Oxfordshire County Council
Preliminary Flood Risk Assessment
Preliminary Assessment Report
June 2011

Revision History

Issue/date	Amendments	Issued to
Draft report (v1.0) 08 April 2011		Chris Brown/Gordon Hunt
Second draft (for Scrutiny Committee) (v2.0) 21 April 2011	Amendments according to review by Chris Brown and Gordon Hunt	Chris Brown/Gordon Hunt
Final report (v3.0) 09 June 2011	Amendments according to review by Oxfordshire County Council Growth and Infrastructure Scrutiny Committee, Environment Agency and District and City Councils.	Chris Brown/Gordon Hunt

Purpose

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Acknowledgments

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Executive Summary

Oxfordshire County Council has carried out a Preliminary Flood Risk Assessment (PFRA) as required by their role as Lead Local Flood Authority (LLFA) for Oxfordshire under the Flood Risk Regulations (2009). Oxfordshire County Council covers five lower tier District and City Councils. It is almost all within the Thames River Basin District and the Environment Agency's South East Region.

This Preliminary Assessment Report (PAR) is a broadscale assessment of flood risk from local sources (surface runoff, groundwater and ordinary watercourses) across the county. Existing available data were gathered from a variety of sources. The main data limitations were the consistency and reliability of the collection of past flooding information, and the level to which flood event consequences are quantified. There were also problems of data licensing and restrictions with Thames Water. None of these limitations has affected the outcome of the PFRA. A data register has been kept to record the data, its quality and any licensing limitations.

Incidents of past flooding from local sources were investigated. Several recent surface water and groundwater events have had an adverse impact for the county in terms of properties flooded and disruption to infrastructure and services. Events have only been included in the summary table and maps where properties are recorded to have flooded internally. One event (July 2007) had a major impact in the county and at a wider national scale, and has been included in Annex 1.

The consequences of future flooding predicted by each of the nationally available datasets for Oxfordshire have been assessed and are shown in Annex 2. The Flood Map for Surface Water was chosen as the „locally agreed surface water information' to assess future flood risk. The spatial distribution of receptors that may be affected by future surface water flooding was analysed. The main flooding hotspots are concentrated in the towns and Oxford city, although the analysis also highlights small rural communities that may be adversely affected particularly where local critical services are affected. Future flooding from groundwater has been assessed using the national Areas Susceptible to Groundwater Flooding map. No predictive information is available on future flood risk from canals or sewer flooding. The effects of climate change and future major developments have been considered.

There are no indicative Flood Risk Areas in Oxfordshire as defined by the Defra guidance (2010). The analysis of available data predicting future flood risk suggests that the level of risk in Oxfordshire is not significant enough to propose a new indicative Flood Risk Area. However, the evidence collected demonstrates that there are flooding issues that must be addressed in the Local Flood Risk Management Strategy.

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Glossary and Abbreviations

CCMT	County Council Management Team
CFMP	Catchment Flood Management Plan
COMAH	Control of Major Accident Hazards
DC	District Council

Defra	Department for Environment Food and Rural Affairs
DG5	A database of sewer flooding incidents by 5 digit postcode area in the last 10 years
Environment Agency	Environment Agency
FAS	Flood Alleviation Scheme
Flood Risk Areas	An area determined as having a significant risk of flooding in accordance with guidance published by Defra
FRA	Flood Risk Assessment
FMfSW	Flood Map for Surface Water
FWMA	Flood and Water Management Act
GHG	Greenhouse gas
GIS	Geographical Information Systems
LCLIP	Local Climate Impacts Profile
LLFA	Lead Local Flood Authority
Main River	A watercourse for which the Environment Agency has responsibilities and powers.
Ordinary Watercourse	All watercourses that are not designated as Main River and which are the responsibility of Local Authorities, or where they exist Internal Drainage Boards
PAR	Preliminary Assessment Report
Preliminary assessment spreadsheet	Reporting spreadsheet which LLFAs need to complete. The spreadsheet will form the basis of the Environment Agency's reporting to the European Commission.
PFRA	Preliminary Flood Risk Assessment
PPS25	Planning Policy Statement 25 Development and Flood Risk
REPPIR	Radiation (Emergency Preparedness and Public Information) Regulations
RMA	Risk Management Authority
SFRA	Strategic Flood Risk Assessment – spatial planning documents prepared by local planning authorities under PPS25
SODC	South Oxfordshire District Council
SUDS	Sustainable Drainage Systems
Surface runoff	Water (including rainwater, snowmelt and other precipitation) which is on the surface of the ground (whether or not it is moving), and has not entered a watercourse, drainage system or public sewer.
SWMP	Surface Water Management Plan
UKCIP	UK Climate Impacts Programme

VOWH	Vale of White Horse District Council
WODC	West Oxfordshire District Council

1 Introduction

1.1 Scope of the report

1.1.1 The Flood Risk Regulations (2009) require Lead Local Flood Authorities (LLFAs) to complete a Preliminary Flood Risk Assessment (PFRA) by June 2011. In Oxfordshire the LLFA is the County Council.

1.1.2 The PFRA is made up of two actions. LLFAs must produce a Preliminary Assessment Report (PAR) investigating past and future flood risk from local sources of flooding. They must also review and identify indicative Flood Risk Areas (areas where flood risk from local sources of flooding is designated as being significant, as defined by regulation 14 and in accordance with guidance issued by Defra in 2010). This report and the attached Annexes cover both of these actions.

1.1.3 Local sources of flooding are defined as:

- Surface runoff - meaning water on the surface that has not yet entered a watercourse, drainage system or public sewer.
- Groundwater - meaning water below the ground that is in direct contact with the ground or subsoil.
- Ordinary watercourses – includes lakes, ponds and other areas of water that flow into an ordinary watercourse. Ordinary watercourses are those that are not defined as Main River by the Water Resources Act (1991) and shown on the Environment Agency's Main River map.

1.1.4 It should be noted that local sources do not include flooding from main rivers, the sea or large raised reservoirs, burst water mains or from any part of a sewerage system unless it is caused by an increase in the volume of rainwater.

1.2 Aims and objectives

1.2.1 The Preliminary Assessment Report is a broadscale and strategic assessment of flood risk across the county so that Oxfordshire County Council can answer the question: "where is local flood risk significant?" This should inform the location of Flood Risk Areas, for which more detailed Flood Risk and Flood Hazard Mapping and Flood Risk Management Plans will be needed in the future. It is an initial screening exercise and is based on readily available information, such as existing Strategic Flood Risk Assessments (SFRAs), Catchment Flood Management Plans (CFMPs) and consideration of past and possible future flooding.

1.2.2 The objectives of the PFRA are to:

- Bring together information on past flooding and its consequences, to understand where there have been significant harmful consequences,
- Bring together information on flooding that may happen in the future „future flooding', to understand where there might be significant harmful consequences in the future,
- Use the information as evidence to determine if there are any Flood Risk Areas in Oxfordshire that meet the national thresholds set by Defra (2010) and review the indicative Flood Risk Areas provided by the Environment Agency, and
- Develop the PFRA in such as way that it contributes to the preparation of the Local Flood Risk Management Strategy and can be used in future as an evidence base to inform Surface Water Management Plans (SWMPs) that might be necessary. This includes working with Risk Management Authorities across

the county, including the four District and Oxford City Councils to inform the assessment.

1.2.3 The data collected and research carried out for the PFRA will also support and feed into the Local Flood Risk Management Strategy in the longer term, which will include a more detailed analysis of risk from local sources of flooding.

1.3 The study area

1.3.1 The study area for the PFRA is the County of Oxfordshire. Oxfordshire covers an area of around 2,600 km² and has a population of 639,800, one of the lowest population densities in the south east region[1].

1.3.2 Oxfordshire covers the five lower tier Councils of South Oxfordshire, West Oxfordshire, Vale of White Horse and Cherwell District Councils and Oxford City Council, shown in Figure 1-1. It is almost all within the Thames River Basin District (96.6%) and the Environment Agency's South East Region. Small areas of the county are in Anglian (2.6 %) and Severn (0.8 %) River Basin Districts.

1.3.3 The main water company is Thames Water, although small areas are covered by Anglian Water and Severn Trent Water. There are no known operational Internal Drainage Boards.

1.3.4 The main urban area is the historic university city of Oxford, with a population of 155,000. Smaller urban centres (42,000 or less) are found at Banbury, Abingdon, Bicester, Witney and Didcot. Over half the population live in settlements of less than 10,000 people.

1.3.5 Oxfordshire has high employment levels and a highly qualified workforce. Key industries and employers include academia, international publishing, high tech business, research and development and biotechnology, car manufacture and motorsport, and tourism.

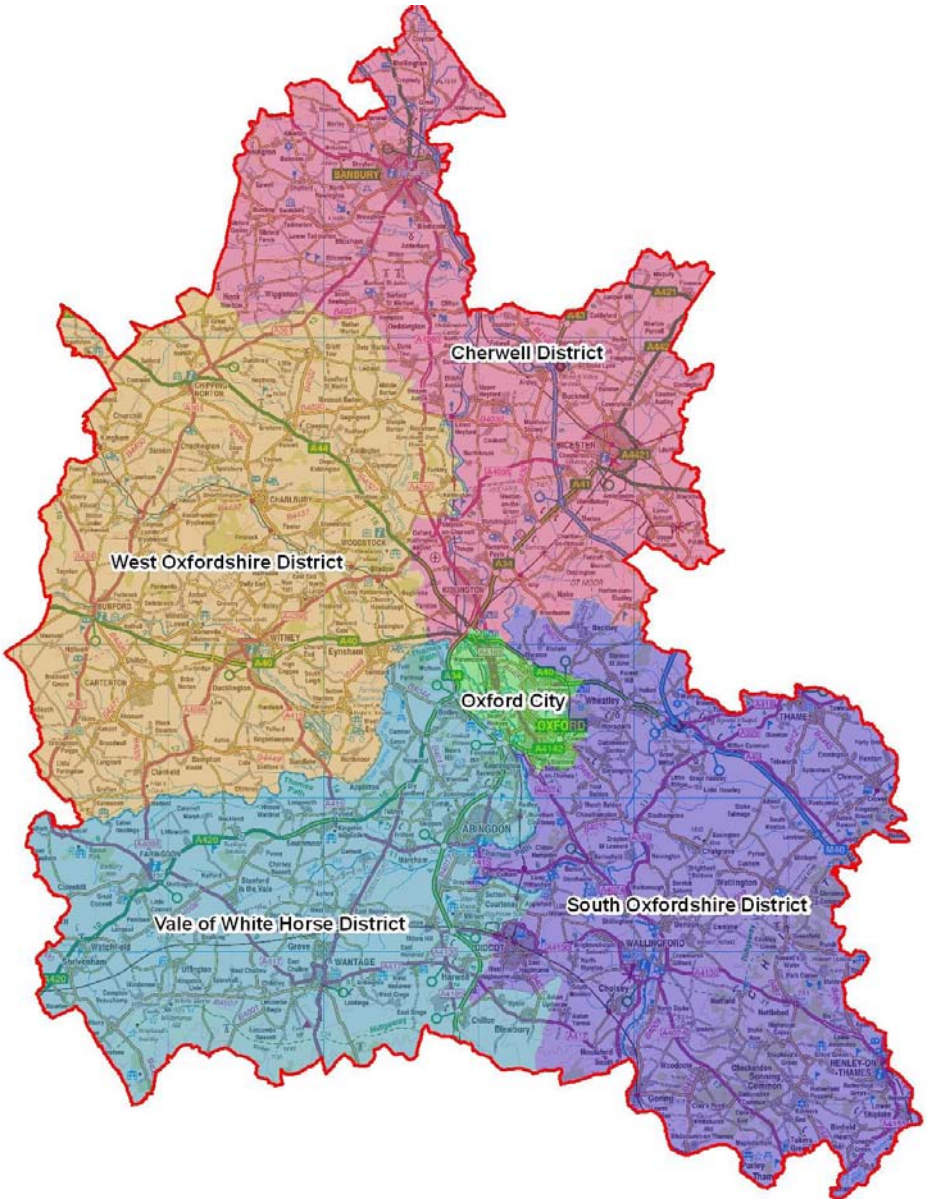
1.3.6 Outside of the urban areas, the county is predominantly rural, over 75% of the land is devoted to agricultural use and almost 25% of the county falls within one of three 'Areas of Outstanding Natural Beauty', including the Chiltern Hills, the Cotswolds and the North Wessex Downs.

1.3.7 The topography of the county is predominantly low rolling hills, dominated by the major river valley of the Thames, and its many tributaries. The highest point in the county is around 260m above ordnance datum, at White Horse Hill.

1.3.8 The underlying bedrock geology follows bands running in a south west to north east direction. In the north-west is the oolitic limestone of the Cotswolds, followed by a band of Oxford clays, mudstone, siltstone and sandstone and into the chalk to the south and south east forming the hills of the North Wessex Downs and the Chilterns.

[1] Information and statistics in this section are from http://www.oxfordshire.gov.uk

Figure 1-1 Map of study area



2 Lead Local Flood Authority responsibilities

2.1 Introduction

2.1.1 Flood risk management is a cross-cutting activity for Oxfordshire County Council that sits across a range of functions, including Highways, Spatial Planning, Emergency Planning and Sustainability and Climate Change. The Council also has responsibilities as a riparian land owner.

2.1.2 During the summer of 2007 many people, properties and infrastructure across Oxfordshire County Council were affected by flooding from local sources (primarily surface water). Since then Oxfordshire County Council has been pro-active in responding to flood risk, responding to key issues identified during the event and addressing the potential impact of new development by advocating the implementation of Sustainable Drainage Systems (SUDS).

2.1.3 Following the flooding in the summer of 2007 the government commissioned an independent review chaired by Sir Michael Pitt. The final report, published in June 2008, highlighted the gaps with respect to responsibility for local sources of flooding. The report made a total of 92 recommendations, including that:

Recommendation 2	The Environment Agency should be a national overview of all flood risk, including surface water and groundwater flood risk, with immediate effect.
Recommendation 14	Local authorities should lead on the management of local flood risk, with the support of the relevant organisations.
Recommendation 17	All relevant organisations should have a duty to share information and cooperate with local authorities and the Environment Agency to facilitate the management of flood risk.

2.1.4 Following legislation has brought forward recommendations from the Pitt Review into legislations, notably:

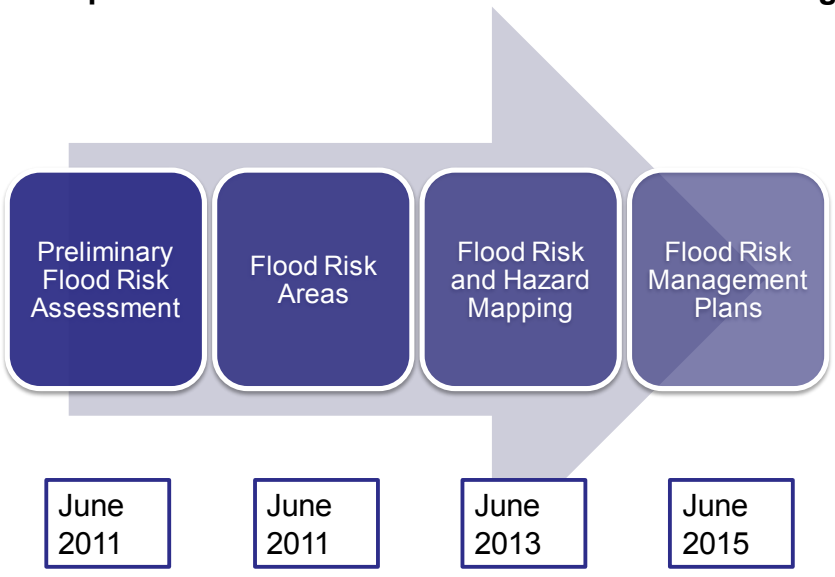
- The Flood Risk Regulations (November 2009)
- The Flood and Water Management Act (April 2010), which is being enacted in stages and for which the full implementation timeframe is not yet available. The most recent stages were enacted in April 2011.

2.1.5 This legislation has significant implications for Oxfordshire County Council in terms of resources, skills and capacity for flood risk management. Since the flooding of July 2007, a team has been built up around the existing County Drainage Manager role. This team has worked closely with the Districts and City Councils, Thames Water and the Environment Agency.

2.1.6 The PFRA has been prepared at a time of transition for Oxfordshire County Council, but the process has been assisted by the communications and engagement links already forged since 2007.

2.1.7 The Flood Risk Regulations (2009) transpose the EU Floods Directive (2007) into law in England and Wales. The Flood Risk Regulations set out a risk based approach to the prioritisation of resources, targeting them at the areas of highest flood risk. The Risk Regulations requirements relevant to LLFAs are summarised in Figure 2-1.

Figure 2-1 Requirements and timescales for the Flood Risk Regulations



2.1.8 LLFAs are required to prepare responses for flooding from surface water, groundwater, ordinary watercourses, lakes and canals. As a LLFA, Oxfordshire are required at this time to prepare a Preliminary Assessment Report (this report) and identify Flood Risk Areas. It is noted that these are areas with what is considered to be significant flood risk on a national scale. The threshold for this has been set by the Minster, one of the indicators being 30,000 people that might be affected.

2.1.9 Whilst no Flood Risk Areas have been identified through this report for Oxfordshire there are clearly flooding issues that are considered locally significant. It is intended that the management of flood risk in these areas and across the wider county will be directed by the Local Flood Risk Management Strategy that Oxfordshire County Council are required to prepare under the Flood and Water Management Act (2010).

2.1.10 The Flood Risk Regulations require LLFA work to be reviewed by the Environment Agency. The dates for submission of the work to the Environment Agency are shown on Figure 2-1. As part of its strategic overview role for all sources of flooding, the Environment Agency is providing guidance for each stage of the process.

2.1.11 The implementation of the Act is a more complex task for an authority where there are two tiers of local government, since many of the functions carried out by the authorities are separated, including:

- Spatial Planning, with Highways Development Control, Minerals and Waste Planning and County Council Development Control sitting at County level, but the majority of planning functions with respect to policy planning and development control sitting within District and Borough Councils,
- Emergency planning, response and recovery being shared across both tiers as appropriate, with the main driver being the Civil Contingencies Act (2004) and
- Drainage, with the Highways Drainage function sitting at County level and land drainage responsibilities under the Land Drainage Act (1991) sitting largely with Borough and District Councils and Internal Drainage Boards.

2.1.12 The Flood and Water Management Act has not attempted to change the majority of the functions performed by respective parties and indeed allows for delegation of responsibilities between Risk Management Authorities as appropriate. Table 2-1 summarises the new responsibilities that different organisations across Oxfordshire will now have under the Flood and Water Management Act.

Table 2-1 Roles and responsibilities under the Flood and Water Management Act

Risk Management Authority	Strategic Level	Operational Level
Environment Agency	Strategic overview for all sources of flooding National Strategy Reporting and general supervision	Main rivers Sea Reservoirs
Lead Local Flood Authority (Oxfordshire County Council)	Input to the National strategy Produce Local Flood Risk Management Strategy	Surface water Groundwater
Four Districts and City Councils Internal Drainage Board	Input to the National and Local Strategies	Ordinary watercourses Potential delegation for other local sources

2.2 Governance and partnership

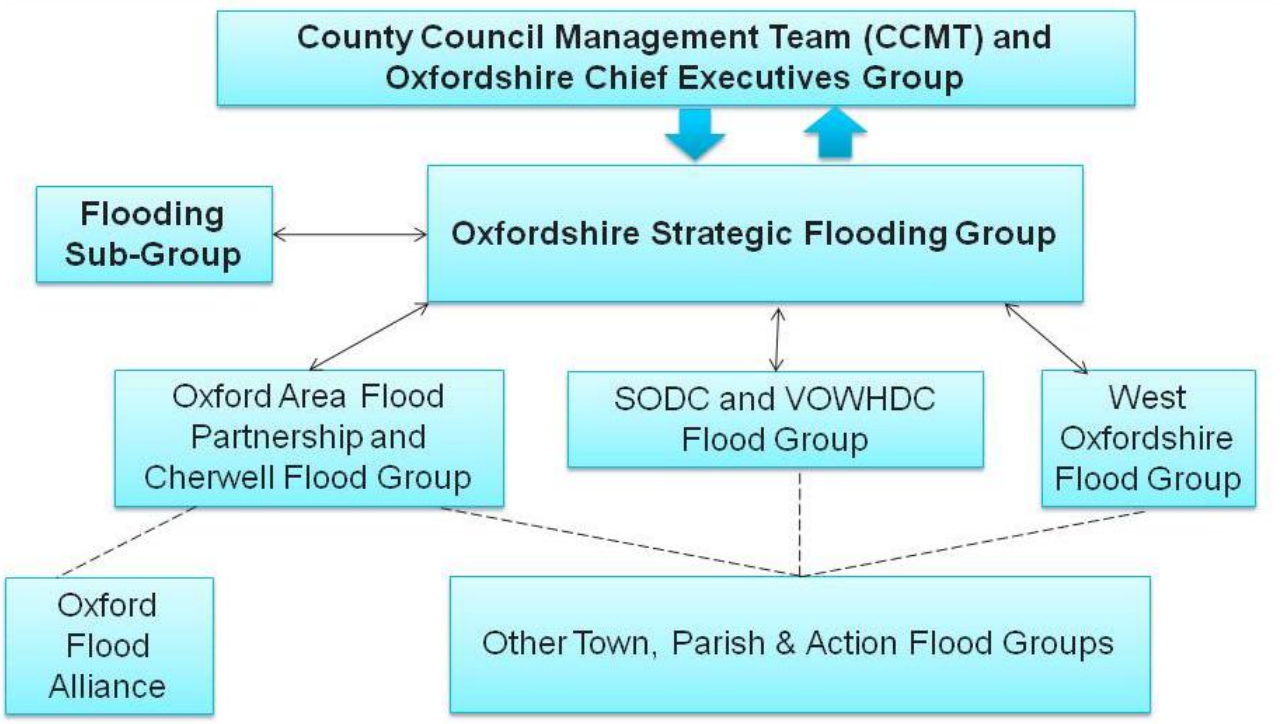
2.2.1 Table 2-2 shows the organisations in Oxfordshire that are now Risk Management Authorities (RMAs). It is noted that as a LLFA, Oxfordshire County Council is also classed as a RMA.

Table 2-2 Risk Management Authorities (RMAs) in Oxfordshire

District or Borough Councils	Internal Drainage Boards	Water Companies	Other
• Cherwell District Council • Oxford City Council • South Oxfordshire District Council • Vale of the White Horse District Council • West Oxfordshire District Council	• Standlake (not known to still be active)	• Thames Water • Anglian Water • Severn Trent Water	• Environment Agency • Highways Agency

2.2.2 There are a number of working groups that have been set up in Oxfordshire to allow partnership working. These are summarised on Figure 2-2.

Figure 2-2 Structure and linkages of Oxfordshire flood groups



2.2.3 The Oxfordshire Strategic Flooding Group (formerly the Oxfordshire Long Term Flooding Issue Group) was set up following the floods of July 2007 and included representatives from Oxfordshire County Council, City and District Councils, the Environment Agency and Thames Water. The role of the group was to consider the issues that arose from the July 2007 floods and to form a partnership for improved joint working and communication within the county in relation to flooding. Meetings are held quarterly. The terms of reference of the Group are given in Appendix A.

2.2.4 The Group has now been in existence for over three years and during this time the Pitt Review has been published with it various recommendations. As a result of the Flood

Risk Regulations (2009) and Flood and Water Management Act (2010) the Group has adopted a more strategic role in order to consider the implications of the new legislation and to work with partners in order to facilitate a joined up approach to flood risk management.

2.2.5 The following organisations are members of the Group:

- Environment Agency
- Oxfordshire County Council
- Cherwell District Council
- Oxford City Council
- South Oxfordshire District Council (SODC)
- Vale of White Horse District Council (VOWH)
- West Oxfordshire District Council (WODC)
- Thames Water

2.2.6 As shown on Figure 2-2, there have been operational Flood Groups set up for each District and Oxford City. A Flooding Sub-Group has recently been set up with the intention of becoming a „task and finish' group for work at a level of detail that is not appropriate for the involvement of the Strategy group.

2.3 Communication with partners and the public

2.3.1 The Strategic Flooding Group Coordinator maintains a communication flow between partners and also arranges the quarterly meeting including coordination of the agenda and associated papers. He has also been involved in setting up and arranging of two specific countywide Flooding Sub-Group meetings where particular issues were discussed and agreed.

2.3.2 As part of the preparation for the PFRA information was requested from Parish, District and City Councils and internally within Oxfordshire County Council relating to flooding incidents. This required information being sent explaining the request and a brief background to the legislation and involving all tiers of local government in the collation of relevant information.

2.3.3 Oxfordshire County Council is in the process of updating its web site to take into account the new responsibilities and there have been articles in District Council newsletters.

3 Methodology and data review

3.1 Methodology and timeline

3.1.1 The PFRA has been carried out in accordance with the methodology set out in the Environment Agency's Preliminary Flood Risk Assessment Final Guidance (December 2010). A schedule showing the stages of development of the PFRA is shown in Table 3-1.

3.1.2 The PFRA was subject to review by the Growth and Infrastructure Scrutiny in May 2011. The Scrutiny committee provides advice to the Cabinet on major policy issues and may review Cabinet decisions. The committee noted and welcomed the report as a high level document. Their comments were incorporated into the final report. The report was signed off by the Cabinet Member for Transport.

Table 3-1 Schedule of development of PFRA

Date	Activity
June 2010 to December 2010	Development of governance and partnerships (based on relationships established following the 2007 flood event). Collation of data on past floods from other organisations, including Parish Councils.
January 2011	Discussion with Environment Agency representative to provide advice regarding PFRA
March 2011	Appointment of JBA Consulting to support preparation of PFRA. Completion of data collation. Start assessment of flood risk based on available data on past and future floods. Determine locally agreed surface water information. Start Preliminary Assessment Report. Extract information for Annex spreadsheet.
April 2011	Complete draft Preliminary Assessment Report and Annex spreadsheet
May 2011	Oxfordshire County Council Growth and Infrastructure Scrutiny Review
June 2011	Complete Preliminary Assessment Report and Annex spreadsheet. Sign off by the Cabinet Member for Transport, Councillor Rose. Submission of PFRA to Environment Agency.

3.2 Data collection

3.2.1 Existing spatial datasets, reports and anecdotal evidence were gathered for this assessment from a variety of sources as per the Environment Agency guidance, as summarised in Table 3-2.

Table 3-2 Data collection

Organisation	Data collected	
Oxfordshire County Council	Drainage	Local knowledge of drainage engineers Capital schemes 2011-2012 Photos of flooding
	Sustainability and climate change	Local Climate Impacts Profile database
	Emergency Planning	Severe Weather Plan COMAH and REPPIR site locations
	Fire and Rescue Service	Records of flooding in July 2007

Organisation	Data collected	
	Minerals and Waste	Oxfordshire Level 1 Strategic Flood Risk Assessment
	Customer Services	Mapping and GIS layers
Town and Parish Councils	Parish Flooding Survey (June 2010)	
Oxford City and District Councils	Strategic Flood Risk Assessments for all districts West Oxfordshire District Council Final Report: 2007 Summer Floods West Oxfordshire District Council Parish Flooding Reports (2008) – individual reports for 47 parishes Cherwell District Council Strategy to Flood Risk and Responses to Recent Flooding (July 2008) Preliminary report on flooding in the South Oxfordshire District Council Area on 3 June 2008 (July 2008) and update (Jan 2009) South Oxfordshire and Vale of White Horse District Council SFRA GIS layers Information on flooding grants issued after July 2007	
Environment Agency	PFRA GIS layers (Flood Map, Main Rivers, Historic Flood Map, Areas Susceptible to Surface Water Flooding, Areas Susceptible to Groundwater Flooding, Detailed River Network, National Receptors Database, Flood Map for Surface Water) PFRA data CD Review of Thames Region Summer Floods 2007: Technical report and spreadsheet of properties flooded by surface water. GIS layer of watercourses affected by groundwater flooding in 2001 Thames Catchment Flood Management Plan	
British Waterways	GIS layers of canal information and incidents of overtopping/breaching in 2007	
Thames Valley Police	No information available	
Thames Water	No information received	

3.3 Availability and limitations of information

3.3.1 The main data limitations from the perspective of the PFRA are with the recording of past flooding information. Prior to the Pitt Review (2008) there was uncertainty regarding responsibility for collecting data on local sources of flooding and little incentive for any party to collect such data.

3.3.2 This means the availability of past flooding information is generally sparse. Due to the historically poor recording of incidents of flooding from non-main river sources many of the flooding records are descriptive, incomplete, or not geographically referenced, and

recording of the consequences is not clear. This is a widespread problem nationally, but clearly one which needs to be addressed by the LLFA as part of its new responsibilities, with the development of standard methods of collecting, recording and storing information during an event.

3.3.3 Despite this limitation, there was a surprising amount of data available about the July 2007 event, perhaps because it had a relatively big impact. The different data sources are summarised in Table 3-3 which illustrates the difficulty in deciding which data to use when assessing the impact of the event.

Table 3-3 Sources of data on July 2007 flood event

Data source	Information on source of flooding?	Estimate of number of properties?	Geographically referenced?	Complete coverage across County?
Environment Agency Thames Region's Technical Review of Summer Floods 2007	Fluvial, surface water and combination	Yes	Yes	Yes
Fire and Rescue Service records	Main river, drainage and ordinary watercourse	Yes	Yes	Yes
Information on flood grants issued	Not specified	Yes	No	WODC, VOWH and City
Cherwell District Council records	Fluvial, surface water and land drainage	Yes	Yes	Cherwell
Oxford City Council estimate	Groundwater	Yes	No	City
West Oxfordshire Parish Reports	Yes	Yes	To parish/street level	WODC only
Parish Survey	Not consistent	Not consistent	Not consistent	66 of 322 parishes

3.3.4 There were two main sources which recorded numbers and geographical locations of properties flooded, which identified the source of flooding, and which had consistent coverage across the county. These were:

- Environment Agency Thames Region's Technical Review of Summer Floods 2007
- Fire and Rescue Service records of flooding in July 2007

3.3.5 It was found that the two datasets were quite different, in terms of the total numbers of properties flooded, and in some cases the locations of flooding. This may be due to differences in the way the source of flooding has been defined, and illustrates the problems faced in collecting data of this kind. When compared with other sources such as the West Oxfordshire Parish Reports, it is clear that neither dataset fully represents the true scale of the event. In particular it seems that flooding from ordinary watercourses may not be well represented in either dataset. It was considered that the

Fire and Rescue Service records were more consistent in the way the data was collected, and the data recorded more properties flooded. However there were additional locations recorded by the Environment Agency that do not appear in the Fire and Rescue records. Together they give a good indication of the geographical impact of the event. Both datasets have been shown on Map 1 and the differences can be seen.

3.3.6 The Parish Flooding Survey (see Appendix B) was very detailed in identifying locations where local sources of flooding cause problems, and covers a range of different events, however they are mostly descriptive and are not always quantified in terms of dates, or number of properties flooded. There was not enough time available to this study to standardise the data format and fully analyse the results. Not all parishes returned the surveys (66 out of 322), including some that are known to have flooded. The majority of the records relate to July 2007, and the more quantitative evidence available has been used in preference for the PFRA.

3.3.7 The West Oxfordshire Parish Reports were more comprehensive and consistent than the rest of the Parish Surveys and included estimates of consequences, although they only cover the July 2007 event. These reports have been used to provide a more accurate estimate of numbers of properties flooded, but have not been included in Map 1 as they do not cover the whole county, and the time was not available to be able to map the information.

3.3.8 Both the Parish Flooding Survey and the West Oxfordshire Parish Reports will be analysed fully and utilised in the more detailed Local Flood Risk Management Strategy.

3.3.9 The number of properties issued with a flooding grant is a good indicator of the scale of the impact. However it is likely to be an underestimate, because not all properties that were flooded will take up a flooding grant (for example due to suspicion about insurance premiums). This information also does not identify the source of flooding.

3.3.10 The Environment Agency's Historic Flood Map only covers past flooding from rivers, the sea and groundwater, as these sources have traditionally been the Environment Agency's responsibility. It therefore does not include most of the local sources of interest to the PFRA. It is also not attributed with the source of flooding, date or any other more detailed information.

3.3.11 These limitations highlight the need for flood event data to be collected more methodically in the future using a formal system and approach that is common to all parties who collect data. This is required under the Flood and Water Management Act through the responsibility to investigate flooding. In developing the investigation procedures it would be prudent to ensure that the information collected satisfied data collected to meet the needs of the Flood Risk Regulations.

3.3.12 The other main limitation to the PFRA was the lack of sewer flooding information. DG5 data (a database of sewer flooding incidents by 5 digit postcode area in the last 10 years) was formally requested from Thames Water on areas known to them of historical flooding incidents but this was not received. Thames Water requested that the LLFA enters in to a data sharing agreement that restricted the use of the information, and as a result no data has been received. The issue of data sharing in general is currently being considered by Environment Agency at a national level especially in relation to water companies and it is hoped that the issue will be resolved in time for the Local Flood Risk Management Strategy. The assessment of sewer flooding for the PFRA has been based on the information available in the county's SFRAs and other available documents.

3.3.13 It should be made clear that none of the data limitations described have affected the outcome of the PFRA. Even if the DG5 data had been available, we would not have identified any further significant Flood Risk Areas based on the Defra guidance (2010).

3.4 Information sharing and management

3.4.1 Flood related information exists in a number of different formats (both hard and digital) across a number of different service areas. Information has been collected from various different organisations over time for different purposes. A formal data register has been kept to record the data collected and used for the PFRA, and any licensing limitations.

3.4.2 It is recommended that Oxfordshire County Council put in place a system to collect, manage and store flood related information to underpin the work of the LLFA. This system should ideally have a Data Custodian, who acts as a focal point for flood related information in the county. The Data Custodian should have access to, and the skills to use, suitable GIS software in order to be able to manage the spatial data that is integral to flood risk management. These arrangements should be outlined in the Local Flood Risk Management Strategy.

3.4.3 As described the data on local flooding has not been collected using methodical procedures. It is often very good descriptive information, but it is difficult to determine the accuracy and completeness of the data. Thus it is difficult to define quantitative measures of data quality and confidence in the data. To assist with the future use of the data for the Local Flood Risk Management Strategy, the following quality tags have been used:

Data quality tag	Description
High	Flood event information/consequences are quantified Consistent collection method, likely to be accurate and reliable Source of information is known Geo-referenced Based on computer modelling with high confidence
Medium	Flood event information/consequences are more qualitative or descriptive Less consistent collection methods, accuracy and reliability are harder to determine Multiple sources of information May be geo-referenced Based on computer modelling with reasonable confidence
Low	Flood event information/consequences are not given Significant doubt over consistency, accuracy and reliability Source of information is unknown Not georeferenced Based on computer modelling with low confidence

3.5 Appropriate uses of information

3.5.1 In order to protect data from unauthorised use, change, copying or loss and cover Intellectual Property Rights, the vast majority of data that is used to inform flood risk management is shared under license agreements. Different license agreements have been entered into as appropriate.

3.5.2 Much of the information on flooding is sensitive, particularly where this related to information on individual properties that have been affected by past flooding, for reasons of property blight and also related to the quality of the information, since many records of past flooding are anecdotal and incomplete.

3.5.3 Predictive mapping for future flood events is reliant on the underlying assumptions and level of detail that any flood modelling study will necessarily take, since modelling is a simplification of reality. Hence it is common to describe flooding locations by street or community and show flood mapping at a scale at which individual properties cannot be identified, especially where this is being used in a strategic context, such as to inform the PFRA.

3.5.4 The assessment of data quality, as described in section 3.4, should be taken into account in the re-use of any of the information collected for the PFRA.

3.5.5 The PFRA will be quality assured by review within JBA Consulting and Oxfordshire County Council. The Environment Agency PFRA checklist will be used to assure quality, and the Environment Agency will also review the document.

4 Past flood risk

4.1 Significant harmful consequences

4.1.1 Defra and the Minister have determined a very high threshold to determine whether the risk should be classified as „significant' on a European scale for the purpose of responding to the Floods Directive (there are only 10 indicative Flood Risk Areas where flood risk is deemed to be significant in the whole of England).

4.1.2 Annex 1 is a standard spreadsheet that has been provided by the Environment Agency with their PFRA guidance, and must be included with the Preliminary Assessment Report. It will be used to report past flood event information to the European Commission. It has several mandatory fields and the format cannot be changed. An Environment Agency briefing note (undated) advises that:

- "There is only a need to include information in Annex 1 if the LLFA has reliable information on past floods and believes those floods had significant harmful consequences.
- The purpose is to include reports of those past floods that had consequences of a level sufficient to justify reporting to Europe. This would normally imply that they were memorable or otherwise registered on a national scale.
- To reduce workload and focus on the key requirements of the PFRA, we suggest that reporting of past floods in Annex 1 be kept to the more major flood events."

4.1.3 Following this guidance, it was decided that one event, July 2007, met these criteria. It had a major impact in the county and at a wider national scale, and has therefore been included in Annex 1. The mechanisms and impacts of flooding in this event are discussed in the following sections.

4.1.4 However, it is important to understand that the information in the PFRA report will be used to prepare the Local Flood Risk Management Strategy. This local strategy will consider the consequences of flooding for circumstances where the consequences are much less than those determined by Defra and the Minister.

4.1.5 This is demonstrated by the fact that several other recent events have had a local impact for the county in terms of properties flooded and disruption to infrastructure and services. Such events have only been included in the PFRA summary table (Table 4-1) and maps (Map 1 to Map 3) where the consequences are easily quantifiable i.e. properties are recorded to have flooded internally.

4.2 Interaction between sources of flooding

4.2.1 Interaction between different sources of local flooding, and between local sources and main river sources is common, and it is often difficult to determine exactly what source is responsible for any impact.

4.2.2 There is often a timing factor associated with this interaction. For example:

- High intensity rainfall may initially result in water that runs across the land and causes surface water flooding. This flood water eventually is collected in drainage systems and causes flows in rivers and channels to increase, resulting in flooding hours or days later that is a result of the capacity of the river channels being exceeded (thus the flooding can change from surface runoff flooding to river flooding).
- Where rainfall occurs over a longer period, river levels may start to rise slowly. This causes groundwater levels in alluvial gravels to rise, and groundwater flooding may occur before the river itself floods, and persist after the river level has receded. This is an interaction that occurs along the River Thames.

4.3 Main rivers

4.3.1 The purpose of the PAR is to focus on local sources of flooding. However it is important to place this in the wider context of flooding in Oxfordshire. A severe river flooding event in the Thames catchment is likely to have a much greater impact in Oxfordshire than flooding from local sources alone, although most river flooding events involve interaction with local sources of flooding.

4.3.2 Recorded major river flooding events across the River Thames catchment have occurred in November 1894, March 1947, October/November 2000, January 2003 and July 2007. Other events have affected tributaries more severely than the River Thames, for example the impact of the Easter 1998 event was mainly limited to the Cherwell catchment.

4.3.3 The Environment Agency's website (2011) suggests that the river flooding in 2007 had around a 1 in 20 to 1 in 50 chance of occurring in any given year at Oxford, a 1 in 50 to 1 in 100 chance at Abingdon and Pangbourne, and a 1 in 100 to 1 in 150 chance at Witney.

4.3.4 Oxfordshire County Council (Environment and Economy Scrutiny Committee report, September 2008) estimates that around 2100 properties were flooded (from all sources) in the July 2007 event. This study has calculated the best estimate for each district from all the sources of data available, which gives a total of 2682. The best estimate of the split between residential and non-residential properties is given by Oxfordshire Fire and Rescue Service, which identifies 115 non-residential addresses affected by internal flooding. The majority of these were from main rivers.

4.3.5 In terms of other human health impacts the river flooding also affected four care homes, one surgery and at least one school. Caravan sites at Clifton Hampden and Bablock Hythe were affected, and 60 people were evacuated from Bablock Hythe.

4.3.6 The river flooding also had a major impact on local infrastructure and economy, as indicated by the Environment Agency's Post Flood Technical Report (2007). Many roads were flooded throughout the county including the M40 and several A-roads. Several roads in Oxford were closed for over 5 days, including A420 Botley Road and A4144 Abingdon Road. Railway lines were closed between Didcot and Bristol, Didcot and Oxford, and Oxford to Banbury and Worcester (some for over a week), and services were cut between Didcot and Reading, causing major disruption to customers.

Banbury railway station was flooded. Grimsbury Water Treatment Site in Banbury was seriously flooded and was out of action for several months. Bampton and Sandford-on-Thames Water Treatment Sites experienced power failures which affected their operation.

4.3.7 Work has been carried out to mitigate the impact of river flooding following events in the last few decades. Properties on the River Cherwell have benefited from actions that were undertaken after the 1998 event. With the Environment Agency, Cherwell District Council has constructed permanent flood defences as part of Banbury Flood Alleviation Scheme (FAS) which saved more than 600 properties in July 2007. As a result, Cherwell DC experienced only 66 internally flooded households and 15 businesses during July 2007 (Environment and Economy Scrutiny Committee report, September 2008).

4.3.8 The Oxford Flood Risk Management Strategy was adopted by the Environment Agency's Board of Directors in autumn 2010 following public consultation in 2009. This includes a raft of different measures to improve flood risk in Oxford. A number of measures have already been completed including maintenance and engineering improvements, provision of demountable flood barriers for Osney Island and Hinksey Park, and development of a multi-agency flood plan. Further flood defence improvements and household protection measures are planned, along with a conveyance channel around the west and south of Oxford and upstream flood storage if they are shown to be required.

4.4 Surface water and ordinary watercourses

4.4.1 The majority of recorded incidents of local sources of flooding in the county have been due to intense rainfall events. This leads to flooding from surface water runoff, both on its own or in combination with flooding caused by the exceedence of capacity of local drainage, ordinary watercourses and associated structures such as culverts. The two sources are closely interlinked and have been considered together for the purposes of the PAR.

4.4.2 The surface water event which had the biggest impact on receptors, and was best recorded, occurred in July 2007 and affected many settlements across the county. This event also registered on a national scale and has therefore been included in Annex 1. According to the Environment Agency's Post Flood Technical Report (2007), after an unseasonably wet May, June and July, widespread torrential downpours on 19th and 20th July occurred across Oxfordshire, but were most severe in the west of the county. The maximum total in Oxfordshire was recorded at Uffington (140.7mm over 48 hours), and many locations recorded continuous heavy rainfall for around 20 hours. The rainfall event was estimated to have between a 1 in 140 and 1 in 360 chance of happening in any given year depending on location. The immediate effect of the intense rainfall was widespread surface water and ordinary watercourse flooding.

4.4.3 Over the following days and weeks, this event resulted in a major river flood (see section 4.3), so there was significant interaction with main river sources, and it is therefore difficult to be certain about the exact number of properties and infrastructure flooded by non-main river sources alone (see 4.2).

4.4.4 Out of the 2682 properties affected from all sources in July 2007, the estimate of properties identified as flooded internally from surface water and ordinary watercourse sources alone in July 2007 varies between 100 (Environment Agency) and over 250 (Oxfordshire Fire and Rescue Service). In reality the number of properties flooded from surface water and interaction of sources is likely to be greater. The distribution of records from these two data sources is shown in Map 1 – it should be noted that neither

of these data sources is comprehensive and there are locations where flooding from local sources is known to have occurred that are not included on the map.

4.4.5 The worst affected areas according to the Fire and Rescue Service records were (in order of number of properties affected): Bampton, Appleton, Brize Norton, Witney and Bloxham. Critical services are also recorded as flooding from local sources, including one emergency service. Many pre-schools, schools and colleges were closed and several were actually flooded by surface water runoff, including those at Appleton, Bampton, Cropredy, and Carterton.

4.4.6 There are around 40 other dated events mentioned in the Parish Flooding Survey (see Appendix B), data collection spreadsheets and SFRAs. The most mentioned events after July 2007 are October-December 2000, June 2008, and January 2003. October-December 2000 and January 2003 were predominantly river flooding events so have not been included here.

4.4.7 In June 2008 surface water flooding occurred after a very intense summer rainfall event. The impact was generally concentrated but not confined to South Oxfordshire district according to the available data. An estimate of properties flooded (at least 75) has been made from the Parish Surveys and SODC report on the event, which suggest that the worst affected communities included Berrick Salome/Roke, Chalgrove, Kidlington, Thame, Tiddington and Wheatley. A teenage boy also drowned after being trapped in a culvert in Witney. SODC have invested £135,000 in flood alleviation works following the event. This event has been included on Map 2 and in Table 4-1.

4.4.8 Other surface water flooding events in the county have been on a smaller and more localised scale. Where adverse consequences could be easily quantified in the time available from the existing information, the events are shown on Map 2 and included in Table 4-1. These events have affected single communities such as Bladon (see Figure 4-1) and Nuneham Courtney.

4.4.9 Other problematic areas are indicated by the locations of planned drainage capital schemes and works provided by Oxfordshire County Council (see Appendix B).

4.4.10 The more qualitative information that has been collected on other events and locations will be fully utilised in the more detailed Local Flood Risk Management Strategy.

Figure 4-1 Surface water flooding in Bladon, January 2007

4.5 Groundwater

4.5.1 There is only one groundwater-only event in the records which is clearly recorded as causing flooding to property. The prolonged event of winter 2000/1 saw some of the

highest groundwater levels recorded within the chalk and oolitic limestone aquifers in the county, causing flooding in watercourses including Assendon Spring, Harpsden Court Drain (Henley), Stert Brook (Thame) and Ewelme Brook (Ewelme/Benson). Cumnor and Botley, near Oxford, were also affected in this event according to SODC and VOWH SFRA (2009). Locations of watercourses affected in this event were provided by the Environment Agency and are shown on Map 3.

4.5.2 According to the Parish Flooding Survey, 22 properties are estimated to have flooded on the Assendon Spring (an ephemeral groundwater fed ordinary watercourse), which flows through Stonor, Middle Assendon, Lower Assendon, and Henley, before entering a long culvert through Henley. This type of flooding is particularly disruptive because it can continue for weeks and even months before water levels subside. 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.

4.5.3 In the Parish of Bix and Assendon, the Parish Council has established a monitoring arrangement with the Environment Agency, the County Council and SODC to alert householders to high groundwater levels which would lead to flooding from the Assendon Stream (SODC and VOWH SFRA, 2009).

4.5.4 Aside from those described above, which are all in South Oxfordshire, other areas that experience groundwater flooding issues are identified by the District and City SFRAs as follows:

- Oxford City: Grandpont and New Hinksey, Oxford District area (east of the city centre), Headington.
- Cherwell: The base of Crouch Hill in Banbury, Upper Heyford, Kidlington, Bodicote, Hook Norton, Steeple Aston and Mollington.
- West Oxfordshire: Shilton, Alvescot, Northmoor, Langford, Combe and Kelmscott.

4.5.5 Groundwater flooding also occurs in combination with main rivers. In particular, some areas of Oxford, including New Botley (January 2003) and New Hinksey (July 2007), have suffered basement flooding when groundwater in alluvial gravels has risen, driven by river flooding in the River Thames. Oxford City Council noted approximately 190 properties flooded in Hinksey Park ward by this mechanism in July 2007. These have been included in the total number of properties flooded from local sources in 2007 in Table 4-1.

4.5.6 Groundwater/fluvial interaction such as that experienced in Oxford is a particularly „grey' area in terms of responsibility. Although the responsibility for groundwater flooding lies with the LLFA, the Environment Agency recognises the interaction with river flooding and expects to work in partnership to reduce flood risk. The Oxford Flood Risk Management Strategy has included an examination of information relating to groundwater and its interaction with fluvial flooding.

4.6 Canals

4.6.1 Oxford Canal is the only canal in the county. It enters Oxfordshire in the very northern tip of the county near Claydon, and extends southwards through Banbury and into central Oxford, ending close to the railway station. Some overtopping and breaching of the Oxford Canal occurred during the July 2007 event.

4.6.2 The canal interacts closely with the River Cherwell (main river) through locks and overflow structures, and at certain points they occupy the same channel. It is therefore virtually impossible to separate any impacts from the main river flooding. Most of the breach/overtopping locations are in rural areas and would have had very little impact on

properties. However there are five overtopping locations in Banbury that may have contributed to the main river flooding that occurred there during the event.

4.6.3 Map 4 illustrates the route of the canal and locations of breaching and overtopping for information only. It is not known whether any properties flooded directly from the canal.

4.7 Sewer flooding

4.7.1 Sewer flooding occurs when intense rainfall overloads the sewer system capacity, and can be exacerbated where there is a blockage or collapse of a sewer. 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.

4.7.2 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. Sewer flooding is therefore a problem that could occur in many locations across the county. It is highly likely that the „surface water' flooding of July 2007 was exacerbated by the sewer system being overloaded by the intensity of the rainfall.

4.7.3 The Thames Water DG5 database details sewer flooding incidents by 5 digit postcode area in the last 10 years. This can give an overall picture of relatively large geographical areas where sewer flooding may be more of a problem. Given that only ten years of incidents are included however, it is reasonable to assume that there are significantly more properties at risk of sewer flooding but which have not experienced the rainfall or other conditions to cause flooding during this period. Thames Water has not provided DG5 data for this study. However, it was provided for the SFRAs covering Oxfordshire, which assessed risk from sewer flooding.

4.7.4 The following areas are identified by the SFRAs and other documents available to this study (indicated in brackets) as experiencing sewer flooding problems:

- West Oxfordshire: Shipton-Under-Wychwood, Ascott-Under-Wychwood, Alvescot, Northmoor, Combe (Parish reports/DG5 data, Cherwell and West Oxfordshire SFRA)
- Cherwell: Spiceball Park Road, Banbury (Cherwell District Council, 2008)
- South Oxfordshire: Botley (DG5 data, SODC and VOWH SFRA)
- Vale of White Horse: Coleshill (DG5 data, SODC and VOWH SFRA)
- City: New Botley and Osney (DG5 data, SODC and VOWH SFRA – postcode crossed the SODC and City boundary)

4.7.5 The problems experienced in New Botley and Osney are likely to have been exacerbated by interaction with groundwater flooding (see section 4.5), which can drive sewer flooding through infiltration into the pipes. According to SODC and VOWH SFRA (2009), Thames Water has identified a solution to the problem and funding has been allocated. Currently a planning application is being drawn up and it is hoped that the scheme will be completed by 2012.

4.7.6 On their website (http://www.thameswater.co.uk/cps/rde/xchg/corp/hs.xsl/7711.htm), Thames Water state that under their planned service improvements in Oxfordshire, they

will make improvements to their sewer network in Oxfordshire to reduce the risk of sewer flooding to 153 properties that have flooded previously.

Table 4-1 Summary of past flooding with adverse consequences in Oxfordshire

This is a summary of the most severe flooding events from local sources in Oxfordshire. Events and locations have only been included where the available data gives an estimate of the number of properties flooded internally. Other local flooding events in the county have been on a smaller scale and no estimates of consequences were available, so have not been included in the table.

Date*	Location	Source of flooding	Approximate number of properties affected	Source of information	Comments
February 2001	Stonor, Middle Assendon, Lower Assendon, Henley	Groundwater/ ordinary watercourse	22	Oxfordshire County Council Drainage/ Parish Survey	Rare event in a normally dry stream.
October 2006	Nuneham Courtney	Surface water/ ordinary watercourse	25	OCC Drainage/ SFRA/Parish Survey	Flooding occurs regularly. Also flooded properties in October 2008.
January 2007	Bladon	Surface water/ ordinary watercourse	20	Oxfordshire County Council Drainage	

Date*	Location	Source of flooding	Approximate number of properties affected	Source of information	Comments
July 2007	Widespread flooding across the county. Main affected areas by parish/city (may not be an exhaustive list): Oxford, Bampton, Appleton-with-Eaton, Brize Norton, Carterton, Witney, Bloxham, Yarnton, Steventon, Marcham, Banbury, Letcombe Regis, East Hanney, Curbridge, Cassington, Standlake, Milton-under-Wychwood, North Leigh, South Leigh, Goosey, Charney Basset, Abingdon, Tadmarton, Cropredy, Kidlington, Risinghirst and Sandhill, West Hendred, Grove, Garford, Milton, Sunningwell, Islip, Didcot, Somerton, Fringford, Eynsham, Asthall, Aston, Cote, Shifford and Chimney, Ducklington, Chadlington, Charlbury, Clanfield, Shipton-under-Wychwood, Ascott-under-Wychwood, Broadwell and Kencott, Enstone, Fawler, Cornbury and Wychwood, Hanborough, Combe, Blenheim, Steeple Barton, Black Bourton, Bladon, Fulbrook, Northmoor, Grafton and Radcot, Burford, Filkins and Broughton Poggs, Kelmscott, Swinbrook and Widford, Minster Lovell, Kingham, Hardwick with Yelford, Leafield, Little Tew, Westcot Barton, Westwell, Tackley, Stanton Harcourt, Taynton, Ramsden, Salford, Shilton, Finstock, Checkendon, Chinnor, Weston on the Green, Bicester, Launton, Wendlebury, Alvescot, Uffington, Wantage.	Main river, surface water runoff, ordinary watercourses, groundwater, sewer, canals, and interactions.	2682 in total (at least 440 from local sources)	Environment Agency/District and County Councils/Fire and Rescue	Estimates of number of properties flooded varies according to source of information

Date*	Location	Source of flooding	Approximate number of properties affected	Source of information	Comments
June 2008	Main flooded areas by parish (may not be an exhaustive list): Begbroke, Berrick Salome, Chalgrove, Epwell, Kidlington, Wendlebury, Chinnor, Cuddesdon, Cuxham, Great Milton, Horspath, Long Wittenham, Sydenham, Thame, Tiddington, Tinby, Towersey, Watlington, Wheatley, Witney.	Surface water runoff, ordinary watercourses	At least 75	Parish Survey/SODC Scrutiny Committee report (2009)	Not all entries in Parish Survey have an estimate of number of properties flooded.

5 Future flood risk

5.1 Summary of relevant information

5.1.1 The following national future flooding datasets were available to this study:

- Areas Susceptible to Surface Water Flooding
- Flood Map for Surface Water
- Areas Susceptible to Groundwater Flooding
- Flood Map (for rivers and the sea)

5.1.2 There is little locally specific information on future flood risk for Oxfordshire. The Thames CFMP looks at future flood risk at a high level across the Thames catchment. It does not include a great deal of information on surface water flooding, particularly for the rural Oxfordshire area. The South Oxfordshire and Vale of White Horse District Councils SFRA carried out some surface water flood modelling in small areas of particular interest to the Local Planning Authorities.

5.1.3 Annex 2 is a standard spreadsheet that has been provided by the Environment Agency with their PFRA guidance, and must be included with the Preliminary Assessment Report. It will be used to report future flood event information to the European Commission. It has several mandatory fields and the format cannot be changed. It requires the consequences of future flooding for Oxfordshire predicted by each of the national datasets described above to be assessed, in terms of effect on human health, economy and environment. This has been done using available information, and the consequences entered into the spreadsheet.

5.2 Locally agreed surface water information

5.2.1 The surface water modelling carried out for South Oxfordshire and Vale of White Horse District Councils SFRA used older ground data and was at no more detailed resolution than the Flood Map for Surface Water. It was therefore decided to use the Flood Map for Surface Water as the „locally agreed surface water information' for the purposes of assessing future flood risk for the PFRA. This was consulted and agreed upon in March 2011 with interested parties in Oxfordshire County Council, and with the Environment Agency and Thames Water.

5.2.2 As a national dataset is being used and has already been included in Annex 2, no additional lines have been added to the spreadsheet. However, a more detailed assessment of consequences has been made for the Flood Map for Surface Water.

5.2.3 It is important to note that the choice of the Flood Map for Surface Water as the „locally agreed surface water information' is solely made for the purposes of the PFRA and high level strategic work. More detailed flood risk studies should utilise the best available local information and carry out more detailed modelling as appropriate to the level of the study.

5.2.4 The Flood Map for Surface Water 1 in 200 chance of flooding dataset for Oxfordshire is shown in Map 5.

5.2.5 There is no detailed information available on local drainage capacity that could be used to improve the surface water modelling. Thames Water has not provided sewer flooding information and therefore no assumptions can be made regarding areas where capacity is very low. In general, sewers should be built to a standard 1 in 30 chance of flooding capacity where they are to be adopted by the water company. However, the majority of sewers across the county were built before this standard was applied.

5.3 Surface water and ordinary watercourses

5.3.1 The locally agreed surface water information has been analysed to assess the consequences of surface water flooding on receptors (human health, economic activity, environment and cultural heritage). The results are given in Annex 2 (see 5.1.3) and are summarised in Table 5-1.

5.3.2 For the purposes of the PFRA, the Flood Map to Surface Water has also been assumed to reasonably predict areas flooded by exceedence of capacity of ordinary watercourses. It has been checked against the Flood Map for rivers in locations known to flood from ordinary watercourses, such as Appleton, and found to be similar. It was felt that to carry out a separate analysis of ordinary watercourses included in the Flood Map for rivers would be unnecessarily time-consuming and would essentially „double-count' many of the properties at risk.

Table 5-1 Consequences of future surface water flooding in Oxfordshire

Receptor		**Locally agreed surface water information (Flood Map for Surface Water (1 in 200 chance of flooding, >0.3m))***
Human health	Number of people	37900
	Number of critical services	240
Economic activity	Number of non-residential properties	6800
	Length of road (km)	159900
	Length of rail (km)	37600
	Area of agricultural land (km²)	2440
Environmental	Number of PPC sites	10
	Number of COMAH sites	0
	Number of designated environmental sites: RAMSAR SAC SPA SSSI	 0 3 0 60
Heritage	Number of World Heritage sites	1 (Blenheim Palace)
	Number of Scheduled Monuments	86
	Number of listed buildings	1040
	Number of parks and gardens	35

* Figures have been rounded to the nearest 100 except for critical services and area of agricultural land, which have been rounded to the nearest 10

5.3.3 The spatial distribution of receptors (people, critical services and non-residential properties) that may be affected by future surface water flooding in the 1 in 200 chance rainfall event has been analysed to build up a more detailed picture of the

consequences of future floods in Oxfordshire. A similar methodology has been used to the Environment Agency's national „blue squares' mapping, which defined the flood risk clusters and indicative Flood Risk Areas for reporting at a European level. The purpose of the analysis here however is to identify areas that may experience adverse consequences of flooding in the future on a local scale for Oxfordshire, to feed into the Local Flood Management Strategy and future work.

5.3.4 The number of receptors which may be affected by such an event in each 1km square of the county was counted and mapped.

- Number of people (number of residential properties multiplied by 2.34) (Map 6a)
- Number of critical services (includes schools, hospitals, nursing/care/retirement homes, police, fire and ambulance stations, prisons, sewerage treatment works, electricity installations) (Map 6b)
- Number of non-residential properties (includes all industrial, commercial, retail, public buildings etc) (Map 6c)

5.3.5 Number of people and critical services can be considered indicators of the consequences of flooding for human health, and number of non-residential properties an indicator of the consequences for economic activity.

5.3.6 The numbers were calculated using the National Receptors Database v1.1, the Environment Agency's detailed method of counting (based on property outlines) as described in its *Flood Map for Surface Water Property Count Method* guidance. This guidance also states in detail how the OS Base Function classification has been used to define residential and non-residential properties.

5.3.7 The 1km squares are shaded from light to dark purple as the number of receptors affected in each square increases.

5.3.8 Also overlaid on each map are surface water flooding „hot spots', or areas where the consequences of a surface water event are likely to be more severe. These have been defined as 1km grid squares where at least one of the indicators is above a given threshold. These thresholds have been defined to draw out areas that will be adversely affected at a local scale, and are given below:

- More than 200 people affected
- One or more critical services affected
- More than 20 non-residential properties affected

5.3.9 The maps show that the main surface water flooding hotspots are in more urban locations such as parts of Oxford, Banbury, Witney, Bicester, Abingdon, Wantage, Didcot, Wallingford, Henley and Thame. This is mainly due to the concentration of population, industrial and commercial buildings, and critical services in these areas.

5.3.10 However, the analysis also highlights a number of more rural locations where, while numbers of people affected are bound to be lower, there will still be an adverse impact on small communities, particularly those where local critical services are affected, for example Chipping Norton, Carterton, Shipton-under-Wychwood, Charlbury, Burford, Watlington, Chalgrove, Chinnor, Faringdon, Appleton, Frilford, Bloxham (not an exhaustive list).

5.3.11 Many of the communities that have been affected by past flooding are also highlighted by the analysis, providing some verification of the method.

5.4 Groundwater

5.4.1 Future flooding from groundwater is indicated by the national Areas Susceptible to Groundwater Flooding map, shown in Map 7. This shows risk of groundwater emergence as a percentage for each 1km square.

5.4.2 The map shows two broad bands of higher risk running from south west to north east across the county, as dictated by the more permeable underlying geology types (oolitic limestone and chalk). The northern band runs roughly from Clanfield through Bampton, Standlake, Kidlington to Wendlebury and Lower Arncott (just to the south of Bicester). The southern band runs roughly from Wantage through Milton, Sutton Courtney, Long Wittenham to Drayton St Leonard, and also north towards Abingdon and south towards Wallingford and Cholsey.

5.4.3 It is not sensible to analyse this data to count the number of receptors that may be affected, as not all the receptors in each 1km square will be susceptible. However it is reasonable to say that large areas of the county are in the highest category of risk of groundwater emergence.

5.4.4 The Environment Agency guidance suggests that "unless an area identified as „susceptible to groundwater flooding' is also identified as „at risk from surface water flooding', it is unlikely that this location would actually experience groundwater flooding to any appreciable depth, and therefore it is also unlikely that the consequences of such flooding would be significant."

5.4.5 Prompted by this comment, surface water flooding hot spots as identified in section 5.3 have been overlaid on Map 7 to illustrate areas that may be at a higher risk of combined groundwater and surface water flooding. Areas identified by the mapping where a surface water flooding hotspot coincides with a greater than 75% chance of groundwater emergence include: Witney, Swinford, Abingdon, Grove, Wallingford, Goring, Watlington, Chinnor, parts of Oxford, Dorchester, Berinsfield, Drayton St Leonard and Clifton Hampden. It should be noted that these are general indicative areas, not specific locations.

5.5 Canals

5.5.1 No predictive information is available specifically on future flood risk from canals. However due to the close interaction between the Oxford Canal and the River Cherwell, the Flood Map for rivers for the River Cherwell could be used to define the maximum area that may be affected by breaches or overtopping of the canal. The main concentrations of receptors at risk from canal flooding are therefore in Banbury and North Oxford, with possibly a small number of people and property at Cropredy.

5.5.2 It should be noted however that canal flooding is unlikely to occur or have adverse effects independently from a main river flooding event on the River Cherwell.

5.6 Sewer flooding

5.6.1 No predictive information is available on future flood risk from sewer flooding.

5.7 Climate change and long term developments

The evidence

5.7.1 There is clear scientific evidence that global climate change is happening now. It cannot be ignored.

5.7.2 Over the past century around the UK we have seen sea level rise and more of our winter rain falling in intense wet spells. Seasonal rainfall is highly variable. It seems to

have decreased in summer and increased in winter, although winter amounts changed little in the last 50 years. Some of the changes might reflect natural variation, however the broad trends are in line with projections from climate models.

5.7.3 Greenhouse gas (GHG) levels in the atmosphere are likely to cause higher winter rainfall in future. Past GHG emissions mean some climate change is inevitable in the next 20-30 years. Lower emissions could reduce the amount of climate change further into the future, but changes are still projected at least as far ahead as the 2080s.

5.7.4 We have enough confidence in large scale climate models to say that we must plan for change. There is more uncertainty at a local scale but model results can still help us plan to adapt. For example we understand rain storms may become more intense, even if we can't be sure about exactly where or when. By the 2080s, the latest UK climate projections (UKCIP09) are that there could be around three times as many days in winter with heavy rainfall (defined as more than 25mm in a day). It is plausible that the amount of rain in extreme storms (with a 1 in 5 annual chance, or rarer) could increase locally by 40%.

Key projections for Thames River Basin District

5.7.5 If emissions follow a medium future scenario, UKCIP09 projected changes by the 2050s relative to the recent past are:

- Winter precipitation increases of around 15% (very likely to be between 2 and 32%).
- Precipitation on the wettest day in winter up by around 15% (very unlikely to be more than 31%).
- Relative sea level at Sheerness very likely to be up between 10 and 40cm from 1990 levels (not including extra potential rises from polar ice sheet loss).
- Peak river flows in a typical catchment likely to increase between 8 and 18%.

Implications for flood risk

5.7.6 Climate changes can affect local flood risk in several ways. Impacts will depend on local conditions and vulnerability.

5.7.7 Wetter winters and more of this rain falling in wet spells may increase river flooding in both rural and heavily urbanised catchments. More intense rainfall causes more surface runoff, increasing localised flooding and erosion. In turn, this may increase pressure on drains, sewers and water quality. Storm intensity in summer could increase even in drier summers, so we need to be prepared for the unexpected.

5.7.8 Rising sea or river levels may increase local flood risk inland or away from major rivers because of interactions with drains, sewers and smaller watercourses.

5.7.9 There is a risk of flooding from groundwater-bearing chalk and limestone aquifers across the district. Recharge may increase in wetter winters, or decrease in drier summers.

5.7.10 Where appropriate, we need local studies to understand climate impacts in detail, including effects from other factors like land use. Sustainable development and drainage will help us adapt to climate change and manage the risk of damaging floods in future.

Adapting to change

5.7.11 Past emission means some climate change is inevitable. It is essential we respond by planning ahead. We can prepare by understanding our current and future vulnerability to flooding, developing plans for increased resilience and building the capacity to adapt.

Regular review and adherence to these plans is key to achieving long-term, sustainable benefits.

5.7.12 Although the broad climate change picture is clear, we have to make local decisions against deeper uncertainty. We will therefore consider a range of measures and retain flexibility to adapt. This approach, embodied within flood risk appraisal guidance, will help to ensure that we do not increase our vulnerability to flooding.

Long term developments

5.7.13 It is possible that long term developments might affect the occurrence and significance of flooding. However current planning policy aims to prevent new development from increasing flood risk.

5.7.14 In England, Planning Policy Statement 25 (PPS25) on development and flood risk aims to "ensure that flood risk is taken into account at all stages in 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, exceptionally, necessary in such areas, policy aims to make it safe without increasing flood risk elsewhere and where possible, reducing flood risk overall."

5.7.15 Adherence to Government policy ensures that new development does not increase local flood risk. However, in exceptional circumstances the Local Planning Authority may accept that flood risk can be increased contrary to Government policy, usually because of the wider benefits of a new or proposed major development. Any exceptions would not be expected to increase risk to levels which are "significant" (in terms of the Government's criteria).

5.8 Local information on climate change impacts

5.8.1 Oxfordshire County Council has produced a Local Climate Impacts Profile (LCLIP) document, which involved research into weather-related incidents in the county. This document's remit is not to quantify climate change impacts on local flood risk. However, it does make a number of conclusions and recommendations about Oxfordshire County Council's ability and need to adapt to any changes in the climate. Flooding is identified as the weather event with the most frequent impact on Council services and resources.

5.9 New or proposed major developments in Oxfordshire

5.9.1 A desk study of the five SFRAs covering Oxfordshire suggests that some planned development areas may be in areas at risk from local sources, for instance in Didcot. However, local planning policy in all cases is to follow PPS25, meaning that any development over 1ha or within Flood Zone 2 and 3 would need to have an appropriate Flood Risk Assessment (FRA) to ensure that they did not have an adverse impact on flooding from all sources.

5.9.2 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. The aim of this is to manage water at source and try to reduce the likelihood of flooding.

5.9.3 It is concluded that there are no major developments planned of the kind described in section 5.7.15 that would be expected to increase flood risk from local sources.

6 Review of indicative Flood Risk Areas

6.1 Review of indicative Flood Risk Areas

6.1.1 Defra (2010) defined significance criteria and thresholds for identifying indicative Flood Risk Areas under the Floods Directive. The Environment Agency applied these criteria nationally by 1km squares (known as the „blue squares' analysis). This was then used to identify clusters of adjoining squares where the criteria were met. Finally, 10 indicative Flood Risk Areas where flood risk was significant at a European scale were defined by Defra for England (30,000 people, 150 critical services or 3000 non-residential properties per cluster).

6.1.2 Five flood risk „clusters' were identified by the analysis in Oxfordshire, as shown in Table 6-1.

Table 6-1 Flood risk 'clusters' in Oxfordshire

Name of Flood Risk Area	Human health consequences			Economic consequences
	Residential properties	People	Critical services	Non-residential properties
Reading (a small part of the Reading cluster is in Oxfordshire)	8763	20505	67	1370
Oxford (named Barton by the analysis)	1865	4364	13	318
Banbury	966	2260	12	229
Witney	930	2176	8	222
Abingdon	860	2012	7	213

6.1.3 None of these clusters meet the criteria set by Defra, therefore this analysis did not identify any indicative Flood Risk Areas in Oxfordshire.

6.2 Identification of Flood Risk Areas

6.2.1 The analysis of available data and existing evidence predicting future flood risk in Section 4 supports the national analysis. It is concluded that the level of risk in Oxfordshire is not significant enough to propose a new indicative Flood Risk Area as defined by the Defra guidance (2010).

7 Next steps

7.1.1 The PFRA has not identified any new indicative Flood Risk Areas in Oxfordshire where the consequences are deemed to be worthy of reporting to the European Commission. However, the evidence collected demonstrates that there are flooding issues that must be addressed in the Local Flood Risk Management Strategy. The information collected for the purpose of preparing the Preliminary Assessment Report will be used in to formulate a local strategy that addresses the local issues and the need for adaptation in the light of climate change effects (this will be performed to meet the requirements of the Flood and Water Management Act).

7.1.2 The next step for Oxfordshire County Council under the Flood Risk Regulations is to repeat the process of preparing a PFRA and identifying Flood Risk Areas for submission in 2017, as part of a six year cycle. Flood Risk and Hazard Mapping and the preparation of a Flood Risk Management Plan is not required in Oxfordshire as part of the initial six year cycle.

7.1.3 As shown by the summer floods of 2007 and other events, flooding can and has caused locally significant consequences to local communities in Oxfordshire. Oxfordshire County Council is proactively planning for its new roles and responsibilities under the Flood and Water Management Act as a LLFA. Partnership working with other Risk Management Authorities and local communities will be key to managing local flood risk in the future across the county.

7.1.4 To underpin both the next round of Preliminary Flood Risk Assessment and inform other roles and responsibilities, including the development of the Local Flood Risk Management Strategy and duty to investigate flood incidents, it is important that a system is put in place to consistently record, collect and store flood event information. Oxfordshire County Council is currently developing such as system with their partners through the Flooding Sub-Group. This should include information that will be mandatory to inform the next round of PFRA.

8 References

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Appendix A: Oxfordshire Strategic Flooding Group Terms of Reference

The terms of reference are as follows:

- To ensure a long term approach to flood risk management in Oxfordshire ensuring clear accountability and co-ordination between all relevant parties as appropriate.
- To lead on the mapping of surface water drainage resources, to identify „hot spots' and priorities for investment to prevent surface water flooding
- To set the overarching strategy for flood risk management in Oxfordshire.
- To provide leadership and accountability for ensuring effective management of local flood risk from main river, ordinary water courses, surface run off, sewer flooding and ground water.
- To provide high level guidance in order to prioritise and co-ordinate local investment in flood management assets, maintenance and improvement works.
- To work in partnership to facilitate the production of Strategic Flood Risk Assessments.
- To be the central point where all flooding issues in Oxfordshire can be discussed by all agencies involved and appropriate action agreed and then taken.
- To endeavour to provide advance warning of public statement messages to be communicated by partners in Oxfordshire in relation to flooding issues and to consider whether they could be produced as a partnership.
- To share information, taking into account Data Protection issues, to facilitate the management of flood risk and to enable the LLA and other relevant organisations to fulfil their functions in relation to flood risk management.
- To provide strategic advice and assistance regards prioritisation and co-ordination of local investment in flood management assets, maintenance and improvement works.

Appendix B: Available information on problem drainage areas

Parish flooding survey

A questionnaire on past flooding and drainage problems was sent out to all parishes in Oxfordshire in June 2010 by the Oxfordshire County Council drainage team. The parishes were asked to list flood incidents/events and answer the following questions:

1. State the location of the flood event.
2. State the date of the flood event if known.
3. Was the flood event surface water or drainage flooding?
4. What were the weather conditions on the day of the flood event?
5. What was the suspected cause of the flood event?
6. What was the frequency of the flood event and the duration? Flood magnitude: depth, area etc.
7. What was the impact of the event? E.g. on residents/ businesses/ infrastructure. Please indicate whether properties were flooded, and how many.
8. Do you have any relevant photographs of the event?
9. Is there any other information, such as structures, walls or bunds which you feel would be useful for us to know about? Please state where there are blockages or defects, if any.

Questionnaires were returned from 66 of the 322 parishes in Oxfordshire (6 in West Oxfordshire, 7 in Cherwell, 41 in South Oxfordshire and 12 in Vale of White Horse, 0 in Oxford City). This return rate does not necessarily mean that these are the only parishes that have experienced problems. A further 47 parishes had already been surveyed by West Oxfordshire as part of their 2007 flood review, and these records were also included.

All parishes for which flooding survey information is available are given below:

District/City	Parishes for which flooding survey information is available	Number of returns
West Oxfordshire	Alvescot, Ascott-under-Wychwood, Asthall, Aston, Combe, Cote, Shifford & Chimney, Bampton, Black Bourton, Bladon, Brize Norton, Broadwell and Kencot, Burford, Carterton, Cassington, Charlbury, Clanfield, Crawley, Curbridge and Lew. Ducklington. Enstone, Eynsham, Fawler, Filkins & Broughton Poggs, Finstock, Fulbrook, Grafton and Radcot, Hailey, Hanborough, Kelmscott, Kingham, Langford, Leafield, Little Tew, Milton-under-Wychwood, Minster Lovell, North Leigh, Northmoor, Ramsden, Salford, Shipton-Under-Wynchwood South Leigh, Standlake, Stanton Harcourt, Taynton, Westwell, Witney	53
Cherwell	Banbury, Begbroke, Duns Tew, Gosford and Water Eaton, Kidlington, Sibford Gower, Somerton	7

District/City	Parishes for which flooding survey information is available	Number of returns
South Oxfordshire	Aston Tirrold, Aston Upthorpe, Beckley and Stowood, Benson, Berinsfield, Berrick Salome/ Roke/ Rokemarsh, Brightwell Baldwin, Brightwell-cum-Sotwell, Chalgrove, Chinnor, Cholsey, Clifton Hampden, Cuddesden, Coxham with Easington, Didcot, Dorchester, East Hagbourne, Ewelme, Garsington, Great Milton, Henley, Horspath, Lewknor, Little Milton, Long Wittenham, Lower Assendon, Marsh Baldon, Middle Assendon, North Moreton, Nuneham Courtney, Pishill with Stonor, Sandford on Thames, Stonor, Sydenham, Thame, Tiddington with Albury, Towersey, Warborough, Watlington, Wheatley, Woodcote	41
Vale of White Horse	Abingdon, Cumnor, East Hendred, Faringdon, Grove, Kingston Bagpuize with Southmoor, Letcombe Bassett, Longworth, Botley (North Hinksey), South Hinksey, Sparsholt, West Hanney	12
Oxford City	No returns	0

Capital schemes

The locations of Oxfordshire County Council's planned capital schemes for 2011 to 2012 are a good indicator of current problem drainage areas. These locations are shown in Map B1.