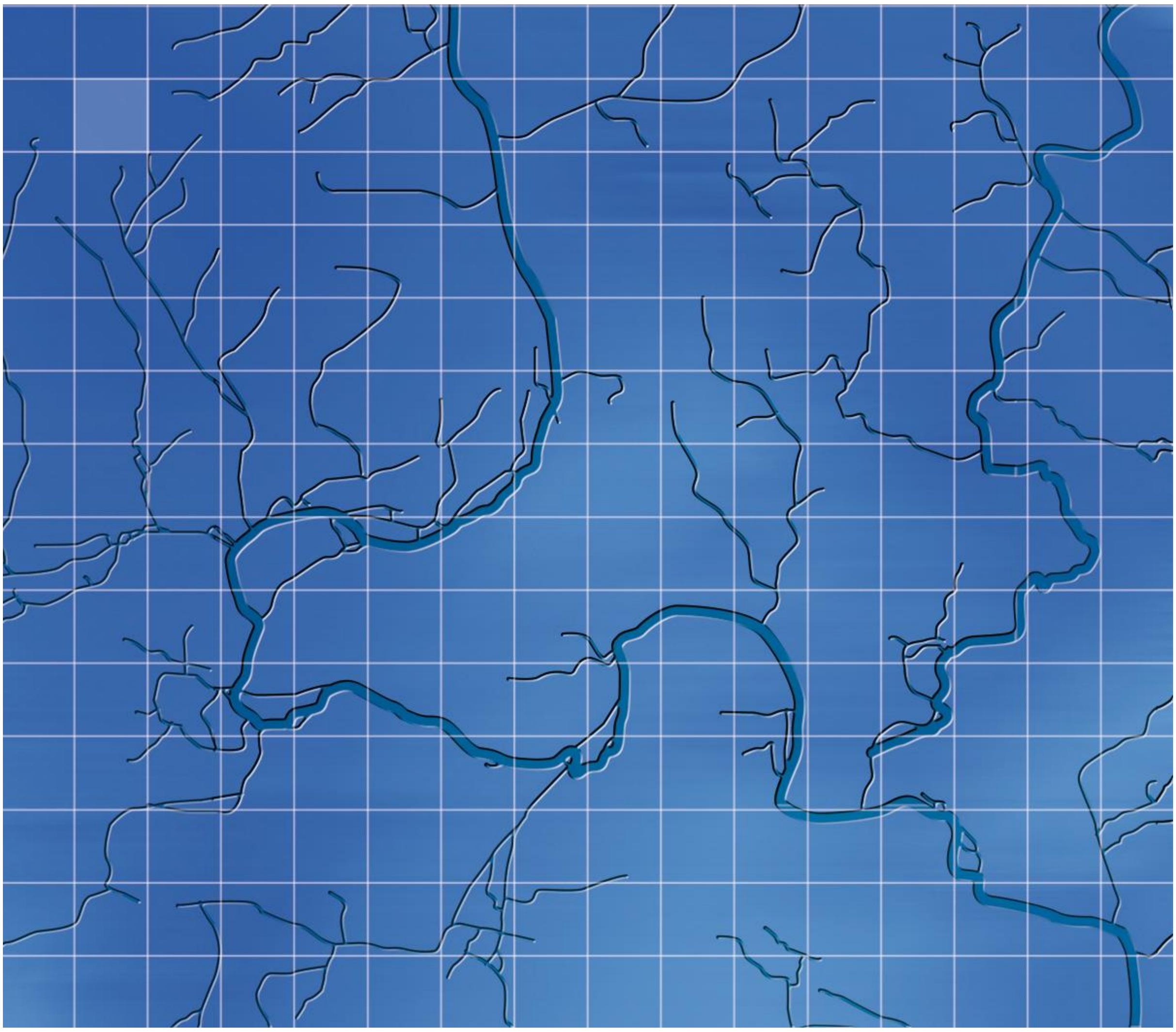
Oxford City Council

November 2023

Oxford City Level 1 Strategic Flood Risk Assessment



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Document issue details

WHS10035

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1.0	13/09/2023	Draft	Daniel Hamilton (*Principal Consultant*)	Paul Blackman (*Director*)
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For and on behalf of Wallingford HydroSolutions Ltd.

The WHS Quality & Environmental Management system is certified as meeting the requirements of ISO 9001:2015 and ISO 14001:2015 providing environmental consultancy (including monitoring and surveying), the development of hydrological software and associated training.

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1 Introduction

1.1 Scope of Assessment

Wallingford HydroSolutions (WHS) has been commissioned by Oxford City Council (OCC) to undertake a Strategic Flood Risk Assessment (SFRA) to identify the extent of flood risk and to inform the Oxford Local Plan 2040 and its Sustainability Appraisal.

The study will identify key flood risk constraints within the development plan area to enable OCC to assess the suitability of future development and inform land use policy with regards to flood risk.

1.2 SFRA Objectives

SFRAs are overarching technical studies that are used to guide development and inform the selection of sites in relation to flood risk.

A major part of this study will be to assess flood risk from all sources which will first involve the collation of available model data, historical information on flooding and details on flood risk management infrastructure. Flood risk will be assessed for the baseline and the future scenario, which will consider the latest climate change guidance.

In this context, we will i) identify and map flood risk from all sources, ii) assess existing and future flood management infrastructure and iii) outline measures to reduce the causes and impacts of flooding.

This information will enable OCC to make informed decisions on allocating sites for development in the local plan and identify sites where a further level 2 SFRA assessment is required.

Figure 1 shows the main watercourses within the Oxford City administrative boundary.

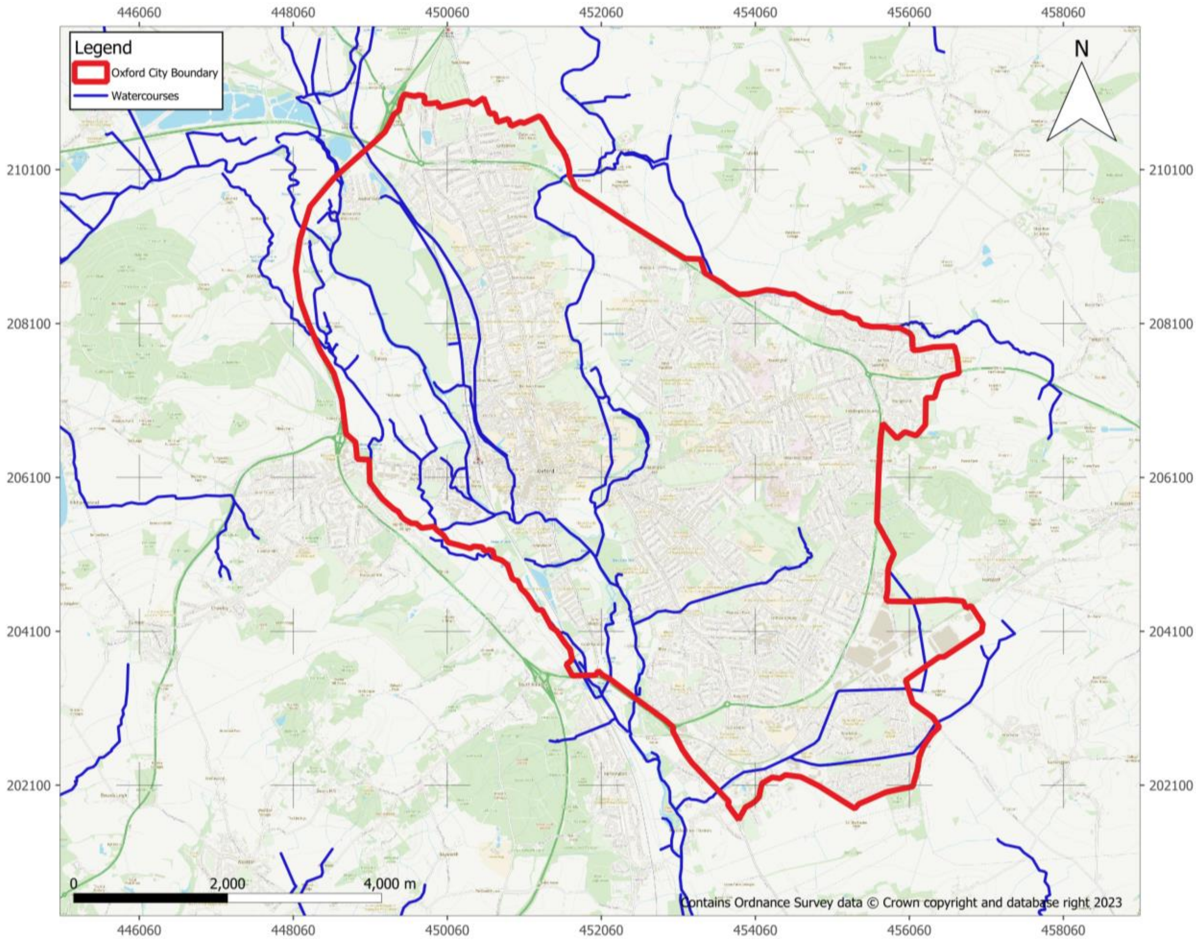

Figure 1- Overview of Study Area

1.3 Overview of National Planning Policy

1.3.1 National Planning Policy Framework (NPPF)

The National Planning Policy Framework (NPPF)[1] sets out the Government's planning policies for England and how these should be applied. It provides a framework within which locally-prepared plans for housing and other development can be produced. The latest NPPF was updated in September 2023 and replaces the previous NPPF published in July 2021.

In terms of flood risk, NPPF states that a sequential risk-based approach (the sequential test) should be taken for development to ensure that it is directed away from areas at highest risk. Where development is necessary in such areas, an exception test should be applied ensuring development is i) made safe for its lifetime without increasing flood risk elsewhere, and ii) provides wider sustainability benefits to the community (see section 3.2 for more details).

[1] Ministry of Housing, Communities & Local Government (2023) *National Planning Policy Framework*, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1182995/NPPF_Sept_23.pdf

To inform strategic development policies in the context of flood risk, NPPF specifies the requirement for an SFRA that considers flood risk from all sources, the potential impacts of climate change and the effects of development on flood risk. The SFRA should take account of flood risk management policies and provides the basis for application of the sequential test.

1.3.2 NPPF Flood Zones

Flood risk is a function of the probability of a flood occurrence and the direct consequences to the community or a receptor. The NPPF categorises areas within the fluvial floodplain into zones of low, medium and high probability, as shown in Table 1.

Table 1- Flood Zones

Flood Zone	Definition
Flood Zone 1 (Low Probability)	Land having a less than 0.1% annual probability of river or sea flooding.
Flood Zone 2 (Medium Probability)	Land having between a 1% and 0.1% annual probability of river flooding; or land having between a 0.5% and 0.1% annual probability of sea flooding.
Flood Zone 3a (High Probability)	Land having a 1% or greater annual probability of river flooding; or Land having a 0.5% or greater annual probability of sea flooding.
Flood Zone 3b (Functional Floodplain)	This zone comprises land where water from rivers or the sea has to flow or be stored in times of flood. The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. Functional floodplain will normally comprise: • land having a 3.3% or greater annual probability of flooding, with any existing flood risk management infrastructure operating effectively; or • land that is designed to flood (such as a flood attenuation scheme), even if it would only flood in more extreme events (such as 0.1% annual probability of flooding).

1.3.3 Planning Practice Guidance- Flood Risk and coastal change

The Planning Practice Guidance (PPG)[2] supports the NPPF. The PPG on flood risk and coastal change was last updated in June 2021 and advises how to take account of and address the risks associated with flooding and coastal change in the planning process. It supports and aligns with the principles espoused by the NPPF but sets out more specific guidance for developers and planners. The main areas covered by the PPG include:

- Taking flood risk into account in preparing plans
- Site-specific flood risk assessments
- The sequential approach & exception test
- The role of the Environment Agency (EA) and Lead Local Flood Authorities (LLFA)
- Addressing residual flood risk

[2] Ministry of Housing, Communities & Local Government (2022) *Flood risk and coastal change*, https://www.gov.uk/guidance/flood-risk-and-coastal-change

- The flood risk issues raised by minor developments & changes of use
- Permitted development rights and flood risk
- Proximity to watercourses and the need for a flood risk activity permit
- Sustainable drainage systems (SuDS)
- Flood resistance and flood resilience
- Planning and development in areas of coastal change
- Flood Zone and flood risk tables

In terms of taking flood risk into account in preparing plans, the document outlines how local planning authorities (LPAs) should use SFRAs to:

- Inform the sustainability appraisal of the Local Plan, so that flood risk is fully taken into account when considering allocation options and in the preparation of plan policies;
- Apply the sequential test and, where necessary, the exception test when determining land use allocations;
- Inform the allocation of land to safeguard it for flood risk management infrastructure;
- Inform policies for change of use and reducing the causes and impacts of flooding;
- Identify the requirements for site-specific flood risk assessments in particular locations, including those at risk from sources other than river and sea flooding;
- Determine the acceptability of flood risk in relation to emergency planning capability;
- Help demonstrate how the adaptation to climate change could be met.

1.3.4 Climate Change

The EA release guidance[3] on how local planning authorities, developers and their agents should use climate change allowances in flood risk assessments. Making allowances for climate change minimises vulnerability and provides resilience to flooding and coastal change.

The climate change allowances are predictions of anticipated change and are provided for:

- Peak river flow
- Peak rainfall intensity
- Sea level rise
- Offshore wind speed and extreme wave height

There are allowances for different climate scenarios over different epochs, or periods of time, over the coming century. For Oxford City the peak river flow and peak rainfall intensity allowances are relevant and are covered in more detail below.

Peak river flow

Peak river flow allowances show the anticipated changes to peak flow by management catchment. Management catchments are sub-catchments of river basin districts. The range of allowances is based on percentiles, as follows.

- Central allowance is based on the 50th percentile
- Higher Central allowance is based on the 70th percentile
- Upper End allowance is based on the 95th percentile

[3] EA (2022), *Flood risk assessments: climate change allowances*, https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

The Oxford City administrative boundary crosses two management catchments in total. As, the Gloucestershire and the Vale management catchment applies to the majority of the city, for consistency this has been applied when determining potential climate change impacts. The peak river flow allowances for the two management catchments are summarised in Table 2.

Table 2- Peak river flow allowances for Oxford City Management Catchments

Allowance	Total Potential Change (2020s)	Total Potential Change (2050s)	Total Potential Change (2080s)
Cherwell and Ray			
Central	6%	4%	15%
Higher	11%	10%	25%
Upper	24%	27%	49%
Gloucestershire and the Vale			
Central	11%	11%	26%
Higher	17%	19%	41%
Upper	33%	43%	84%

The guidance states that both the central and higher central allowances should be assessed as part of an SFRA. When applied at a site specific level for the purposes of a flood risk assessment (FRA), the flood risk vulnerability classification as defined in the NPPF should first be used to classify the vulnerability of your development. Subsequently the location of the development with respect to different flood zones should be determined. Following this exercise, the recommended allowances are summarised below:

In flood zones 2 or 3a for:

- essential infrastructure – use the higher central allowance
- highly vulnerable – use central allowance (development should not be permitted in Flood Zone 3a)
- more vulnerable, less vulnerable & water compatible – use the central allowance

In Flood Zone 3b for:

- essential infrastructure – use the higher central allowance
- highly vulnerable, more vulnerable & less vulnerable – development should not be permitted
- water compatible – use the central allowance

The peak river flow allowances should also be applied to development that is currently located in Flood Zone 1 but might be in Flood Zone 2 or 3 in the future.

Peak rainfall

Increased rainfall affects surface water flood risk and the design of drainage systems. Peak rainfall allowances are provided for the central and upper percentile and across two epochs. Once more the allowances are specified for each management catchment. The two management catchments spanning the city have the same central and upper end allowances. These are summarised in Table 3.

Table 3- Peak rainfall allowances applicable to Oxford City

Allowance	Total Potential Change (2050s)	Total Potential Change (2070s)
3.3% Annual Exceedance Probability (AEP)		
Central	20%	25%
Upper	35%	35%
1.0% Annual Exceedance Probability (AEP)		
Central	20%	25%
Upper	40%	40%

In terms of what allowances to apply the guidance is based on the proposed lifetime of the development. For developments with a lifetime beyond 2100, FRAs should assess the upper end allowances for both the 1% and 3.3% annual exceedance probability (AEP) events for the 2070s epoch (2061 to 2125).

For development with a lifetime between 2061 and 2100 take the same approach but use the central allowance for the 2070s epoch (2061 to 2125).

For development with a lifetime up to 2060, take the same approach but use the central allowance for the 2050s epoch (2022 to 2060).

1.3.5 Flood and Water Management Act 2010

The Flood and Water Management Act (FWMA) (2010)[4], sets out legislation on the management of risks in connection with flooding and coastal erosion for the United Kingdom. It highlights the need for an effective flood risk strategy, which must be developed, maintained, applied, and monitored regularly to adequately manage flood risk.

It gives a new responsibility to the EA for developing a National Flood and Coastal Risk Management Strategy, and gives a new responsibility to local authorities (LAs), as LLFAs, to co-ordinate flood risk management in their area.

Duties for the LLFA include being the statutory consultee for ordinary watercourses, investigating significant flooding incidents (typically defined as five or more properties), maintaining a register of designated flood assets and provision of information.

1.3.6 National Flood and Coastal Erosion Risk Management Strategy for England

The Flood and Water Management Act 2010 sets out how the EA must develop, maintain and apply a National Strategy for Flood and Coastal Erosion Risk Management (FCERM) in England.

The most recent strategy was published in July 2020[5]. The strategy sets out how the EA will manage the risks from flooding and coastal erosion across England. It clarifies roles and responsibilities before setting out the policies and direction for all England's Flood Risk Management Authorities to follow,

[4] UK Parliament (2010) *Flood and Water Management Act*, https://www.legislation.gov.uk/ukpga/2010/29/contents

[5] EA (2020) *National Strategy for Flood and Coastal Erosion Risk Management*, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/920944/023_15482_Environment_agency_digitalAW_Strategy.pdf

with measures to explain how targets will be achieved. The strategy highlights the importance of climate resilience in the development of future infrastructure.

1.3.7 Non-statutory guidance for SuDS

The non-statutory guidance[6] for SuDS published by DeFRA (2015), sets out the technical Standards for SuDS systems in England. For greenfield developments, the peak runoff rate from the development to any highway drain, sewer or surface water body for the 1 in 1 year and 1 in 100-year rainfall event should never exceed the peak greenfield runoff rate for the same event. For developments which were previously developed, the peak runoff rate from the development must be as close as reasonably practicable to the equivalent greenfield runoff rate over the same area; never exceeding the rate of discharge from the development prior to redevelopment for any event.

1.3.8 Overview of Local Guidance and Past Studies

A wide range of local planning documents developed by Oxfordshire County Council exist related to flood risk and surface water management.

As the LLFA, Oxfordshire County Council is responsible for flooding from surface water, groundwater and ordinary watercourses and develop a Local Flood Risk Management Strategy[7]. The strategy sets a long-term programme for the reduction of flood risk, establishes how to identify areas where flood risk management will achieve multiple benefits and seeks to facilitate greater engagement with the community. The strategy is due for review and an update in the near future.

The LLFA also sets out local standards and guidance[8] on SuDS and drainage requirements within the county which makes reference to the FWMA. Major developments within Oxfordshire should meet these standards.

Existing planning policy in Oxford City includes the Local Plan 2016-2036[9], which is to be superseded by the Oxford Local Plan 2040. The Local Plan 2016-2036 has provided a framework for the development of new homes, jobs, community facilities and infrastructure within the city up to 2036. It was supported by a Level 1 and Level 2 SFRA completed in 2017. The plan sets out several polices relevant to the management of flood risk which remain applicable. The two most relevant are summarised below:

RE 3- Flood risk management: Specifies the flood zones where different development types are permissible. Outlines the requirements Flood Risk Assessments (FRAs) need to meet to demonstrate development being suitable.
RE4 - Sustainable Flood Risk Management: States that all development proposals will be required to manage surface water through Sustainable Drainage Systems (SuDS) or techniques.

[6] Department for Environmental, Food and Rural Affairs (2015) *Sustainable Drainage Systems Non-statutory technical standards for sustainable drainage systems*, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/415773/sustainable-drainage-technical-standards.pdf
[7] Local Flood Risk Management Strategy. OCC. 2015 Available from: https://www.oxfordshirefloodtoolkit.com/wp-content/uploads/2016/04/OxfordshireFloodRiskManagementStrategy.pdf
[8] Local Standards and Guidance for Surface Water Drainage on Major Development in Oxfordshire, OCC. 2021. Available from: https://www.oxfordshirefloodtoolkit.com/wp-content/uploads/2022/01/LOCAL-STANDARDS-AND-GUIDANCE-FOR-SURFACE-WATER-DRAINAGE-ON-MAJOR-DEVELOPMENT-IN-OXFORDSHIRE-Jan-22-2.pdf
[9] Oxford City Council (2020) *Adopted Oxford Local Plan* https://www.oxford.gov.uk/downloads/download/1176/oxford_local_plan_2016-2036

Runoff should be managed as close to source as possible. Also details requirement for planning applications to consider any impacts on groundwater flow.

Oxford City also falls within the Thames catchment so is subject to the Thames Catchment Flood Management Plan[10] (CFMPs) developed by the EA in 2009. The CFMP seeks to establish the scale and extent of flooding now and in the future and sets policies for managing flood risk within the catchment. It should be used to inform planning and decision making by LAs.

1.4 Data Sources

To inform the assessment of flood risk, existing information and model data have been identified and collated for different sources of flooding. Any recent and relevant studies on flood risk within the study area have also been incorporated into the SFRA, along with details on flood defences and flood management schemes. This information and the available model data have been used to assess flood risk across the study area as well as at each of the preferred sites. Detailed flood maps utilising the latest GIS software have also been created. The main sources of data to inform this SFRA include:

- EA Fluvial Flood Maps[11] [12]– to quantify fluvial flood risk where detailed model data are not available
- EA Surface Water Flood Maps[13] – to quantify the pluvial flood risk and flood risk from ordinary watercourses where appropriate
- EA Reservoir Flood Mapping[14] – to quantify the risk of reservoir flooding
- EA Historical Flood Map[15] and Recorded Flood Outlines[16] – to review historical flood events
- Hydraulic modelling data for the River Thames and tributaries (2018[17], 2021[18]) – to assess fluvial flood risk from the River Thames and major tributaries
- Hydraulic modelling data from the Northfield and Littlemore Brook (2011[19]) – to assess fluvial flood risk from the Northfield and Littlemore Brook
- Hydraulic modelling data for the Boundary Brook (2010[20]) – to assess fluvial flood risk from the Boundary Brook
- Hydraulic modelling data from the Lower Cherwell Flood Risk Mapping Study (2005)[21]- to assess fluvial flood risk from the River Cherwell beyond the upstream extent of the existing Thames model (NGR: 451560, 209990)
- Flooding incident data provided by LLFA[22] – to provide information on local and historical flooding from surface water flooding across the study area

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[10] EA (2009) *Thames Catchment Flood Management Plan* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/293903/Thames_Catchment_Flood_Management_Plan.pdf
[11] EA (2023) *Flood Map for Planning (Rivers and Sea) – Flood Zone 2* https://www.data.gov.uk/dataset/cf494c44-05cd-4060-a029-35937970c9c6/flood-map-for-planning-rivers-and-sea-flood-zone-2
[12] EA (2023) *Flood Map for Planning (Rivers and Sea) – Flood Zone 3* https://www.data.gov.uk/dataset/cf494c44-05cd-4060-a029-35937970c9c6/flood-map-for-planning-rivers-and-sea-flood-zone-3
[13] EA (2023) *Risk of surface water flooding* https://environment.data.gov.uk/DefraDataDownload/?Mode=rofsw
[14] EA (2023) *Risk of Flooding from Reservoirs - Maximum Flood Extent* https://www.data.gov.uk/dataset/44b9df6e-c1d4-40e9-98eb-bb3698ecb076/risk-of-flooding-from-reservoirs-maximum-flood-extent-web-mapping-service
[15] EA (2023) *Recorded Flood Outlines,* https://www.data.gov.uk/dataset/16e32c53-35a6-4d54-a111-ca09031eaaaf/recorded-flood-outlines
[16] EA (2023) *Historic Flood Map,* https://www.data.gov.uk/dataset/76292bec-7d8b-43e8-9c98-02734fd89c81/historic-flood-map
[17] CH2M (2018) *Oxford Baseline Hydraulic Modelling*
[18] Jacobs (2022) *Oxford Flood Alleviation Scheme Modelling*
[19] EA (2011) *Northfield & Littlemore Brook Hydraulic Model*
[20] EA (2010) *Boundary Brook Hydraulic Model*
[21] EA (2005) *Cherwell (Thrupps_Bridge to Thames_Confluence) Products 5-7*
[22] Oxfordshire County Council (2023) *Flood incidents- Oxford City*

- EA flood defence structures[23] – to assess existing formal and informal flood defences present
- British Geological Survey (BGS) geoviewer[24] – To determine local bedrock and its expected permeability informing assessment of groundwater flood risk
- Soilscapes map[25] – To determine local soil and its expected permeability informing assessment of groundwater flood risk
- Thames Water sewer flooding data[26] – to determine risk of sewer flooding based on incidences of sewer flooding
- Breach analysis data and overtopping records from the Canal and River Trust (CRT)[27] – to assess the potential of flooding from the Oxford Canal
- Previous flood risk studies previously completed by OCC and the LLFA (see section 1.3.8)

1.5 Updates to Hydraulic Models

As part of the level 1 SFRA, the inputs to the hydraulic model for the River Thames and tributaries model and the Northfield and Littlemore Brook model were updated. This exercise was undertaken to provide results for i) the 3.3% AEP event and ii) a range of updated climate change scenarios.

This update was necessary following a revision of Flood Zone 3b in the 2021 NPPF whereby Flood Zone 3b was redefined as the 3.3% AEP extent, formerly being the 5.0% AEP extent. Both models pre-dated this redefinition and did not have results for the 3.3% AEP event.

In terms of climate change scenarios, the Thames model used allowances for the Cotswolds management catchment. The majority of Oxford lies in the Gloucestershire and the Vale management catchment. Therefore, it was necessary to re-run the model considering the allowances relevant to this catchment. The latest central (26%), higher central (41%) and upper end (84%) allowances for the 2080s epoch were applied. The Northfield and Littlemore Brook model applied the old blanket allowance of 20%, it was also updated to account for the latest allowances within the Gloucestershire and the Vale management catchment. As a result of these updates the hydraulic model was re-run for the following scenarios:

- 3.3% AEP Event
- 3.3% AEP (plus 26% Climate Change) Event
- 3.3% AEP (plus 41% Climate Change) Event
- 3.3% AEP (plus 84% Climate Change) Event
- 1.0% AEP (plus 26% Climate Change) Event
- 1.0% AEP (plus 41% Climate Change) Event
- 1.0% AEP (plus 84% Climate Change) Event

The two other detailed hydraulic models used in the study include the Boundary Brook model and Lower Cherwell model. Significant development is not being considered for allocation in either of the model extents and they inform a relatively small proportion of the flood map within Oxford City. As the Cherwell model is relatively old (2005) and the Boundary Brook model is 1D only, the updates required to both would be significant. In this regard an update to the Boundary Brook model and Lower Cherwell model was not undertaken for the purposes of this SFRA.

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[23] EA(2023) AIMS Spatial Flood Defences (inc. standardised attributes) https://www.data.gov.uk/dataset/cc76738e-fc17-49f9-a216-977c61858dda/aims-spatial-flood-defences-inc-standardised-attributes
[24] BGS (2023) *BGS Geology Viewer*, https://geologyviewer.bgs.ac.uk/
[25] Cranfield Soil and Agrifood Institute (2023) *Soilscapes map*, http://www.landis.org.uk/soilscapes/
[26] Thames Water (2023) Sewer flooding data for Oxfordshire *Oxfordshire CC SFHD data_Mar23.xlxs*
[27] Canal & River Trust (2023) *Breach and Overtopping data for Oxford Canal*

1.6 Limitations & Assumptions

1.6.1 Age and Extent of Modelling Data

The EA regularly review and update the Flood Map, with any amendments to the Flood Zone mapping being informed by more detailed information as and when it becomes available. This can either be as a result of more detailed hydraulic modelling carried out by the EA and/or external parties; or recorded flood extents following a flood event. Furthermore, real-world upgrades to flood defence infrastructure will also alter the degree of flood risk in a particular area. In this regard, this SFRA is a snapshot of flood risk based on data available at the time of publication, with the conclusions on flood risk presented subject to change in accordance with any updates to the EA Flood Map and existing flood defence infrastructure.

Detailed modelling data is available for the main watercourses running through Oxford City, however there are many watercourses which are not included in the detailed hydraulic models available. The flood extents for these watercourses are likely to be based on JFLOW mapping. JFLOW is appropriate for a strategic assessment of flood risk, however it is generally not advised for site-specific purposes.

1.6.2 Flood Zone 3b (Functional Floodplain)

In the EA flood map, the functional floodplain or Flood Zone 3b (FZ3b) is not distinguished from zone 3a. As part of their SFRAs, LPAs should identify areas of functional floodplain and its boundaries accordingly.

As shown in Table 1, the flood extents for the 3.3% AEP (30-year) event and/or any land that is designed to flood is generally considered the basis for the delineation of FZ3b. Therefore, as a starting point it is proposed that land which naturally floods during a 30-year event or is designed to flood be classified as FZ3b.

As mentioned, detailed modelling is unavailable in some areas and for the Cherwell and Boundary Brook model only the 5.0% AEP (20-year) events were provided. Where this was the case in agreement with OCC as a precautionary approach FZ3a is used as a proxy for FZ3b.

The approach outlined above is suitable for the purposes of a level 1 SFRA. However, where detailed modelled outlines for 3.3% AEP event are unavailable for sites at risk of fluvial flooding, further detailed modelling will need to be undertaken to refine the assessment of the latest allowances. This should be carried out as part of a site-specific FRA.

1.6.3 Assessing the impacts of Climate Change

As part of their SFRAs, LPAs should assess and map the effects of climate change on flood risk to identify areas where flood risk will increase and ensure that future development is sustainable.

Where modelling predates the latest climate change allowances and has not been updated the modelling results supplied do not contain a suite of runs assessing the latest allowances. Instead, the models (Boundary Brook and Lower Cherwell) apply the old blanket allowance of 20%. Fortunately, the old 20% allowance aligns reasonably well with current central allowances (26%) for the Gloucestershire and Vale management catchment. Thus, results from the 1.0% AEP +20% event are used as a proxy to assess the central allowance in this case.

The higher central allowance for the Gloucestershire and Vale management catchment is 41%. For the higher central allowance, the model results for the 0.1% AEP event are used as a proxy. Where detailed modelling data is unavailable, the Flood Zone 2 extent shown in the EA's fluvial flood map is used to assess the impacts of climate change in general.

The approach outlined above is suitable for the purposes of a level 1 SFRA. However, where detailed modelled outlines for new climate change scenarios are unavailable for sites at risk of fluvial flooding, further detailed modelling will need to be undertaken to refine the assessment of the latest allowances. This should be carried out as part of a site-specific FRA.

2 Summary of Flood Risk in Oxford City

2.1 Review of Flooding Sources

The following sections provide a detailed summary of baseline flood risk from all relevant sources across Oxford City. They identify where flood risk is most significant and is likely to pose a risk to people or property. Where data is available, the future scenario considering the impacts of climate change is also considered. A series of supporting GIS maps offer a visual representation of the risks outlined and are provided in Appendix 1-8 of this report.

The assessment of flood risk has been based on the collation of available model data, historical information on flooding and details on flood risk management infrastructure.

2.1.1 Fluvial Flood Risk

The risk of fluvial flooding has been assessed using the mapped flood extents through the Oxford City area, as shown by existing hydraulic modelling data and EA's Fluvial Flood Map. Flood risk from the main rivers running across the district is summarised below. Larger watercourses are usually designated as main rivers. The EA carries out maintenance, improvement or construction work on main rivers to manage flood risk.

River Thames

The risk of fluvial flooding has been assessed using the mapped flood extents through the Oxford City administrative area, as shown by the EA's Fluvial Flood Map. The EA has confirmed that the predicted flood extents for the River Thames and River Cherwell within Oxford City are primarily based on an existing 1D/2D model for Oxford which was developed as part of the EA WEM Lot 3 project for the Oxford Flood Alleviation Scheme. The EA Flood Map is informed by the baseline 2018 outputs from this study. The model was re-run in 2021 to derive updated climate change extents accounting for the latest allowances (Cotswolds management catchment) for peak river flows released in 2021. As mentioned, these have been updated for this study to the allowances for the Gloucestershire and the Vale management catchment.

The model includes modelled sections of the River Thames, River Cherwell, Castle Mill Stream, Osney Ditch, Hinksey Stream, Wytham Stream, Bulstake Stream, and the Oxford Canal. The principal model inflows are from the River Thames, River Cherwell and River Evenlode. Inflows are represented elsewhere by minor lateral inflows further downstream.

The extents for the Northfield and Littlemore Brooks are informed by a 1D/2D hydraulic model. A separate 1D hydraulic model also exists for the Boundary Brook. Both these models were developed in 2011 and there have been no subsequent updates to the baseline output data. A model of the lower Cherwell developed in 2005 was also provided, this informs the flood map for a very small area within Oxford City beyond the upstream extent of the existing Thames model at NGR: 451560, 209990.

Fluvial flooding is the primary source of flood risk in Oxford in terms of flooding extent, the number of properties at risk and historical flood damages. Oxford is located at the confluence of the River Thames and River Cherwell, and is at risk from both watercourses independently, as well as concurrently in large flood events.

The River Thames, the largest river running through Oxford, bifurcates north of the city boundary splitting into a main branch which flows north to south through Godstow and a second branch, the Wolvercote Mill stream which flows from north to south east, passing through Wolvercote. Both of these watercourses reconvene as the River Thames just downstream of Godstow. In the North, the main flood risk posed is to Wolvercote.

As the river flows southwards downstream of Wolvercote, it enters a wide and flat floodplain corridor in the form of Port Meadow. The meadow serves as a large flood storage area during significant flood events and consists mostly of farmland with few properties at risk.

The Thames subsequently bifurcates with the main branch flowing through Botley and Osney and a second branch, forming the Castle Mill stream, a backwater of the Thames which rejoins it to the south of the city centre. New Botley and Osney are at risk of flooding from the main branch based on the model outputs and historical flooding with many properties located in Flood Zone 3. The majority of flooding from the main branch is constrained to the west of the raised railway embankment serving Oxford station. Castle Mill Stream flows to the east of this embankment and poses a risk to properties close to the city centre, although damage to properties is rare.

In addition to the Thames, several other watercourses pose a risk to New Botley and Osney, these include Botley Stream, Fiddler's Island Stream, Wytham Stream, Osney Ditch and Mill Stream. The EA model incorporates these watercourses, which are either tributaries or backwaters of the Thames formed from bifurcations upstream of Oxford. Many of these watercourses are located to the west of the Thames and cause many properties along the Botley Road to fall within Flood Zone 3.

Downstream of Osney, the River Thames heads in a south easterly direction where it is joined by Bulstake stream. Here it poses a risk to properties in Grandpont. Subsequently it meets the River Cherwell at Christ Church Meadow.

The River Cherwell originates from the north east and passes between Marston and Summertown, entering the city centre to the east before it flows into the River Thames. The floodplain of the River Cherwell is mostly characterised by farm and recreational land as it flows between Marston and Summertown. The overall risk to properties and infrastructure is low, with only small areas of Summertown and New Marston shown to be at risk based on the model outputs.

The River Cherwell adds a significant discharge to the River Thames to the south of the city centre, and as the River Thames flows southwards out of the city boundary, it poses a significant flood risk to the suburb of New Hinksey. In this area, the floodplain contains a number of housing estates which are at significant flood risk and are known to have flooded in the past. The modelled outputs show this with the majority of these areas located in Flood Zone 3.

In these areas Hinksey Stream also poses a significant flood risk. It flows to the west of the city and along the western boundary of the built-up area of New Hinksey, joining the River Thames south of New Hinksey. Flood mapping indicates that this watercourse poses a significant flood risk and has in the past caused widespread flooding to the area west of New Hinksey.

In terms of the Boundary Brook, the watercourse flows from west to east from Headington through Cowley and Iffley before joining the River Thames south of New Hinksey. The Flood Map shows that at the upstream extent of the existing model, the flood extent is minimal and the floodplain comprises mostly of recreational land. The main flood risk is further downstream in Cowley and Iffley, associated with a culverted section of channel. Significant flooding is predicted within the surrounding residential areas which fall largely in Flood Zone 3.

The Littlemore Brook runs from the Blackbird Leys to Littlemore before joining the Thames at Sandford. It is joined by the Northfield Brook in Blackbird Leys downstream of the Kassam Stadium. The modelled flood extents are constrained for both watercourses but do pose a flood risk to limited areas in Blackbird Leys and Littlemore with several properties lying in Flood Zones 2 and 3.

A city-wide map and local maps showing modelled flood outlines in the affected areas for the main rivers in Oxford are provided in Appendix 1.

2.1.2 Climate change

As outlined in section 1.4, the Thames and Littlemore-Northfield Brook models were updated to include climate change scenarios applying the latest allowances for the Gloucestershire and the Vale management catchment. This was applied to the 3.3% AEP event to represent potential impacts on the Flood Zone 3b extent, and the 1.0% AEP event to represent potential impacts on the Flood Zone 3a extent. For the Boundary Brook and Lower Cherwell models, the 1.0% AEP + 20% extent was available as a proxy to determine potential climate impacts on the Flood Zone 3a extent for these watercourses.

When considering the central allowance (26%) for the 1.0% AEP event, there are significant increases in flood extents in Jericho, Oxford railway station, along Thames Street and Grandpont which lead to increased risk to a number of properties. Notable increases in flood extents are also predicted along Castle Mill Stream as it runs through the city centre, with additional areas at fluvial flood risk shown near Hollybush Row and Oxpens Road. Elsewhere changes in flood extent are mostly isolated to open floodplain, which is void of development. For the lower order 3.3% AEP event the changes are less significant but also tend to be most noticeable in these areas with the exception of Jericho.

When considering the higher central allowance (41%) it is again in these areas where the changes in extent are most pronounced. For the 3.3% AEP event, large parts of Jericho are modelled to be at risk in this scenario. Large changes in extent are also observed for the River Cherwell when considering both return periods however most properties remain outside of the flood extents.

When considering the upper end allowance (84%) the impacts upon flood extents are more widespread. In addition to the areas above, large changes of extent putting properties at risk are also modelled in Wolvercote and Blackbird Leys. Property in New Marston is also inundated by floodwater from the Cherwell when considering the 1.0% AEP event.

Appendix 2 shows the fluvial flood mapping when accounting for climate change.

2.1.3 Surface Water Flooding

Surface water flooding is often the result of high peak rainfall intensities, and/or insufficient capacity in the sewer network. Surface water flooding is a significant flood risk in urban areas due to the high proportion of impermeable surfaces, which cause a significant increase in runoff rates and consequently the volume of water that flows into the sewer network.

Although managing the risk of flooding from surface water is the responsibility of LLFAs, the EA have produced the updated Flood Map for Surface Water (uFMfSW) under their strategic role in England. This combines the EA's nationally produced surface water flood mapping and appropriate locally produced maps from LLFAs. The map is intended to be the best single source of information on surface water flooding, incorporating the latest EA modelling techniques and local data.

The surface water flood map show areas of High Risk which relates to land estimated to flood in a 3.3% AEP pluvial event, Medium Risk which relates to land estimated to flood in a 1.0% AEP pluvial event and Low Risk which relates to land estimated to flood in a 0.1% AEP pluvial event.

The maps are currently based on a number of assumptions, and only indicate where surface water flooding would occur as a result of local rainfall. Caution should be exercised when reviewing the uFMfSW as it may show an over or under-estimation of the surface water flood risk in certain areas. Furthermore, due to the modelling techniques used, the mapping picks out depressions in the ground surface and simulates some flow along natural drainage channels and rivers. Where this is the case, the dominant flooding mechanism is considered to be fluvial and these areas are therefore ignored in the assessment of surface water flooding throughout Oxford City.

Based on the assumptions and limitations listed above the maps should only be used at the strategic planning level. To further assess surface water flood risk Oxfordshire County Council's flood incident dataset has also been used to identify any recent (since 2007) recorded incidents of flooding from events which were pluvial in origin. In this regard, the analysis has sought to combine both data sources to identify areas at significant risk of surface water flooding; particularly where historical incidents corroborate flooding shown by the mapping. The at-risk areas are summarised below:

- **Jericho** – There is a high risk of surface water flooding along several roads in Jericho including Great Clarendon St, Jericho St and Wellington St. No recent surface water flood incidents have been recorded in Jericho.
- **Headington** – There is a high risk of surface water flooding along several roads in Headington including Gipsy Ln, Grays Rd, St Leonard's Rd, York Rd, Wharton Rd and Margaret Rd. One surface water flood incident has been recorded in Headington off Old Rd in 2020.
- **Summertown** – There is a high risk of surface water flooding along several roads in Summertown including Staverton Rd, Apsley Rd, Lathbury Rd, Rogers St, Grove St, Hobston Rd, Hamilton Rd and Portland Rd. Two surface water flood incidents have been recorded in Summertown on Summerhill Rd in 2020 and in Water Eaton Rd in 2023.
- **Woodstock Rd** – There is a high risk of surface water flooding along parts of Woodstock Rd including St Jennings Way and near Osberton Rd. One surface water flood incidents has been recorded near the Woodstock Rd on Blandon Close in 2020.
- **Oxford City Centre** - There are several high-risk areas near the city centre where surface water pools, these include large parts of St Aldates and Speedwell St to the south of the city, and George St to the west. Ground levels to the west and south of the city are lower than those in the city centre, which may explain why water is shown to pool in these locations. No recent surface water flood incidents have been recorded in the city centre.

Most of the areas identified above tend to be located outside of the floodplains of the River Thames and River Cherwell, meaning that the main source of flooding shown in these areas is likely to be pluvial in origin rather than fluvial.

Maps showing the extent of the flood outlines for the surface water flood maps and a spreadsheet showing the flood incidents recorded in the Oxford City are provided in Appendix 3.

2.1.4 Ordinary Watercourses

Ordinary watercourses include every river, stream, ditch, drain, cut, dyke, surface water sewer (other than public sewers) and passage through which water flows, above ground or culverted, which is not designated as a main river.

To assess flood risk from these watercourses the EA's flood maps are used. The EA's fluvial flood map does not typically show flood extents for catchments less than $3km^2$, therefore the EA's surface water flood map is used in combination to determine flood risk from these watercourses.

The surface water maps, accounting for local rainfall patterns and topography, show the majority of ordinary watercourses. It should be noted that not all the conveyance area of ordinary watercourses is explicitly modelled nor structures such as culverts in most cases. Therefore, they usually provide a conservative assessment of the flood risk from ordinary watercourses and should not be used as definitive mapping. This said they remain a valuable tool when combined and validated against local experience and knowledge.

Further to this, OCC has supplied a map of the ordinary watercourses and assets within Oxford City, which identifies the majority of the watercourses in the area, together with culverted stream lengths and in-line structures. Using this local knowledge and data from OCC, combined with the outputs from the EA's surface water flood maps, the key ordinary watercourses have been identified as follows:

- Marston Brook: A stream running towards Old Marston from the Northern Bypass road. Based on the surface water flood maps a number of properties in Old Marston are at medium to high risk of flooding.
- Peasmoor Brook: This watercourse lies to the southeast of Marston Brook, it poses a risk in its upper reaches to properties to the east of Marsh Lane in New Marston which are sited in areas of medium to high risk. It should be noted that the catchment is now served by a flood alleviation scheme completed in mid-2017. This is unlikely to be represented in the surface water flood maps. In this regard the flood risk to properties may be less than shown in the surface water flood maps.
- Unnamed watercourse at Cutteslowe: A small unnamed watercourse and drainage ditch, both run through Cutteslowe Park towards Cutteslowe. Based on the surface water flood maps the two channels appear to act as a conveyance route for flood water from the River Cherwell. This puts many parts of Cutteslowe at medium to high risk of flooding.
- East and west branches of the Boundary Brook: Two upstream branches of the Boundary Brook are not modelled in the existing fluvial model. These are located upstream of Churchill Hospital. They pose a risk to many parts of Headington which are shown to be at Medium to High Risk.

Maps showing the location of main rivers and ordinary watercourses are provided in Appendix 4.

2.1.5 Groundwater Flooding

Groundwater flooding is defined as the emergence of groundwater at ground level. There are limited local data with respect to groundwater flooding. However, for a strategic level assessment of the potential for groundwater flooding, the BGS UK Geoviewer has been used to determine the bedrock across the study area, with the Landis Soilscapes map used to determine the soils present.

BGS mapping shows that the majority of Oxford is underlain by the Oxford Clay, West Walton, Ampthill and Weymouth formations all of which are comprised of Mudstone. This includes Wolvercote, Summertown, Jericho, Cutteslowe, New Botley, Osney, Oxford City Centre, New Hinksey, St Clements, New Marston and Iffley. The general permeability of the bedrock in these areas is expected to be low to moderate.

Based on soilscapes mapping, where these areas are within the floodplains of the Thames and Cherwell (New Hinksey, New Botley and Osney), they are underlain by loamy and clayey floodplain soils with naturally high groundwater. Where this is the case groundwater flood risk is considered to be high.

In areas outside of the floodplain including the majority of Oxford City Centre, Summertown and Jericho soils are freely draining lime-rich soils. In these locations groundwater flood risk is likely to be moderate given the mobile water table in such soils.

In New Marston, St Clements and the Iffley, soils tend to be slowly permeable loamy and clayey soils. Here drainage is likely to be more impeded so groundwater emergence is likely less of a risk.

Areas in south and east Oxford lie outside of the mudstone formations. This includes, Barton, Temple Cowley, Littlemore, Blackbird Leys and west Headington which are underlain by the Beckley Sand

Member formation comprised of Sandstone. It is expected to have moderate to high permeability. It also includes Cowley and East Headington which are underlain by the Wheatley Limestone member. It is expected to have high permeability.

Based on the soilscapes mapping, the soils overlying these areas are either freely draining lime-rich loamy soils or shallow lime-rich soils. Both are expected to be freely draining allowing for a mobile water table which again poses a moderate groundwater flood risk.

Maps showing the bedrock and soils across Oxford City are provided in Appendix 5.

2.1.6 Sewer Flooding

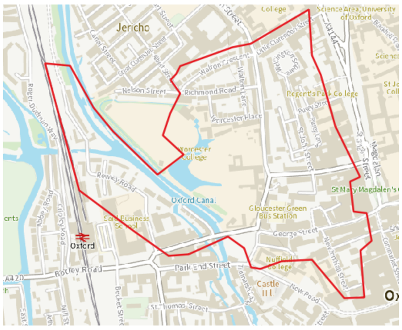
Sewer flooding often occurs because of an existing drainage system having insufficient capacity to drain rainfall, consequently causing the release of water at manholes. Sewer flooding can also occur should there be a fault/failure at an existing drainage system.

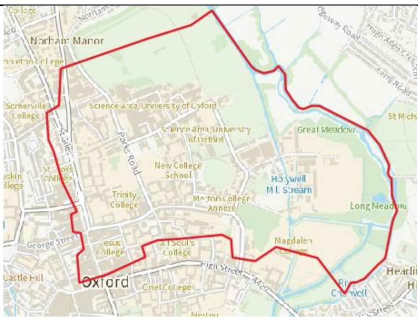
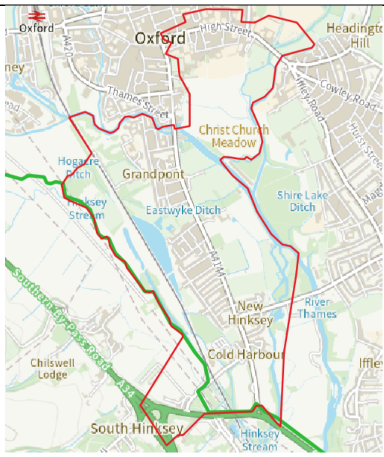
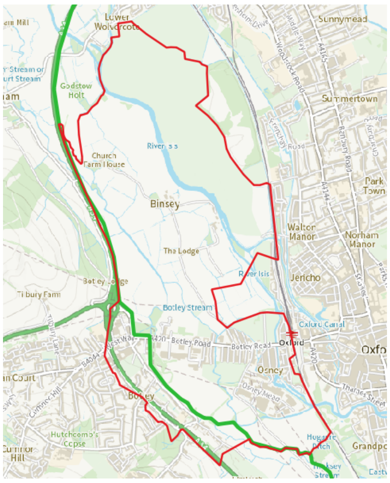
The responsible authority for sewer flooding across the study area is Thames Water (TW), the sewerage undertaker. TW was contacted to gather available data on sewer flooding. A total of 155 historic records of sewer flooding have been recorded for the study area since records began.

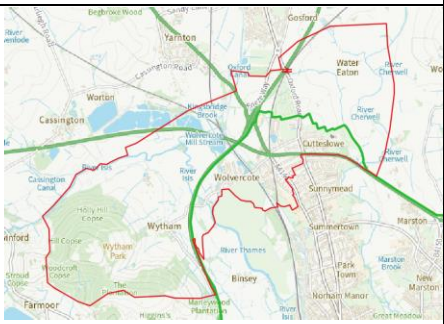
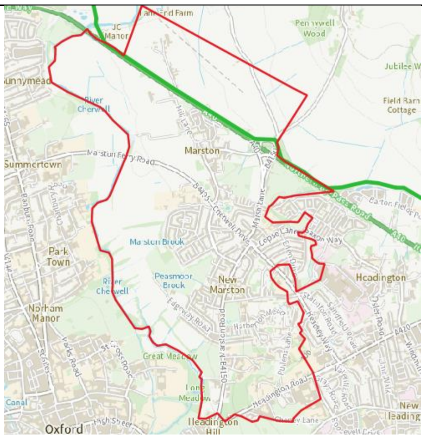
It should be noted that the records are somewhat dependent on reporting and are given for broad post code areas. In this regard, caution should be exercised when ascribing a sewer flood risk to a particular location.

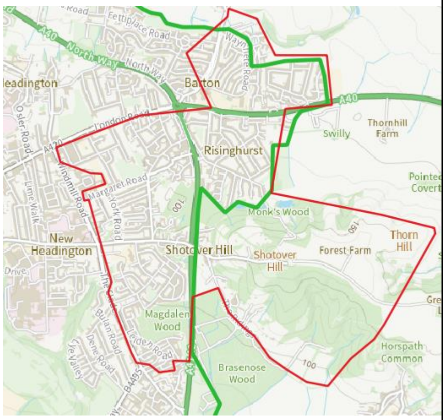
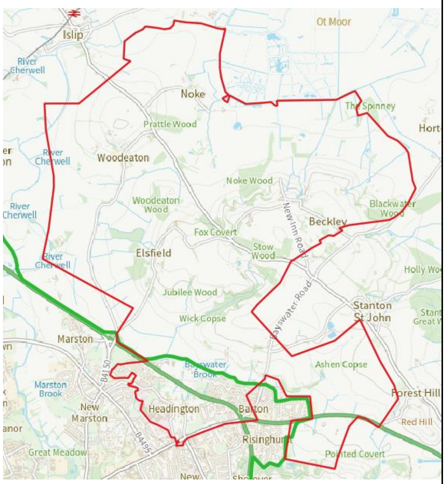
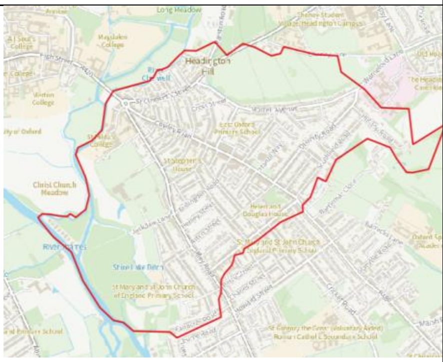
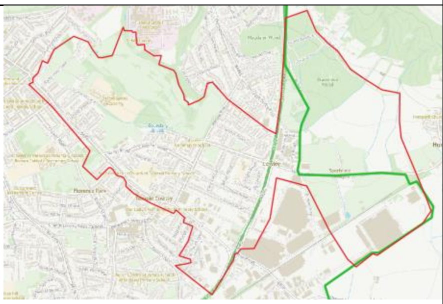
A summary of the spatial distribution of incidents of sewer flooding by post code area is summarised in Table 4. These predominantly show that built up areas in New Hinksey and Grandpont (OX1 4), Botley and Osney (OX2 0) and Marston (OX3 0) generally have the most incidents. Incidents are generally less common in the built-up areas of Summertown (OX2 7) and Headington (OX3 7).

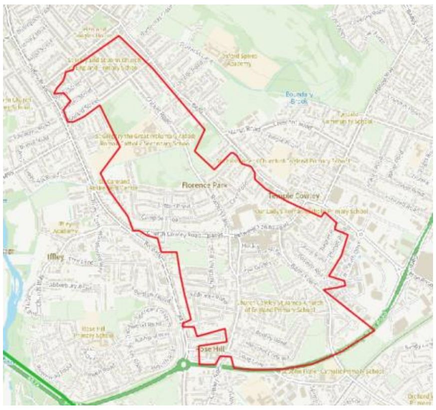
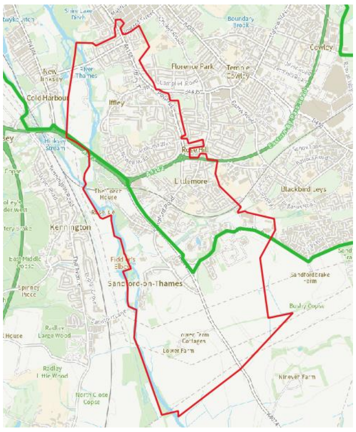
Table 4 - Sewer Flooding Incidents by Post code area

Post Code	Post Code Area	External Flooding	Internal Flooding	Total
OX1 1		1	0	1
OX1 2		0	2	2

OX1 3		0	1	1
OX1 4		22	3	25
OX2 0		16	6	22
OX2 6		3	3	6

OX2 7		0	2	2
OX2 8*		2	1	3
OX3 0*		30	0	30
OX3 7		2	0	2

OX3 8*		8	2	10
OX3 9*		1	0	1
OX4 1		4	0	4
OX4 2		2	2	4

OX4 3		19	12	31
OX4 4*		2	9	11
Total		**112**	**43**	**155**

* Please note, that post code area crosses the city boundary so may include events in neighbouring authorities.

2.1.7 Reservoir Flooding

In 2021 the EA published updated maps showing the flood risk associated with reservoirs. Dam breach and flood modelling techniques were used to produce a new national set of reservoir flood maps for England. The maps show two flooding scenarios, including a 'dry-day' and a 'wet-day'. The 'dry-day' scenario predicts the flooding that would occur if the dam or reservoir failed when rivers are at normal levels. The 'wet day' scenario predicts how much worse the flooding might be if a river is already experiencing an extreme natural flood.

The main reservoirs which could impact Oxford City include the following:

- Banbury FAS (grid reference SP4672443436) Owner: EA
- Farmoor No.1 (grid reference: SP4450006800) Owner: Thames Water Limited
- Farmoor No.2 (grid reference: SP4450006000) Owner: Thames Water Limited

The modelled extents tend to lie along the River Thames and River Cherwell. The two Farmoor reservoirs impact the River Thames whilst the Banbury FAS impacts the River Cherwell and River Thames downstream of the confluence between the two watercourses.

Areas affected within the Thames floodplain include parts of Wolvercote, New Botley, Osney, Grandpont and New Hinksey. Areas affected within the Cherwell floodplain include limited parts of Summertown, New Marston, Headington, St Clements and Iffley.

Whilst these areas are shown to be at risk, reservoir failure is a rare event with a very low probability of occurrence. Current reservoir regulation, which has been further enhanced by the FWMA, aims to ensure that all reservoirs are properly maintained and monitored to detect and repair any problem.

Maps showing the reservoir flood extents in Oxford City are provided in Appendix 6.

2.1.8 Canal Flooding

The Oxford Canal is 78 miles long (126 km) and links Oxford with Coventry via Banbury and Rugby. Running adjacent to Port Meadow in the north of Oxford, the canal joins the River Thames near the centre of the city, between the Jericho area and New Osney.

As the canal approaches the city centre, it runs parallel to the Castle Mill Stream for approximately 800m, before it terminates.

At this location the Oxford canal, Castle Mill Stream and the River Thames are linked through a series of locks and spills which manage water levels near the city centre and allow safe passage for boats in the area.

The Canal and River Trust have recorded two isolated breaches north of the city at the Thrupp culvert (NGR: 448000, 215658) in 2004 and at the Twyford culvert (NGR: 448510, 236775) in 2005. These were a significant distance upstream of the city and the trust have not identified any historical breach occurrences within the city limits.

The Canal and River Trust have also recorded incidents of overtopping. A number of incidents have been recorded in the Cherwell district and Northamptonshire during floods in 2007 (32), 2009 (1) 2012 (18) and 2013 (1). Once again, no overtopping incidents have been recorded within the city boundary.

Despite the lack of incidents within the city boundary, given the proximity of the canal to other watercourses in the centre of the town, flooding from the canal should still be recognised as a potential risk.

Upstream of Hythe Bridge Street, the canal and Castle Mill Stream are separated by close to 5m in places. Whilst water levels in the canal tend to sit 1m above those in Castle Mill Stream, failure of the canal bank and subsequent spill into the stream could drain a large volume of the canal up to Wolvercote lock, 3.5 km upstream.

A further potential flood risk comes from raised water levels in Castle Mill Stream. Should any of the water control assets located upstream near Jericho cricket ground fail, water within the stream could rise and overtop into the canal, which would form a conveyance route for flood water into Oxford city centre. Overall, the likelihood of these potential events are rare, however ongoing maintenance and management of the canal is important.

2.2 Review of Historic Flood Events

Historical flood events are recorded by the EA and subsequently documented in the form of reports, photographs and maps. This information is used to update the recorded flood outlines map, which shows the extent of all individual recorded flood outlines. Information provided by OCC as part of the previous SFRA has also been used to identify any events not shown in the EA records.

In Oxford eleven flood events have been identified dating back to Spring 1947, ten of which are shown in the EA recorded flood outlines mapping, with the winter 2012 event being the only exception. Table 5 shows a list of the notable flood events identified.

Based on all the available records, flooding associated with the River Thames affects the largest number of areas. Areas within Oxford that have been affected include large parts of North Hinksey, New Hinksey, New Botley, Osney, and in the 1947 flood, Wolvercote. During all of the events, the open area between Wolvercote and the city centre, Port Meadow, was subject to inundation and acts regularly to store large volumes of flood water.

Historically, the area surrounding the confluence to the River Cherwell and River Thames has experienced the greatest extent and frequency of flooding. Records indicate that this area has the greatest number of recorded instances of properties having flooded; with the flood events in 1947 and 2003 having the largest flood extents.

Flooding along the River Cherwell is mainly isolated to the open areas of recreational land which characterise the floodplain as it flows towards the city centre. Very few properties have been reported as having flooded during the listed events. Those properties which do appear in the floodplain are predominantly sporting facilities, where finished floor levels are expected to have been set above the 1947 flood level which is the largest recorded event on record.

The two most recent widespread flood events were in 2012 and 2014. In the 2012 event, large areas of New Hinksey, Osney and New Botley were flooded, however only three properties were recorded as having internally flooded; all of which were located in New Botley.

The 2014 flood affected similar areas, in this case eighteen properties were recorded as flooding, many of which were in New Hinksey, with overtopping of both the River Thames and Hinksey Stream.

Since, 2014, whilst there have been some isolated flooding incidents it is understood that there have been no widespread flood events across Oxford impacting upon properties.

Appendix 7 shows the recorded flood outlines for Oxford.

Table 5- Summary of Historic Flood Events in the Cherwell District

Date
Spring 1947
Summer 1977
Winter 1979
Autumn 1992
Autumn 1993
Spring 1998
Winter 2000
Winter 2003
Summer 2007
Winter 2012
Winter 2014

2.3 Review of Flood Defences

The EA national flood defence layer and a separate mapping table provided by the EA for Oxford City have been used to identify significant flood defence infrastructure across the city.

The majority of the defences identified are privately owned with the exception of an embankment downstream of Botley Rd protecting Osney Island, which the EA flood defence layer identifies as being owned by the local authority.

OCC have confirmed that with the exception of this asset, they do not own or maintain formal flood defences within their administrative boundary. However, OCC are responsible for a series of small-scale demountable flood defences at Bulstake Close in New Botley, and also operate a number of pumps.

The EA has confirmed that they do not own or maintain any formal flood defences within Oxford City. However, they are responsible for deploying demountable flood defences at Osney Island and New Hinksey, which are erected during significant flood events. It is also understood that the EA also control a sluice gate and 8 overflow pipes set in a stone headwall either side of an earth bank walkway upstream of Hythe Bridge Street. They also operate a number of pumps.

For the defence structures identified, the majority in the Thames floodplain are located around New Botley and Osney. For the River Cherwell, there are a series of embankments and retaining walls serving as flood protection near the city centre as the river approaches its confluence with the Thames. For the defences identified, the standard of protection tends to be low, generally offering protection for a 5-yr flood event (20% AEP). Although it should be recognised that this information was not available for the defences detailed in the mapping table.

Table 6 provides a summary of the flood defences including where available their condition, extent and standard of protection. Maps showing the location of flood defences in Oxford City are provided in Appendix 8.

Table 6- Flood Defences in Oxford City

Location	Defence Type	Length (m)	Condition	Design SOP
Bulstake Stream US of Botley Rd (NGR: 449710, 206229)	Wall (Private owned)	185	3-Fair	5
Osney Ditch US of Botley Rd (NGR: 450111, 206232)	Wall (Private owned)	291	2- Good	5
River Thames, Osney Island (NGR: 450332, 206123)	Wall (Private owned)	196	3-Fair	25
River Thames, Osney Island (NGR: 450332, 206123)	Embankment (Local authority)	259	3-Fair	5
River Thames, DS of Donnington Bridge (NGR: 452170, 204229)	Embankment (Private owned)	38	2- Good	5
River Cherwell, Mesopotania Walk to Kings Mill Lane (NGR: 452495, 206886)	Embankment (Private owned)	730	Not provided	Not provided
River Cherwell, DS of Kings Mill Lane (NGR: 452680, 206549)	Wall (Private owned)	270	Not provided	Not provided
River Cherwell in St Clements (NGR: 452167, 205835)	Wall (Private owned)	445	Not provided	Not provided
River Cherwell near St Hilda's college (NGR: 446082, 240489)	Wall (Private owned)	302	Not provided	Not provided
Holywell Mill Stream near St Catherine's College (NGR: 452192, 206478)	Wall (Private owned)	200	Not provided	Not provided
Holywell Mill Stream near Magdalen College grounds (NGR: 452190, 206482)	Wall (Private owned)	70	Not provided	Not provided
River Cherwell from Botanica gardens to Christ Church Meadow (NGR: 451942, 205890)	Wall (Private owned)	940	Not provided	Not provided
River Thames DS of Folly Bridge (NGR: 451512, 205488)	Wall (Private owned)	135	Not provided	Not provided
Osney Stream near St Frideswide Church (NGR: 450209,206213)	Wall (Private owned)	190	Not provided	Not provided
Osney Stream near St Frideswide Church (NGR:450152, 206128)	Wall (Private owned)	28	Not provided	Not provided
Hinksey Stream near Bertie Place (NGR: 451668, 203961)	Wall (Private owned)	370	Not provided	Not provided

The defences identified above do not include flood storage schemes. As mentioned, an upstream flood storage scheme associated with the Peasmoor Brook was completed in 2017 protecting 110 properties in Northway and Marston. It included a reach of the brook and involved natural embankments being installed, the channel being realigned and a wetland reserve created to use as temporary flood storage. Flood resilience measures were also introduced in the area.

The Oxford Flood Alleviation Scheme is also currently in development and will manage risk across large parts of the Oxford. It will be designed to manage floods of a major scale and seeks to protect the city as risk increases with climate change. The scheme forms part of a wider programme to improve flood resilience planned by the EA across the Thames Valley area.

The scheme specifically involves a new 5-km long channel, it will run from north of Botley Road down to south of the A423 southern by-pass where it re-joins the River Thames. The scheme will also involve lowering parts of the floodplain and working on some of the existing rivers and streams that run through this area already to make more space for water. Some areas will have new flood walls and embankments. As well as reducing flood risk, the scheme will create over 20 hectares of new wetland habitat, which will link with existing wildlife sites and increase biodiversity.

In spring 2022, the Oxford Flood Alleviation Scheme project team submitted the planning application for the scheme to Oxfordshire County Council. The council held a public consultation on the application. In August 2022, Oxfordshire County Council requested further information in support of the application. In February 2023 the project team submitted the further information. The Council held a public consultation on the response and will consider this alongside the rest of the application.

2.4 Review of Flood Warning

The EA is responsible for issuing flood warnings in the Oxford City area. In regularly monitoring the river network they aim to give the public notice of any local main river overtopping its bank (flood alert) or flooding properties (flood warning).

Water levels are monitored at a number of locations, and this information is used to inform flood warnings at the four flood warning areas within the study area. Flood warning areas are geographical areas where the EA expect flooding to occur and where the EA provide a flood warning service. A flood warning is issued when there is a risk of property flooding. The flood warning areas in the study area are listed below:

- River Thames and tributaries at Wolvercote
- River Thames and tributaries in the Binsey, Osney and Osney Island areas
- River Thames and tributaries at New Botley, New Hinksey, North Hinksey, South Hinksey and Grandpont
- River Cherwell for Oxford area

Gauges along watercourses are also used to issue flood alerts across wider flood alert areas. Flood alert areas are geographical areas where it is possible for flooding to occur. A flood alert is issued to warn people of the possibility of flooding. For Oxford City there are two flood alert areas, these are listed below. Figure 2 shows the flood alert areas relative to the flood warning areas.

- River Thames and tributaries in the Oxford area
- River Cherwell from Lower Heyford down to and including Oxford

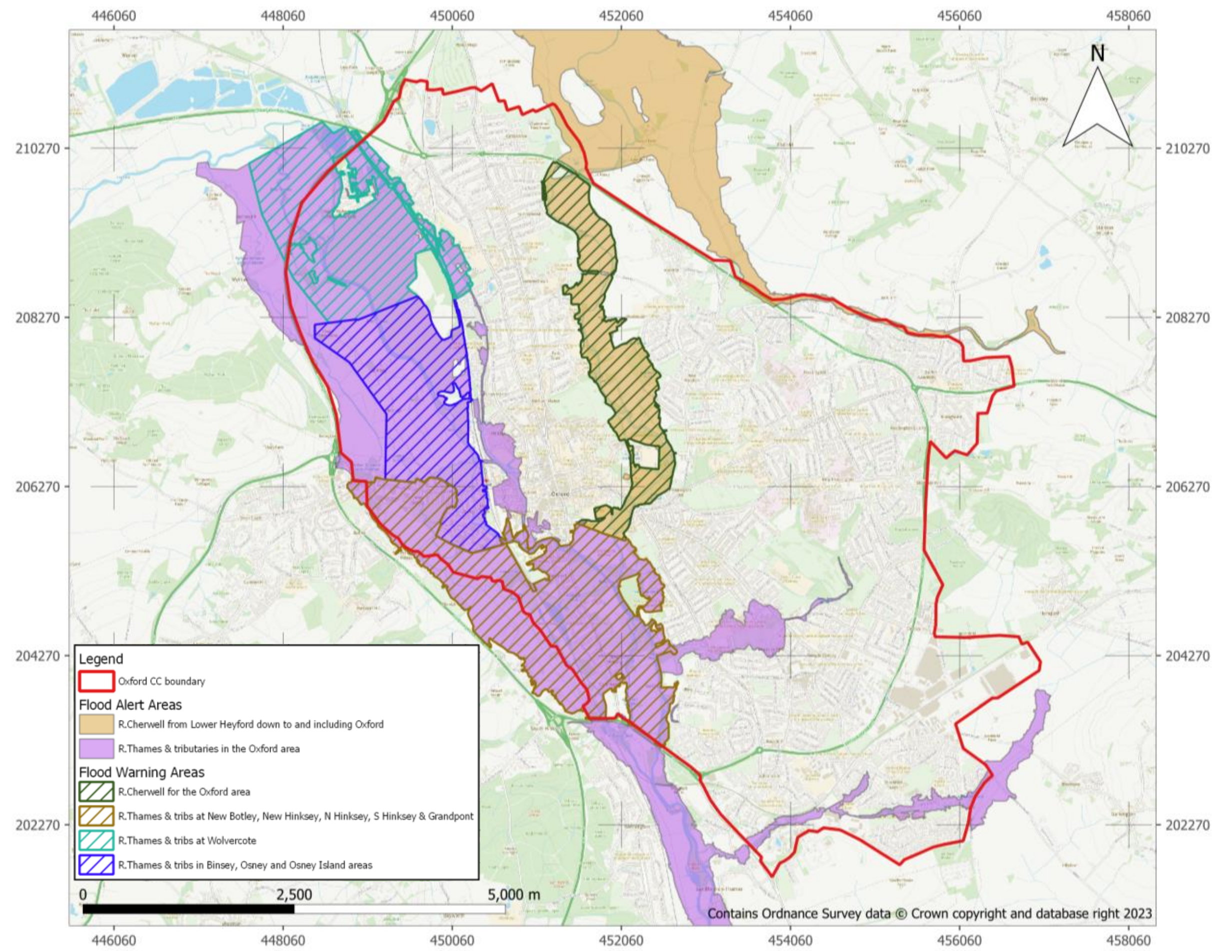


Figure 2 – Flood Warning Areas and Flood Alert Area

The timings of flood alerts and warnings are typically determined by trigger levels at the gauges which relate to the following:

- **FAL – Flood Alert**
  The level where flood waters first come out of bank if there were no defences.
- **FW – Flood Warning**
  The level where flood waters flood 1 property.
- **SFW – Severe Flood Warning**
  The level where flood waters flood 50 properties.

Flood alerts and warnings are available from the EA by a preferred contact method e.g. by phone or email. It is recommended that landowners/property owners in flood risk areas sign up to this service.

As a large proportion of the lower River Thames and River Cherwell catchments upstream of Oxford are rural and underlain by permeable bedrock (i.e. limestone) both tend to be relatively slow when responding to rainfall. Due to this there is potentially a significant lead time between peak rainfall and peak water levels. This means there is a significant amount of time for flood warning procedures to be implemented. The same does not apply for some of the smaller watercourses within Oxford City which due to the size of their catchments and urbanisation may elicit faster runoff responses and reduced lead in times, which increases the need for efficient flood warning systems.

3 Flood Risk at Site Allocations (Oxford Local Plan 2040)

3.1 Sequential Test

This SFRA provides information to support application of the sequential test to the preferred sites identified by OCC.

The sequential test ensures that a sequential, risk-based approach is followed to steer new development to areas with the lowest risk of flooding, taking all sources of flood risk and climate change into account. Where it is not possible to locate development in low-risk areas (Flood Zone 1), the sequential test should go on to compare reasonably available sites:

- Within medium risk areas (Flood Zone 2); and
- Within high-risk areas (Flood Zone 3), only where there are no reasonably available sites in low and medium risk areas

The sequential test should then consider the spatial variation of risk within medium and then high flood risk areas to identify the lowest risk sites in these areas.

Site specific FRAs should apply the sequential test at a site level locating the most vulnerable infrastructure in lower risk areas. To support such an assessment information on flood depth, velocity, hazard and speed-of-onset should be considered, along with the role of flood management infrastructure and the potential impacts of climate change.

3.2 Exception Test

In situations where sites at lower risk of flooding are not available following application of the sequential test, potential development may be located in medium to high-risk areas. In these cases, it may be necessary to apply the exception test.

The exception test requires two additional elements to be satisfied before allowing development to be allocated or permitted. It should be demonstrated that:

- development will provide wider sustainability benefits to the community that outweigh flood risk; and
- the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

Table 7 sets out the circumstances when the exception test will be required. More guidance on application of the sequential and exception test is provided in the NPPF and flood risk and coastal change PPG.

Table 7- Flood risk vulnerability and flood zone 'incompatibility'

Flood Zones	Essential infrastructure	Highly vulnerable	More vulnerable	Less vulnerable	Water compatible
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	Exception Test required	✓	✓	✓
Zone 3a	Exception Test required	x	Exception Test required	✓	✓
Zone 3b	Exception Test required	x	x	x	✓

3.3 Site Allocations (Oxford Local Plan 2040)

A total of 50 sites have been identified for potential development by OCC as part of the Oxford Local Plan 2040 (OLP2040). The SFRA seeks to provide sufficient information to allow OCC to apply the sequential test. The SFRA also outlines any requirements for the exception test. In this way, the SFRA will help OCC to implement national policy to direct development away from areas of flood risk through assessing these sites and helping inform strategic decisions on future development. Table 8 summarises the sites and Figure 3 shows the location of sites across the Oxford City area.

Table 8 – OLP2040 Site Allocations

OLP Ref	Site
SPN1	Northern Gateway
SPN2	Oxford University Press Sports Ground
SPN3	Diamond Place & Ewert House
SPS1	ARC Oxford
SPS2	Kassam Stadium and Ozone Leisure Park
SPS3	Overflow Car Park, Kassam Stadium
SPS4	MINI Plant Oxford
SPS5	Oxford Science Park
SPS6	Sandy Lane Recreation Ground
SPS7	Unipart
SPS8	Bertie Place Recreation Ground
SPS9	Blackbird Leys Central Area
SPS10	Knights Road
SPS11	Cowley Marsh Depot
SPS12	Templars Square
SPS13	Land at Meadow Lane
SPS14	Former Iffley Mead Playing Field
SPS15	Redbridge Paddock
SPS16	Crescent Hall
SPS17	Edge of Playing Fields, Oxford Academy
SPS18	474 Cowley Road (Former Powells Timber Yard)
SPE1	Government Buildings and Harcourt House
SPE2	Land Surrounding St Clement's Church
SPE3	Headington Hill Hall and Clive Booth Student Village
SPE4	Oxford Brookes University Marston Road Campus
SPE5	1 Pullens Lane
SPE6	Churchill Hospital
SPE7	Nuffield Orthopaedic Centre (NOC)
SPE8	Warneford Hospital
SPE9	Bayards Hill Primary School Part Playing Fields
SPE10	Hill View Farm
SPE11	Land West of Mill Lane
SPE12	Marston Paddock
SPE13	Manzil Way Resource Centre
SPE14	Slade House
SPE15	Thornhill Park
SPE16	Union Street Car Park and 159 –161 Cowley Road
SPE17	Jesus and Lincoln College Sports Grounds
SPE18	Ruskin College Campus
SPE19	Ruskin Field
SPE20	John Radcliffe Hospital
SPE21	Rectory Centre
SPCW1	West Wellington Square
SPCW2	Land at Winchester Road, Banbury Road and Bevington Road
SPCW3	Manor Place
SPCW4	Canalside Land, Jericho
SPCW5	Oxpens
SPCW6	Nuffield Sites
SPCW7	Osney Mead
SPCW8	Botley Road Retail Park

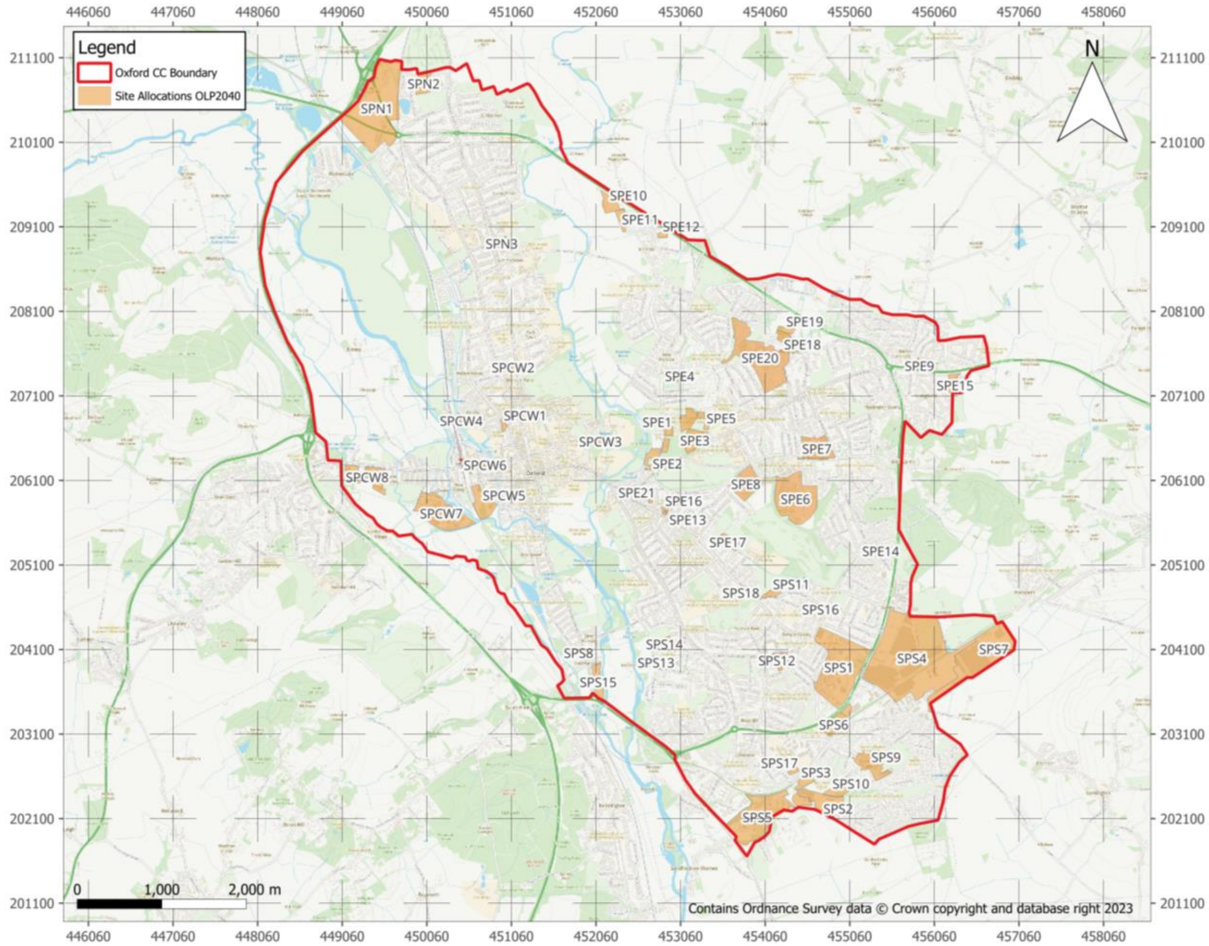


Figure 3- OLP 2040 Site Allocations

Based on the information and mapping provided as part of this SFRA, OCC will undertake a sequential test of the sites identified above. Should the results of which show that a number of sites may need to be located in Flood Zone 2, Flood Zone 3a and/or Flood Zone 3b a level 2 SFRA will likely be required. This will include a detailed assessment of flooding at each of the sites and review the appropriateness of development.

It should also be noted, that even for sites in Flood Zone 1 a site-specific FRA will still be required where developments are:

- More than 1 hectare (ha)
- Less than 1 ha in Flood Zone 1, including a change of use in development type to a more vulnerable class (for example from commercial to residential), where they could be affected by sources of flooding other than rivers and the sea (for example surface water drains, reservoirs)
- In an area within Flood Zone 1 which has critical drainage problems as notified by the EA

4 Flood Risk Management

4.1 Opportunities to Reduce Flood Risk

This section identifies at a strategic level how proposed development has the potential to improve the water environment via the use of SuDS and Natural Flood Management (NFM), in addition to remedial work on structures (i.e. culverts and bridges) and the provision of green spaces. Some of the potential measures and key benefits are outlined below:

- Runoff control using SuDS - SuDS slow the rate of surface water run-off and improve infiltration, by mimicking natural drainage in both rural and urban areas. This reduces the risk of "flash-flooding" which occurs when rainwater rapidly flows into the public sewerage and drainage systems. Runoff is controlled at or near source and typically, greenfield rates are maintained or there is betterment on brownfield rates at existing development sites. This minimises excess runoff to third party land, thereby managing and reducing flood risk where possible. Provided SuDS is correctly implemented it should safeguard against the cumulative impact of development causing an increase of flood risk within Oxford city.
- Promoting the use of infiltration SuDS- The PPG sets out the hierarchy of drainage to promote the use of SuDS, by aligning modern drainage systems with natural water processes. The aim of hierachy is to drain surface water run-off as sustainable, as reasonably practicable. The most sustainable option is infiltration of surface water run-off into the ground. This generally requires i) soils and/or bedrock to be permeable ii) groundwater levels to be a significant distance below the surface reducing the risk of groundwater emergence, iii) minimal land stability issues and iv) sites to be flat or gently sloping. Where infiltration is proposed, infiltration rates should be confirmed through BRE Digest 365 Soakaway Tests. Additional groundwater monitoring may also be required where there is a risk of groundwater emergence.
- Increasing flood storage and attenuation using natural flood management (NFM) - NFM involves techniques that aim to work with natural hydromorphological processes, features and characteristics to manage the sources and pathways of flood waters. Examples include the introduction of storage/conveyance features such as water meadows along with incorporation of riverside vegetation or leaky barriers to help slow overland flows and increase interception. This in turn prevents a flashy catchment response and serves to attenuate peak flows; mainly for lower order rainfall events and in smaller catchments.
- Land Management using NFM - Incorporating good practice into the management of land for the purpose of increasing infiltration of water and sediments into soils and reducing surface runoff. Woodland creation is also encouraged in some cases. The former relates to encouraging the use of infiltration SuDS where feasible at new development sites, but also improving management on existing land. Woodland creation would likely be a catchment wide measure to be considered by OCC, although opportunities may be limited given the degree of urbanisation within the local authority area.
- River and Floodplain restoration using NFM - The stabilisation of excessively eroding river banks in order to reduce deposition of sediment downstream and works that restore an altered river to a more appropriate shape and in turn reconnect the river with its floodplain. These options could be considered at the catchment scale and at the site scale. For example where future development is located in the vicinity of an eroding river bank or altered river, restoration could be considered as part of the scheme to bring wider benefits. Where this may be feasible at the preferred sites, it could be explored at the planning stage.
- Maintaining and removing existing structures/channels - developments can serve to adapt problem structures within a watercourse/floodplain, which can improve conveyance and reduce

impact of flooding. Diverting and daylighting of watercourses can also provide more effective flow routing through an area as well as environmental benefits. This is particularly relevant at urban sites which relates to most of those being considered, where manmade structures are likely to be more numerous and have a larger impact on flood risk to people and property.

- Managing water quality using SuDS - incorporation of SuDS features which provide filtration and capture of pollutants. These can include features such as permeable pavements and swales within the surface water system, which can settle and filter contaminants to provide treatment of surface water before being discharged. The level of treatment provided can be set relative to the risk index of the site. Particular attention should be applied to sites in groundwater source protection zones (SPZs) where additional measures may be necessary to protect the water environment. None of the preferred sites lie within an SPZ, however where waterbodies are proximal, the EA and LLFA should be consulted to determine local sensitivities.
- Enhancing biodiversity & amenity - developments can improve the quality of existing habitats and help create new habitats through landscape change. Sites offer an opportunity to establish green corridors and create coherent ecological networks. Development sites can also provide amenity benefits in the form of publicly accessible green spaces and improved access networks. SuDS and NFM often create new water features which can if correctly implemented bring associated educational benefits. For the allocated sites and for future development in general, biodiversity and amenity should always be factored into site design and the provision of SuDS/NFM.

4.2 SuDS

In terms of SuDS specifically, these form a vital part of the planning process and the text below provides guidance on how SuDS should be considered at a site-level. The NPPF states that any development should give priority to their use, and local authorities often assess planning proposals based on their ability to mitigate the impacts that development has on surface water runoff rates and volumes.

There are many types of SuDS component, which means that sustainable drainage can be tailored to a range of sites. They are generally split into two categories; infiltration systems and attenuation systems.

- Infiltration Systems- Infiltration components facilitate the infiltration of water into the ground. These often consist of temporary storage zones which allow for the slow release of water into the soil. They include permeable surfaces such as gravel, grassed areas, swales and permeable paving, and sub-surface components such as filter drains, geocellular systems and soakaways.
- Attenuation Systems- Attenuation SuDS capture runoff and control its subsequent discharge off-site. They are divided into conveyance systems which convey flows to downstream storage systems, and storage systems, which control the flows being discharged from a site by storing water and slowly releasing it. Examples of attenuation SuDS include detention basins, wetlands, ponds and swales.

The use of both systems tends to be determined by the permeability of the soil, and a site's topography. Relatively flat or gently sloping sites are often necessary for infiltration SuDS, and geotechnical investigations required to determine whether infiltration rates are sufficient. If ground conditions cannot support infiltration systems, surface water may need to be attenuated using measures to capture surface water. Attenuation systems do not offer the same range of sustainability benefits as infiltration systems and therefore infiltration SuDS are always preferred where viable.

At a number of sites SuDS designs often include a combination of infiltration and attenuation systems. A central design component for SuDS is the SuDS management train. SuDS should not be thought of as individual components, but as an interconnected system designed to manage, treat and make best use of surface water. The use of a sequence of components that collectively provide the necessary processes to control runoff and water quality is therefore often encouraged.

In terms of guidance the SuDS Manual published in 2007 and updated in 2015, is highly regarded. It incorporates the very latest research, industry practice and guidance. In delivering SuDS there is a requirement to meet the framework set out by the Government's 'non statutory technical standards' and the SuDS Manual complements these.

Runoff rates and volumes for a development site can be derived using the FEH methods specifically the rainfall runoff method implemented in ReFH 2. This is the current recommended method outlined in the CIRIA SuDS Manual[28]. Existing run-off rates are estimated by extracting point or catchment data. This data includes variables which describe rainfall and runoff characteristics in a particular area. For a development site the runoff characteristics derived can be linearly scaled based on the site area, yielding runoff rates and volumes for that area. The rates derived either need to be maintained or bettered depending on if the site is on green or brownfield land.

OCC's Local Standards and Guidance for Surface Water Drainage on Major Development in Oxfordshire[29] document sets out standards and guidance relevant to Oxford City on SuDS and drainage requirements. This was published in 2021 and aligns with the latest national guidance on SuDS, so is not due for major revision in the near term. Major developments within Oxfordshire should meet these standards and contact the LLFA directly to discuss drainage plans where possible.

In terms of existing drainage across the city no areas have been identified as having critical drainage problems. The EA has also confirmed that no critical drainage areas exist in the area. Surface water flooding is mainly isolated to small individual streets rather than the major roads running into the city and is largely intermittent. It is recommended at the detailed planning stage that these localised areas be assessed to identify development areas which are likely to have the potential to increase flood risk and where the implementation of SuDS needs to be carefully considered.

4.3 Flood Resilience

Property Flood Resilience is an approach to building design which aims to reduce flood damage and speed recovery and reoccupation following a flood. It uses a combination of flood resistance and recovery measures and is described in the industry-developed CIRIA Property Flood Resilience Code of Practice, which provides advice for both new-build and retrofit. It includes specific guidance for local authority planners.

The first preference is to apply the avoidance measures set out in the sequential approach to planning. Where this is not possible, flood resistance and flood resilience measures may need to be incorporated into the design of buildings and other infrastructure, including behind flood defence systems. Resistance and resilience measures are unlikely to be suitable as the only mitigation measure to manage flood risk, but they may be suitable in some circumstances, such as:

- Water-compatible and less vulnerable uses where temporary disruption is acceptable and the development remains safe;

[28] CIRIA (2015). *The SuDS Manual C753*
[29] Oxfordshire County Council (2021) *Local Standards and Guidance for surface water drainage on major development in Oxfordshire* https://www.oxfordshirefloodtoolkit.com/planning/surface-water-drainage/

- Where the use of an existing building is to be changed and it can be demonstrated that the avoidance measures set are not practicable and the development remains safe;
- As a measure to manage residual flood risk from flood risk management infrastructure when avoidance measures have been exhausted.

In these cases, and where existing development is already in flood risk areas, flood resilience measures could be considered. These are typically defined as sustainable measures that can be incorporated into the building fabric, fixtures and fittings to reduce the impact of floodwater on property. They allow for easier drying and cleaning, ensure that the structural integrity of the building is not compromised and reduce the amount of time until the building can be re-occupied. Flood repairability should also be considered which involves the design and construction of building elements, to ensure the ease of replacement and repair, should they suffer flood damage.

Some of the main flood resilience measures are outlined below:

- Flood doors and windows - These can prevent water from entering a property by creating a watertight seal during a flood.
- Flood barriers - These can be fitted to external doorways, windows, across driveways, garage doors and gardens. It is recommended that they are not fitted higher than 600mm in order to prevent structural damage to walls.
- Flooring - Concreate floors with damp proof membranes can be used in properties which are at particular risk of groundwater flooding as they prevent water rising up through the floors.
- Walls - Pointing which is in poor condition should be repaired with a water-resistant mortar and any cracks or holes in brickwork can be repaired with a waterproof silicone sealant.
- Drains and pipes - Fitting non-return valves to pipes will prevent backflow from toilets, sinks, drains and manholes when drains and sewers become overwhelmed with flood water.
- Airbricks and vents - There are a number of products available, examples include automatic (self closing) air bricks which allow ventilation but prevent flood water coming in when needed. Alternatively, air brick covers can be placed over airbricks.
- Adaption measures - Where flooding does occur waterproof plaster, solid concrete floors and tiled floor coverings, can reduce flood damage and greatly shorten the recovery time after a flood. Other steps include raising electric sockets to preserve electricity supply and moving paperwork and valuables to higher levels to minimise potential damage.

Planning and building standards have a complementary role in flood management and the use of flood damage resistant and mitigation measures could be considered at the proposed preferred sites where appropriate. These may be required as part of ensuring that consequences of flooding are acceptable.

It should be noted that mitigation and flood resilience measures are not sufficient justification to permit a development if the tolerable conditions are exceeded during an extreme flood event. High velocities and/or depths of floodwater pose a potential risk to life, may cause structural damage to buildings and could impact on human health and wellbeing.

4.4 Emergency Planning

The Oxford Area Flood Partnership (OAFP) plays a key role in emergency planning in Oxford City. It was formed after the floods in 2003. The partners represent the following local councils and national organisations:

- Environment Agency
- Network Rail,
- Oxford City Council
- Oxfordshire County Council
- Vale of White Horse District Council
- Thames Water PLC

The partners work in combination to assess variations in the timing, rate, location and total amount of rainfall, along with experience of previous floods to enable a response based on the developing situation. As the flood develops incident coordination centres are set up that liaise with regional and national centres, enabling a rapid and targeted response.

The partners each look after different parts of the network of pipes, culverts, ditches and rivers that carry water through Oxford. However, riparian owners (whose land includes or adjoins waterways) are also responsible for keeping those waterways open. The partners share information about flooding in the Oxford area and help each other to develop affordable remedies when problems involve two or more partners.

In terms of the main rivers in Oxford, Jurassic limestone and chalk characterise much of the Thames catchment upstream of Oxford leading to a significant base flow component in the catchment's storm response. A large proportion of the River Cherwell's catchment is rural and it is also slow to respond to rainfall. Due to this there is potentially a lead time of 20 hours between peak rainfall in the upstream parts of the catchment and peak water levels through Oxford City. This means there is significant amount of time for flood warning procedures to be implemented throughout Oxford.

The EA aim to give the public a minimum of 1-2 hours lead time of any local main river overtopping its bank (flood alert) or flooding properties (flood warning). In regularly monitoring the river network through Oxford, flood response organisations will normally be prepared at least one day ahead of a major flood event.

Flood Warnings apply to flooding caused by rivers and streams, not to flooding from other sources, such as sewer flooding, surface water flooding, and burst water mains. For fast responding catchments (particularly in urban areas) it may be necessary to issue Flood Warnings (or even Severe Flood Warnings) directly without issuing a Flood Alert first. The Flood Warning areas and Flood Alert areas within Oxford City are shown in section 2.4.

Oxford City Council have the responsibility of checking critical river levels several times a day once they have been alerted by the EA.

Based on the national receptors database, historical flooding and modelled flood extents, the major infrastructure at risk of flooding in a large flood event have been identified.

The main transport links impacted in a large flood event are the Botley Road in New Botley, and the Abingdon Road in New Hinksey, these run into the city centre from the west and south respectively. Parts of both roads lie in Flood Zone 3b and are prone to regular flooding. There is also a potential flood risk along the Cowley Road associated with the Boundary Brook.

In terms of energy infrastructure, the main flood risk is to a substation to the south of Osney, which is located within Flood Zone 3b. It is expected that its major assets are set above the predicted flood level for the majority of storm events.

The two largest hospitals in Oxford, the John Radcliffe and the Churchill Hospitals are located on higher ground in Headington and are therefore not at risk of flooding. The majority of medical practices are also not at risk of flooding, with the exception of St Bartholomew's Medical Centre-Lake Street Site in New Hinksey which lies in Flood Zone 3b.

The main secondary Schools in Oxford are located outside of the floodplain and are not considered to be at risk of flooding in a major flood event. However primary schools including New Hinksey Primary School, and West Oxford Community Primary School in New Botley are at risk. The City of Oxford College on Oxpens Road is also at risk of flooding from the Castle Mill Stream. None of the major assets in the City Centre are at risk of flooding in all events up to and including the 1 in 1000-year event, although there may be a residual risk due to surface water flooding.

5 Conclusions and Recommendations

5.1 Conclusions

5.1.1 A collation of potential sources of flood risk has been carried out in accordance with NPPF and associated legislation and guidance. The SFRA has been developed in close consultation with OCC, the LLFA, the EA and TW.

5.1.2 The dominant flooding mechanism in Oxford tends to be fluvial in origin associated with flooding from the Thames and its associated tributaries.

5.1.3 In general, a number of properties lie within the Thames fluvial flood extents. This includes properties in Wolvercote, New Botley, Osney, Grandpont and New Hinksey.

5.1.4 Parts of New Marston are shown to be at risk from the River Cherwell with the Boundary Brook and Littlemore Brook posing a risk to Cowley and Blackbird Leys respectively.

5.1.5 Smaller ordinary watercourses including the Marston Brook and Peasmoor Brook pose a further risk to New Marston, with an unnamed watercourse in Cutteslowe posing a significant risk to the Cutteslowe area. The upper reaches of the Boundary Brook also appear to bring significant risk to parts of Headington.

5.1.6 Flood risk also arises from surface water flooding with a limited number of properties in Jericho, Headington, Summertown, the Woodstock Rd and Oxford City Centre at high or medium risk of flooding.

5.1.7 In terms of groundwater flood risk, many areas are likely to be at risk, both in areas where the water table is high and in areas where it is likely to be mobile. The only exception may be parts of New Marston, St Clements and Iffley, where drainage is likely to be more impeded so groundwater emergence less likely.

5.1.8 Sewer flooding incidents have been recorded across the Oxford City area. These predominantly show that built up areas in New Hinksey, Grandpont, New Botley, Osney and New Marston generally have the most incidents.

5.1.9 Reservoir flooding has been assessed using EA's reservoir flood maps. Large areas within the floodplains of the River Thames and River Cherwell are shown to be at risk of reservoir flooding, however such an event is rare with very low probability of occurrence.

5.1.10 There have been no recorded breach or overtopping incidents along the Oxford canal within the city boundary, however the canal does offer a potential conveyance route for floodwater from the River Thames and Castle Mill stream in the city's centre.

5.1.11 Flood defences are present alongside the River Thames and River Cherwell, however these are mostly privately owned and offer a low standard of protection (i.e. 5-year event). Temporary demountable defences are employed in New Hinksey, Osney and New Botley by the EA and OCC. Both also manage a series of pumps.

5.1.12 The Oxford Flood Alleviation Scheme currently in development and will manage risk across large parts of Oxford. As of February 2023, Oxfordshire County Council held a public consultation and is considering this alongside the rest of the application.

5.1.13 There are a total of four flood warning areas and two flood alert areas within Oxford city. The Thames and Cherwell catchments tend to be relatively slow when responding to rainfall. This means there is a significant amount of time for flood warning procedures to be implemented.

5.1.14 The same does not apply for some of the smaller watercourses within Oxford city which due to the size of their catchments and urbanisation may elicit faster runoff responses and reduced lead in times, which increases the need for efficient flood warning systems.

5.2 Recommendations

5.2.1 In general, development should be located in Flood Zone 1 wherever possible. In cases where this is not possible, a sequential approach should be taken with highly or more vulnerable development prioritised for areas where flood risk is lowest and less vulnerable development located in areas at higher risk if necessary.

5.2.2 Where flood risk is significant and access may be compromised in extreme events, a comprehensive Emergency Flood Plan can help manage any residual risk.

5.2.3 Sustainable drainage principles should be followed at every site to safeguard against increasing flood risk both onsite and to third party land downstream.

5.2.4 For greenfield development sites runoff rates should be controlled to be no greater than the existing greenfield rate of runoff from the site.

5.2.5 For developments on previously developed brownfield sites the rate of runoff should not exceed the runoff of the site in its previously developed condition, and may seek a betterment on pre-existing rates, especially in locations where drainage is poor.

5.2.6 Many parts of the city offer good potential for infiltration SuDS given their geology and topography. The use of infiltration SuDS should be encouraged where possible, although groundwater may be too high in some areas.

5.2.7 Where possible, opportunities to reduce flood risk at sites and downstream should be identified, for example through the creation of wetland features, encouraging vegetation growth and use of NFM practices. The limited rural spaces in the city prevent NFM being implemented in some areas.

5.2.8 This SFRA does not replace the need for site specific FRAs. A greater level of detail should be provided by such assessments. FRAs should factor in the latest climate change guidance where sites are at risk.

5.2.9 Site specific FRAs are required for all sites over 1 hectare in size and for all sites located within Flood Zones 2 and 3. FRAs for sites within Flood Zone 1 may be required to assess surface water and non-fluvial forms of flood risk.

Appendix 1 – Baseline Fluvial Flood Maps

Appendix 2 – Fluvial Climate Change Flood Maps

Appendix 3 – Surface Water Flood Maps & Incidents

Appendix 4 – Watercourse Classification Maps

Appendix 5 – Geology and Soils Mapping

Appendix 6 – Reservoir Flood Maps

Appendix 7 – Recorded Flood Outlines Maps

Appendix 8 – Flood Defences Maps