A1-A63.

Table 6.2: Flood Defences Maintained by Cotswold District Council

Location	Watercourse/ Defence	NGR		Total Length (m)
		Upstream	Downstream	
Moreton-in-Marsh	Flood relief channel: Bourton Road, Moreton through to discharge into main River Evenlode	SP 19643234	SP 2114 3176	2100
Bourton-on-the-Water	Designated flood relief channel – The Steeps, Clapton Road, Bourton	SP 1629 2024	SP 1738 1961	1482
Chipping Campden	River Cam downstream of Blind Lane culvert to Badgers Field off George Lane	SP 1460 3887	SP 1528 3907	736
Willersey	Un-named watercourse downstream of Collin Lane culvert to old railway culvert, rear of Timms Green	SP 1019 3991	SP 1031 3969	230
Blockley Draycott Village	Un-named watercourse downstream of village crossroad and terminating at culvert grille adjacent to Wellacres Barn	SP 1813 3576	SP 1811 3586	101

Informal Defences

6.5.7 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-A13.

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

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- 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).

6.5.9 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.

6.6 Culverts

6.6.1 Sections of culverted watercourse as identified within NFCDD have been demonstrated in Volume 2, Tiles A1-A63 and detailed in Table 6.3. 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 6.8.

6.6.2 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 6.3: Culverted Watercourses as identified within NFCDD

Watercourse	Location	NGR	Owner	Approx. Length (m)	Comments
Darin to Broadway brook	Willersey, downstream of Collin Lane	SP 1025 3978	Unknown	264.8	Culverted channel. Trim banks and remove debris from channel and culvert along the designated length.
The Cam	Chipping Campden, downstream of Blind Lane culvert	SP 1498 3898	Unknown	731	Culverted channel. Trim banks and remove debris from channel and culverts along the designated length. On right bank.
	Draycott, downstream of village crossroad	SP 1813 3581	Unknown	110.8	Culverted channel. Trim banks and remove debris from channel along the designated length
River Evenlode	NE of Bledington	SP 2521 2300	Unknown	78.5	Twin brick arch culvert (Total length 262)
River Windrush	The Mill House Bourton on the Water	SP 1632 2092	Unknown	7	Masonry arch culvert under old mill building. Approx 3m wide.
River Dikler	Rissington Bridge	SP 1801 1968	Unknown	16	Side Culvert - Concrete Pipe. 2 sections of approx specified length on left and right banks.
River Windrush	Windrush Mill	SP 1922 1354	Unknown	11	Stone culvert under old mill building. 2 sections of approx specified length on left and right banks.
Drain to River Windrush	Barrington Park	SP 2034 1335	Unknown	15	Stone side culvert to drainage ditch. 2 sections of approx specified length on left and right banks.
Drain to River Windrush	Barrington Mill	SP 2097 1310	Unknown	10	Stone block side walls have been eroded at water level. On right bank.

Watercourse	Location	NGR	Owner	Approx. Length (m)	Comments
River Leach	Coate Mill	SP 2011 0452	Unknown	15.9	Stone block arch culvert running under mill.
Drain to River Thames or Isis	Orchard house-Tollgate House. Downington, Nr. Lechlade.	SU 2066 9972	Local authority	172	2 x 300mm concrete pipes with concrete headwalls U/S end. On right bank.
River Coln	Whelford Mill.	SU 1707 9922	Unknown	18.5	Right hand channel: 4.0m w masonry fixed crest weir u/s with 0.6 w x 0.5m h opening. Left hand channel: Steel trash screen u/s. 2 sections of approx specified length on left and right banks.
Daglingworth stream	Cirencester, Spital Gate Lane, Hereward road.	SP 0221 0240	Unknown	354.1	Culverted channel
Daglingworth stream	Cirencester, Abbey grounds	SP 0242 0222	Unknown	575.2	Culverted channel
Drain to River Thames or Isis	Somerford Keynes	SU 0212 9443	Unknown	86.3	4no. 2.0mx1.0m culverts (& weir 8.0m wide) and 2no. 2.5mx1.25m culverts linking FSAs. 2 sections on right bank.
Drain to River Thames or Isis	Cotswold Water Park	SU 0282 9363	Unknown	15.6	1no. 2.0mx2.0m culvert linking FSAs. On right bank.

6.7 Storage Areas

- 6.7.1 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.
- 6.7.2 There are a number of areas of extended floodplain acting as natural storage within the District. It is imperative that any storage areas used as a means of attenuation of flood waters should be 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.
- 6.7.3 Towards the southern extent of the District the Cotswold Water Park extends across the Council boundary and into the District on North Wiltshire. The Cotswold Water Park is located in the Upper Thames catchment area and lies between Swindon to the south and Cirencester to the north. It is Britain's largest water park, consisting of over 140 man-made lakes created by gravel extraction, covering some 40 square miles stretching from Poole Keynes in the West to Lechlade in the east. Complex hydrological interactions exist within the water park between the rivers, streams and lakes which also interact with groundwater in the sand and gravel deposits and an integrated approach to understanding these interactions and their impacts on flood risk is essential to managing the Cotswold Water Park in a co-ordinated way, in particular with future development pressures in mind. The CWP

Joint Committee recently commissioned a consultant to complete a Strategic Review and Implementation Plan (or Master Plan)¹⁴ with the aim to produce a vision for the future of the area.

- 6.7.4 The lakes within the Cotswold Water Park were formed as a consequence of gravel extraction work areas being allowed to fill up with water from the surrounding shallow groundwater. One of the key issues identified within the Cotswold Water Park Master Plan is the impact that continued growth of the lakes will have upon the natural hydrological processes both in terms of low flows and flood risk. Severe flooding was experienced in the Cotswold Water Park area during summer 2007. Mineral extraction can have a direct impact on flood risk if not appropriately managed and restoration is not suitably designed¹¹. Flood risk can increase from the backfilling of sites with impermeable material; alterations to the topography of the floodplain can affect flood flow routes; and development within the floodplain can increase surface runoff rates. Mineral extraction can also be used as a mechanism for alleviating flood risk. Assessment of the Flood Zone maps within the Cotswold Water Park (Section 4.6) has demonstrated the extent of the natural floodplain in this area as a form of storage and the necessity of maintaining the natural floodplain has been further highlighted following the summer 2007 floods.
- 6.7.5 It is fundamental that the hydrological interactions within the Cotswold Water Park are fully understood as part of any proposed development. However, consultation with both the Environment Agency and the District Council has indicated that there are a number of inaccuracies associated with the existing Flood Zone maps for the River Thames in the Cotswold Water Park area and that the complex interactions between all of the hydrological components are currently not appropriately represented within existing models. In addition, existing hydraulic models of the River Thames and River Churn built in 1996 do not incorporate recent development and structures that have been constructed within the floodplain. It has been recommended by the Environment Agency that further detailed modelling is undertaken in this area to improve the quality and accuracy of the Flood Zone maps. It is essential that a strategic approach is taken to modelling this area as one combined project involving all of the relevant stakeholders to ensure that the downstream effects of any further development within the area are fully understood.
- 6.7.6 Dowdeswell Reservoir is also located within the Council area at the boundary with Cheltenham Borough Council. Formerly owned by Severn Trent Water and used to supply water to Cheltenham, the reservoir was purchased as part of the Cheltenham Flood Alleviation Scheme and is now used for attenuation of flood waters.
- 6.7.7 Consultation with the District Council has indicated that the Council maintains a number of flood relief ditches and lakes within the District.

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Table 6. 4: Schedule of Flood Storage and Attenuation/Balancing Ponds

Location	Grid Reference	Type
Dowdeswell, adjacent to A40 trunk road.	SO 3988 2197	Former reservoir, currently land drainage flood storage area – Environment Agency Maintained
Cirencester, Cranhams Park,	SP 4016 2005	Attenuation/balancing pond
Moreton-in-Marsh, Blenheim Park	SP 4207 2326	Attenuation/balancing pond
Chipping Campden, Industrial Park, Battlebrook Drive, off Station Road.	SP 4169 2395	Attenuation/balancing pond

6.7.8 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.

6.8 Residual Risk

6.8.1 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

6.8.2 One ABD has been produced by the Environment Agency within the District, shown in Volume 2, Tiles A1-A63. This is located in south east Cirencester and includes a small areas behind a raised defence along the River Churn.

6.8.3 However, an assessment of residual risk should be made at the site-specific level as there are other defences in the study area which do not have ABDs produced for them. 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-A63 to assist with this.

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

6.8.4 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-A63. 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-A63. In some cases site visits may be required.

6.8.5 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.

6.8.6 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.

6.9 Existing Flood Warning System

6.9.1 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. The Cotswold District falls within the Thames and Midlands Regions of the Environment Agency.

6.9.2 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.

6.9.3 A flood warning system is in operation for the main rivers within the Cotswold 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



6.9.4 Flood Watch Areas can be seen in Volume 2, Tile F1. 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

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- **All Clear:** Flood Watches or Warnings are no longer in force. An All Clear can be issued at any stage e.g. a Flood Warning could be downgraded to All Clear without going to Flood Watch First. The following is recommended:
 - Flood water levels receding
 - Check all is safe to return
 - Seek advice

6.9.5 Table 6.5 details the flood warning coverage within the Cotswold District.

Table 6.5: Flood Warning coverage within Cotswold District Council

Type of Warning	Coverage	EA Region
Flood Watch	Rivers in the Cotswolds	Midlands
Flood Watch	The River Churn Catchment	Thames
Flood Watch	The Ampney Brook Catchment	Thames
Flood Watch	The River Coln Catchment	Thames
Flood Watch	The River Leach Catchment	Thames
Flood Watch	The River Windrush Catchment	Thames
Flood Watch	The River Evenlode Catchment	Thames
Flood Watch	River Thames from Cirencester to St Johns Lock, Lechlade	Thames
Flood Watch	River Thames from St Johns Lock, Lechlade to Eynsham Lock, Eynsham	Thames
Flood Warning & Severe Flood Warning	Ampney Brook and its tributaries from Ampney Crucis to Cricklade	Thames
Flood Warning & Severe Flood Warning	River Churn and its tributaries from Baunton to Cricklade	Thames
Flood Warning & Severe Flood Warning	River Coln and its tributaries from Compton to Lechlade	Thames
Flood Warning & Severe Flood Warning	River Evenlode and its tributaries from Moreton-in-Marsh to Shipton-under-Wychwood	Thames
Flood Warning & Severe Flood Warning	River Leach and its tributaries from Eastleach Martin to Lechlade	Thames
Flood Warning & Severe Flood Warning	River Stour from Shipston-on-Stour to Clifford Chambers	Thames
Flood Warning & Severe Flood Warning	River Thames from Cirencester to St Johns Lock, Lechlade	Thames
Flood Warning & Severe Flood Warning	River Thames from St Johns Lock, Lechlade to Eynsham Lock, Eynsham	Thames
Flood Warning & Severe Flood Warning	River Windrush and its tributaries from Bourton-on-the-Water to Worsham	Thames

- 6.9.6 The Environment Agency have identified a number of locations within the Thames West Area where a river level monitoring station is required to help provide or improve the flood warning and forecasting service offered. A planning programme of installations of such monitoring is currently underway on a priority basis and work on the installations is due to commence in April 2008 with the full programme expected to run for 3 to 5 years. Moreton-in-Marsh has been identified as a high priority site with the monitoring station scheduled to be installed during 2008/09. However, the installation process may take some time. It is recommended that any improvements to the flood watch and flood warning system are identified and the information incorporated into the SFRA when it becomes available.

6.10 Flood Response Plan

County Council Flood Response Plan¹⁵

- 6.10.1 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.
- 6.10.2 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:

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

Table 6.6: 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

- 6.10.3 The plan goes on to give details of flood warning and mitigation (as presented in Section 6.9), 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.
- 6.10.4 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.
- 6.10.5 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

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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. 7: 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	✓		

6.10.6 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.

6.10.7 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.

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- 6.10.8 The Council works in partnership with colleagues internally within the Council and externally, particularly with County Emergency Management Service, to prepare for emergencies. The Council also liaises closely with Health agencies, Government departments and agencies, Police, Emergency Services, other local authorities, voluntary agencies, and private organisations. The aim is to ensure that the Council is prepared for any major emergency and is able to respond to support the Emergency Services as required and assist those affected.
- 6.10.9 Following the summer 2007 flood events, the Council is currently updating the Emergency Plan.

Emergency Response Plan Recommendations

- 6.10.10 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.
- 6.10.11 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.
- 6.10.12 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

6.10.13 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.

6.11 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 sequentially 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 Floodline 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.

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.
- **CFMPs** - strategic planning documents 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
- 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 or resilient design, raised floor levels). No new building should be allowed in a flood risk area that is not flood resilient
- Identify long-term opportunities to remove development from the floodplain through land swapping
- Ensure development is 'safe'. For residential developments to be classed as 'safe', dry pedestrian access/egress should be possible for the 1% AEP (1 in 100 year) flood event with an appropriate allowance for climate change and residual risk; 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 0.1% AEP (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. All sites require the following approach to be taken:
 - The drainage system should 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 is required
 - 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

- Where prevention, source control/infiltration cannot deal with all on-site site drainage, for both Greenfield and Brownfield sites, the development runoff volumes and peak flow rates leaving the site should be attenuated to the Greenfield discharge conditions. Note: For some currently highly constrained Brownfield sites it may not be feasible to meet this requirement. In these exceptional circumstances (subject to agreement with Cotswold District and/or the Environment Agency) those proposing the development will be required to use the Greenfield conditions as the starting position for identifying what the next best option feasible on-site is. When involved, the Environment Agency will wish to see full justification as to why Greenfield conditions cannot be met.
- Exceedance design measures should 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
- 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)
- Promote environmental stewardship schemes to reduce water and soil runoff from agricultural land

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.
- Existing structures should only be removed once it can be demonstrated that it will not cause an unacceptable increase in flood risk, on-site and elsewhere
- 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 8.3 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. Typically, a Drainage Impact Assessment will be required to demonstrate that runoff from the site is reduced, thereby reducing surface water flood risk. This will involve the use of SUDS techniques which should take into account the local geological and groundwater conditions. Where prevention, source control/infiltration cannot deal with all on-site site drainage, for both Greenfield and Brownfield sites, the development runoff volumes and peak flow rates leaving the site should be attenuated to the Greenfield discharge conditions. Note: For some currently highly constrained Brownfield sites it may not be feasible to meet this requirement. In these exceptional circumstances (subject to agreement with Cotswold District and/or the Environment Agency) those proposing the development will be required to use the Greenfield conditions as the starting position for identifying what the next best option feasible on-site is. When involved, the Environment Agency will wish to see full justification as to why Greenfield conditions cannot be met.

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

- 7.3.4 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.
- 7.3.5 Any underground development e.g. basements or swimming pools should consider both the impact they may have upon the movement of groundwater and the potential to increase risk elsewhere, as well as the risk to the development.

Future Development within Flood Zone 2

- 7.3.6 Following application of the Sequential Test, 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.
- 7.3.7 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.
- 7.3.8 The following is required:
- A detailed site-specific FRA should be prepared in accordance with PPS25 and Council Development Control policies
 - A sequential approach should be followed within the site layout locating the higher vulnerability uses to the parts of the site with the lowest probability of flooding and to allow for SUDS.
 - Floor levels should be situated above the 100 year plus climate change predicted maximum level plus a minimum freeboard of 300mm
 - 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 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 1 in 1000 year event
 - SUDS should be implemented to ensure that runoff from the site (post development) is reduced. Where prevention, source control/infiltration cannot deal with all on-site site drainage, for both Greenfield and Brownfield sites, the development runoff volumes and peak flow rates leaving the site should be attenuated to the Greenfield discharge conditions. Note: For some currently highly constrained Brownfield sites it may not be feasible to meet this requirement. In these exceptional circumstances (subject to agreement with Cotswold District and/or the Environment Agency) those proposing the development will be required to use the Greenfield conditions as the starting position for identifying what the next best option feasible on-site is. When involved, the

Environment Agency will wish to see full justification as to why Greenfield conditions cannot be met.

- 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 3a or 3b, the site should be considered as if being within that higher Flood Zone itself.
- Any underground development e.g. basements or swimming pools should consider both the impact they may have upon the movement of groundwater and the potential to increase risk elsewhere, as well as the risk to the development.

Future development within High Probability Flood Zone 3a

7.3.9 Following application of the Sequential Test, 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.

7.3.10 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 either Cotswold District, the Environment Agency and/or the operating authority, as appropriate.
- A sequential approach should be followed within the site layout locating the higher vulnerability uses to the parts of the site with the lowest probability of flooding and to allow for SUDS.
- 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 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 and safe 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/or 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 300 mm above the 1 in 100 year flood level plus climate change.
- SUDS should be implemented to ensure that runoff from the site (post development) is reduced. Where prevention, source control/infiltration cannot deal with all on-site site drainage, for both Greenfield and Brownfield sites, the development runoff volumes and peak flow rates leaving the site should be attenuated to the Greenfield discharge conditions. Note: For some currently highly constrained Brownfield sites it may not be feasible to meet this requirement. In these exceptional circumstances (subject to agreement with Cotswold District and/or the Environment Agency) those proposing the development will be required to use the Greenfield conditions as the starting position for identifying what the next best option feasible on-site is. When involved, the Environment Agency will wish to see full justification as to why Greenfield conditions cannot be met.
- 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 3b, the site should be considered as if being within that higher Flood Zone itself.
- Any underground development e.g. basements or swimming pools should consider both the impact they may have upon the movement of groundwater and the potential to increase risk elsewhere, as well as the risk to the development.

Future development within Functional Floodplain Zone 3b

7.3.11 The functional floodplain is defined in paragraph 2.3.7 and the methodology used to map it is further describe in paragraph 5.1.3.

- Following application of the Sequential Test, 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).

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- '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). A sequential approach should be followed within the site layout locating the higher vulnerability uses to the parts of the site with the lowest probability of flooding and to allow for SUDS.
- 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.
- Any underground development e.g. swimming pools should consider both the impact they may have upon the movement of groundwater and the potential to increase risk elsewhere, as well as the risk to the development.

7.4 Council Specific Policy Issues

7.4.1 The CFMPs which affect the study area have been reviewed so that relevant policies can be included in the SFRA. The below paragraph outlines the policies that are relevant to Cotswold District Council.

7.4.2 The Environment Agency's proposed approach for managing flood risk within the majority of the District is based on maintaining the function of the floodplain to retain water and maximising this function wherever possible. The Environment Agency's priority will be to prevent development that works against this objective and adapt the maintenance activity to improve the capacity of the natural floodplain. The Council can help manage flood risk by seeking to ensure that the remaining floodplain is retained for flood risk management compatible uses by using the Sequential Test, using redevelopment opportunities to reduce flood risk (e.g. reduce building footprints or relocate to lower flood risk zones) identifying land for formal flood storage areas (ideally upstream of existing urban areas) and promoting the use of flood resilience measures. Within existing urban areas, efforts to reduce the impact of low order flooding by maintaining conveyance where it is both effective and sustainable to do so should be explored. Developer contributions could be sought for this purpose.

7.4.3 Towards the north of the District, including Chipping Campden, the level of flood preparedness (flood warning, flood proofing and flood resilience) should be increased and promoted in this area, and promotion of Environmental Stewardship Schemes will have the beneficial effects of decreasing run-off. Close communication between the Environment Agency Development Control and Local Planning Authority is required to ensure that inappropriate development does not occur in areas of flood risk. The application of the Sequential Test to new development is therefore vital.

7.5 Sensitive Development Locations

7.5.1 The main area in the District which has particularly complex flood risk issues is the Cotswold Water Park. The Environment Agency has advised that any further development in this area will require further work to fully appreciate the complex fluvial, groundwater and lake interactions. Without a full appreciation of this interaction, development should not go ahead.

7.5.2 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.

- 7.5.3 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.
- 7.5.4 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”.*
- 7.5.5 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.
- 7.5.6 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.
- 7.5.7 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 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 as outlined in Chapter 4). 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 G). 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: Sequentially 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). Those proposing windfall development should provide all the information necessary (using data agreed by Cotswold District) for Cotswold District to be able to fully identify whether there are any suitably alternative sites available in lower flood risk areas. The Council 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 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.

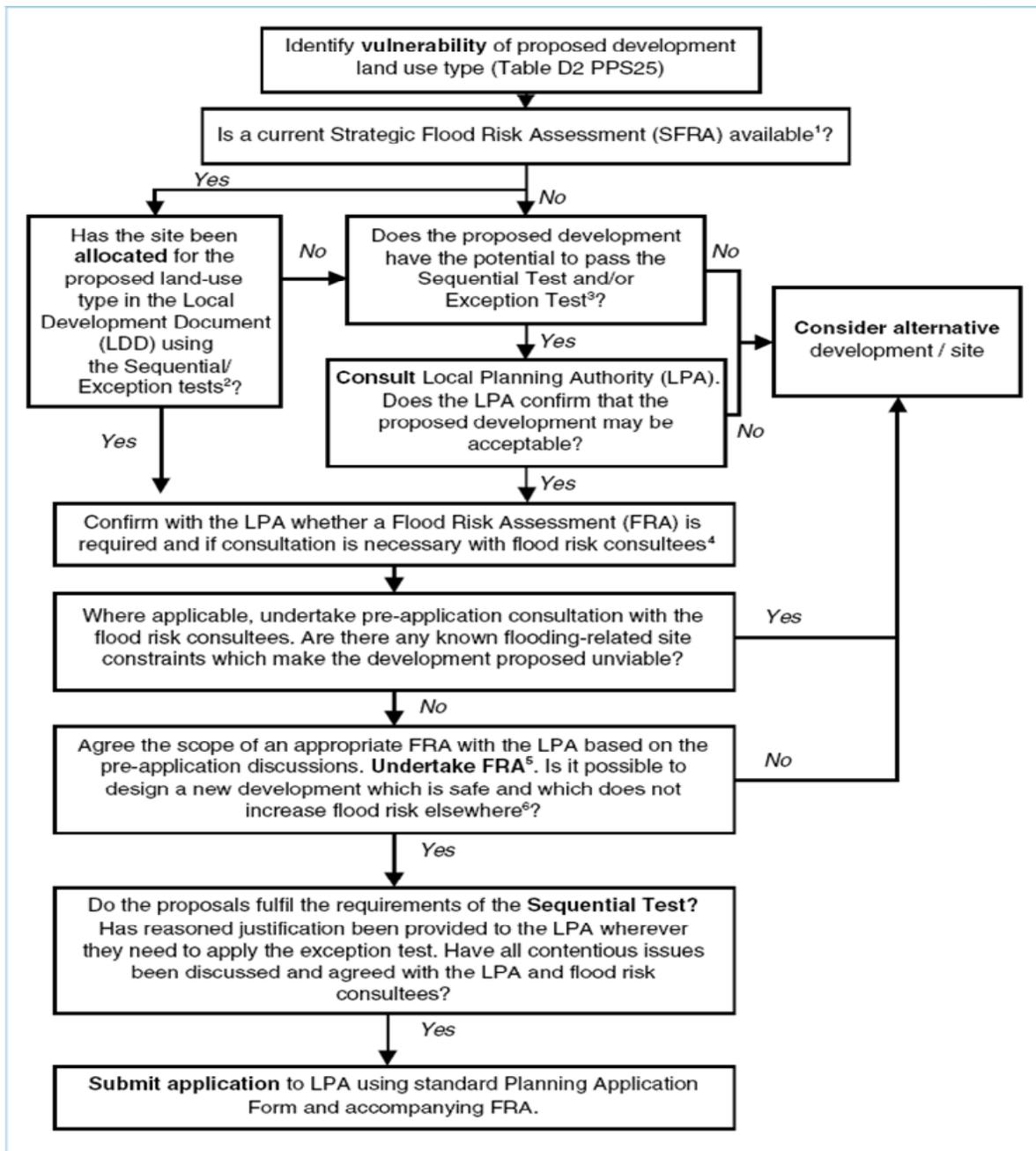
- 8.7.3 It should also be noted that paragraphs 4.33-4.39 of the PPS25 Practice Guide (2008) give guidance on applying the Sequential Test to areas requiring redevelopment or regeneration; redevelopment of an existing property and change of use.

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 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 is provided in Appendix G). 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.
- The Sequential Test should be applied to windfall sites, unless the area 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 Zones 1 and 2

- 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 (Chapter 7) 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.
- 9.2.3 Further guidance on the requirements of site specific FRAs for sites identified as potentially at risk of non-fluvial sources can be found in the CIRIA document C624 *'Development and flood risk – guidance for the construction industry'* (Lancaster et al) available from the CIRIA bookshop (www.ciria.org).

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.
- 9.3.2 Further guidance on the requirements of site specific FRAs for sites identified as potentially at risk of non-fluvial sources can be found in the CIRIA document C624 *'Development and flood risk – guidance for the construction industry'* (Lancaster et al) available from the CIRIA bookshop (www.ciria.org).

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
- Further guidance on the requirements of site specific FRAs for sites identified as potentially at risk of non-fluvial sources can be found in the CIRIA document C624 'Development and flood risk – guidance for the construction industry' (Lancaster et al) available from the CIRIA bookshop (www.ciria.org).

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.

- 9.5.2 Further guidance on the requirements of site specific FRAs for sites identified as potentially at risk of non-fluvial sources can be found in the CIRIA document C624 'Development and flood risk – guidance for the construction industry' (Lancaster et al) available from the CIRIA bookshop (www.ciria.org).

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. The documents 'Rainfall runoff management for developments – interim national procedure' and 'Preliminary rainfall runoff management for developments (R&D Technical Report W5-074/A Revision D) Environment Agency and Kellagher R, 2005 also provide detailed guidance on what is required to meet, as well as how to meet, the requirements of PPS25 for surface water drainage.
- 9.6.2 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, for both Greenfield and Brownfield sites, the development runoff volumes and peak flow rates leaving the site should be attenuated to the Greenfield discharge conditions. Note: For some currently highly constrained Brownfield sites it may not be feasible to meet this requirement. In these exceptional circumstances (subject to agreement with Cotswold District and/or the Environment Agency) those proposing the development will be required to use the Greenfield conditions as the starting position for identifying what the next best option feasible on-site is. When involved, the Environment Agency will wish to see full justification as to why Greenfield conditions cannot be met.
 - 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 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% annual probability 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 300 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 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 300 mm above the 100 year plus climate change flood level. 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.

9.8 Development Behind Defences

- 9.8.1 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.
- 9.8.2 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.
- 9.8.3 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
- 9.8.4 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.

9.9 Car Parks

- 9.9.1 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.

9.10 Developer Contributions

- 9.10.1 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.

9.11 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/or 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 300 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 require 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 an 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).

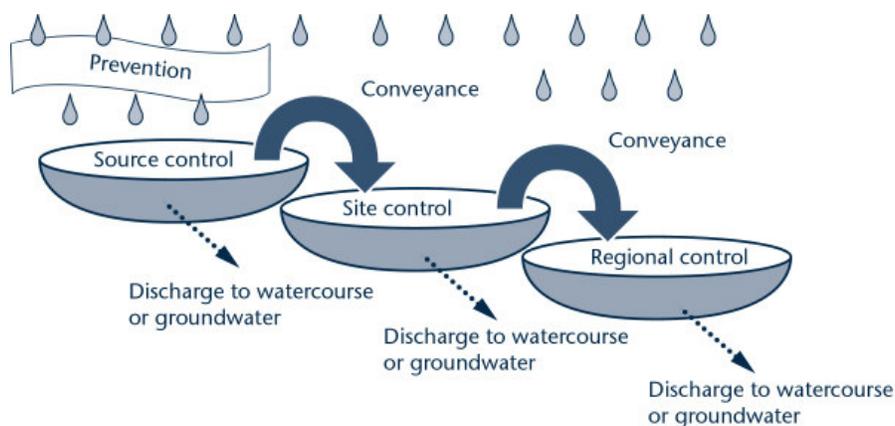


Figure 10.1: SUDS Management Train (from the Environment Agency website)

- 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 For all sites (both Greenfield and Brownfield), the post development runoff volumes and peak flow rates leaving the site should be attenuated to the Greenfield discharge conditions. Where prevention, source control/infiltration cannot deal with all on-site site drainage, for both Greenfield and Brownfield sites, the development runoff volumes and peak flow rates leaving the site should be attenuated to the Greenfield discharge conditions. Note: For some currently highly constrained Brownfield sites it may not be feasible to meet this requirement. In these exceptional circumstances (subject to agreement with Cotswold District and/or the Environment Agency) those proposing the development will be required to use the Greenfield conditions as the starting position for identifying what the next best option feasible on-site is. When involved, the Environment Agency will wish to see full justification as to why Greenfield conditions cannot be met.

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.

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- 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)
- www.ciria.org.uk/suds/

10.4 Application of SUDS for Cotswold District Council

- 10.4.1 Chapter 5 of the freely available SUDS Manual (CIRIA C697, 2007) provides guidance on how to select the most suitable SUDS for a specific site. Table 5.3 identifies the influence of site characteristics, such as geology, on SUDS selection. Table 5.4 identifies what SUDS are likely to be suitable following identification of the site characteristics. It may be possible to use the geological maps in this SFRA (Volume 2 Tiles D1 and D2) to help towards an early outline indication as to what SUDS may be suitable at an individual site. However, detailed site investigations will still need to be undertaken at the appropriate stage in the design process of the SUDS to identify whether infiltration systems are feasible.
- 10.4.2 The District has predominantly shallow lime-rich soils over chalk or limestone, with some impeded drainage and slowly permeable acidic loamy and clayey soil areas. 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.

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- 10.4.3 The entire district has been highlighted by DEFRA as a Nitrate Vulnerable Zone (NVZ) and a large area in the centre and several others in the west and north are 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.
- 10.4.4 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.
- 10.4.5 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 0.1 to 15.0 Kilometres. The Outer Zones are also sensitive to contamination and vary in diameter from 0.9 to 19.5 Kilometres. The GSPZ requires attenuated storage of runoff to prevent infiltration and contamination.
- 10.4.6 There are four major GSPZ inner zones (Figure 10.1) in the central of the Cotswolds District surrounding Cirencester and several others situated in the following areas:
 - Northern area of the district: Four in Chipping Campden
 - Western area of the district: Four in Tetbury

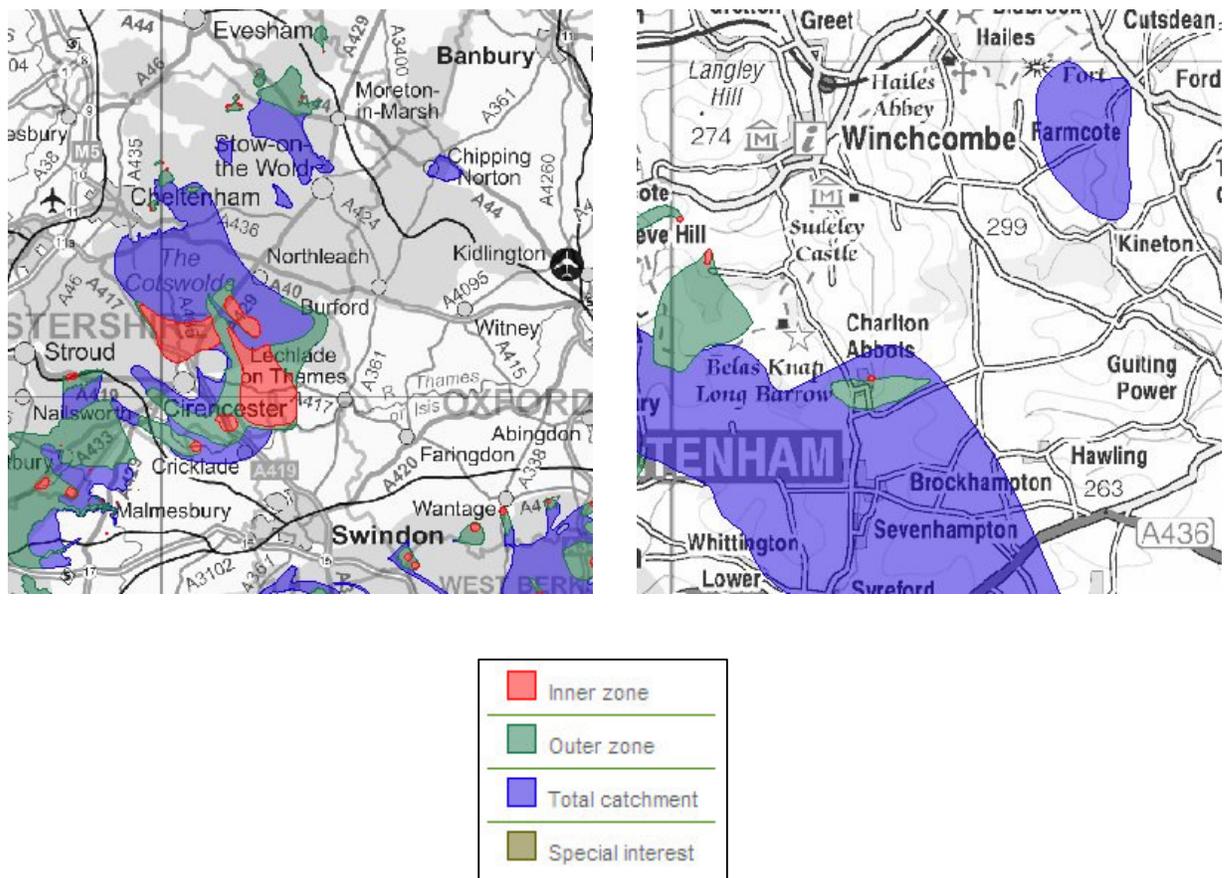


Figure 10. 2: GSPZ Inner Zones identified by the Environment Agency

- 10.4.7 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.
- 10.4.8 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.
- 10.4.9 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.
- Where prevention, source control/infiltration cannot deal with all on-site site drainage, for both Greenfield and Brownfield sites, the development runoff volumes and peak flow rates leaving the site should be attenuated to the Greenfield discharge conditions. For some currently highly constrained Brownfield sites it may not be feasible to meet this requirement. In these exceptional circumstances (subject to agreement with Cotswold District and/or the Environment Agency) those proposing the development will be required to use the Greenfield conditions as the starting position for identifying what the next best option feasible on-site is. When involved, the Environment Agency will wish to see full justification as to why Greenfield conditions cannot be met.
- 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 Level 1 SFRA, flood risk issues within the District can be summarised as follows:

- The Cotswold District occupies the western end of the Upper Thames catchment. The majority of the District drains south east toward the River Thames, with only small areas to the west draining toward the Severn. The steep topography can facilitate flash flooding.
- The greatest area at risk of fluvial flooding is in the south near the River Thames and the Cotswold Water Park. Smaller areas in towns such as Bourton-on-the-Water and Cirencester are also at risk.
- The underlying bedrock of the District is predominantly limestone which is highly permeable and an excellent aquifer. Percolation of precipitation through to the water table is therefore significant and corresponding runoff in limestone catchments can be relatively slow. However, if the groundwater level is already high and soil moisture deficit very low due to previous rainfall events or prolonged wet weather, limestone catchments have the potential to respond very rapidly to rainfall, which can result in both fluvial and groundwater flooding. The greatest flood risk in the area is therefore during periods of prolonged wet weather more common during winter months than in the summer.
- The main locations shown to be at risk from flooding from the River Thames and its main tributaries include: Ewen, Somerford Keynes, a caravan park by Ashton Keynes, Kempford and Lechlade on Thames on the River Thames; Northleach and Baxter's Farm on the River Leach; Andoversford, Bibury, Quenington, Fairford, and Whelford on the River Coln; Ampney Circus on the Ampney Brook; Cirencester, Siddington and South Cerney on the River Coln and Gumstool Brook
- In general the level of flood risk from artificial drainage systems within the District is medium to low with the exception of postcode area GL7 5 where there is a high level of risk.
- It is evident that surface water flooding is a problem throughout the District with reported incidents referring to runoff from hills and drains being unable to cope with storm water. During the summer 2007 floods exceptional rainfall was experienced at RAF Fairford resulting in flooding to the airfield and surrounding villages of Whelford, Dunfield and Marston Meysey.
- There is one canal located within the District. The Thames and Severn Canal is located at the northern extent of the District and runs parallel to the River Frome for much of its length. There are no records of breach or overtopping of this canal in the District, nor are there any raised sections.
- Consultation with the Environment Agency has indicated that there are no records of breaching/overtopping of reservoirs within Cotswold District.

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- Consultation with the Environment Agency has indicated that groundwater flooding has been reported within the District at a number of locations including: areas to the south west of the District around Cirencester (January 2004), Dalington (January 2008) and Whitelands Wood (2000, 2003 and April 2004); and towards the north of the District by Shipton Oliffe (June 2007), Cold Aston (July 2007) and Bledington (July 2007).
- There are a number of locations at risk of flooding that are currently protected by permanent defences within the District. In addition, council-owned defences and flood alleviation schemes are located at: Moreton-in-Marsh, Bourton-on-the-Water, Chipping Campden, Willersey, and Blockley Draycott Village.
- A number of areas of extended floodplain acting as natural storage can be found within the District. Of particular importance is the Cotswold Water Park located in the Upper Thames catchment between Swindon to the south and Cirencester to the north. Complex hydrological interactions exist within the water park between the rivers, streams and lakes which also interact with groundwater in the sand and gravel deposits and an integrated approach to understanding these interactions and their impacts on flood risk is essential to managing the Cotswold Water Park in a co-ordinated way, in particular with future development pressures in mind.
- One of the key issues identified within the Cotswold Water Park Master Plan is the impact that continued growth of the lakes will have upon the natural hydrological processes both in terms of low flows and flood risk. Severe flooding was experienced in the Cotswold Water Park area during summer 2007. Mineral extraction can have a direct impact on flood risk if not appropriately managed and restoration is not suitably designed. Flood risk can increase from the backfilling of sites with impermeable material; alterations to the topography of the floodplain can affect flood flow routes; and development within the floodplain can increase surface runoff rates. Mineral extraction can also be used as a mechanism for alleviating flood risk. Assessment of the Flood Zone maps within the Cotswold Water Park has demonstrated the extent of the natural floodplain in this area as a form of storage and the necessity of maintaining the natural floodplain has been further highlighted following the summer 2007 floods.
- Storage areas within the District have been identified at Dowdeswell Reservoir. This is currently used for attenuation of flood waters in Cheltenham. A number of flood relief ditches and lakes within the District are currently maintained by the Council.

Further investigations undertaken in a Level 2 SFRA may improve our understanding of these flood risk issues, or identify further issues.

11.3 Summary: Flood Zone Data Issues

- 11.3.1 The main area in the District which has particularly complex flood risk issues is the Cotswold Water Park. The Environment Agency has advised that any further development in this area will require further work to fully appreciate the complex fluvial, groundwater and lake interactions. It has been recommended that detailed modelling is undertaken to improve the quality and accuracy of the Flood Zone maps, should development be planned for this area. The watercourses in question are linked politically with North Wiltshire and Swindon, therefore the modelling should be undertaken as a combined project involving all the relevant stakeholders (i.e. Cotswold District, North Wiltshire, Swindon, County Councils and the Environment Agency). This will prevent unnecessary repetition of work and may facilitate the opportunity for value for money.

11.3.2 When viewing the Flood Zone data with OS Tiles a number of inaccuracies are apparent. 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. The Environment Agency has advised that some further modelling work may be required in order to gain better Flood Zone information.

11.4 Summary: Climate Change Issues

11.4.1 The floodplains in the District are generally narrow and well defined in the upland areas, though they widen and flatter to the south of the District. Well-defined floodplains generally mean that the change in extent of flooding expected is negligible under climate change scenario. 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. 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 fluvial flood risk in flat areas can be dramatic. 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. Locations where it might be prudent to do so are at the south of the District along the Thames corridor and its tributaries. 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.

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 across the study area. For all watercourses except the River Frome, Flood Zone 3 (1% AEP [1 in 100 year] flood extent) has been used to represent Flood Zone 3b. For the River Frome, the modelled outline for the 4% AEP (1 in 25 year) event 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 G. 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 developments situated behind raised 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
- Seek to ensure Flood Zones 2 and 3 remain undeveloped and 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)
- The Council should aim to manage flood risk by taking opportunities to maximise the potential of the floodplain to store water
- Conveyance should be improved through urban areas e.g. by removing restrictions and through river restoration opportunities
- 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

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- Ensure all new development has safe access, 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 consequences of flooding to existing development in flood risk areas should be managed by retrofitting flood resistance and resilience measures wherever possible and via emergency planning
- Require the use of SUDS in all Flood Zones for both Brownfield and Greenfield sites, to achieve Greenfield discharge rates. Space should be set-aside for SUDS.
- 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 Policy Relevant to the Council

11.7.1 The Environment Agency's proposed approach for managing flood risk within the majority of the District is based on maintaining the function of the floodplain to retain water and maximising this function wherever possible. The Environment Agency's priority will be to prevent development that works against this objective and adapt the maintenance activity to improve the capacity of the natural floodplain. The Council can help manage flood risk by seeking to ensure that the remaining floodplain is retained for flood risk management compatible uses by using the Sequential Test, using redevelopment opportunities to reduce flood risk (e.g. reduce building footprints or relocate to lower flood risk zones) identifying land for formal flood storage areas (ideally upstream of existing urban areas) and promoting the use of flood resilience measures. Within existing urban areas, efforts to reduce the impact of low order flooding by maintaining conveyance where it is both effective and sustainable to do so should be explored. Developer contributions could be sought for this purpose.

11.7.2 Towards the north of the District, including Chipping Campden, the level of flood preparedness (flood warning, flood proofing and flood resilience) should be increased and promoted in this area, and promotion of Environmental Stewardship Schemes will have the beneficial effects of decreasing run-off. Close communication between the Environment Agency Development Control and Local Planning Authority is required to ensure that inappropriate development does not occur in areas of flood risk. The application of the Sequential Test to new development is therefore vital.

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 Floodline Warning Direct service where it

can be provided. 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.

11.9 Recommendations: General

11.9.1 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 3km². 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. The exact location of where the SWMP should be targeted should be identified through future work.

11.10 Recommendations: Future Updates to the SFRA

11.10.1 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

11.11 Recommendations: Next Stage of Work

- 11.11.1 It is recommended that a detailed interrogation of emerging allocations is carried out using the SFRA data and the table supplied in Appendix G. 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.
- 11.11.2 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, or where information in the Level 1 suggests there may be a high risk to existing developed areas that warrants further investigation into the source and pathway of flooding. This will particularly assist in Development Control and emergency planning decisions and may also help to identify where Surface Water Management Plans may be necessary.
- 11.11.3 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.

11.12 Recommendations: Level 2 SFRA

- 11.12.1 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.
- 11.12.2 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 or where information in the Level 1 suggests there may be a need to investigate the source and pathway of flooding to existing developed areas.
- 11.12.3 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.
- 11.12.4 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

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

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 may be 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 1 in 20 year design event. In any one year the chance of a 1 in 20 year event occurring is 5%.
- 26) **GEMs** - Groundwater Emergence Maps
- 27) **GIS** – Geographic Information System. GIS is any system which stores geographical data, such as elevations, location of buildings and extent of flood outlines.
- 28) **High probability Zone 3a** - Defined as areas at risk of flooding in the 1 in 100 year design event. In any one year the chance of a 1 in 100 year event occurring is 1%.
- 29) **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).

- 30) **Integrated urban drainage** – An integrated approach to surface water management
- 31) **JFLOW** - A computer river model based on routing 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.
- 32) **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.
- 33) **LDD** – Local Development Documents
- 34) **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.
- 35) **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.
- 36) **LDS** – Local Development Scheme. A schedule and timetable for production of LDF documents.
- 37) **Low Probability Zone 1** – The area outside Zone 2. Defined as an area with less than 1 in 1000 year chance of flooding. In any one year the chance of a 1 in 100 year event occurring is less than 0.1%.
- 38) **LPA** – Local Planning Authority
- 39) **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.
- 40) **‘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.
- 41) **Medium probability Zone 2** - Defined as an area at risk of flooding from flood events that are greater than the 1 in 100 year, and less than the 1 in 1000 year design event. The probability of flooding occurring in this area in any one year is between 1% and 0.1%.
- 42) **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
- 43) **mAOD** – Metres Above Ordnance Datum

- 44) **NGR** – National Grid Reference
- 45) **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.
- 46) **OS** - Ordnance Survey
- 47) **Ordinary Watercourse (non-main river, minor watercourse)** – Any section of watercourse not designated as a Main River.
- 48) **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).
- 49) **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.
- 50) **PPS 25** - Planning Policy Statement 25: Development and Flood Risk. PPS 25 reflects the general direction set out in 'Making Space for Water'.
- 51) **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.
- 52) **Residual Risk** - The risk which remains after all risk avoidance, reduction and mitigation measures have been implemented.
- 53) **Return Period** – The probability of a flood of a given magnitude occurring within any one year e.g. a 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 in 100 year event could occur twice or more within 100 years, or not at all.
- 54) **RFRA** – Regional Flood Risk Assessment
- 55) **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.
- 56) **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.
- 57) **SEA** - Strategic Environmental Assessment.
- 58) **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.

- 59) **SFRM** – Strategic Flood Risk Management. An Environment Agency Framework which facilitates the implementation of **Flood Risk Management**.
- 60) **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.
- 61) **SPR** – Standard percentage runoff from the Hydrology of Soil Types classification.
- 62) **SA** - Sustainability Appraisal. An SA is an appraisal of plans, strategies and proposals to test them against broad sustainability objectives.
- 63) **SoP** – Standard of Protection. The return period against which a defence offers protection.
- 64) **SSSI** – Site of Special Scientific Interest. SSSIs are designated protected areas in the UK. NNRs and SACs are both SSSIs.
- 65) **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.
- 66) **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)
- 67) **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

Groundwater Emergence Map

APPENDIX G

Template to Assist with Sequential Test