- River Thames (Shifford to Eynsham) and Windrush (A40 to Thames Confluence), 2011
- River Thames (Eynsham to Sandford), 2000
- River Thames (Wolvercote to Kennington), 2006
- River Thames (Sandford to Whitchurch), 2000
- River Thames (Whitchurch to Henley), 2000
- River Thames (Mapledurham to Sonning), 2011
- River Thames (Henley to Hurley), 2002
- River Ock (Frilford to A34), 2007
- River Ock (A34 to Thames confluence), 2009
- Stert (Harcourt Way to Thames confluence), 2009
- Northfield and Littlemore Brooks, 2011
- Letcombe Brook, 2009
- Moor Ditch (Didcot to Thames confluence), 2007
- Bradford's Brook, 2009
- River Cherwell (Thrupps Bridge to Thames Confluence), 2006
- River Cole EDA (A419 to South Marston Brook), 2011

The Environment Agency's ongoing modelling and mapping programme includes the following planned projects:

- Ewelme Brook, Benson – 2014/15
- Assendon Stream – 2013/14
- Chalgrove Brook, Watlington – 2013/14

As part of the 2007/9 SFRAs, JBA Consulting and HR Wallingford carried out hydraulic modelling of many of the ordinary watercourses in the Districts to provide further information on flood risk in key settlements/potential development areas. The following watercourses were modelled:

- Ewelme Brook, Benson (JBA)
- Assendon Stream and Harpsden Court Stream, Henley-on-Thames (JBA)
- Baldon Brook/Garsington Stream, Northfield Brook/Littlemore Brook and Toot Baldon Ditch/Sandford Brook , Oxford Fringe (JBA)
- Black Ditch, Cuttle Brook and River Thame, Thame (JBA)
- Bradford's Brook/Mill Brook, Wallingford (JBA)
- Larkhill Stream/Wildmoor Brook, River Ock and River Stert/Penn Stream, Abingdon (JBA)
- Woodhill Brook, Wantage/Grove (JBA)
- Moor Ditch and Hakkas Brook, Didcot (HR Wallingford)

3.3.2 Topographical data

A range of topographical data is available in the Districts, which has been used in the assessment of risk for the SFRA, and also can be used by future FRAs.

The Environment Agency holds a large number of channel surveys, covering many of the watercourses within the Districts. For some channels only scanned paper drawings are available, for others the data is stored in EEBY format, making import into hydraulic models simpler.

Digital terrain data is available for some watercourses in the form of LIDAR data, and full coverage of the area at a lower resolution is available from the Flood Map for Surface Water DTM.

3.3.3 Assets and infrastructure

In early February 2013, the Environment Agency launched its new flood and coastal risk asset inventory, in England and Wales. The new Asset Information Management System (AIMS) now replaces the National Flood and Coastal Defence Database (NFCDD).

The Environment Agency supplied GIS files of flood defences and structures extracted from AIMS. This database includes both structures owned or maintained by the Environment Agency, by the Districts and by third parties.

The available flood defence data are shown in Map 9.

3.3.4 Flood history

Records of local flooding incidents have been collected from a range of sources. These sources of information are summarised in Table 3-2.

Table 3-2: Sources of historical flood data and information

Source	Data	Description	When provided/ updated?
Environment Agency	Groundwater flooding 2000/1	GIS layer of incidents of groundwater flooding at the property level.	2007
Environment Agency	Groundwater flooding 2004-2013	GIS layer of incidents of groundwater flooding at the property level.	2013
Environment Agency	Groundwater flood locations 2001	GIS layer identifying flow paths of groundwater flooding incidents during the 2001 event.	2007
Environment Agency	Previous FRA reports	FRAs for sites in Didcot - Great Western Park, Ladygrove North, Didcot Power Station Plot 9 and Unit 6, Hawkesworth, Southmead Industrial Estate	2007
SODC	Requests for sandbags	Record of incidents where the District Council were notified, normally to request sandbags. Properties can appear more than once if they have multiple incidents.	2007, updated 2008/9 and 2013
SODC	Monson Flood Investigation reports	Several reports into incidents of flooding.	Various
VOWH	Flood Management Database	Records incidents of flooding from all sources, where the District Council have been contacted, normally to provide sandbags.	2007, updated 2008/9 and 2013
VOWH	2007 flood grant claimants	GIS layer of location of claimants of flood grants for properties flooded internally after the 2007 event.	2007
VOWH	Frank Graham & Partners (1986). Land Drainage / Flood Study – Abingdon	Study of Stert and Penn Stream, looking at feasibility of flood alleviation scheme.	2007
VOWH	Parish Council Survey	Results of questionnaire to Parish Councils on flooding	2007
Didcot SFRA	Data collection report	Flood history review of Didcot	2007

The Chronology of British Hydrological Events (http://www.dundee.ac.uk/geography/cbhe/) provides a wealth of historical references to floods within the Districts. However, the majority of references do not give sufficient information to map the flood extents. A full listing of all events within the Districts since 1800 is provided in Appendix A.

A further internet search was carried out for references to flooding in the Districts beyond those already listed above, or identified on the Environment Agency Historic Flood Map. The results are summarised in Appendix A.

Map 8b summarises the historic flooding information compiled by the Didcot SFRA in 2007.

4 Understanding flood risk in the Districts

4.1 Introduction

This section assesses flood risk in the Districts from all sources, now and in the future. It makes use of all the data and information described in Chapter 3. It assesses flood risk from all sources, providing enough information for the councils to perform the Sequential Test.

Guidance on the planning implications is given in Chapter 6.

4.2 Fluvial flood risk

Fluvial flooding is flooding caused by high flows in rivers or streams exceeding the capacity of the river channel and spilling onto the floodplain, usually after a period of heavy rainfall.

Of 58,749 existing properties within South Oxfordshire, 3356 (6%) are within Flood Zone 2 and 1866 (3%) are within Flood Zone 3. Of 50,931 properties within the Vale, 3183 (6%) are within Flood Zone 2 and 2228 (4%) are within Flood Zone 3.

Fluvial risk is present on both main rivers (which are the responsibility of the Environment Agency) and ordinary watercourses (which are the responsibility of the Councils and riparian owners). The following sections briefly describe fluvial flood risk in the two Districts by watercourse. Map 2 and the GIS layers provided with this report should be referred to for further detail.

4.2.1 Fluvial flood risk by watercourse

River Thames

With one of the largest catchment areas in the UK, flooding on the Thames and its larger tributaries is relatively predictable, with lead times being in the order of days rather than hours. There have been many floods over the last century or so, notably 1894, 1947, 1977, 1979, 2000, 2003, 2007 and 2012.

The upper reach of the Thames has a wide rural floodplain and does not pose a high risk to property. The middle reach of the Thames has a substantial history of flooding of urban areas. Outside of the urban areas, the floodplain remains extensive, but less so than the Upper Thames, being typically less than 1km wide. This narrows to around 500m between Goring and Reading, as the river cuts through the Chilterns, with land rising steeply to both banks.

In Botley, whilst the majority of at risk properties are to the left bank within the City of Oxford jurisdiction, the Botley Road area has suffered fluvial flooding in all of the events mentioned above.

In Abingdon, significant areas of residential and town centre development are within the floodplain. Fluvial flooding was experienced in 1894, 1947, 1979, 2000, 2007 and 2012.

Between Abingdon and Wallingford, various settlements lie within or at the edge of the floodplain, including Sutton Courtenay, Appleford, Long Wittenham, Clifton Hampden, Burcot and Shillingford. Wallingford has experienced fluvial flooding to a relatively small number of properties in 1894, 1947, 1968, 2003 and 2007. Tributaries joining the Thames between Abingdon and Wallingford include the Ginge, Moor Ditch / Ladygrove Ditch, Thame and Bradford Brook / Mill Brook. Amongst these, flood risk is most notable on the Ginge at Steventon, with 161 properties at risk from a 100 year event.

Through Goring, Whitchurch and Mapledurham, the floodplain is typically well defined, with only a small number of properties at risk. The Thames then exits the study area as it passes through Reading. Downstream, back in the SODC area, the entire hamlet of Sonning Eye, and part of Playhatch are in the floodplain, with flooding having been recorded in 1947, 2003 and 2007.

Approximately six riverside properties in Shiplake experienced fluvial flooding in 2007, with a larger number at risk within Zones 2 and 3. At Henley, whilst the floodplain is relatively narrow, some flooding to property was reported in 1947, 1990, 2000 and 2003, though not in 2007 or 2012.

River Cole and tributaries

The River Cole is a tributary of the Upper Thames, forming part of the western boundary of Vale of White Horse District Council. The Tuckmill Brook tributary flows between Shrivenham and Watchfield, with some properties in Northford Close and Lake Road at risk.

River Ock and tributaries

The River Ock catchment contains a large number of small watercourses, draining a mainly clay catchment between the oolitic limestones (to north) and chalk (to south). In its lower reaches it represents a flood risk to a large number of properties in Abingdon. Flooding was recorded in 1947, 1979, 1992, 2003, 2007 and 2012.

In the upper reaches, its floodplain impacts on parts of several villages, notably Stanford in the Vale (Frogmore Brook), Charney Basset and Lyford (Ock) and Wantage, Grove and East Hanney (Letcombe Brook). Historic flood events are mapped for the Ock from Charney Basset downstream.

River Thame and tributaries

The Thame originates to the north and east of Aylesbury, but flows into the SODC area immediately to the north of Thame. Historic flood outlines are mapped for 1992 and 1993, but no serious property flooding resulted.

In contrast to the majority of the study area, the Thames CFMP has selected the policy: “accept the flood risk - reduce existing flood risk management actions.” For the Thame catchment, this would effectively mean allowing increased flooding in undeveloped areas. The Environment Agency anticipate that any flood relief solutions required within the catchment would be localised and would not impact on the wider catchment.

Other watercourses

Numerous other watercourses (both main river and ordinary watercourses) within the Districts pose a flood risk to small numbers of properties. Where these impact upon the key settlements, they are discussed in Appendix B.

4.3 Fluvial defences, assets and structures

The Flood Zones do not take into account the effect of flood defences and assets on flood risk. **Three** GIS layers are provided alongside the Flood Map which define national Defences, Areas Benefiting from Defences (ABD) and Flood Storage Areas. These datasets do not identify any assets within either District.

The Environment Agency has provided data from its AIMS system, which is a database of all known assets on main rivers. The data is in GIS format and includes points (e.g. for individual structures like weirs and bridges) and lines (e.g. for embankments or walls). This information is shown on Map 9, and summarised below.

4.3.1 Flood defence structures and raised defences

There are 152 'flood defence structures' in SODC and 195 in VOWH. The vast majority of these are point structures such as flood arches, weirs, locks and bridges that affect or control water levels in the event of a flood, rather than what would be considered a formal flood defence scheme. There are a small number of minor embankments. Most are privately or Local Authority maintained.

There are 6 'raised defences (man-made)' in SODC and 13 in VOWH. Again these are mostly minor embankments rather than formal flood defences. It does include the embankments of a flood storage area at Tilsley Park in Abingdon and the embankments of Farmoor Reservoir. Farmoor Reservoir is not a flood storage area. It may have an impact on reducing flows in the Thames in some flood events, but its operating regime is not specifically designed to do so.

The Oxford Flood Risk Management strategy[14] has been adopted by the Environment Agency to tackle flood risk in Oxford. It includes recommendations for the 'Western Conveyance Channel' to divert flood water around the west and south of Oxford. If built, this would impact

[14] Environment Agency (2010) Oxford Flood Risk Management Strategy http://www.environment-agency.gov.uk/homeandleisure/floods/127355.aspx

on a corridor of land within VOWH. The Environment Agency are looking to safeguard this land against development and have requested this to be included in the Local Plan.

4.3.2 Non flood defence structures

There are over 800 'non-flood defence structures' in SODC and over 1300 in VOWH. These include features such as railway embankments, bunds, sheet piling which may affect water level, and also bridges and footbridges. Some of the larger embankments include the railway embankment at Kennington and the railway crossing of the Thames south of Radley. Inspection of LIDAR data and model results indicate that neither of these is likely to have a significant defensive impact, and therefore that any “residual risk” is nominal.

Whilst some minor embankments within the Districts may offer a degree of protection to some areas, historic flood outlines indicate that they are not operating as effective flood defence structures.

4.3.3 Culverts

Culverts may frequently increase flood risk, both due to blockages, either of the culvert itself or trash screens, or where they are hydraulically inadequate due to under-capacity or condition. In general the Districts have a low proportion of culverted watercourse, but where they do exist they can be problematic. Responsibility for maintenance of culverts can be difficult to determine between riparian owners, District and County Councils and the Environment Agency.

All culverts recorded on the Environment Agency’s AIMS database are shown on Map 9. The AIMS database only includes culverts on main rivers. The Councils do not keep a formal record of culverts or other assets on ordinary watercourses, however additional culverts of interest have been marked on Map 9, and Council Drainage teams can be contacted for further information on culvert locations.

Notable culverts in the districts include:

- River Stert, Abingdon - Culverted through Abingdon town centre
- Radley Park Ditch, Abingdon - Culverted from the south end of Chilton Close to Radley Road
- Ladygrove Brook, Didcot - Culverted under the Ladygrove Estate.
- Mill Brook, Wallingford - Flows into the head of this culvert were reversed in the 1970s, directing all natural flows into the Bradford’s Brook. Only local surface water sewers and highway drainage connect into this culvert.
- Assendon Stream, Henley - The course of Assendon Stream enters a culvert along Fair Mile, but is not recorded on AIMS. A crude route plan was obtained from Oxfordshire County Council. This culvert was found to be in poor condition during the last flood in 2000/1.
- Wheatley Brook, Wheatley - Culverted from west to east under the High Street to Crown Square. Takes high natural flows from surrounding land.
- Town Ditch, Henley - Runs from upper Henley through the town centre between Hart Street and Friday Street. Takes highway drainage and spring flows.

This is by no means an exhaustive list, and risk from culverts should be assessed on a local basis, particularly on ordinary watercourses.

4.3.4 Local flood alleviation schemes

The Councils provided details of schemes carried out on Ordinary Watercourses, funded under the Flood and Coastal Erosion Risk Management Grant in Aid scheme (FCRMGiA).

SODC have carried out works at Chalgrove, Roke, Tiddington, Wheatley, Clifton Hampden, East Hagbourne, Nuneham Courtney, Sydenham, Towersey, Thame, Pyrton and Chinnor since 2009, with work at Berrick Salome, Sandford-on-Thames ongoing. Further work at Wheatley is planned in 2013/14. Most of this work is watercourse or culvert improvements, but includes a Property Level Protection (PLP) scheme at Thame.

VOWH has completed schemes at Longcot and East Hanney, and a PLP scheme at Cumnor Road (Oxford), since 2010. A scheme to improve a culvert at Appleton is ongoing and work at Farm Road Abingdon due to start in 2013.

4.4 Surface water flooding

Flooding of land from surface water runoff is usually caused by intense rainfall that may only last a few hours, and usually occurs in lower lying areas often where the drainage system is unable to cope with the volume of water. Of course surface water flooding problems are inextricably linked to issues of poor drainage or drainage blockage by debris, and sewer flooding.

The Flood Map for Surface Water (Map 5) predominantly follows topographical flow paths of existing watercourses or dry valleys with some isolated ponding located in low lying areas. If the FMfSW indicate a risk to a site allocation or settlement this has been discussed in further detail in Appendix B. It should be noted that because of its broad-scale nature, wherever possible, these mapped outlines should be used in conjunction with other sources of local flooding information to confirm the presence of a surface water risk.

A review of the local flooding history, PFRA, and discussions with Council drainage teams has been undertaken to assess where there are known surface water flooding problems in the Districts. Changes to legislation in recent years means surface water flooding is being recorded as a specific cause of flooding more effectively, so most of the known events are in the last 10 years. The following settlements have suffered surface water flooding problems in recent years:

- Wheatley and Horspath - July and October 2012.
- Berrick Salome/Roke, Chalgrove, Kidlington, Thame, Tiddington and Wheatley (among others mostly in South Oxfordshire District) - June 2008.
- Nuneham Courtenay - January 2003, August 2004, October 2006, July 2007.
- Abingdon, Appleton, Ashbury, Buckland, Charney Basset, Childrey, Chinnor, Cumnor, Denchworth, Drayton, East Challow, East Hanney, East Hendred, Eaton, Faringdon, Fernham, Fyfield, Frilford, Goosey, Grove, Kingston Lisle, Letcombe Regis, Longcot, Milton, Netherton, Shrivenham, Southmoor, Stanford in the Vale, Sutton Courtney, Uffington, Wantage, West Hendred, Woodcote, Wootton - July 2007.

The July 2007 event was a major incident with flooding occurring from all sources over the course of the event, but the above settlements were specifically recorded as being affected by surface water flooding by the PFRA and the VOWH July 2007 Flooded Properties spreadsheet. There are other more isolated surface water incidents recorded

Many of these areas have received Flood and Coastal Erosion Risk Management Grant in Aid (FCRMGiA) funded flood alleviation works since the events.

4.5 Groundwater flooding

Groundwater flooding can occur, after prolonged periods of high winter rainfall, when the regional water table rises above the land surface and inundates limited areas of low lying ground. It occurs in the unconfined parts of aquifers (where strata comes to the surface). It is often differentiated from fluvial flooding by the clarity of the flood waters.

Amongst the general population there is a poor understanding of groundwater flooding, however, on the basis of experience gained from the two events this century we are now in a better position to predict which areas are likely to experience groundwater flooding.

This type of flooding is particularly disruptive because it can continue for weeks and even months before groundwater levels recede. The consequences of groundwater flooding include, groundwater seeping into dwelling foundations, supercharging of storm/foul sewers, road flooding and road surface damage.

A Defra report into groundwater flooding[15] identified the Environment Agency's Thames West Area (which includes the Districts) as having had the second highest number of groundwater flooding incidents from hard rock aquifers for all Environment Agency regions in 2000/1 (77 incidents) and 2003 (20 incidents). It indicates that the majority of incidents are coincidental

[15] Defra (2004) Strategy for Flood and Coastal Erosion Management: Groundwater Flooding Scoping Study (LDS23)

with the chalk aquifer. It notes that there were no groundwater flooding incidents reported on the oolitic limestones found to the north and west of the Vale area. However, the Environment Agency have observed groundwater flooding at the head waters of the River Thames from Oolitic limestones, although they have not received reports of properties experiencing groundwater flooding. Due to the nature of the flow within Oolitic limestones the duration of the flooding experienced in likely to be shorter than that from the Chalk.

The Environment Agency supplied locations of 62 groundwater flooding reports since 2000, 33 in South Oxfordshire and 29 in the Vale of White Horse. These are shown on Map 6. Fifteen of these incidents were recorded in the winter of 2012/13. In addition, polylines were provided representing flow paths of groundwater flooding paths during the 2000/1 event.

Groundwater flooding also occurs in combination with main rivers. In particular, some areas of Oxford, including South Hinksey, in VOWH District, have suffered basement flooding when groundwater in alluvial gravels has risen, driven by river flooding in the River Thames.

Notable areas that suffer from groundwater-related flooding problems are:

- Assendon Stream: According to the Parish Flooding Survey (2010), approximately 14 properties are estimated to have flooded on the Assendon Stream in 2001 (an ephemeral groundwater fed ordinary watercourse), which flows through Middle Assendon, Lower Assendon, and Henley, before entering a long culvert through Henley. The flood was especially notable on the Assendon Spring because the watercourse is normally dry. Prior to 2001, the stream had last flowed in 1969.
- Harpsden, Henley-on-Thames: A normally dry valley, similar to Assendon Stream (2 incidents in Environment Agency database).
- Ewelme Brook from Ewelme village to east end of Benson: Environment Agency identified as a groundwater flow path, and 1 recorded incident.
- Headwaters of the Stert Brook at Kingston Blount - Environment Agency identified as a groundwater flow path, but no recorded incidents.
- Cumnor and Botley - identified by the council as suffering from groundwater flooding associated with the River Thames gravels. Environment Agency recorded 3 incidents.
- South Hinksey - identified by the council as suffering from groundwater flooding associated with the River Thames gravels.
- Chilton - identified by the council as suffering from groundwater flooding during 2012/13. Environment Agency recorded 1 incident.
- Blewbury - an area close to the edge of the chalk aquifer, where numerous springs flow, forming the streams of the Vale of White Horse. Due to the exceptionally high groundwater levels in 2012-2013 spring heads were observed higher up the valleys as at Blewbury and groundwater could be seen seeping out of the ground over a wide areas as at Hagbourne around the A417.
- Appleford - according to the Environment Agency a couple of properties were flooded in 2013, probably caused by raised ground water levels in gravels which were unable to discharge naturally due to flooding in the River Thames nearby.

4.6 Flooding from sewers

Sewer flooding occurs when intense rainfall overloads the sewer system capacity (surface water, foul or combined), and/or when sewers cannot discharge properly to watercourses due to high water levels. Sewer flooding can also be caused when problems such as blockages, collapses or equipment failure occur in the sewerage system.

Many sewers in the county are over 100 years old and little is known about their capacity and state of repair. Since 1980, the Sewers for Adoption guidelines have meant that most new sewers have been designed to have capacity for a rainfall event with a 1 in 30 chance of occurring in any given year, although until recently this did not apply to smaller private systems.

This means that even where sewers are built to current specification, they are likely to be overwhelmed by larger events of the magnitude often considered when looking at river or surface water flooding (e.g. a 1 in 100 chance of occurring in a given year). Existing sewers can also become overloaded as new development adds to their catchment, or due to

incremental increases in roofed and paved surfaces at the individual property scale (urban creep). Sewer flooding is therefore a problem that could occur in many locations across the Districts.

The Thames Water sewer flooding register (Map 7) is only available at a 5 digit postcode level. A review of the local flooding history, PFRA, and discussions with Council drainage teams have been undertaken to assess where there are known sewer flooding problems in the Districts. Notable areas where sewer flooding is an issue are:

- South Hinksey and Botley have a history of sewer flooding problems, in combination with other sources. Thames Water has put in a scheme which was completed in December 2012[16], which was crucial to allowing development to go ahead in Botley. However the area experienced sewer/surface water flooding at end of November 2012, for which Thames Water blamed 'operational reasons'.
- The Manor Road area of Wantage also has a history of sewer flooding incidents[17], particularly in the last few years.

Other sewer flooding incidents are more isolated, or difficult to distinguish from surface water events. The Vale of White Horse Flooding Database records 42 incidents of flooding related to sewers.

4.7 Flooding from reservoirs, canals and other artificial sources

4.7.1 Reservoirs

Within the Districts, Farmoor is the most notable reservoir, though numerous smaller reservoirs exist. Farmoor is the only reservoir within the Districts which the Environment Agency identifies as falling under the terms of the Reservoir Act. Reservoirs covered by this act are subject to a high level of regulation and inspection, and are therefore considered to have a low risk of failure.

The risk of inundation to VOWH and SODC as a result of reservoir breach or failure of a number of reservoirs within the area was assessed as part of the National Inundation Reservoir Maps (NRIM) study. The mapping for the Districts shows a significant inundation area from Farmoor reservoir that follows the Thames valley as far as Abingdon, plus several other smaller areas in the Thame and upper Thames catchment (see Figure 3-2). However, the extents of the flooding appear to be within the bounds of the Flood Zones.

Reservoir flooding is very different from other forms of flooding. It may happen with little or no warning and evacuation will need to happen immediately. The likelihood of such flooding is very difficult to estimate, but it is less likely than flooding from rivers or surface water. It may not be possible to seek refuge from floodwaters upstairs as buildings could be unsafe or unstable due to the force of water from the reservoir breach or failure. The Environment Agency maps represent a credible worst case scenario. In these circumstances it is the time to inundation, the depth of inundation, the duration of flooding and the velocity of flood flows that will be most influential.

4.7.2 Canals

The only canal in either District is the Wilts and Berks Canal, which is currently derelict but with plans for restoration by the Wilts and Berks Canal Trust. It originally linked the Thames at Abingdon with the Kennet & Avon Canal near Melksham.

Although derelict, the canal still receives surface water from drains and runoff from the surrounding land, so there is a risk of overtopping if the outlet is overwhelmed or not operating correctly. For example two properties were threatened by flooding at East Challow in the winter of 2012/13 when the outlet from the canal was blocked and surface water drainage filled the canal to capacity.

[16] Water projects online, Botley Sewer Renewal
http://www.ukwaterprojects.com/case_studies/2012/Thames_Botley_2012.pdf
[17] Herald Series (March 2013) Firm promises to stop the sewage
http://www.heraldseries.co.uk/news/10310538.Firm_promises_to_stop_the_sewage/

4.8 The impact of climate change

The impact of climate change on fluvial flooding has been examined by comparing Flood Zone 3 with the modelled 100 year + 20% climate change outline (where available) (Map 4). This indicates that the impacts of a 20% increase in flows on flood extents will be relatively minor in many areas, but more significant in others. Figure 4-1 illustrates the impacts on Flood Zone 3 on the River Thames as modelled at Burcot, Dorchester and the Wittenhams.

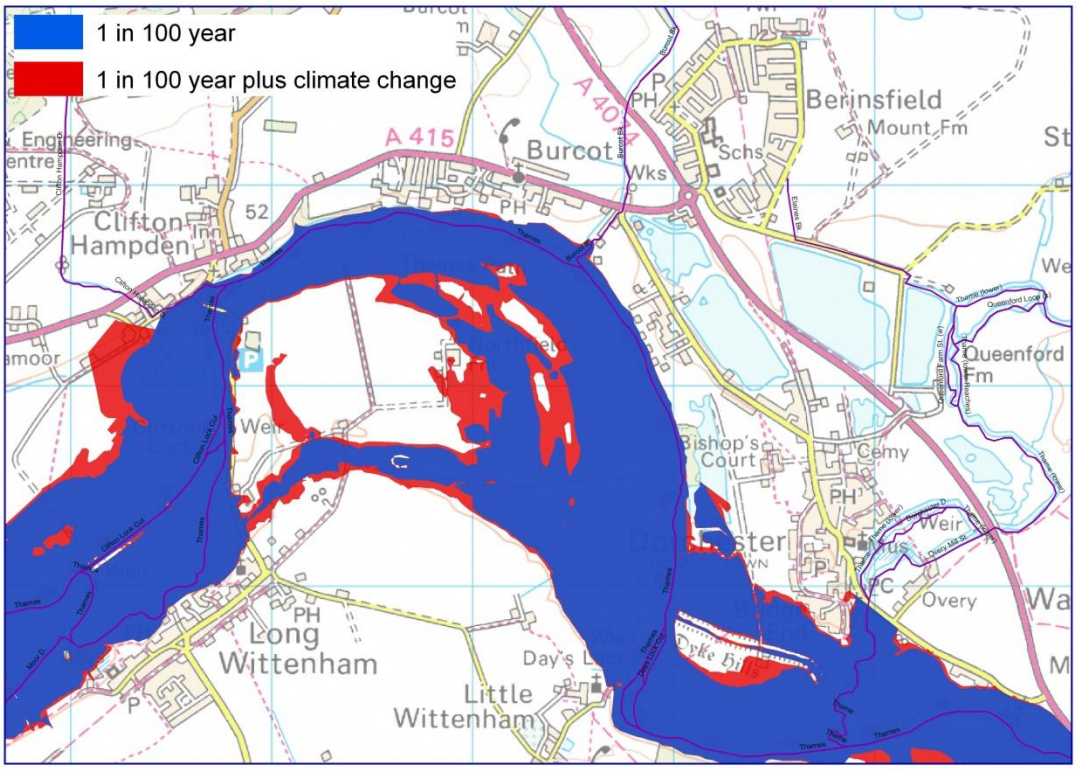

Figure 4-1: Effect of climate change on Flood Zone 3 on the Thames

On minor watercourses, the change to Flood Zone 3 when the 20% increase in flow is applied has been tested in some sample locations and is in most cases very minor, particularly where there is no LIDAR data available.

It should be noted however that even where extent does not increase significantly for a particular event, climate change is still likely to increase the frequency and severity of flooding.

Increased rainfall intensity in the future is likely to increase the likelihood and frequency of surface water flooding. Any locations where surface water or sewer flooding are an issue should consider the impact of climate change on rainfall intensity as outlined in the NPPF Technical Guidance.

Climate change is also likely to result in wetter winters, which may result in more frequent groundwater flooding problems in areas which are already susceptible.

5 Review of potential development areas

5.1 Introduction

Both Councils have a strong policy of locating development sequentially in areas of lowest flood risk. In VOWH this is covered by Core Policy 32: Flood Risk in the Local Plan, and in SODC it is covered by paragraphs 14.12 and 14.13 on Flood Risk Management in the Core Strategy.

This section, along with the detailed information contained in Appendix B, should provide enough information to enable them to do this and carry out the Sequential Test as outlined in the NPPF Technical Guidance.

Vale of White Horse has identified several strategic sites, Larger Villages and Main Towns. South Oxfordshire has identified one strategic site plus several Larger Villages and Main Towns. The following sections summarise what is known about flood risk from all sources for each of these areas.

5.2 South Oxfordshire District Council

At the time of production of the SFRA, South Oxfordshire District Council had just adopted their Core strategy and were about to start work on a Site Allocations DPD.

They identified 12 larger villages (Berinsfield, Benson, Chalgrove, Cholsey, Chinnor, Crowmarsh Gifford, Goring-on-Thames, Nettlebed, Sonning Common, Wheatley, Watlington, Woodcote and) and four main towns (Didcot, Henley-on-Thames, Wallingford and Thame) as key settlements for investigation in this SFRA. They also intend to allocate homes at Bayswater Farm.

The SFRA has therefore examined flood risk in and around these settlements.

5.2.1 Summary of key settlements and sites

Table 5-1: Flood risk to South Oxfordshire key settlements

Key settlement	Fluvial		Surface water	Groundwater	Sewer
	Flood Zone 3	Flood Zone 2			
Bayswater Farm	Y	Y	Medium	Low	Low
Benson	Y	Y	Low	High	Low
Berinsfield	Y	Y	Medium	Medium	Low
Chalgrove	Y	Y	High	Medium	Low
Chinnor	N	N	Medium	Medium	Low
Cholsey	Y	Y	Medium	Low	Low
Crowmarsh Gifford	Y	Y	Medium	Medium	Low
Didcot	Y	Y	Medium	Low	Low
Goring-on-Thames	Y	Y	Low	Medium	Low
Henley-on-Thames	Y	Y	Low	High	Low
Horspath	N	N	High	Medium	Low
Nettlebed	N	N	Low	Low	Low
Sonning Common	N	N	Low	Low	Low
Thame	Y	Y	Medium	Low	Low
Wallingford	Y	Y	Medium	Medium	Low
Watlington	Y	Y	Medium	High	Low
Wheatley	Y	Y	High	Low	Low
Woodcote	N	N	Low	Low	Low

Note, this table refers to both the existing village, and the surrounding land.

5.3 Vale of White Horse District Council

5.3.1 Summary of strategic sites

Table 5-2: Flood risk to Vale of White Horse strategic sites

Strategic site	Fluvial		Surface water	Ground-water	Sewer
	Flood Zone 3	Flood Zone 2			
Land at Park Road, Faringdon	Immediately adjacent to site.	Immediately adjacent to site	Low	Low	Low
Crab Hill, Wantage	Yes. Tiny area intersects at A417 bridge.	Yes. Tiny area intersects at A417 bridge.	Medium	Low	Low
Valley Park, Didcot	Yes, small area to north of site	Yes, small area to north of site	Medium	Medium to high	Low
Harwell Campus, Harwell	No	No	Medium	Low	Low
Monks Farm, Grove	Yes.	Yes.	Medium	High	Low

5.3.2 Summary of key settlements

Table 5-3: Flood risk to Vale of White Horse key settlements

Key settlement	Fluvial		Surface water	Groundwater	Sewer
	Flood Zone 3	Flood Zone 2			
Abingdon	Y	Y	Medium	Low	Low
Botley	Y	Y	High	High	High
Kingston Bagpuize with Southmoor	Y	Y	Medium	Low	Low
Shrivenham and Watchfield	Y	Y	Medium	Low	Low

5.4 Site and settlement summary sheets

Flood risk from all sources has been described in more detail and mapped for each key settlement and strategic site. This information is provided in a 'summary sheet' format in Appendix B. Each summary sheet also gives further information about the implications for development. The following information is provided for each site:

- Fluvial flood risk summary, Flood Zone map, source of Flood Zone information, flood defences.
- Surface water flood risk summary and Flood Map for Surface Water map
- Groundwater flood risk summary
- Sewer flood risk summary
- Reservoir flood risk summary (where applicable)
- Effects of climate change
- Available survey and detailed modelling
- Implications for development

5.5 Increased scope assessment

The NPPF Technical Guidance states that where there is a flood risk to an allocated site, the scope of the SFRA must be increased to provide a more detailed assessment of flood risk to inform the Exception Test if necessary.

As the majority of potential development areas have only been identified at the settlement level for the two Districts, it is not possible or necessary to increase the scope for most of them. However there are two exceptions, Monks Farm, a strategic site in VOWH, and Abingdon.

5.5.1 Monks Farm

The Letcombe Brook flows through the centre of the Monks Farm strategic site. The council have allocated the site in the Local Plan, but with the proviso that all development is situated in Flood Zone 1.

After discussion with the Environment Agency, it was decided that the SFRA should increase its scope for this site to clearly define the areas of high flood risk in this allocation, and therefore, to carry out a sequential approach to directing all development.

This additional information has been included in an extended summary sheet for Monks Farm, which can be found in Appendix B.2.3.

5.5.2 Abingdon

In Abingdon, redevelopment of the town centre is ongoing within a flood risk area. This has been the subject of separate report to carry out the Sequential and Exception Test[18].

Hazard maps for the River Stert in central Abingdon were prepared as part of the 2007 SFRA to inform the allocation of sites within the town centre. These are shown in Map 10 to Map 13.

Table 5-4 makes suggestions for how the hazard classifications and vulnerability classes could be used to locate development appropriately within Flood Zone 3.

Table 5-4: Matrix of vulnerability and hazard classification

Hazard classification	Vulnerability				
	Essential infrastructure	Highly vulnerable	More vulnerable	Less vulnerable	Water compatible
Not classified	Suitable	Suitable	Suitable	Suitable (but see note 1)	Suitable (but see note 1)
Low (Danger to none)	Suitable	Suitable	Suitable	Suitable (but see note 1)	Suitable (but see note 1)
Moderate (Danger for some)	Possibly Suitable	Possibly Suitable	Suitable (but see note 2)	Suitable	Suitable (but see note 1)
Significant (Danger for most)	Not suitable	Not suitable	Possibly Suitable (but see note 2)	Suitable	Suitable
Extreme (Danger for all)	Not suitable	Not suitable	Not suitable	Suitable	Suitable

Notes:

1. Consider reserving areas of lower hazard for higher vulnerability classes.
2. Safe internal or external escape routes must be provided.

There are proposals to improve flood storage at Tilsey Park on the River Stert, but these are currently still at an options testing stage.

[18] JBA (2010) Sequential and Exception Test for Bury Street and the Charter Area, Abingdon Town Centre. Report on behalf of Vale of White Horse District Council
http://www.whitehorsedc.gov.uk/sites/default/files/Sequential%20and%20exception%20test%20for%20Bury%20Street%20and%20Charter%20Area,%20Abingdon.pdf

6 Guidance for planners and developers

6.1 Introduction

Planners and developers should follow the Environment Agency Flood Risk Standing Advice[19] as a starting point when considering applications for new development. This section will summarise guidance for the Councils on the appropriate planning response for all development in Flood Zones 1, 2, 3a and 3b (from large strategic sites to small windfall sites) and provide guidance for developers in what should be included within an appropriate Flood Risk Assessment. It should be read with reference to Map 2, 3 and 4 which show the location of the Flood Zones.

Table 3 of the NPPF Technical Guide highlights the type of development considered appropriate for each Flood Zone, where development is not permitted, and where development is allowed only when the Exception Test is passed, see Figure 2-3. Further detail is provided in the NPPF Technical Guidance.

6.2 Permitted development in Flood Zones

6.2.1 Flood Zone 1

All development (essential infrastructure, highly vulnerable, more vulnerable, less vulnerable and water-compatible development) is allowed in Flood Zone 1. All development proposals should consider the following about the sites:

- Their vulnerability to flooding from other sources as well as from fluvial flooding.
- Their potential to increase flood risk elsewhere through the addition of hard surfaces and the effect of the new development on surface water runoff.

Developments >1ha in Flood Zone 1

A detailed FRA must be undertaken by a suitably qualified professional. It should:

- Assess risk from other sources of flooding which are not considered within the Flood Zone maps.
- Recommend mitigation measures in response to any identified flood risk.
- Assess the impact of a proposed development upon surface water drainage following an increase in impermeable area, including the potential impact upon areas and receiving watercourses downstream, and recommend the approach to control surface water discharge.
- Demonstrate the ability to meet the following drainage requirements to avoid increasing flood risk elsewhere:
- Greenfield discharge rates
- Attenuation up to the 1% annual probability event plus climate change
- Consider the use of SuDS

Opportunities for developing an Integrated Water Management Strategy across development site boundaries should be explored, and a catchment led approach should be adopted. An integrated approach to controlling surface water drainage can lead to a more efficient and reliable surface water management system as it enables a wider variety of potential flood mitigation options to be used. In addition to controlling flood risk, integrated management of surface water has potential benefits, including improved water quality and a reduction of water demand through rain-water recycling and reuse.

Integrated drainage systems may be considered suitable for catchments where other development is being planned or constructed, and where on-site measures are set in isolation of the systems and processes downstream.

Further information on the details to be provided within the FRA can be found in the Environment Agency's FRA Guidance Note 1[20], CIRIA report C624[21], and PPS 25 Practice Guide[22].

19 Environment Agency Flood Risk Standing Advice http://www.environment-agency.gov.uk/research/planning/82584.aspx

20 Environment Agency, FRA Guidance Note 1 http://www.environment-

Developments <1ha

If a site within Flood Zone 1 site has been identified by the SFRA as having a known drainage problem, or has experienced flooding from other sources, then a detailed FRA is required as outlined in Environment Agency's FRA Guidance Note 1[20].

For those proposed developments where there is not a known drainage issue then a detailed FRA is not required. Nevertheless, the proposed development should include the appropriate application of sustainable drainage techniques so as to maintain, or preferably reduce the existing runoff and flood risk in the area.

6.2.2 Flood Zone 2

Flood Zone 2 is considered suitable for water-compatible, less vulnerable, more vulnerable and essential infrastructure, following application of the Sequential Test. Highly vulnerable development is only allowed where the Exception Test is passed. Depending on the type of development proposed, a Flood Risk Assessment may be required, see Table 3 Flood risk vulnerability and flood zone 'compatibility' within the NPPF Technical Guide. Planners and developers are to be aware that a FRA should be appropriate to the scale and size of the development and undertaken by a suitably qualified professional. The following should be included within a FRA for developments within Flood Zone 2:

- Consideration of all sources of flooding (e.g. surface water, sewer, and groundwater), not just fluvial flood risk, for the lifetime of the development.
- Demonstration of the ability to avoid increasing flood risk elsewhere through the addition of hard surfaces, to control the potential impact new development may have on the surface water run-off regime. To control the effect of new development on potential depth and speed of flooding to adjacent and surrounding property and to meet the following drainage requirements:
    - Greenfield discharge rates
    - Attenuation up to the 1% annual probability event plus climate change
    - Use of SuDS
- An assessment of the effect of climate change on flood risk.
- Recommendations of mitigation measures in response any identified flood risk.
- Demonstration that residual risks of flooding (after existing and proposed flood management and mitigation measures are taken into account. This includes flood defences, flood resilient and resistant design, escape/evacuation, effective flood warning and emergency planning) are acceptable

Any proposed development will be required to provide evidence that the Sequential Test, and if required the Exception Test, have been passed, see Figure 2-3. A preliminary FRA, using data from the SFRA, PFRA and any necessary further modelling work (where detailed modelling has not already been provided as part of the SFRA), will be required to ascertain the level of flood risk for Sequential Test purposes. It is strongly recommended that the Sequential Test, and, if necessary, the Exception Test be satisfied before the FRA detailing design and mitigation measures is commenced.

Further information on the details to be provided within the FRA can be found in the Environment Agency's FRA Guidance Note 3[20], CIRIA report C624[21], and the PPS 25 Practice Guide[22].

6.2.3 Flood Zone 3a

Water-compatible uses and less vulnerable development are allowed in this Flood Zone, following application of the Sequential Test. Highly vulnerable development is not permitted, and essential infrastructure and more vulnerable development need to pass the Exception Test.

agency.gov.uk/static/documents/Utility/FRAGuidanceNote1_v3.1.pdf

21 CIRIA (2004) Development and Flood Risk: Guidance for the Construction Industry. Report C624 http://www.ciria.org/service/AM/ContentManagerNet/Search/SearchRedirect.aspx?Section=Search1&content=product_excerpts&template=/contentmanagernet/contentdisplay.aspx&contentfileid=1417

22 Department of Communities and Local Government (2009) Planning Policy Statement 25: Development and Flood Risk Practice Guide.

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/7772/pps25guideupdate.pdf

Essential infrastructure should be designed and constructed to remain operational and safe for users in times of flood.

Where, due to wider sustainable development reasons, there are no other suitable sites available in lower risk zones then an assessment of the residual risk within Flood Zone 3 is required. For developments to proceed it must also be shown that the development will not increase flood risk elsewhere through a loss of storage or conveyance. Flood risk must be reduced or kept at current levels.

A detailed FRA must be undertaken by a suitably qualified professional. It is required to provide evidence that the Sequential Test, and if required the Exception Test, have been passed. A preliminary FRA, using data from the SFRA, PFRA and any necessary further modelling work (where detailed modelling has not already been provided as part of the SFRA), will be required to ascertain the level of flood risk for Sequential Test purposes.

It is strongly recommended that the Sequential Test, and, if necessary, the Exception Test be satisfied before the FRA detailing design and mitigation measures is commenced. The Sequential Test will already have been applied to adopted site allocations. In the case of windfall sites, developers should speak to the local planning authority to confirm whether developer or planning authority will undertake the sequential test. However, there will be a presumption against development within Flood Zone 3a and 3b.

The FRA should:

- Consider all sources of flooding (e.g. surface water, sewer, and groundwater), not just fluvial flood risk.
- Demonstrate the ability to meet the following drainage requirements to avoid increasing flood risk elsewhere:
- Greenfield discharge rates
- Attenuation up to the 1% annual probability event plus climate change
- Use of SuDS
- Assess the effect of climate change on flood risk.
- Consider the residual risks behind defences, if present.
- Any new “More Vulnerable” or “Highly Vulnerable” development, particularly involving the creation of new residential units, will require dry access and egress up to the 1 in 100 year flood event, with an allowance for climate change over the lifetime of the development.
- Ensure that flood risk is reduced overall, for example that:
    - Flood flow routes are preserved
    - Floodplain storage capacity is not reduced, and where necessary is compensated for on a level for level basis outside of the floodplain.
    - The site is designed sequentially. Relocate existing development to land in zones with a lower probability of flooding. Ensure mitigation measures are provided in response to flood risk and
    - Safe access and egress from the proposed development to safe ground can be assured.

Further information on the details to be provided within the FRA can be found in the Environment Agency’s FRA Guidance Note 3[23] and the NPPF Technical Guidance.

6.2.4 Flood Zone 3b – the Functional Floodplain

The functional flood plain is defined as “land where water has to flow or be stored in times of flood.” Only water-compatible uses are allowed in this Flood Zone. Essential infrastructure can be permitted after the Exceptions Test is passed. Essential infrastructure built within the functional floodplain should:

- Remain operational and safe for users in times of flood;
- Result in no net loss of floodplain storage;

[23] Environment Agency, FRA Guidance Note 3
http://www.environment-agency.gov.uk/static/documents/Utility/FRAGuidanceNote3_v3.1.pdf

- Not impede water flows; and
- Not increase flood risk elsewhere.

The NPPF Technical Guidance recommends that Local Planning Authorities define the functional flood plain in discussion with the Environment Agency. This was done at project meetings for this SFRA.

Flood Zone 3b should be considered as the 1 in 20 year flood extents where these have been modelled and mapped, with the exception of the Oxford area (Thames Wolvercote to Kennington 2006) where the 1 in 25 year modelled flood extent should be used. Where the 1 in 20 year extents have not been mapped, a precautionary approach should be followed and Flood Zone 3 should be considered as equivalent to the functional floodplain (see Map 3).

The Councils should be seeking risk reduction on any sites within Flood Zone 3b. When such land comes up for redevelopment, planning applications should strive for:

- Removal of buildings and restoration of the functional floodplain, including linkage between the watercourse and floodplain.
- Changing the land use to a less vulnerable classification.
- Changing the layout and form of the development (e.g. reducing the building footprint).
- Preserving flow routes.
- Improving conveyance/storage, e.g. replacing solid building with floodable structures.
- Sequential approach to design of site (see Section 6.2.6)

6.2.5 Dry islands

Both Districts contain numerous isolated areas of Flood Zone 1 where land rises above the Flood Zone 3 level (see Figure 6-1). These areas require special consideration as they can present hazards in terms of access and egress in a flood event.

Environment Agency guidance is that dry-islands, areas of land totally surrounded by Flood Zone 3a, should, for spatial planning purposes, be considered as Flood Zone 3a. Dry islands within Flood Zone 2 should be treated as Flood Zone 1. The Councils should follow this guidance and treat them as such when carrying out the Sequential Test.

Any development planned in a Flood Zone 3a island areas must therefore pass the Exception Test and have a detailed flood risk assessment with emphasis on safe access and egress. It may also be appropriate to consider the size of the dry-island, and the duration for which access to a site is expected to compromised. Where a dry island forms between the floodplains of two or more rivers, it may be appropriate to consider the joint probability of both watercourses being in flood at the same time.

Any new “More Vulnerable” or “Highly Vulnerable” development, particularly involving the creation of new residential units, will require dry access and egress up to the 1 in 100 year flood event, with an allowance for climate change over the lifetime of the development. Further guidance on spatial planning within dry-islands is provided in the “Flood Risk to People” report.[24]

[24] Defra/Environment Agency (2006) Flood Risks to People Phase 2. R&D Technical Report FD2321/TR2. http://randd.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=12016

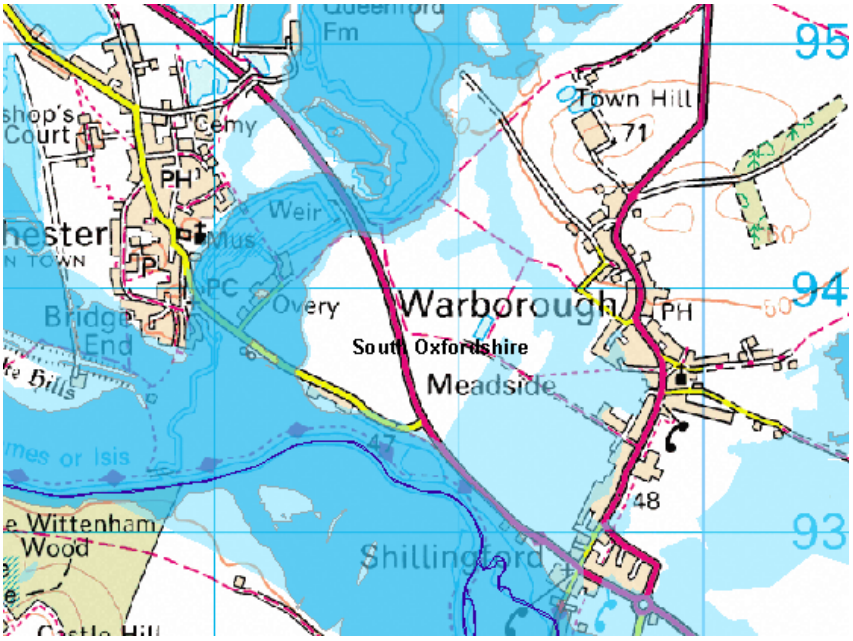

Figure 6-1: Example of a dry island between Warborough and Dorchester

6.2.6 Sites within more than one Flood Zone

Flood risk should be considered at an early stage in deciding the layout and design of a site to provide an opportunity to reduce flood risk within the development. In particular large development proposals may include a variety of land uses of varying vulnerability to flooding.

Where a site covers more than one Flood Zone, the sequential approach should be applied within development sites to design the site layout to reduce flood risk as much as possible.

A sequential, risk-based approach should be applied to try to locate more vulnerable land use to higher ground, while more flood-compatible development (e.g. recreational space) can be located in more high risk areas subject to appropriate management.

Low-lying waterside areas, or areas along known surface water flow routes, can be used for recreation, amenity and environmental purposes, allowing the preservation of flow routes and flood storage, and at the same time providing valuable social and environmental benefits contributing to other sustainability objectives.

Landscaping should ensure safe access to higher ground from these areas, and avoid the creation of isolated islands as water levels rise.

6.2.7 Planning policies for existing settlements within Flood Zones 2 and 3

Below are recommendations for specific policies within Flood Zones 2 and 3 which could be applied following a Sequential Test. There is an opportunity for both SODC and VOWH to incorporate these policies into the Site Allocations and Development Policies and the Local Plan 2029 Part 2 respectively:

Reducing vulnerability: On change of use of sites, opportunities should be taken to reduce vulnerability to flooding, by promoting less vulnerable and water compatible land uses.

Layout and footprint: On redevelopment of a site, opportunities should be taken to reduce the building footprint, thus improving floodplain storage and flow paths.

Residential Infill: Residential infill (for example construction of a new property in the garden of an existing property) will be required to pass the Sequential Test within established residential areas in Flood Zones 2 and 3.

Extensions: Extensions to existing properties should not be permitted in Flood Zone 3a, unless their design is flood resilient.

Residential development above shops: Residential developments above shops in Flood Zone 3 should demonstrate that dry access and egress will be maintained. Where this is not feasible, safe access should be ensured.

6.3 Flooding from other sources

Planners and developers should use the evidence and maps presented in this SFRA, along with other records, to identify where there is significant evidence of other sources flooding at all sites, including those in Flood Zone 1. Recommended criteria for identifying significant evidence of flooding from other sources, using this SFRA, are:

Table 6-1: Identifying significant evidence of flooding from other sources

Source of Flooding	Sources of Evidence	Criteria for evidence of "significant risk"
Historic flooding	Map 8	Any reliable evidence of historic flooding at or adjacent to the site.
Minor watercourses	Appendix B	Proximity to the watercourse
Surface water	Map 5 and Appendix B	Predicted surface water depths greater than 0.3m at or adjacent to the site.
Groundwater	Map 6 and Appendix B	Risk in highest category on AStGWF map, supported by evidence of groundwater events in the local area.
Sewer	Appendix B.	Sewer flooding to existing properties on or near the site. Sewer flooding records provided by Thames Water are not detailed enough to identify site-specific risks. However, Thames Water will comment on larger planning applications, and on Local Plans.
Flooding from reservoirs, canals and other artificial sources	Environment Agency reservoir flood plans - can be viewed on the Environment Agency website under Risk of Flooding from Reservoirs[13],	Within flood envelope on Environment Agency reservoir maps

In considering allocations or applications for development on sites with a risk of other sources flooding, planners should:

- Provide a detailed assessment of the risk from that source, for example using hydraulic modelling, surface water modelling or groundwater investigations as appropriate.
- Sequentially design the site to locate the built element of the development away from the source of flood risk.
- Ensure that the development will not make flooding any worse, and if possible reduce the level of flood risk, e.g. by preserving surface water flow routes.
- Consider the effect of climate change on flooding from other sources.
- Ensure that suitable mitigation measures against flooding from other sources are included in the development.
- Substitute less vulnerable development types for those incompatible with the degree of flood risk.

6.4 Surface water runoff and drainage

A FRA should consider how surface water will be managed on the development site. A preliminary drainage strategy should be fully outlined in the FRA, even at a speculative stage. Any locations where surface water or sewer flooding are an issue should consider the impact of climate change on rainfall intensity as outlined in the NPPF Technical Guidance.

Site drainage should be to SuDS infiltration systems where practicable. Where it is not practicable to drain the entire site to infiltration systems, appropriate assessments should be carried out for green and brownfield developments.

Redevelopment of brownfield sites offers the opportunity to remove connectivity to foul or combined sewerage systems, with consequent benefits for reducing sewer flooding and the potential of pollution from combined sewer overflows (CSOs).

6.4.1 Runoff rates

The design philosophy for greenfield sites requires that site drainage be limited to the greenfield runoff rate, up to the 1 in 100 year design event. Guidance on calculating greenfield runoff rates is given in the Defra/EA guide to preliminary rainfall runoff management for developments[25].

The Environment Agency will expect, where practicable, that the developer should design drainage of a brownfield site such that there is a reduction in flows from the previous usage.

6.4.2 Sustainable Drainage Systems (SuDS)

Sustainable Drainage Systems (SuDS) are management practices which enable surface water to be drained in a more sustainable manner.

There are many different SuDS techniques which can be implemented. The effectiveness of a flow management scheme within a single site is heavily limited by site constraints including (but not limited to) topography, geology (soil permeability), and available area. The design, construction and ongoing maintenance regime of such a scheme must be carefully defined, and a clear and comprehensive understanding of the catchment hydrological processes (i.e. nature and capacity of the existing drainage system) is essential. Additionally, for infiltration SuDS it is imperative that the water table is low enough and a site specific infiltration test is undertaken. Where sites lie within or close to source protection zones further restrictions may be applicable, and guidance should be sought from the Environment Agency.

FRAs should consider the long-term maintenance and ownership of SuDS.

Oxfordshire County Council will become a SuDS Approval Body (SAB) by the enactment of Schedule 3 of the Flood and Water Management Act 2010, which is likely to be from April 2014. This means that all new development which has surface water drainage implications will potentially require SAB approval and need to conform to National and Local Standards. In the interim Oxfordshire County Council has taken a pro-active stance to its role and, relative to many other Lead Local Flood Authorities, has been actively involved in assessing the suitability of SuDS schemes for new development, working with colleagues in Highways, Development Control, City and District Councils and developers.

Further guidance on SuDS can be found at the documents and websites below:

- Susdrain website[26] - online community for delivering sustainable drainage
- CIRIA documents - there are several CIRIA guides relating to SuDS, most notably The SuDS Manual[27], although this is currently undergoing an update. The Susdrain website is a good guide to the available documentation.
- Environment Agency SuDS guidance[28] - Environment Agency advice for developers
- Interim Code of Practice for Sustainable Drainage Systems[29]

Connection of surface water drainage to an existing surface water sewer should only be considered as a last resort. Thames Water should be consulted at an early stage to ensure that sufficient capacity is available in the existing drainage system.

6.5 Wastewater

Major developments must carry out wastewater capacity checks and should liaise with Thames Water at an early stage to prevent an increase in sewer flooding and/or spills from combined sewer overflows (CSOs) further down the wastewater system as a result of the development.

[25] Defra/ Environment Agency (2005) Preliminary rainfall runoff management for developments. R&D Technical Report W5-074/A/TR/1. http://archive.defra.gov.uk/environment/flooding/documents/research/sc030219.pdf

[26] Susdrain website http://www.susdrain.org/

[27] CIRIA (2007) The SuDS Manual (C697)

[28] Environment Agency SuDS guidance http://www.environment-agency.gov.uk/business/sectors/39909.aspx

[29] National SuDS Working Group (2004) Interim Code of Practice for Sustainable Drainage Systems. http://www.environment-agency.gov.uk/static/documents/Business/icop_final_0704_872183.pdf

The impact of an increased volume of foul water discharge on watercourses should also be considered for large sites, or where several sites are likely to be developed in the same Sewage Treatment Works (STW) catchment, particularly where the receiving STW discharges into the same watercourse as the surface water runoff from the site.

6.6 Making development safe

6.6.1 Flood resistance and resilience

Resistance and resilience measures are measures which reduce the impact of flooding or increase the ability of people or buildings affected to recover from flooding. These measures are particularly relevant where minor developments (such as domestic extensions) are allowed in flood risk areas. Further useful guidance is provided in the PPS25 practice guide[22], which describes the possible measures:

- Flood resistance measures are used to prevent water from entering a building, e.g. flood barriers across doorways and airbricks, raising flood levels, non-return valves.
- Flood resilience measures are used when water is designed to enter the building, but cause minimal damage and can be quickly returned to use after a flood, e.g. raising electrical sockets, tiled floors.

The measures chosen will depend on the nature of the flood risk, and obviously development vulnerable to sewer flooding will require a different approach to one at risk from flooding of the River Thames.

Further guidance is available in the Department of Communities and Local Government's document, Improving the flood performance of new buildings[30].

6.6.2 Safe access and egress

For development in Flood Zone 3 it is necessary to provide safe access and egress during a flood.

'Safe' access should remain dry for 'more' and 'highly vulnerable' uses and should preferably be dry for other uses such as 'less vulnerable' land use classifications.. Dry escape for residential dwellings should be up to the 1% annual probability event (100 year return period) taking into account climate change for fluvial flood risk.

The developer will be asked (if this is not already included in the FRA) to review the acceptability of the proposed access using the 'Flood Risk to People' FD 2320 calculator. In this instance it needs to be demonstrated that depths and velocities of flood water will be acceptable to the 'risks to some' category of this calculator.

6.7 Water quality and biodiversity

All development should assess the impact of site drainage on the WFD status of the waterbody the water will drain into. The assessment should consider both water quality and quantity as a change to one or both of these may have a detrimental impact on the waterbody which will need to be mitigated for. For example SuDS schemes can alter the discharge runoff rate into watercourses and consideration needs to be given to the impact of this change on the physical structure of the watercourse and its ecology.

An impact assessment should also be carried out if the floodplain habitat currently depends on periodic inundation, for example water meadows.

6.8 River restoration and enhancement

All new development close to rivers and culverts should consider the opportunity presented to improve and enhance the river environment. As a minimum, the Councils and developers should aim to set back development 8m from the river, providing a buffer strip to ‘make space for water’ and allow additional capacity to accommodate climate change. The 8m buffer should not contain any built environment including roads, lighting and fencing.

[30] Department of Communities and Local Government (2007) Improving the Flood Performance of New Buildings: Flood Resilient Construction http://www.planningportal.gov.uk/uploads/br/flood_performance.pdf

Developments should look at opportunities for river restoration, de-culverting and river enhancement as part of the development. Restoration can take place on various scales, from small enhancement measures to full river restoration. Options include backwater creation, in-channel and bank habitat enhancement, removal of structures e.g. weirs, removal of toe-boarding, restoration of banks and reinstatement of meanders.

When designed properly, such measures can have benefits such as reducing the costs of maintaining hard engineering structures, reducing flood risk, improving water quality and increasing biodiversity. Social benefits are also gained by increasing green space and access to the river. Advice on river restoration, de-culverting and providing other environmental enhancements on development sites is available from the Environment Agency[31]. Early consultation is recommended.

Any modifications made as part of a proposed opening up and/ or restoration of river channels and corridors should be designed by suitable professionals and a full flood risk assessment of the impact of the modifications will be required to be carried out.

6.9 Existing watercourses, defences and assets

Permanent or temporary works within or adjacent to a watercourse require a Land Drainage Consent from the Environment Agency (in the case of Main rivers) or from the District Councils who act on behalf of the LLFA for ordinary watercourses.

Proposed developments which are adjacent to Environment Agency assets must demonstrate a minimum clearance of 8m from these assets to permit maintenance and renewal.

Where developers are riparian owners, they should also assess existing assets (e.g. bridges, culverts, river walls, embankments) and renew them to last the lifetime of the development. Enhancement opportunities should be sought when renewing assets, e.g. bioengineered river walls, raising bridge soffits to account for climate change.

There should be a presumption against further culverting and building over culverts. All new developments with culverts running through the site should seek to de-culvert rivers for flood risk management and conservation benefit. Wherever possible, existing watercourses and drainage channels should be retained, offering risk management authorities benefits in terms of maintenance, future upgrading, biodiversity and pollution prevention. The CIRIA (2010) Culvert Design and Operation Guide provides guidance in this area[32].

Where a culvert is present, the FRA must consider risk from the culvert being both 0% blocked and 75% blocked.

6.10 Developer contributions to flood risk improvements

Major development offers a unique opportunity to reduce the level of flood risk, both to the development area, and also to existing communities downstream. Changes to legislation mean that it is now much easier for developers to contribute towards the cost of flood risk improvements.

Without allocated sites, location specific recommendations on developer contributions or strategic options cannot be made at this stage. In the case of the Districts, there are no large strategic alleviation schemes planned, but improvements tend to be small scale channel and culvert improvements works, generally funded at the moment by FCRMGiA. Developers can be asked to make direct contributions to flood alleviation schemes affecting the communities close to the development.

6.11 Climate change adaptation and mitigation

An important part of the SFRA analysis process is the consideration of future climate change and the increased impact that development may have as a result of that climate change. When reviewing development plans it is important to understand not only the current predicted flood risk to a site but also the flood risk for the life time of the development. For residential development the analysis is undertaken based on a development lifetime of 100 years. The

[31] Environment Agency (2006). Building a better environment. A guide for developers http://www.environment-agency.gov.uk/static/documents/1_GETH1106BLNE-e-e(1).pdf

[32] CIRIA (2010) Culvert Design and Operation Guide. CIRIA report C689

focus has been on new development however the key features apply equally to retro-fit of adaptation and mitigation measures to existing development.

6.11.1 Adaptation

The UK Climate Change Impacts Programme (UKCCIP) report Identification of Adaptation Options[33] presents a framework for identifying and appraising adaptation measures.

Adaptation options can be grouped into four categories, which are discussed below:

No-regrets options

No-regrets options are adaptive measures that deliver benefit whatever the extent of future climate change. Those relevant to the SFRA include the following examples:

- Avoiding building in high-risk areas (e.g. flood plains) when locating development (Sequential Test)
- Reducing water usage in new development
- Building/designing property and buildings to minimise over-heating in summer months though the use of green space and running water.
- Reducing the consequences of flooding (increasing resilience) through the use of water-resistant materials for floors, walls and fixtures, and the sitting of electrical controls, cables and appliances at a higher than normal level.

Such options will require investments but overall are at least cost neutral when the immediacy of the targeted risks and realised benefits are considered.

Low-regrets options

Low-regret adaptation options include actions or activities that directly target the consequences of climate change but have a low relative cost. Those relevant to the SFRA include:

- Building extra climate headroom in new developments to allow for further modifications (e.g. increased drainage and increased finished floor level)
- Restricting the type and extent of development in flood-prone areas
- Promoting the creation and preservation of space (e.g. verges, agricultural land, and green urban areas, including roofs) in support of additional temporary storage of runoff or flood water.
- Sharing in developing and operating additional water storage facilities (e.g. Community groups, Local Flood Risk Management partnership working arrangements to identify and implement measures).
- Improving the flood resilience of critical infrastructure, when it is renewed (such as electricity sub stations).

Both no- and low-regrets options have merit in that they are directed at maximising the return on investment when certainty of the associated risk is low.

Win-Win options

Win-win adaptation options are measures that have the desired result in terms of minimising the climate risks or exploiting potential opportunities but also have other social, environmental or economic benefits.

- Flood management that includes creating or re-establishing flood plains which increase flood management capacity and support biodiversity and habitat conservation objectives;
- Improving preparedness and contingency planning to deal with risks (including climate);
- Green roofs and green walls which have multiple benefits in terms of reducing building temperature and rainfall runoff from buildings, and increased green spaces within urban areas, but also reduces energy use for both heating and cooling.
- Flood mitigation measures that also contribute to improved water quality within the catchment (e.g. SuDS measures that improve the quality of discharges to the watercourses)

[33] UK Climate Change Impacts Programme, Identifying adaptation options http://www.ukcip.org.uk/wordpress/wp-content/PDFs/ID_Adapt_options.pdf

Flexible or adaptive management options

Flexible or adaptive management adaptation options involve putting in place incremental adaptation options, rather than undertaking large-scale adaptation in one fell swoop. Measures are introduced through an assessment of what is appropriate today, but are designed to allow for incremental change, including changing tack, as knowledge, experience and technology evolve.

Examples of flexible or adaptive management adaptation options that are relevant to the SFRA include:

- Delay implementing specific adaptation measures while improving understanding of risk
- Introducing progressive withdrawal from areas at risk of flooding and creation or re-establishment of floodplains consistent with risks and development lifetimes
- Progressive development and investments in adaptation measures consistent with projected changes in climate (e.g. progressive investments in defence maintenance and level rising to maintain status quo).

Flexible or adaptive management options are perhaps the most important to plan ahead of time and should be a key feature of any local flood risk management plan. By identifying this type of opportunity early on it is possible to invest in a flexible plan of action and avoid repetition of work each time the scheme or measure is reviewed. Such measures also allow for careful financial management of the funding which should spread the whole life cost across a number of different funding streams as they become available.

6.11.2 Mitigation measures

New development and re-development present an important opportunity to 'design-in' capacity for climate change mitigation into new development. The key opportunity is to build in additional capacity into systems to counter the predicted effects of climate change. This form of adaptation linked to new development is particularly important in densely developed urban areas, where it is possible to gradually introduce measures that contribute to a reduction in the overall effects of climate change in subsequent planning cycles and periods of redevelopment.

By requiring sites to mitigate today for the effects of 100 years of climate change it has the additional benefit of introducing local capacity in the present day systems. The mitigation schemes that include provision for the level of service, which will be required in 100 years, will provide an augmented level of service under present day conditions.

7 Summary and conclusions

The existing South Oxfordshire and Vale of White Horse SFRA (2009) and Didcot SFRA (2007) have been updated to reflect changes in policy and legislation, and bring the planning context and flood risk information up to date.

The SFRA provides general advice for planners and developers on:

- Sources of flood risk mapping and other evidence to inform the Sequential Test
- Summarises flood risk from each source of flooding in the Districts
- What is required from a Flood Risk Assessment
- Other issues that need to be considered when carrying out development close to watercourses.

It also provides more specific flood risk information and advice for each of the strategic sites and key settlements under consideration by the Councils as potential development areas at the time of writing.

It is important to remember that information on flood risk is being updated continuously. This is particularly true now that the Councils have taken responsibility for carrying out and recording flood investigations under the FWMA. The Environment Agency has a rolling programme of flood modelling and mapping studies, and updates to the Flood Map are made quarterly. Where new mapping studies have been carried out, this will also affect the definition of the functional floodplain (Flood Zone 3b) and the climate change outline. The Flood Map for Surface Water is currently undergoing an update and should be released and available to the public by the end of 2013.

As the Councils move forward with their Local Plans and Site Allocations DPDs, they must use the most up to date information in the Sequential Test, and developers should be aware of the latest information for use in Flood Risk Assessments.

The Flood and Water Management Act (2010), the Localism Act (2011) and the National Planning Policy Framework (2012) all offer opportunities for a more integrated approach to flood risk management and development. As they are both in the relatively early stages of the site allocation process, the Councils have a real chance to make sure development provides improvements to flood risk overall and enhancements to the river environment.

8 Useful documents and links

District Council planning policy documents (including Local Plan and Core Strategy)

Vale of White Horse planning website

http://www.whitehorsedc.gov.uk/services-and-advice/planning-and-building/planning-policy

Vale of White Horse Neighbourhood plans

www.whitehorsedc.gov.uk/neighbourhoodplans.

South Oxfordshire planning website

http://www.southoxon.gov.uk/services-and-advice/planning-and-building/planning-policy

South Oxfordshire Neighbourhood Plans

http://www.southoxon.gov.uk/services-and-advice/planning-and-building/planning-policy/neighbourhood-plans.

JBA (2010) Sequential and Exception Test for Bury Street and the Charter Area, Abingdon Town Centre. Report on behalf of Vale of White Horse District Council

http://www.whitehorsedc.gov.uk/sites/default/files/Sequential%20and%20exception%20test%20for%20Bury%20Street%20and%20Charter%20Area,%20Abingdon.pdf

Lead Local Flood Authority flood risk management documents

Oxfordshire County Council Local Flood Risk Management Strategy website

http://www.oxfordshire.gov.uk/cms/content/oxfordshire-local-flood-risk-management-strategy

Oxfordshire County Council (June 2011) Preliminary Flood Risk Assessment

http://www.oxfordshire.gov.uk/cms/sites/default/files/folders/documents/environmentandplanning/flooding/pfra/PFRApreliminaryreport.pdf

Legislation and government guidance

Localism Act (2011) Section 110: Duty to cooperate in relation to planning of sustainable development

http://www.legislation.gov.uk/ukpga/2011/20/section/110

Flood and Water Management Act (2010)

http://www.legislation.gov.uk/ukpga/2010/29/contents

National Planning Policy Framework, Department of Communities and Local Government (2012)

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/6077/2116950.pdf

Technical Guidance to the National Planning Policy Framework, Department of Communities and Local Government (2012)

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/6000/2115548.pdf

Defra (March 2010) Surface Water Management Plan Technical Guidance

http://www.defra.gov.uk/publications/files/pb13546-swmp-guidance-100319.pdf

Department of Communities and Local Government (2009) Planning Policy Statement 25: Development and Flood Risk Practice Guide

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/7772/pps25guideupdate.pdf

Department of Communities and Local Government (2007) Improving the Flood Performance of New Buildings: Flood Resilient Construction

http://www.planningportal.gov.uk/uploads/br/flood_performance.pdf

Environment Agency resources and guidance

Environment Agency website, Flood information

http://www.environment-agency.gov.uk/homeandleisure/floods/default.aspx

Environment Agency, Risk of flooding from reservoirs map

http://maps.environment-agency.gov.uk/wiyby/wiybyController?x=357683.0&y=355134.0&scale=1&layerGroups=default&ep=map&textonly=off&lang=_e&topic=reservoir

Environment Agency, Flood Map (Risk of flooding from rivers and the sea)

http://maps.environment-agency.gov.uk/wiyby/wiybyController?x=357683.0&y=355134.0&scale=1&layerGroups=default&ep=map&textonly=off&lang=_e&topic=floodmap

Environment Agency Flood Risk Standing Advice

http://www.environment-agency.gov.uk/research/planning/82584.aspx

Environment Agency, FRA Guidance Note 1

http://www.environment-agency.gov.uk/static/documents/Utility/FRAGuidanceNote1_v3.1.pdf

Environment Agency, FRA Guidance Note 3

http://www.environment-agency.gov.uk/static/documents/Utility/FRAGuidanceNote3_v3.1.pdf

Environment Agency (2012) Demonstrating the flood risk Sequential Test for Planning Applications version 3.1

http://www.environment-agency.gov.uk/static/documents/Business/SequentialTestProcess_v3.1.pdf

Environment Agency SUDS guidance

http://www.environment-agency.gov.uk/business/sectors/39909.aspx

Environment Agency (2006) Building a better environment: A guide for developers

http://www.environment-agency.gov.uk/static/documents/1_GETH1106BLNE-e-e(1).pdf

Environment Agency (2010) Oxford Flood Risk Management Strategy

http://www.environment-agency.gov.uk/homeandleisure/floods/127355.aspx

Environment Agency (2008) Thames Catchment Flood Management Plan

http://a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/geth1209bqyl-e-e.pdf

Other resources and guidance

Association of British Insurers and National Flood Forum (April 2012) Guidance on Insurance and Planning in Flood Risk Areas for Local Planning Authorities in England

http://www.planningofficers.org.uk/downloads/pdf/ABI%20%20NFF%20Guidance%20on%20Insurance%20and%20Planning%20for%20Local%20Planning%20Authorities.pdf

CIRIA (2004) Development and Flood Risk: Guidance for the Construction Industry. Report C624

http://www.ciria.org/service/AM/ContentManagerNet/Search/SearchRedirect.aspx?Section=Search1&content=product_excerpts&template=/contentmanagernet/contentdisplay.aspx&contentfileid=1417

CIRIA (2007) The SuDS Manual (C697) (can be purchased at www.ciria.org)

CIRIA (2010) Culvert Design and Operation Guide. CIRIA report C689 (available free by registering at www.ciria.org)

Defra (2004) Strategy for Flood and Coastal Erosion Management: Groundwater Flooding Scoping Study (LDS23)

Defra/Environment Agency (2005) Preliminary rainfall runoff management for developments. R&D Technical Report W5-074/A/TR/1

http://archive.defra.gov.uk/environment/flooding/documents/research/sc030219.pdf

Defra/Environment Agency (2006) Flood Risks to People Phase 2. R&D Technical Report FD2321/TR2

http://randd.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=12016

National SuDS Working Group (2004) Interim Code of Practice for Sustainable Drainage Systems

http://www.environment-agency.gov.uk/static/documents/Business/icop_final_0704_872183.pdf

Susdrain website http://www.susdrain.org/

UK Climate Change Impacts Programme, Identifying adaptation options

http://www.ukcip.org.uk/wordpress/wp-content/PDFs/ID_Adapt_options.pdf

Offices at

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Doncaster
Edinburgh
Haywards Heath
Limerick
Newcastle upon Tyne
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