CITY OF LONDON

STRATEGIC FLOOD RISK ASSESSMENT 2023

April 2023

City of London Corporation

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CITY OF LONDON

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Executive summary

This review of the Strategic Flood Risk Assessment (SFRA) for the City of London builds upon the previous SFRAs prepared in 2007, 2012 and 2017. Since 2017 new information has been produced and national guidance relating to flood risk management has been updated. This includes changes to the flooding sources considered in the application of the Sequential and Exception Test, and new climate change allowances to be used for modelling. This version of the SFRA builds substantially on the 2017 SFRA prepared by WSP.

The review considered the suitability of the existing flood modelling and determined that no additional modelling was required for this update. Flood risk mapping continues to be used, from the most up-to-date modelling from the Environment Agency in relation to fluvial and tidal flooding, and the detailed surface water mapping that was modelled as part of the 2012 SFRA.

The review also incorporates local policy changes, which built on recommendations from previous SFRAs. This includes proposed new guidance on flood evacuation plans for new developments, the adoption of the City of London Riverside Strategy, and guidance for minor developments and public realm developments. A review of recent flooding was also undertaken as part of the wider review and is included in this document. The internal Section 19 Flood Investigation process has also been reviewed and updated.

Flood risk within the City of London has remained stable throughout the last five years since the previous review was undertaken. There continues to be fluvial flood risk associated with the River Thames including a residual risk from defence failure. Surface water and sewer flooding hotspots persist along and near New Bridge Street, Farringdon Street and the riverside. Groundwater flooding and flooding from burst watermains continues to present a risk across the City of London, with some areas known to be more susceptible than others. The impacts of climate change, changes to assets and new policies are all expected to change flood risk and its management in the Square Mile, some of these will begin to be realised ahead of the next planned review. A new chapter covering a ‘future look’ will assist users by signposting them to anticipated changes to ensure that the most up to date information is available.

The document has been reformatted, with new chapters created to increase legibility, maps introduced within the text to assist with understanding and standardisations of chapters describing risk and making recommendations. The flooding mapping is also being made available online with an associated guidance report.

1 Introduction

1.1 Project background

The Strategic Flood Risk Assessment (SFRA) for the City of London was originally prepared by Mouchel Parkman in August 2007 and was updated by Halcrow in May 2012 to include a Level 2 assessment. Since then, there have been a number of updates in flood risk guidance and planning policy, and new flood risk data has been produced.

In 2017 WSP were commissioned by the City of London Corporation to review the 2012 SFRA and incorporate any up-to-date information on flood risk which affects the City of London.

A further review was undertaken by the City Corporation in 2022-23 which has resulted in the current version of the SFRA. This review did not undertake further modelling as the existing was determined to remain relevant. It did however update further flood risk information and incorporate new sections. This internal review was subject to a 3rd party 'critical friend' check by WSP.

Flooding is a natural process which can occur at any time, in a wide variety of locations. The speed of inundation and duration of flood events can vary drastically, which affects the severity of the impacts. As a result of climate change, the frequency, velocity, depth, patterns and severity of flood events will cause a greater risk of flooding and any subsequent damages.

Typically, fluvial and coastal sources are the principal causes of flooding. However, in high density urban areas such as the City, there are other sources which may result in large flood damages i.e. surface water, sewer surcharge, burst water mains and groundwater.

This SFRA provides information on all the likely sources of flooding within the City of London's administrative boundary. It also acts as an evidence base in development planning, assisting with defining local flood risk policies and emergency planning procedures.

1.2 The local context

The City of London is located on the north bank of the River Thames within Greater London (see Figure 33014-COL-101 – Study Area in Appendix A). It is the historic core of London and was founded on higher ground than the neighbouring boroughs, which provides natural protection from tidal and fluvial flooding. The topography for the City of London can be found in Figure 33014-COL-102 - Topography in Appendix A.

The City of London has an area of approximately 2.9km^2 and borders the London Boroughs of Camden, Islington, Hackney, Tower Hamlets and the City of Westminster. It also borders the London Boroughs of Southwark and Lambeth, on the opposite side of the River Thames (see Figure 33014-COL-103 – Borough Boundary and Neighbouring Boundaries in Appendix A).

Two historical watercourses flow through the City of London: the River Fleet and the River Walbrook. They join the Thames within the City of London boundary; however, they are now culverted within the sewer network. The Fleet was fully culverted within the City by the 18th century, and the Walbrook was largely culverted by the 15th century.

The City of London is heavily urbanised, with primarily commercial buildings and infrastructure. Approximately 8,600 people live within the City of London but it has a working population of around 450,000 people who commute to work within its boundaries. The City of London is one of the main financial districts in the world. In addition to commercial buildings, it is also home to historic landmarks and buildings; including St Paul's Cathedral and the Mansion House. There are small areas of open space – primarily private and public gardens, and churchyards.

1.3 Outline approach

This SFRA approach refines, reviews, and builds upon the 2007, 2012 and 2017 SFRAs which assessed all forms of flood risk: fluvial, tidal, surface water, sewer and groundwater, taking into account any future impacts as a result of climate change. The study has reviewed the modelling results for tidal and surface water flooding produced as part of the Level 2 Assessment undertaken by Halcrow in 2012 and built upon in the 2017 SFRA. In this iteration updates have been included on recent policy changes from the Riverside Strategy, further guidance on flood evacuation plans and will be displaying the flood mapping produced previously in more interactive formats.

This review has been carried out in-house by the City Corporation and has been independently checked by a third party.

Flood risk data for this and previous studies has been obtained from the City of London Corporation, the Environment Agency and Thames Water.

This report supersedes the three previous SFRA's written in 2007, 2012 and 2017.

1.4 SFRA review aims and objectives

The main aim of this SFRA review (Level 2) is to assess whether the existing assessment of flood risk within the City of London remains accurate, to update and inform planning and policy and to improve the useability of the document. The objectives agreed as part of the scope of the review are as follows:

- Reviewing the existing fluvial, tidal, surface water, sewer and groundwater modelling and confirming that it remains sufficient.
    - This will include assessing if the original assumptions remain valid.
    - Reviewing if there have been any significant changes to input data.

  - It will not include a full review of the models.
- Rationalising the existing document including clarifications on Critical Drainage Areas (CDAs) to confirm that the whole City of London should be treated as a CDA.
- Updating following recent policy changes to the National Planning Policy Framework, London Plan 2021, recent flooding events, Local Flood Risk Management Strategy.
- Highlighting upcoming changes including to the Drainage and Wastewater Management Plan (DWMP), Local Plan, Thames Estuary 2100 Plan (TE2100) ten-year review.
- Incorporating new sections on Flood Emergency Plan guidance and the Riverside Strategy.
- Producing new procedures on conducting Section 19 flood investigations.
- Expanding the sections on SuDS/resistance/resilience measures guidance to include public realm/ minor developments.
- Incorporating further information for mapping including heritage assets at risk of flooding.
- Integrating mapping into GIS and creating a supporting report.
- Refreshing the document including corporate branding and acronym guide.

This SFRA review provides the necessary information to assist with the application of the Sequential and Exception Test. It also forms part of the evidence base for the update of the local development plan. Alongside other planning policies, this SFRA allows the City of London Corporation to:

- Prepare appropriate policies for the management of flood risk;
- Inform the Sustainability Appraisal of planning policy documents so that flood risk is taken into account when considering options, and in the preparation of strategic spatial planning policies;
- Identify the level of detail and supplementary information required for site-specific flood risk assessments (FRAs); and,
- Help inform the acceptability of flood risk in relation to emergency planning capability and determining the suitability of flood evacuation egress and access routes.

2 Planning policy and context

2.1 Relevant legislation, plans and policies

National policy	National Planning Policy Framework (NPPF) 2021 (MHCLG)
	Flood and Water Management Act 2010
	Flood Risk Regulations 2009
	Civil Contingencies Act 2004
	Flood risk assessments: climate change allowances (2022)
Local and regional plans	City of London Local Plan 2015
	The London Plan (2021)
	City of London Thames Strategy SPG 2015
	South East Marine Plan 2021 (MMO)
Local and regional flood risk management strategies	City of London Local Flood Risk Management Strategy 2021
	Greater London Surface Water Management Plan 2021-27
	Thames River Basin Management Plan 2022
	Thames Estuary Plan 2100 Plan
	City of London Riverside Strategy
	London Sustainable Drainage Action Plan 2016

2.2 National policy

National Planning Policy Framework

The National Planning Policy Framework (NPPF) sets out the Government's strategy for planning in England. It was first published in March 2012 and updated most recently in July 2021.

The NPFF is accompanied by a series of Practice Planning Guidance (PPG) documents. The Flood Risk and Coastal Change (FRCC) PPG provides additional guidance on the preparation of Strategic Flood Risk Assessments. The FRCC PPG was updated in August 2022.

The FRCC PPG states that a local authority should use a SFRA to apply a risk-based approach to development, applying the Sequential Test to potential site allocations. The SFRA informs the Sustainability Appraisal to ensure flood risk is fully taken into account from all sources now and in the future. It is used to inform the Sequential Test and where necessary the Exception Test. Where the Sequential Test is unable to deliver a sufficient number of sites to meet planning requirements, the Exception Test should be applied to deliver additional development sites. Applying the Sequential and Exception Tests is discussed in detail in Chapter 3.

Flood and Water Management Act 2010

The Flood and Water Management Act 2010 is a key piece of legislation which was introduced to improve flood risk management and to support continuity of water supply and other essential services. A key feature of the Act is to implement the recommendations made in the Pitt Review, following the exceptional flooding during the summer of 2007. The Flood and Water

Management Act increases the emphasis on all sources of flooding, especially surface water which was particularly devastating during the 2007 floods.

The Act has given the City of London Corporation, as a Lead Local Flood Authority (LLFA), a number of responsibilities and powers with regards to managing local flood risk, which includes surface runoff, groundwater and ordinary watercourses (including lakes and ponds). The City of London does not have any ordinary watercourses. LLFAs are encouraged to work in partnership with other organisations, who hold valuable local knowledge which in this case are Thames Water, Transport for London, the Environment Agency, the Greater London Authority and nearby London Boroughs.

Flood Risk Regulations 2009

The Flood Risk Regulations 2009 converts the EU Floods Directive into UK law. In accordance with this, the City of London Corporation has a duty to carry out a Preliminary Flood Risk Assessment (PFRA). The PFRA is a high-level screening exercise looking at readily available flood risk information and determining flood risk areas of national significance. Information from the SFRA is used to inform the PFRA and vice-versa.

Civil Contingencies Act 2004

The Civil Contingencies Act provides a single framework for civil protection in the United Kingdom. It is split into two separate parts:

- Part 1: Local arrangements for civil protection; and,
- Part 2: Emergency powers.

An emergency is defined as 'an event or situation which threatens serious damage to human welfare in a place in the UK' and 'an event or situation which threatens serious damage to the environment of a place in the UK'.

Part 1 establishes a clear set of roles and responsibilities for those involved in emergency preparation and response at a local level. The City of London Corporation are a Category 1 organisation and are subject to the following civil protection duties:

- Assess the risk of emergencies occurring and use this to inform contingency planning;
- Put in place emergency plans;
- Put in place business continuity management arrangements;
- Put in place arrangements to make information available to the public about civil protection matters and maintain arrangements to warn, inform and advise the public in the event of an emergency;
- Share information with other local responders to enhance co-ordination;
- Co-operate with other local responders to enhance co-ordination and efficiency; and,

- Provide advice and assistance to businesses and voluntary organisations about business continuity management.

Part 2 updates the 1920 Emergency Power Act to reflect any developments since the Act was written and includes the current and future risk profile. Part 2 allows for the making of temporary special legislation to assist with the most serious emergencies.

Flood risk assessments: climate change allowances (May 2022)

In May 2022, the Environment Agency released an updated version of the 'Flood risk assessments: climate change allowances' guidance (Environment Agency, 2022). This guidance supports the NPPF (updated in July 2021). The climate change allowances are predictions of anticipated change for:

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

The most significant risks to the City of London arise from surface water flooding and from fluvial and tidal flood risk, albeit these are defended against. Therefore, the most relevant climate change considerations for the SFRA are associated with peak rainfall intensity and sea level rise. Peak rainfall intensity is also relevant to the risk of flooding from the combined sewer system, as increased rainfall intensity will increase the volumes of water that the sewer system will have to deal with in the future.

Below are summaries of the climate change allowances as they relate to the City of London. The 'Flood risk assessments: climate change allowances' is available online with supporting explanatory information. It is recommended that this source is used rather than relying on the summaries here to ensure that the most up-to-date version is being used.

Within the guidance it states that flood risk assessments should consider both the central and upper end allowances for increases in peak rainfall intensity to understand the range of impact that may occur as a result of climate change. For the London Management Catchment the allowances are given in Table 1. Epochs relate to the proposed lifetime of a development with the 2050s epoch covering up to 2060 and the 2070s epoch covering 2061-2125. The lifetime of the development should be considered when selecting the allowance used. Residential development must assess using the Upper End Allowance for both the 1% & and 3.3% Annual Exceedance Probability (AEP) for the 2070s.

Table 1: Peak rainfall intensity climate change allowances for the London Management Catchment

Annual exceedance rainfall event	3.3%		1%	
Epoch	**Central**	**Upper end**	**Central**	**Upper end**
2050s	20%	35%	20%	40%
2070s	20%	35%	25%	40%

The sea level rise allowances for London are expected to increase by between 1.20 and 1.60m from 2000 and 2125. Increases for the South East, per epoch, are given in Table 2.

Table 2: Sea level rise allowances for the South East

Allowance	2000 to 2035 (mm/year)	2036 to 2065 (mm/year)	2066 to 2095 (mm/year)	2096 to 2125 (mm/year)	Cumulative rise 2000 to 2125 (metres)
Higher central	5.7	8.7	11.6	13.1	1.20
Upper end	6.9	11.3	15.8	18.2	1.60

Sea level rise will gradually reduce the level of protection that defences offer. However, due to the presence of the Thames Barrier, sea level rise within the City of London will be different to the numbers indicated above. The Riverside Strategy and TE2100 Plan supersede these allowances when considering the combined tidal-fluvial risk to the City of London (for more information refer to Chapter 6 and 13).

2.3 Local and regional plans

City of London Local Plan 2015

At the time of the SFRA 2023 review the City Corporation was in the early stages of developing the new Local Plan, this should be in place before the next planned SFRA review. It is advisable to check the City Corporation website for the most up to date information on Local Plan policies. The below summarises flood risk policies in the City of London Local Plan 2015 which will remain relevant until 2026 or until replaced by a new Local Plan.

The City of London Local Plan 2015 sets out the City of London Corporation's vision, strategy, objectives and policies for the City. The Local Plan was adopted in January 2015 and is being reviewed and rolled forward under the banner City Plan 2040.

Section 3.18 sets out Core Strategic Policy CS18 which aims to ensure the City of London remains at low risk from all types of flooding by:

- Minimising river flooding risk, requiring development in the City Flood Risk Area, defined in Figure S of the Local Plan and Figure 33014-COL-104 – City Flood Risk Area in Appendix A, to seek opportunities to deliver a reduction in flood risk compared with the existing situation:
    - Applying the Sequential Test and Exception Test as set out in the NPPF and FRCC PPG and requiring Flood Risk Assessments to be submitted, in support of all planning applications in the City of London Flood Risk Area (Environment Agency Flood Zones 2 and 3 and surface water flood risk hotspots) and for major development proposals elsewhere; and,
    - Protecting and enhancing existing flood defences along the riverside, particularly those identified as fair or poor in the current City of London SFRA. Development adjacent to the River Thames must be designed to allow for maintenance of flood defences.
- Reducing the risks of flooding from surface water throughout the City of London, ensuring that development proposals minimise water use and reduce demands on the combined surface water and sewerage network by applying the London Plan drainage hierarchy;
- Reducing rainwater run-off, through the use of suitable Sustainable Drainage Systems (SuDS), such as green roofs and rainwater attenuation measures throughout the City of London;
- Ensuring that wider flood defences afford the highest category of protection for the City of London, participating in the development and implementation of the Environment Agency's Thames Estuary 2100 Plan; and,
- Reviewing and updating the City of London's Strategic Flood Risk Assessment at least every 5 years or more frequently if circumstances require, ensuring that changes in flood risk are identified and suitable responses implemented.

Policy CS18 is supported by three Development Management Policies which are as follows: Policy DM 18.1 'Development in a City Flood Risk Area' states that:

- Where development is proposed within the City Flood Risk Area evidence must be presented to demonstrate that:
    - The site is suitable for the intended use, in accordance with Environment Agency and Lead Local Flood Authority advice;
    - The benefits of the development outweigh the flood risk to future occupants; and,

    - The development will be safe for occupants and visitors and will not compromise the safety of other premises or increase the risk of flooding elsewhere.
- Development proposals, including change of use, must be accompanied by a site-specific flood risk assessment for:
    - All sites within the City Flood Risk Area as shown on the Policies Map; and,
    - All Major Development elsewhere within the City of London.
- Site-specific flood risk assessments must address the risk of flooding from all sources and take account of the City of London Strategic Flood Risk Assessment. Necessary mitigation measures must be designed into and integrated with the development and may be required to provide protection from flooding for properties beyond the site boundaries, where feasible and viable;
- Where development is within the City Flood Risk Area, the most vulnerable users must be located in those parts of the development which are least at risk. Safe access and egress routes must be identified;
- For minor development outside of the City Flood Risk Area, an appropriate flood risk statement may be included in the Design and Access Statement; and,
- Flood resistant and resilient designs which reduce the impact of flooding and enable efficient recovery and business continuity will be encouraged.

Policy DM 18.2 'Sustainable Drainage Systems (SuDS)' states that:

- The design of the surface water drainage system should be integrated into the design of proposed buildings or landscaping, where feasible and practical, and should follow the SuDS management train and London Plan drainage hierarchy;
- SuDS designs must take into account the City's archaeological heritage, complex underground utilities, transport infrastructure and other underground structures, incorporating suitable SuDS elements for the City's high density urban situation; and,
- SuDS should be designed, where possible, to maximise contributions to water resource efficiency, biodiversity enhancement and the provision of multifunctional open spaces.

Policy DM 18.3 'Flood protection and climate change resilience' states that:

- Development must protect the integrity and effectiveness of structures intended to minimise flood risk and, where appropriate, enhance their effectiveness; and,
- Wherever practicable, development should contribute to an overall reduction in flood risk within and beyond the site boundaries, incorporating flood alleviation measures for the public realm, where feasible.

Core Strategic Policy CS9: Thames and Riverside promotes the City of London's unique riverside location and provides a clause relating to 'refusing development on or over the River, except for structures which specifically require a waterside location for river-related uses'.

The London Plan

The current London Plan was adopted in March 2021. It provides an overall strategic plan for the Mayor of London, 32 London boroughs, the Mayoral Development Corporations and the City of London. The plan sets out an integrated economic, environmental, transport and social framework for any development in London over the next 20 – 25 years.

Policies SI 12 and S13 are related to improving flood risk management and reducing flood risk through Sustainable Drainage Systems.

Policy SI 12 Flood risk management states that:

- Current and expected flood risk from all sources across London should be managed in a sustainable and cost-effective way in collaboration with the Environment Agency, the Lead Local Flood Authorities, developers and infrastructure providers.
- Development Plans should use the Mayor's Regional Flood Risk Appraisal and their Strategic Flood Risk Assessment as well as Local Flood Risk Management Strategies, where necessary, to identify areas where particular and cumulative flood risk issues exist and to develop actions and policy approaches aimed at reducing these risks. Boroughs should cooperate and jointly address cross-boundary flood risk issues including with authorities outside London.
- Development proposals should ensure that flood risk is minimised and mitigated, and that residual risk is addressed. This should include, where possible, making space for water and aiming for development to be set back from the banks of watercourses.
- Developments Plans and development proposals should contribute to the delivery of the measures set out in the Thames Estuary 2100 Plan. The Mayor will work with the Environment Agency and relevant local planning authorities, including authorities outside London, to safeguard an appropriate location for a new Thames Barrier.
- Development proposals for utility services should be designed to remain operational under flood conditions and buildings should be designed for quick recovery following a flood.
- Development proposals adjacent to flood defences will be required to protect the integrity of the flood defences and allow access for future maintenance and upgrading. Unless exceptional circumstances are demonstrated for not doing so, development proposals should be set back from flood defences to allow for any foreseeable future maintenance and upgrades in a sustainable and cost-effective way.

- Natural flood management methods should be employed in development proposals due to their multiple benefits including increasing flood storage and creating recreational areas and habitat.

Policy SI 13 Sustainable drainage states that:

- Lead Local Flood Authorities should identify – through their Local Flood Risk Management Strategies and Surface Water Management Plans – areas where there are particular surface water management issues and aim to reduce these risks. Increases in surface water run-off outside these areas also need to be identified and addressed.
- Development proposals should aim to achieve greenfield run-off rates and ensure that surface water run-off is managed as close to its source as possible. There should also be a preference for green over grey features, in line with the following drainage hierarchy:
    1. rainwater use as a resource (for example rainwater harvesting, blue roofs for irrigation)
    2. rainwater infiltration to ground at or close to source
    3. rainwater attenuation in green infrastructure features for gradual release (for example green roofs, rain gardens)
    4. rainwater discharge direct to a watercourse (unless not appropriate)
    5. controlled rainwater discharge to a surface water sewer or drain
    6. controlled rainwater discharge to a combined sewer.
- Development proposals for impermeable surfacing should normally be resisted unless they can be shown to be unavoidable, including on small surfaces such as front gardens and driveways.
- Drainage should be designed and implemented in ways that promote multiple benefits including increased water use efficiency, improved water quality, and enhanced biodiversity, urban greening, amenity and recreation.

City of London Thames Strategy supplementary planning document 2015

The London Plan requires Thames-side boroughs and the City Corporation to identify a Thames Policy Area and formulate policies and a strategy for this area. The City's part of the Thames Policy Area is identified in the Local Plan and on the Local Plan Policies Map. The Thames Strategy Supplementary Planning Document provides guidance on the following topics:

- Development and public realm enhancement within the Thames Policy Area;
- Assisting the implementation of improved river transport, navigation and recreation opportunities;
- Protection and enhancement of heritage assets;
- Inclusive access for all wherever practicable;
- Flood risk, climate resilience and biodiversity enhancement; and,

- The implications for development of site safeguarding at Blackfriars for the Thames Tideway Tunnel and at Walbrook Wharf for waterborne freight traffic including waste management.

South East Marine Plan 2021

The South East Marine Plan was prepared by the Marine Management Organisation (MMO) and published in June 2021. It covers the South East inshore marine area from Felixstowe to Dover including the tidal extent of the Thames. The plan introduces a strategic approach to planning within the English inshore waters, applying national policies in a local context. Policies cover a wide range of topics, including activities and uses, economic, social and environmental considerations, and cross-cutting issues such as the integration of decision-making on land and at sea.

The policies within the South East Marine Plan are relevant to the development in the City of London in so far as it impacts the tidal extent. This therefore includes development immediately adjacent to the river or where alterations impact the river flood defences.

2.4 Local and regional flood risk managements strategies

City of London Local Flood Risk Management Strategy 2021

The Flood and Water Management Act 2010 places a duty on Lead Local Flood Authorities to produce a Local Flood Risk Management Strategy (LFRMS). These documents help to understand the broad nature and extent of local flood risk and how it will be managed. The LFRMS is an over-arching strategy which is seen as the first step of understanding and managing local flood risk (risks from ordinary watercourses, surface water and groundwater). The LFRMS includes a Flood Risk Action Plan which identifies the practical steps that the City Corporation and other partners need to take to reduce the risks from flooding.

The City of London LFRMS was adopted in February 2021 and has the following objectives that will be delivered through specific actions outlined in the action plan:

- To develop and implement adaptive approaches to future flooding to enhance the resilience of the flood risk area.
- To develop and deliver a programme of flood risk management capital schemes and maintenance to reduce risk of flooding and coastal change and its adverse consequences for human health and wellbeing.
- To help achieve the environmental objectives set out in the river basin district's river basin management plan.

- To provide evidence and advice to infrastructure providers and to support them to take account of future flooding and coastal change in their infrastructure investment.
- To work with communities and businesses to understand and implement a plan for how flood and coastal erosion risk management activities can contribute towards sustainable growth and prosperity in a climate resilient way (and vice versa).
- To work with communities across the risk area: to raise awareness of the level of flood risk that they face; help them understand the role of emergency responders and ensure they know what to do in an emergency to help themselves.

Greater London Surface Water Flood Risk Management Plan 2021-27

The Greater London Surface Water Flood Risk Management Plan (FRMP) published in December 2022 has been produced in collaboration between the Environment Agency and the London Lead Local Flood Authorities. The FRMP addresses a statutory duty for LLFAs to produce a management plan for areas of identified flood risk. The whole of Greater London has been identified as an area of surface water flood risk. The Greater London FRMP standardises and coordinates the approach to surface water management across London authorities.

The FRMP makes policy recommendations for each of the LLFA's including the City of London. The objectives and measures are the basis of the City Corporation's LFRMS 2021.

Thames River Basin Management Plan 2022

The River Basin Management Plans (RBMP) provide a framework for protecting and enhancing the benefits provided by the water environments within their districts. They are an integrated approach to catchment-based planning for water. To achieve this, and because water and land resources are closely linked, it also informs decisions on land-use planning.

The Thames River Basin District encompasses all of Greater London and extends from north Oxfordshire southwards to Surrey and from Gloucester in the west to the Thames Estuary in the east. The Thames RBMP does not provide any flood risk management policies for the City of London and indicates that the future management of tidal flood risk in London is being addressed by the Thames Estuary 2100 Plan.

Thames Estuary 2100 Plan

The Environment Agency led Thames Estuary 2100 Plan (TE2100) identifies actions that will need to be taken during this century to protect the land adjacent to the tidal Thames from flood risk. This area, including parts of the City of London, is protected from severe tidal flooding by the Thames Barrier and the other estuary defences. However, climate change impacts such as sea level rise and the prevalence of more extreme weather events mean that additional local and estuary-wide protection will be needed later this century.

The primary function of the Thames Barrier is to prevent tidal flooding in London, and it is currently closed when water levels are forecast to overtop the river flood defences upstream of the Barrier. Water levels in the tidal Thames are increasing as a result of climate change resulting in more frequent barrier closures. Raising the statutory heights of local flood defences along the Thames will help to manage the frequency of barrier closures by allowing higher water levels to pass up the Thames thus maintaining the reliability of the existing barrier. As water levels increase further, a major upgrade or replacement of the Thames Barrier will be required to protect London in the future. These options are being considered in the TE2100 Plan.

Within the City, the TE2100 Plan identifies the need to raise flood defences to 5.85m AOD (above ordinance datum) by 2065 and 6.35m AOD by 2100. For the City’s riverside this means raising parts of the flood defence by up to one meter, although some sections are already at the required level for 2100.

A 10-year review of the TE2100 Plan is expected to complete in 2023. It is anticipated that this review will result in key decision dates and raising deadlines within the plan being brought forward since sea level rise is accelerating faster than previously predicted.

City of London Riverside Strategy

The City of London Riverside Strategy provides a roadmap the City Corporation as LLFA and Local Planning Authority for the Square Mile. The strategy’s aim is to ensure that the City remains at low risk of flooding throughout this century and beyond, taking account of the predicted changes in sea level rise as a result of climate change. The strategy sets out how we plan to deliver the local flood defences that contribute to this overall aim.

The strategy is based on the Riverside Strategies Approach in the TE2100 Plan. This integrates improvements to flood risk management defences into wider redevelopment, enhancing the social, environmental, and commercial aspects of the riverside. Following this approach, the City’s ambition is to take every opportunity to create an attractive and accessible riverside which is resilient to the increasing risks of flooding.

The City of London Riverside Strategy is covered in more detail in Chapter 13.

London Sustainable Drainage Action Plan 2016

The London Sustainable Drainage Action Plan was published by the Greater London Authority in December 2016. The main focus of the action plan is on the ‘retrofitting of sustainable drainage to existing buildings, land infrastructure’, and subsequently managing rainwater as a valuable resource as opposed to a waste product. The action plan includes 40 actions to be undertaken within the next 5 years. Actions include:

- Providing strategic guidance on sustainable drainage requirements for major development locations;
- Providing guidance and good examples of sustainable drainage applicable to all sectors (education, housing, retail, etc.); and,
- Identifying opportunities and funding for sustainable drainage retrofit at the same time as planned maintenance, repair and improvement works in all sectors (education, housing, retail, etc.).

3 Sequential and Exception Tests

3.1 Overview

The National Planning Policy Framework and its supporting Flood Risk and Coastal Change Practical Planning Guidance (FRCC PPG) states that local authorities should use a SFRA to apply a risk-based approach to development. This should be done by first applying the Sequential Test to identify potential site allocations in relation to flood risk taking into account the risk across the site from all sources. Where the sequential test is unable to deliver a sufficient number of sites to meet planning requirements, the Exception Test should be used to enable additional development sites.

The following sections cover the two tests in detail. Due to the nature of development in the City of London the use of the Sequential Test is limited, and most developments will have to be justified using the Exception Test when necessary and take a sequential approach.

3.2 The Sequential Test

The aim of the Sequential Test is to assess potential site allocations in relation to flood risk ensuring development is located in the areas of lowest risk, first taking into account the risk variation across the site from all sources. This means avoiding, so far as possible, development in current and future medium and high flood risk areas: considering all sources of flooding including areas at risk of surface water flooding. Avoiding flood risk through the Sequential Test is the most effective way of addressing flood risk because it places the least reliance on measures like flood defences, flood warnings and property level resilience features. Even where a flood risk assessment shows the development can be made safe throughout its lifetime without increasing risk elsewhere the Sequential Test still needs to be satisfied.

The application of the Sequential Test within the City of London is difficult as it relies on parcels of land being specifically allocated for development within the Local Plan. Individual site allocation is not generally promoted in the City of London as the majority of developable land is brownfield (land that has been previously developed). However, the typical process of the Sequential Test is as follows:

- Only where no sites are available in areas of low flood risk (both now and in the future) should a site in the higher risk flood risk areas be considered. Sequentially, development should be located in areas of medium flood risk before sites in areas of higher flood risk are considered. The functional floodplain, Flood Zone 3b, should be protected; only essential infrastructure development that passes the Exception Test and water compatible development should be permitted here;
- When locating sites in areas with medium or higher flood risk, it is necessary to take the vulnerability of the proposed development into account. The flood vulnerability reflects the land uses within the proposed development and is a measure of the level of resilience to

damage from flooding. The FRCC PPG categorises land uses into five vulnerability classes, ranging from essential infrastructure to water compatible development. These categories are used to determine the appropriateness of a given land use within each flood zone. The flood risk vulnerability classification is shown in Table 3 (taken from Table 2 of the FRCC PPG), and the flood risk vulnerability and flood zone 'incompatibility' is indicated in Table 4 (taken from Table 3 of the FRCC PPG); and,

- When allocating several developments of different vulnerabilities, it is practical to allocate the most vulnerable developments first to ensure optimum placement at lowest flood risk. However, less vulnerable developments should continue to follow the sequential approach within their boundaries in order to steer as much development as possible to areas of low flood risk. Developments should not simply be allocated to areas with an 'acceptable' level of flood risk, for example a 'more vulnerable' development should not be put in an area of medium flood risk if a suitable site is available in an area of low flood risk (i.e. taking other development considerations into account). A specific consideration for the City of London is commercial basement properties where critical infrastructure such as IT equipment can be located below ground level and but should be avoided if other areas with a lower risk of flooding are feasible on the site.

Within each area of flooding, new development should be directed to sites with lower flood risk, which generally involves allocating new development as close as possible towards the adjacent zone of lower probability.

The Sequential Test takes account of all sources of flooding such as fluvial, surface water runoff, groundwater or sewer flooding. Tidal and fluvial flood risk is specified using zones. The risk from other sources may be perceived as significant if persistent flooding has historically occurred or if modelling indicates a high likelihood of deep or fast flowing water.

More specifically, this SFRA identifies areas which are considered to have a high surface water flood risk. Proposed development within areas considered to be at a high risk of surface water flooding should be classified as though they are part of Flood Zone 3a when applying the Sequential and Exception Tests. However, it should be noted that the majority of new developments in the City of London fall within the Less Vulnerable classification and therefore the flood damage to people is likely to be limited.

Sequential approach

The City of London benefits from significant Tidal Flood Defence infrastructure and under ordinary operational conditions is not at risk of flooding from the Thames. It is considered appropriate to assess flood risk from tidal and fluvial sources within the City of London as 'low', however some areas are considered at greater residual risk which are located in an area impacted by Breach Modelling as shown in Figure 33014-COL-806-A and Figure 33014-COL-

807-A. These areas will therefore require greater consideration of factors such as flood resilience and safe access and egress.

Surface water, sometimes associated with sewer flooding, is a recognised source of flood risk within the City of London although limited. As shown in the risk of flooding from surface water mapping, a number of areas are impacted by surface water flooding. Avoiding areas at risk of surface water flooding is difficult, however new development can be designed to mitigate any associated risk. In addition, all brownfield redevelopment provides the opportunity to reduce surface water flood risk locally in a sustainable way, by implementing Sustainable Drainage Systems (SuDS), and reducing the peak rate and volume of surface water run-off when compared to the baseline condition. Redevelopment within areas of existing surface water flood risk must include appropriate mitigation measures to reduce flood risk.

Although there are a number of potential sources of flooding in the City of London, it is not practicable to apply the Sequential Test to differentiate potential development sites. There are several development pressures on the City of London due to the existing highly built form and shortage of land. Strategic Policy S3 of the City of London Plan identifies the housing need for City of London, with the number of new homes built by 2036 to exceed 2482. In order to achieve this target, it is necessary to fully optimise the delivery of new provision across the City of London, using land efficiently. Due to this shortage of options, some sites at risk of flooding may need to be considered.

Development in Flood Zone 2 and 3, and in areas at medium and high flood risk from all sources, will be considered although preference will be given to Flood Zone 1 and areas with no risk of flooding from all sources. Therefore proposals for development within Flood Zone 2 and 3 and in areas at medium and high flood risk from all sources will be generally deemed sequentially acceptable; however this will be subject to the criteria in Table 3 (which replicates Table 2 of the Flood Risk and Coastal Change PPG, 'Flood risk vulnerability and flood zone incompatibility') and meeting the requirements of the Exception Test, where applicable (e.g. residential development in Flood Zone 3).

In addition, self-contained basements or basement flats wholly or partially below ground, without freely available access to a habitable space above ground within the same dwelling are 'highly vulnerable' uses in accordance with Table 3. The City of London approach is to not allow these in high or medium surface water risk areas, Flood Zone 2, Flood Zone 3 or Rapid Inundation Zones.

Due to the built nature of the City of London and lack of developable space the Sequential Approach will be carried out vertically on development sites with 'Less Vulnerable' uses on lower floors and 'more vulnerable' uses located on higher levels where appropriate.

Table 3: Flood Risk Vulnerability Classification (from Flood Risk and Coastal Change PPG Table 2)

Classification	Land uses
Essential Infrastructure	• Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk. • Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including electricity generating power stations and grid and primary substations; and water treatment works that need to remain operational in times of flood. • Wind turbines.
Highly Vulnerable	• Police and ambulance stations; fire stations and command centres; telecommunications installations required to be operational during flooding. • Emergency dispersal points. • Basement dwellings. • Caravans, mobile homes and park homes intended for permanent residential use. • Installations requiring hazardous substances consent. (Where there is a demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or such installations with energy infrastructure or carbon capture and storage installations, that require coastal or water-side locations, or need to be located in other high flood risk areas, in these instances the facilities should be classified as 'Essential Infrastructure').
More Vulnerable	• Hospitals. • Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels. • Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels. • Non-residential uses for health services, nurseries and educational establishments. • Landfill and sites used for waste management facilities for hazardous waste. • Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.

Less Vulnerable	• Police, ambulance and fire stations which are not required to be operational during flooding. • Buildings used for: shops; financial, professional and other services; restaurants, cafes and hot food takeaways; offices; general industry, storage and distribution; non-residential institutions not included in the 'more vulnerable' class; and assembly and leisure. • Land and buildings used for agriculture and forestry. • Waste treatment (except landfill and hazardous waste facilities). • Minerals working and processing (except for sand and gravel working). • Water treatment works which do not need to remain operational during times of flood. • Sewage treatment works, if adequate measures to control pollution and manage sewage during flooding events are in place.
Water-Compatible Development	• Flood control infrastructure. • Water transmission infrastructure and pumping stations. • Sewage transmission infrastructure and pumping stations. • Sand and gravel workings. • Docks, marinas and wharves. • Navigation facilities. • Ministry of Defence, defence installations. • Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location. • Water-based recreation (excluding sleeping accommodation). • Lifeguard and coastguard stations. • Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms. • Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan.

Table 4: Flood Risk Vulnerability and Flood Zone 'incompatibility' (from Flood Risk and Coastal Change PPG, Table 3)

Flood Risk Vulnerability Classification	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
Flood Zone 1 and low risk from other sources	Exception Test not required	Exception Test not required	Exception Test not required	Exception Test not required	Exception Test not required
Flood Zone 2 and medium risk from other sources	Exception Test not required	Exception Test required	Exception Test not required	Exception Test not required	Exception Test not required
Flood Zone 3a and high risk from other sources	Exception Test required*****	Development should not be permitted	Exception Test required	Exception Test not required	Exception Test not required
Flood Zone 3b (functional floodplain)	Exception Test required******	Development should not be permitted	Development should not be permitted	Development should not be permitted	Exception Test not required******

***** In Flood Zone 3a, essential infrastructure should be designed and constructed to remain operational and safe in times of flood.

****** In Flood Zone 3b (functional floodplain), essential infrastructure that has to be there and has passed the Exception Test, and water compatible uses, should be designed and constructed to:

- remain operational and safe for users in times of flood;
- result in no net loss of floodplain storage; and,
- not impede water flows and not increase flood risk elsewhere.

3.3 The Exception Test

The Exception Test is appropriate where the Sequential Test is not able to deliver a sufficient number of suitable sites, and also where some continuing development is necessary for wider sustainable development reasons. This takes into account the need to avoid social or economic blight and the need for certain services to be near the communities they serve. For example, the flood risk due to siting a 'More Vulnerable' health service in Flood Zone 2 or surface water hotspot may be outweighed by the needs of a local community to have a health centre within a practicable distance. It may also be appropriate to use the Exception Test where restrictive national designations such as heritage designations (e.g. Conservation Areas and Listed Buildings), prevent the availability of sites in lower risk areas.

As site allocation is not generally promoted within the City of London, an assessment of the suitability of any proposed development in areas considered to be at risk from flooding must be made in reference to Table 3 and Table 4.

The NPPF requires that for the Exception Test to be passed:

1. It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a SFRA where one has been prepared; and,
2. A site-specific Flood Risk Assessment must demonstrate that 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.

Both elements of the test will have to be passed for development to be allocated or permitted.

Within the City of London, commercial development is the preferred option for sites adjacent to the River Thames, however residential development is occasionally proposed by applicants. Residential development is classified as 'More Vulnerable' and as land neighbouring the river is typically located within Flood Zones 2 or 3, this can conflict with the Sequential Test (refer to Table 3 and Table 4).

Due to the nature of flooding within the City of London, the Exception Test is applied to areas of high local surface water or sewer flood risk, depending on the vulnerability classification of the proposed land use.

3.4 Guidance on site-specific flood risk assessments

A site-specific flood risk assessment is carried out by (or on behalf of) a developer to assess the flood risk to and from a development site and should accompany a planning application where prescribed in footnote 55 of the National Planning Policy Framework. For development in the City of London a site-specific flood risk assessment should be produced for all Major Developments and any development within the City Flood Risk Area.

The assessment should demonstrate to decision makers how flood risk will be managed now and over the development's lifetime, taking climate change into account, and with regard to the vulnerability of its users.

The objectives of a site-specific flood risk assessment are to establish:

- whether a proposed development is likely to be affected by current or future flooding from any source;
- whether it will increase flood risk elsewhere;
- whether the measures proposed to deal with these effects and risks are appropriate;
- the evidence for the local planning authority to apply (if necessary) the Sequential Test, and;
- whether the development will be safe and pass the Exception Test, if applicable.

A flood risk assessment needs to be appropriate to the scale, nature and location of the development. The information provided in the flood risk assessment needs to be credible and fit for purpose. Site-specific flood risk assessments need to be proportionate to the anticipated degree of flood risk and make optimum use of information already available, including information in this Strategic Flood Risk Assessment, and the Environment Agency's flood maps and surface water flood risk information.

For large or vulnerable developments in areas of high risk, developers should consider consultation with the Environment Agency and/or any other relevant flood risk management bodies for more detailed advice in advance of submitting their planning application.

Below is an amended version of the guidance produced by the Environment Agency on what is needed in a site-specific flood risk assessment.

Site-specific flood risk assessment: Checklist

1 - Development site and location

Use this section to describe the site you are proposing to develop. It would be helpful to include a location map which clearly indicates the development site.

a. Where is the development site located? (e.g. postal address or national grid reference)

b. What is the current use of the site? (e.g. undeveloped land, housing, shops, offices)

c. Which Flood Zone (for river or sea flooding) is the site within? (i.e. Flood Zone 1, Flood Zone 2, Flood Zone 3). As a first step, you should check the Flood Map for Planning. Check this Strategic Flood Risk Assessment to identify if the site is within Flood Zone 1 but at increased risk of flooding in future due to climate change.

d. Also check the Strategic Flood Risk Assessment to identify if there are any other sources of flooding that may affect the site now or in the future.

2 - Development proposals

You can use this section to provide a general summary of the development proposals. It would be helpful to include an existing block plan and a proposed block plan, where appropriate.

a. What are the development proposal(s) for this site? Will this involve a change of use of the site and, if so, what will that change be?

b. In terms of vulnerability to flooding, what is the vulnerability classification of the proposed development? See Table 3 for an explanation of the vulnerability classifications.

c. What is the expected or estimated lifetime of the proposed development likely to be (e.g. 100 years or 75 years)?

3 - Sequential Test

For developments in areas identified as being at risk of any source of flooding now or in the future. (If the development lies outside such areas, you can skip this section and go to the next section.)

You can use this section to describe how you have applied the Sequential Test (if needed as set out in paragraphs 162 to 163 of the National Planning Policy Framework) to the proposed development, and the evidence to demonstrate how the requirements of the test have been met. See guidance on the sequential approach for further information.

a. What search area have you used to identify alternative sites with a lower risk of flooding? What is your justification for choosing this search area?

b. Which alternative site(s) within the search area have you identified? Do you consider the site(s) to be reasonably available and appropriate for the proposed development? If not, what is your justification for this? With reference to the relevant strategic and site-specific flood risk assessments, are the sites at lower flood risk than your proposed site?

c. If you have identified any reasonably available, lower risk site(s), appropriate to the proposed development, do you consider there to be any other wider sustainable development objectives that would make steering the development to these other locations inappropriate? If so, please explain and justify this.

d. As well as flood risk from rivers or the sea, have you taken account of the risk from any other sources of flooding, such as surface water, in selecting the location for the development?

4 - Climate Change

How is flood risk at the site likely to be affected by climate change? Further advice on how to take account of the impacts of climate change in flood risk assessments is available from the Environment Agency.

5 - Site specific flood risk

You can use this section to describe the risk of flooding to and from the proposed development over its expected lifetime, including appropriate allowances for the impacts of climate change. It would be helpful to include any evidence, such as maps and level surveys of the site, flood data sets (e.g. flood levels, depths and/or velocities) and any other relevant data (e.g. speed of onset and duration), which can be acquired through consultation with the Environment Agency, the City of London Corporation LLFA, or any other relevant flood risk management authority.

Alternatively, you may consider undertaking or commissioning your own assessment of flood risk, using methods such as computer flood modelling.

a. What is/ are the main source(s) of flood risk to the site? (e.g. tidal/sea, fluvial or rivers, surface water, groundwater, other?). You should consider the flood mapping available from the Environment Agency's Flood Map for Planning, this Strategic Flood Risk Assessment, historic flooding records (e.g. the historic flood map and Section 19 flood investigation reports) and any other relevant and available information.

b. What is the probability of the site flooding, taking account of the maps of flood risk available from the Environment Agency's Flood Map for Planning, this Strategic Flood Risk Assessment and any further flood risk information?

c. Are you aware of any other sources of flooding that may affect the site? What are the interactions between different sources of flooding?

d. What is the expected depth and level for the design flood? If possible, flood levels should be presented in metres above Ordnance Datum (i.e. the height above average sea level).

e. With any relevant flood risk management infrastructure operating effectively, are properties expected to flood internally in the design flood and to what depth and velocity? The nature of any internal flooding resulting from any residual risk should also be specified. Internal flood depths should be provided in metres.

f. How will the development be made safe from flooding and the impacts of climate change, for its lifetime, taking residual risk into account?

g. How will you ensure that the development and any measures to protect the site from flooding will not cause any increase in flood risk off-site and elsewhere? Have you taken into account the impacts of climate change, over the expected lifetime of the development (e.g. providing compensatory flood storage which has been agreed with the Environment Agency)?

h. Are there any opportunities offered by the development to reduce the causes and impacts of flooding?

i. What are the sources of uncertainty in the assessment of risk and how have they been accounted for in the proposed strategy for addressing flood risk?

6. Surface water management

You can use this section to describe your arrangements for surface water management. Alternatively, these details could be presented in a separate sustainable drainage strategy.

7. Occupants and users of the development

You can use this section to provide a summary of the numbers of future occupants and users of the new development; the likely future pattern of occupancy and use; and proposed measures for protecting vulnerable people from flooding.

a. Will the development proposals increase the overall number of occupants and/or people using the building or land, compared with the current use? If this is the case, by approximately how many will the number(s) increase?

b. Will the proposals change the nature or times of occupation or use, such that it may affect the degree of flood risk to these people? If this is the case, describe the extent of the change.

c. Where appropriate, are you able to demonstrate how the occupants and users that may be more vulnerable to the impact of flooding (e.g. residents who will sleep in the building; people with health or mobility issues etc) will be located primarily in the parts of the building and site that are at lowest risk of flooding? If not, are there any overriding reasons why this approach is not being followed?

8. Exception Test

You can use this section to provide the evidence to support certain development proposals in Flood Zones 2 or 3 or other areas of medium to high flood risk if, following application of the Sequential Test, it is appropriate to apply the Exception Test, as set out in paragraphs 163-164 of the National Planning Policy Framework.

a. Would the proposed development provide wider sustainability benefits to the community? If so, with reference to the site-specific flood risk assessment, could these benefits be considered to outweigh the flood risk to and from the proposed development?

b. How can it be demonstrated that the proposed development will remain safe over its lifetime, taking account of the vulnerability of its users, without increasing flood risk elsewhere?

c. Will it be possible for the development to reduce flood risk overall (e.g. through the provision of new or improved flood defences, or improved drainage)?

9. Residual risk

You can use this section to describe any residual risks that remain after the flood risk management and mitigation measures are implemented, and to explain how these risks can be managed to keep the users of the development safe over its lifetime.

a. What flood related risks will remain after the flood risk avoidance, management and mitigation measures have been implemented?

b. How, and by whom, will these residual risks be managed over the lifetime of the development? (e.g. putting in place emergency plans).

10. Flood risk assessment credentials

You can use this section to provide details of the author and date of the flood risk assessment.

a. Who has undertaken the flood risk assessment?

b. When was the flood risk assessment completed?

4 Flood Emergency Plans

4.1 Overview

The National Planning Policy Framework (NPPF) states that development should only be allowed in areas at risk of flooding where it can be demonstrated (supported by a site-specific flood risk assessment) that the following apply:

a. Within the site, the most vulnerable development is located in areas of lowest flood risk, unless there are overriding reasons to prefer a different location;
b. The development is appropriately flood resistant and resilient;
c. It incorporates sustainable drainage systems, unless there is clear evidence that this would be inappropriate;
d. Any residual risk can be safely managed; and
e. Safe access and escape routes are included where appropriate, as part of an agreed emergency plan.

NPPF Practice guide paragraph 047 states 'Access considerations should include the voluntary and free movement of people during a 'design flood', as well as the potential for evacuation before a more extreme flood, considering the effects of climate change for the lifetime of the development. Access and escape routes need to be designed to be functional for changing circumstances over the lifetime of the development'.

To assist with the preparation of a Flood Emergency Plans (FEP) for new developments the City Corporation has produced a planning advice note. This sets in the context of the City of London guidance produced by ADEPT. This guidance is available in Appendix D.

This sets out when a Flood Emergency Plan is needed and when access and escape routes will be agreed or when further information will be required. This is based on the vulnerability of the development and the level of flood hazard on the proposed routes.

5 Recent flooding history

5.1 Overview

The City Corporation investigates all flooding reported to it. As part of this investigation the mechanism causing the flooding is assessed and further actions recommended based on this. Figure 1 shows the spread of these flooding reports in relation to the City Flood Risk Area, each point showing a single report. The City Corporation also writes up a formal Section 19 flood investigation report where flooding (not the result of site maintenance) affects more than one property.

5.2 Flooding Reports 2015-2022

Since the Lead Local Flood Authority formally began investigating flooding reports in April 2015 there have been fourteen such reports covering flooding at sixteen properties. Of these, eleven reports were deemed to be the result of local maintenance issues, either blockages to the local drainage network or inadequacies in basement water tanking. Whilst these reports often coincided with more extreme rainfall incidents their property level issue flooding mechanism means that they were ruled out of the scope flooding considered under a Section 19 flood investigation. This is on the basis that had the reason for flooding (unblocked gully etc) been previously remedied flooding would not have occurred.

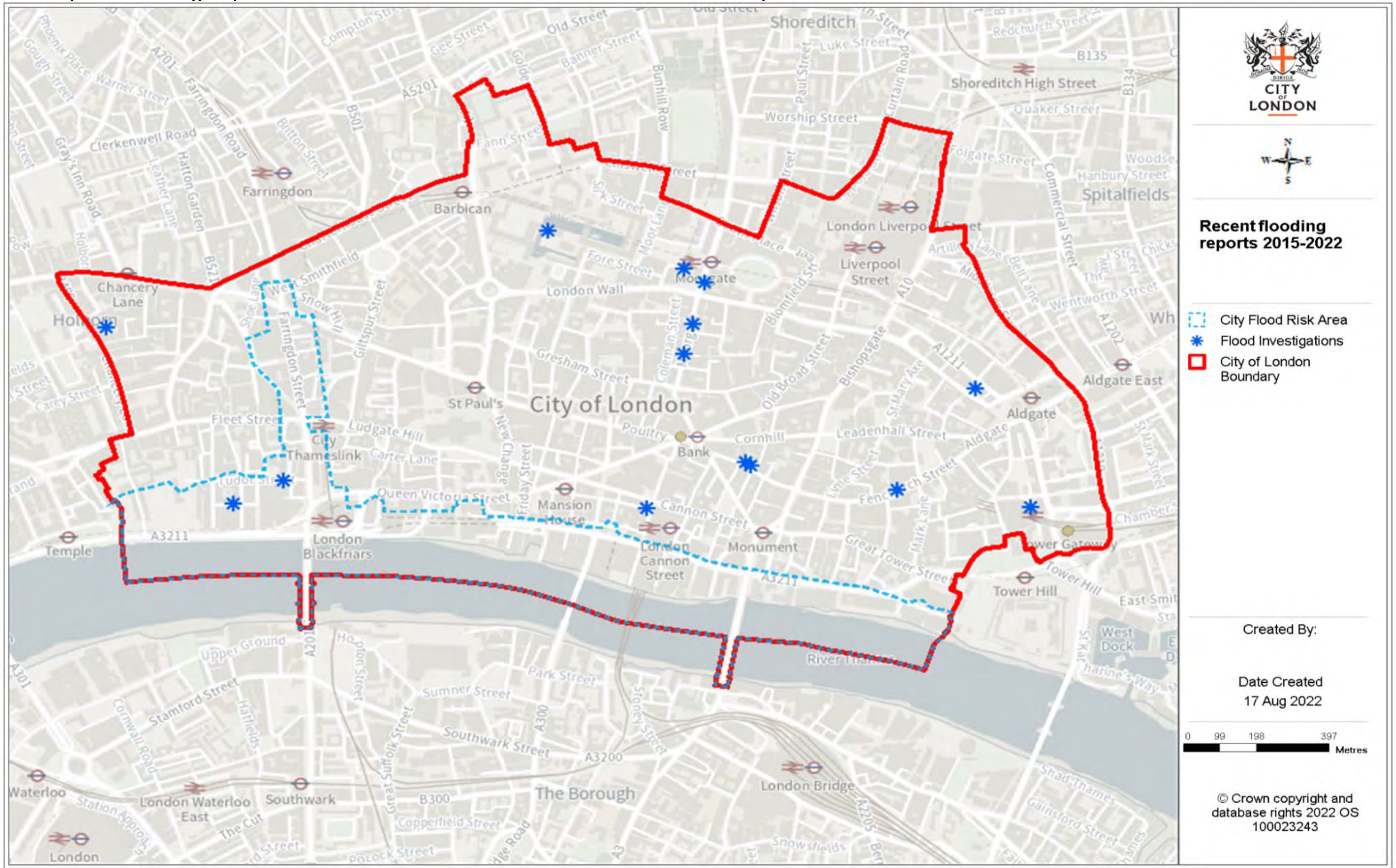
Removing these property level issue flooding reports leaves just three reports, two from June 2016 and one from July 2021.

The flooding on 22nd June 2016 was the result of an extreme rainfall event. Approximately 45mm of rain fell in central London within a couple of hours, the monthly rainfall for June is on average 53mm. This resulted in flooding in two areas of the City (Moorgate and Blackfriars/Temple) flooding two properties in each. This is the only flooding incident to trigger a Section 19 investigation report in this period and occurred before the last SFRA review in 2017. The flooding in Blackfriars and Temple is in an area modelled as being at risk of surface water flooding and validates the modelling in this area. The flooding in Moorgate is not in the City Flood Risk Area or modelled as at risk of surface water flooding. However, in total four of the fourteen reports of flooding have been in the Moorgate area. Moorgate is also known to be the head of the former Walbrook catchment. Whilst the Moorgate area has not been shown to be at risk of flooding through modelling, its clear from the number of property level flooding incidents that it is particularly sensitive to the maintenance of an efficient drainage system.

The flooding on 25th July 2021 was also the result of an extreme rainfall event. The centre of the rainstorm was to the east of the Square Mile and caused widespread flooding across northeast London. Its impact in the City was comparatively limited, albeit significant where it did have an impact.

There has been a relatively limited number of flooding events in the City of London since the LLFA has been investigating flooding. The majority of these

Figure 1: Map of flooding reports between 2015 and 2022 in relation to the City Flood Risk Area



are attributable to just four rainfall events all of which occurred in the summer and early autumn (June 2016, July 2019, September 2019, July 2021). The majority of these reports revealed property level issues with maintenance which led to flooding of individual sites.

Table 5 Flood investigation summary 2015-2022

Date	Location	Number of properties	Flooding mechanism	Section 19
22/06/2016	Moorgate area	2	Sewer surcharge/ waterproofing	Yes
	Temple/ Blackfriars	2	Sewer surcharge/ waterproofing	
11/06/2019	Fenchurch Street	1	Property waterproofing	No
	Lombard Street	1	Property waterproofing	
	Barbican	1	Property waterproofing	
25/09/2019	Moorgate	1	Property waterproofing	No
	Lombard Street	1	Property waterproofing	
	Dowgate Hill	1	Blockage	
	Fore Street/ Moorgate	1	Blockage (temporary site works)	
29/06/2021	Chancery Lane	1	Blockage	No
25/07/2021	Moorgate	1	Blockage	No
	Blackfriars	1	Sewer surcharge	
08/2021	Dukes Place	1	Property waterproofing	No
08/2021	Vine Street	1	Blockage	No

Two of the events (June 2016 and July 2021) resulted in flooding in an area modelled as being a hotspot for surface water flooding. Where this occurred the investigating officers made recommendations to the building owners to install property level flood resilience measures to avoid future surcharging into the premises.

A number of the flood reports occurred in the catchment of the former Walbrook tributary, primarily in the Moorgate area but also in Dowgate. The majority of these were property level maintenance issues. However, the prevalence of incidents within this area demonstrates a reliance on the existing drainage infrastructure. Due to the presence of a normally efficient drainage system this area has not been identified in modelling as at risk of surface water flooding. The increased numbers of reports in this area demonstrates the importance of maintaining drainage systems, and this has been reflected in the recommendations of flood investigating officers.

6 Fluvial and tidal flood risk

6.1 The NPPF flood zones

The City of London is located on the north bank of the tidal River Thames and is defended from fluvial and tidal flooding by the Thames Barrier and its flood defences along the River Thames. Parts of the City of London are however within Flood Zones 2 and 3 because these zones have been created assuming that there are no defences in place (see Figure 33014-COL-301 – Flood Map for Planning – Flood Zone 2 Extent and Figure 33014-COL-302 – Flood Map for Planning – Flood Zone 3 Extent in Appendix A).

In accordance with the NPPF, the City of London Corporation and developers must take into account the potential flood risk to the City of London using the Sequential and Exception Tests which aim to promote development in areas with the lowest probability of flooding. The tests provide a risk-based approach which categorises flood risk using flood zones which have been defined by the Environment Agency, and alternative metrics to account for other sources of flooding.

Flood Zone 1

Land within Flood Zone 1 is considered to have a low probability of flooding with land assessed as having less than a 1 in 1000 annual probability of flooding from rivers and seas (<0.1%). All land uses are considered appropriate within Flood Zone 1.

The policy aims for this zone are for developers and local authorities to seek opportunities to reduce the overall level of flood risk in this area and beyond through the layout and form of the development, and the appropriate application of SuDS.

Flood Zone 2

Land within Flood Zone 2 is considered to have a medium probability of flooding, with land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% - 0.1%), or between a 1 in 200 and 1 in 1,000 annual probability of sea (tidal) flooding (0.5% - 0.1%) in any year. As set out in Table 4, the appropriate uses are essential infrastructure, water compatible developments, less vulnerable and more vulnerable uses. Highly vulnerable uses (i.e. police and ambulance stations) are only appropriate if the Exception Test is passed).

The policy aims for this zone are for developers and local authorities to seek opportunities to reduce the overall level of flood risk in the area through the layout and form of the development, and the appropriate application of SuDS.

Flood Zone 3a

Land within Flood Zone 3a is considered to have a high probability of flooding, with land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year. Water compatible and less vulnerable uses are appropriate in this zone. Highly vulnerable uses are not permitted. More vulnerable uses and essential infrastructure are only permitted if the Exception Test is passed.

The policy aims for this zone are to reduce the overall level of flood risk in the area through the layout and form of the development, and the appropriate application of SuDS. Existing development should be relocated to zones with a lower probability of flooding. Space should be created for flooding to occur by restoring the floodplain and flood flow pathways, and by identifying, allocating and safeguarding open space for flood storage.

Flood Zone 3b

Land within Flood Zone 3b is where water has to flow or be stored in times of flood. The areas and boundaries of the functional floodplain should be agreed with the Environment Agency and identified in the SFRA. The probability of flooding within Flood Zone 3b is defined between the Local Planning Authority and the Environment Agency. However, it is typically a 1 in 30 annual probability of flooding from rivers and seas (3.3%).

There is no Flood Zone 3b in the City of London as all rivers apart from the River Thames have been culverted and form part of the combined sewer network, and the remaining River Thames floodplain is completely defended by a continuous line of flood defence walls.

6.2 Identification of fluvial and tidal flood risk

The Flood Map for Planning (Rivers and Sea) was prepared by the Environment Agency in 2017 to show the natural floodplain, ignoring the presence of defences for flood events occurring from rivers or the sea. The maps provide a high-level assessment for flood risk for England and Wales and should be supplemented with information from local investigations.

The maps have been produced from a combination of a national generalised computer model, more detailed local modelling (where available), and some historic fluvial flood event outlines.

The majority of the City of London, beyond 200m from the River Thames, is within Flood Zone 1 and therefore, has a low probability of flooding from the river. This is due to a rise in ground topography northwards away from the River Thames. In contrast, the areas within 200m from the River Thames are within Flood Zones 2 and 3a.

The Flood Map's for the City of London are provided in Figures 33014-COL-301- Flood Map for Planning – Flood Zone 2 Extent and 33014-COL-302 - Flood Map for Planning – Flood Zone 3 Extent in Appendix A.

6.3 Historical flooding

The City of London is protected by large scale river flood defences. Subsequently, there have been limited historical flood incidents. The last recorded incident of tidal flooding in the City of London was in 1928. Significant flooding was noted along the entire river frontage, extending northwards through Inner Temple Gardens, along Castle Baynard Street and Lower Thames Street. The flooding was caused by tidal inundation, which resulted in overtopping of the existing defences.

The Historic Flood Map for the City of London is provided in Figure 33014-COL-303 – Historic Flood Map in Appendix A.

6.4 The Thames defences

The Thames Barrier is one of the largest movable flood barriers in the world, spanning 520m across the River Thames near Woolwich. It protects approximately 125km^2 of Central London from flooding caused by tidal surges. Additional structures to protect London from flooding include approximately 350km of flood defence walls and embankments, tidal barriers, flood gates and pumping stations. The City of London's defences were designed to offer protection against an event that has an annual probability of occurrence of 1 in 100 (1% AEP) up to 2030.

The statutory flood defence level within the City of London upstream of London Bridge is 5.41m AOD, and downstream of London Bridge is 5.28m AOD. However, the flood defences in the City of London currently range between 5.28m AOD and 6.75m AOD. These levels were obtained from the Environment Agency's Spatial Flood Defence shapefile (Environment.data.gov.uk, 2017) The flood defences are generally in fair condition which means that there are defects that could reduce the performance of the asset.

In 2002, the Thames Estuary 2100 project was set up by the Environment Agency with the aim of developing a strategic flood risk management plan for London and the Thames Estuary through to 2100. The Thames Estuary 2100 Plan published in 2012 sets out a series of options that have been proposed and have been designed to be undertaken in three phases to allow for adaptability as the knowledge of climate change improves:

- For the first 25 years (2010 – 2034), the Environment Agency recommends continuing with how flood risk is managed today by actively maintaining and improving the existing flood protection in London and the Thames Estuary. Space for future flood risk management will be safeguarded. All TE2100 information will be made available so that it can be used to inform regional and local strategic and spatial planning;
- The middle 35 years (2035 – 2069) will see major renewal and replacement of Thames tidal flood defences which will bring

opportunities to reshape and renew the riverside. Defences will require raising approximately 1m during this time period, however this is dependent on the rate of sea level rise. During this period, a decision will be made on the option to be adopted for implementation by the end of the century; and,

- The final 30 years (2070 – 2100) are designated for preparing and moving to the 22nd Century. Based on current climate change guidance, it is envisaged that a major change in how flood risk is managed in London and the Thames Estuary will be required. The two options at the forefront at present are, to continue to maintain and improve existing defences or to build a new barrier at Long Reach.

An updated Thames Estuary 2100 Plan is due to be published in 2023, this follows a ten yearly review that has re-assessed the economic case for the plan, the rate of sea level rise and success of the plan in its first 10 years.

The City of London Riverside Strategy sets out how the changes to the Thames flood defences in the Square Mile could be managed. The City of London Riverside Strategy is covered in more detail in Chapter 13.

The existing flood defences map (and associated condition rating) for the City of London is provided in Figure 33014-COL-304 – Flood Defence Condition Map in Appendix A.

6.5 Fluvial and tidal residual flood risk

Areas behind defences are at risk of residual flooding from fluvial or tidal sources due to a breach or overtopping of the defences.

Breaching of flood defences can cause rapid inundation of areas behind flood defences due to a defence collapsing or failing. Breaching is caused by water eroding the material through the embankment (typically earth embankments) or the surface of the defence i.e. the structure toe. It does not affect the crest level of the structure. Breaching of defences generally occurs with little to no warning and coincides with extreme tides or water levels. There is a significant risk of damage to buildings or loss of life. Environment Agency guidance requires that sleeping accommodation should not be in areas at risk of flooding breach.

Overtopping of flood defences occurs when the water level from an extreme event exceeds the height of the defence. This can cause rapid inundation and prolonged flooding behind a defence. Cyclic overtopping is caused by wave action on water levels below the height of the defence. Climate change will increase the chance of overtopping occurring.

Typically, the height of the defence includes a freeboard to reduce the chance of overtopping occurring. The Maximum Likely Water Level for the City of London is between 4.80m AOD and 4.83m AOD, which means that flood defences in the City of London have a minimum freeboard of 0.48m.

As part of TE2100, a Thames Tidal Upriver Breach Inundation Assessment (May 2017) was carried out by the Environment Agency. Hydraulic modelling was carried out downstream of Teddington Lock to consider the velocity, depth and path of flooding should failure of defences occur. The breach modelling was undertaken for the 'Maximum Likely Water Level' (MLWL). The MLWL was calculated based on the maximum water levels allowed upstream of the Thames Barrier, based on the barrier operating under the current closure rule. The modelling was run for two climate change epochs: 2005 and 2100. Thames tidal water level profiles were obtained from the existing Thames 1D ISIS River Model.

The Thames tidal defence line was used to define the breach locations. It was assumed that the breach length for hard defences was 20m and 50m for soft defences. This resulted in 5,679 potential breach locations. The breach modelling makes assumptions regarding the physical formation of a breach, particularly the sill level and scour zone. A sill level is required to lower the ground model to represent the breaching of the defence and resultant scouring that would occur. The lowered ground model was represented within the model at the start of the simulation and subsequently assumes that the failure of the defence occurred before the water fully abuts the defence line.

The breach mapping for the present day in Appendix A shows more detailed modelling results on flood depth, velocity and flood hazard (Figures 33014-COL-306 to 33014-COL-308). The flood hazard mapping combines water depth, velocity and debris to calculate hazard areas. The majority of the Embankment area is classified as 'danger to most' with the exception of a 350m frontage in Blackfriars which is classified as 'danger for all'.

The breach mapping for the 2100 epoch can be found in Appendix A (Figures 33014-COL-309 to 33014-COL-3011). The majority of the Embankment area is classified as 'danger to most with the exception of Temple Avenue and part of Blackfriars Underpass which are classified as 'danger for all'.

7 Surface water flood risk

7.1 Overview

Surface water flooding occurs when intense rainfall is unable to drain away by traditional means such as into drainage systems, which may already be overloaded, or by infiltrating into the ground. Due to the built-up nature of the City of London, and its limited drainage capacity, surface water flooding is the most likely cause of flooding.

Climate change means that the number of extreme rainfall events within the City of London will increase due to an increase in peak rainfall intensity. The capacity of existing drainage systems will be exceeded more frequently, and the ground will be more saturated - runoff will exceed the rate at which it can soak into the ground. This will result in an increased risk of surface water flooding. Due to the reliance on the drainage system in the City of London surface water flooding is closely linked to sewer flooding which is covered in Chapter 8.

This SFRA has built upon the existing understanding of surface water flooding developed as part of the 2012 update of the SFRA and additional surface water modelling undertaken as part of the 2017 update.

7.2 Historical flooding

There is little evidence of historical flooding from surface water within the City of London apart from fire brigade records which do not determine if flooding has been the result of surface water flooding or other sources.

There are no formal records of significant surface water flooding in the City of London. However, historical flood records are not a good indicator of future flood risk as climate change means that surface water flood events are likely to increase.

The City of London Corporation as LLFA is committed to investigate flooding where more than one property is affected by a single flood event. Recent investigations are covered in detail in Chapter 5.

7.3 Updated flood map for surface water

The Environment Agency has published the updated Flood Map for Surface Water (uFMfSW) which was based on computational hydraulic modelling. The City of London provided additional modelling results for the uFMfSW as a result of the detailed 1d-2d modelling undertaken for the 2012 SFRA, which included the Thames Water sewer network. The mapping provides surface water flood extents for three storm events: the 1 in 30 annual probability, 1 in 100 annual probability and 1 in 1000 annual probability. The mapping also provides information on the depth and velocity of flooding expected.

The Flood Map for Surface Water for the City of London is provided in Figure 33014- COL-401 – Environment Agency Risk of Flooding from Surface Water Mapping in Appendix A.

The Environment Agency as part of the National Flood Risk Assessment 2 (NaFRA2) is undertaking work on new national modelling which will include updated surface water flood modelling. This and any associated new maps are due to be published in 2024.

7.4 Drain London modelling

The Drain London partnership undertook 2d modelling to assess the surface water flood risk within London as part of the Surface Water Management Plan (SWMP) studies.

The 2d model of Greater London was undertaken using TUFLOW. Due to the size of the model of Greater London, it was split into a subset of group areas. The City of London fell within Group 3.

The modelling had a number of limitations. These included:

- The sewer network was not modelled;
- The allowance for the pipe flows was taken off directly from the rainfall in all land use areas;
- Kerbs were not modelled;
- The modelled topography used a constant 5m grid;
- Obstructions such as railway embankments were modelled however, culvert crossings beneath them were not modelled;
- Infiltration was modelled through the use of variable runoff rates depending on land use; however this was limited to the land uses defined by OS MasterMap; and,
- Modelling runs did not include the 0.5% annual probability event.

Critical Drainage Areas

Due to the connected nature of the combined sewer system within the City of London all areas potentially could contribute to an increased risk of flooding elsewhere. Therefore the whole of the City of London should be considered as a Critical Drainage Area (CDA) as designated by the Lead Local Flood Authority.

7.5 The 2012 SFRA model

As part of the 2012 update of the City of London SFRA, Halcrow developed a detailed model (the 2012 SFRA model) which removed many of the assumptions of the model undertaken as part of the Drain London project. It investigated how surface water will behave across the City of London, taking into account the interaction with the existing combined sewer network, the local topography and urbanisation. The study recommended a number of high-level options to resolve flood risk.

The 2012 SFRA model was a 1d-2d model. It used the 1d Thames Water Infoworks sewer Beckton model (the 1d Beckton model) and then was expanded to 2d, to simulate flow paths and flood depths over the digital ground terrain of the City of London.

The 2012 SFRA model applied the event rainfall across the whole of the upstream combined sewer network catchment, which resulted in large flows in the combined sewers in the City. These large flows resulted in flooding at critical locations in the City due to surcharging and overflowing of manholes and gullies, combined with overland flows not being able to enter into the surcharged sewers. A large catchment-wide storm covering many London Boroughs is a rarer event than a localised storm in the City and therefore it represents a conservative assessment of surface water flood risk.

The hydraulic modelling considered the following return periods: 1 in 5, 30, 75, 200 and 100 annual probability plus climate change (30% increases in rainfall intensity). The model has been subsequently re-run with a climate change allowance of a 40% increase in rainfall intensity to take account of the latest guidance.

The 2012 SFRA model identified the following flooding mechanisms at four main flood risk areas:

- Farringdon Street is located on the Fleet sewer, a culverted watercourse that drains a large catchment and subsequently fills to capacity during large rainfall events. Additionally, there is a dip in ground levels on Farringdon Street which results in lower water levels required to surcharge the Fleet Sewer. Finally, due to the proximity of Farringdon Street to the River Thames, water is often unable to discharge into the river and subsequently, backs up along the Fleet sewer. With the construction of the Thames Tideway scheme (which has the purpose of intercepting overflows into the River Thames) backing up will occur less frequently; however this is still anticipated to take place for the design catchment-wide storm adopted in the 2012 SFRA modelling, as the tunnel itself will be full;
- New Bridge Street experiences surface water flooding as an extension to the Farringdon Street flooding. Additionally, the proximity of New Bridge Street to the River Thames means that manholes are more likely to surcharge if surface water cannot be discharged into the river. The Thames Tideway scheme will also in this case reduce the frequency of backing up of water, however not for catchment-wide storms as the tunnel itself will be full;
- Victoria Embankment experiences surface water flooding, during an event with a 3.33% annual probability, due to a single surcharging manhole near to Blackfriars Bridge. Additional rainfall will cause flooding along Victoria Embankment due to two more manholes surcharging at Tallis Street and Temple Avenue. However, due to the local topography, the majority of flooding is relatively shallow; and,
- St Pauls Walk, Thames Riverside floods due to several manholes surcharging at different locations around St Pauls Walk. The

surcharging is caused by the relatively low ground levels relative to the sewer interceptor which they ultimately discharge into.

During more extreme flood events, the modelling indicated that additional flooding occurs at the eastern end of the Thames Embankment and along Blomfield Street, Appold Street, Worship Street and Curtain Road to the north east of the City of London.

7.6 The WCC model

In 2015 Westminster City Council (WCC) undertook similar detailed modelling as the City of London 2012 SFRA; it used the 1d Beckton model from Thames Water and expanded to 2d. The WCC model is relevant for this study as the outputs expanded beyond Westminster and included the adjacent City of London to the east. As part of the 2017 SFRA update the WCC model was expanded, by modelling in further detail within the City of London.

There were two improvements in the WCC model (and the 2017 updated version within the City of London) when compared to the 2012 SFRA model:

1. The 1d Beckton model provided to Westminster City Council in 2015 was a calibrated version for a number of events at key locations in the sewer system (whereas the 1d Beckton model provided for the 2012 SFRA model was not calibrated). None of the calibration events however were large enough to result in flooding of roads or property and therefore, there is still uncertainty in terms of accuracy of the 1d Beckton model for extreme events.
2. In the WCC model and its updated version, direct rainfall was applied on roads in the upstream catchment and surrounding areas to better represent the dynamic attenuation storage and conveyance of roads, whereas the 2012 SFRA model had inflows directly into manholes (with no attenuation on roads).

The Updated WCC model and its updated version include the following rainfall events: 1 in 5, 1 in 30, 1 in 100 and 1 in 100 year plus climate change (40% increase in peak rainfall intensity) annual probability.

A comparison of the results between the 2012 SFRA model and the updated version of the WCC model indicate that the flood mechanism is the same and the flood risk areas are in general similar. However the extents, depth and frequency of flooding are reduced in the updated version of the WCC model (for further details refer to Appendix C).

7.7 Updated 1D Beckton model

Since the release of the 1d Beckton model in 2015 (calibrated version), Thames Water has further improved it and has a new updated version; this new version is no longer available for expansion to 2d as, due to its complexity, Thames Water has decided to only provide the 1d results (not the model).

The updated 1d Beckton model includes all the return periods and climate change scenarios as for the updated WCC model.

The results from the updated 1d Beckton model cannot be represented in 2d, and the accuracy of the model is significantly reduced for return periods above the 1 in 30 annual probability event (a 1d model). Despite these limitations it has been possible to map manholes where these overflow into the 2d domain and to compare against similar maps (of overflowing manholes) from the 2012 SFRA model and the updated WCC model.

A comparison of the results (the number and locations of overflowing manholes) for the City of London, from the 2012 SFRA model, the updated WCC model and the updated 1d Beckton model, indicate that the flood mechanism is the same and the flood risk areas are in general similar from all these models. However the extents, depth and frequency of flooding from the updated 1d Beckton model fall between the results from the 2012 SFRA model and the updated WCC model (for further details refer to Appendix C).

7.8 Modelling outputs for use in this SFRA

This Section has summarised all the relevant catchment-wide storm modelling undertaken to date for the City of London (sensitivity tests for localised models are included in Appendix C). Based on the comparison of the results it is recommended that the surface water modelling outputs from the 2012 SFRA model continue to be used for this SFRA update, to inform policy and SFRA guidance. This is a cautious approach when compared to using the least conservative outputs from the updated WCC model, since the results from the latest 1d Becton model fall in between the more conservative 2012 outputs and the less conservative 2017 outputs (in terms of number and locations of manholes overflowing). Mapping showing the extent and depth of surface water flood risk for a range of flood risk events are provided in Appendix A (Figures (Figures 33014-COL-402 to 33014-COL-405).

This assessment confirms that there is a large uncertainty in the results depending on the type of modelling (1d versus 1d-2d and the level of detail and approach taken in the 2d element), the adopted design storm and the accuracy of the 1d Beckton model. Because of this, it is important that future SFRA updates follow a similar approach to this study; to compare any new modelling outputs against previous modelling prior to selecting the surface water modelling outputs for use in future SFRAs.

8 Sewer flood risk

8.1 Overview

Sewer flooding occurs when there is increased flow in a sewer which may result in the system reaching capacity and becoming overwhelmed. Sewage overflows from manholes and gullies, flooding land, rivers, gardens and, in extreme scenarios, commercial buildings and homes. Within the Thames Water network, 1,216 properties experienced internal flooding as a result of sewer flooding in 2015/2016 (Thames Water, 2017a).

Sewer flooding is typically caused by heavy rainfall or blockages in the system. The frequency of sewer flooding is increasing due to climate change, population growth and increased impermeable areas. There is an increased risk of sewer flooding within the City of London due to London having combined sewers, as opposed to two separate networks which deal with foul water and surface water separately.

The 2007 SFRA collated important information on the existing sewer system which is summarised within this section. Additionally, as part of the 2012 SFRA, the surface water modelling undertaken by Halcrow included the sewer network and subsequently includes an assessment of sewer flood risk combined with overland flows not been able to enter the system (these combined sources of flooding have been included in the surface water flood risk in Section 7.5).

8.2 The sewer system

The existing sewer system in London was constructed in the 19th century. The sewer system consists of combined sewers which were initially designed to collect foul water only. However, the spare capacity of the sewers at the time and surface water flood risk incidents, resulted in a decision to use the sewers, also for the collection of surface water. Six main interceptor sewers were built and fed by 450 miles of main sewers and 13,000 miles of local sewers which historically discharged into the River Thames.

The main sewers and local sewers within the City of London receive flows from Westminster, Kensington and Chelsea, Hammersmith and Fulham, and Camden and Islington. Flows from these ultimately discharge into the two low level relief sewers which pass through the City of London, running parallel to the River Thames. The two low level relief sewers transfer flows towards Tower Hamlets. As a failsafe, 57 combined sewer overflows (CSOs) were built to discharge into the Thames during extreme events.

The six main interceptors incorporated some of London's lost rivers including the River Fleet and the River Walbrook which drained through the City of London. The River Fleet originated from springs on Hampstead Heath and drained through Kentish Town, Camden Town and Holborn before joining the River Thames at Blackfriars Bridge. The River Walbrook has a much smaller catchment as it historically drained a marsh area within the City of London boundary. A map of the sewers within the City of London can be found in

Figure 33014-COL-601 – Sewer Locations in Appendix A. Figure 33014-COL-602 – River Fleet and Walbrook Catchments in Appendix A shows the indicative catchments of the sewers that the Rivers Fleet and Walbrook are contained within.

The combined sewers have brickwork culverts which outfall into the River Thames. Based on present day forecasting for heavy rainfall events, it is predicted that the culverts only have capacity for the 1 in 10 annual probability flood event. Additionally, any new surface water sewers have been designed to hold the 1 in 30 annual probability flood event. Subsequently, London experiences flooding as a result of a lack of sewer capacity, although the events are generally of small consequence (mainly flooding of roads). However, climate change will result in summer storms increasing in frequency, and winter storms becoming more prolonged. This means that the current standard of protection for the existing sewer system will be reduced and more frequent localised flood events, as a result of sewer flooding, can be expected.

Due to the large sewer catchment of the two low level relief sewers, development upstream of the City of London could have a significant impact on flood risk in the City of London if surface water runoff is not properly managed. Similarly, development in the City of London could increase flood risk in Tower Hamlets to the east. The sewer catchments of the surface water flood risk hotspots in the City of London are shown in Figures 33014-COL-603 – Farringdon Street Sewer Catchment Area and Figures 33014-COL-604 – Paul's Walk Sewer Catchment Area in Appendix A.

8.3 Sewer flood risk with fluvial/tidal interaction

The sewer interceptor, which provides a hydraulic connection across the northern bank of the River Thames introduces a potential flood risk mechanism. Breaching or overtopping of defences could result in the defended area becoming inundated with flood water which will discharge into the interceptor sewer towards Tower Hamlets to the east. If the interceptor sewer reaches capacity, flooding may occur elsewhere due to the sewer surcharging. If there was not a sewer interceptor, flood water would naturally flow into the Thames when river levels recede.

This highlights the importance of maintaining the existing flood defences. However, there is still the potential for breaching or overtopping occurring due to riparian owners cutting through defences or carrying out activities which destabilise flood defences without permission.

8.4 Improvement works

As demonstrated in the previous sections, London's existing sewer system has little capacity to deal with increased rainfall. At present, excess rainfall is discharged into the River Thames through 57 storm overflows. The storm overflows within the City of London are located at Blackfriars, Bell Wharf Lane and Custom House. However, should water levels in the River Thames be higher than the overflows, storm water would be unable to discharge into the river and subsequently, the sewers would back up and surcharge. Whilst this risk is relatively low (due to the rarity of a high tide, storm surge and heavy rainfall occurring simultaneously), there is a chance of flooding to the low-lying areas within the Fleet Valley and areas behind the existing defences.

As the existing sewers are combined, flows in the sewers are contaminated with foul waste. In London, 39 million tonnes of foul waste is discharged into the River Thames annually. As little as 2mm of rain can cause sewers to discharge which occurs approximately once a week. Foul waste in the River Thames can damage water quality, endanger wildlife and poses a risk to human health.

As part of the Thames Tidal Tunnel, works are currently in progress to construct two new relief sewers: the Lee Tunnel (completed in January 2016) and the Thames Tideway Tunnel to reduce overflows into the River Thames. Additional works are being undertaken to improve London's five principal sewage treatment works to enable them to deal with additional flows.

With this new sewer interceptor in place, there is still the possibility of backing up and surcharging once the sewer interceptor is full. This situation would only occur however during a rare catchment-wide storm and will not be related to high water levels in the River Thames combined with heavy rainfall.

The Thames Tideway Tunnel is currently under construction with completion expected in 2025. The tunnel is to be constructed under the tidal section of the River Thames which connects to 34 of the most polluting combined sewer overflows and subsequently, will reduce overflows to approximately three or four per year. This number is likely to increase due to population growth and climate change. The tunnel will capture, store and ultimately convey raw sewage and rainwater to the Lee Tunnel. The primary purpose of the tunnel is to prevent pollution of the river. Thames Water has indicated that it will reduce sewer flooding for localised storms within London.

The Lee Tunnel is London's most recent super sewer to be constructed and runs from Stratford to East Ham. The tunnel is designed to convey sewage and rainwater which would otherwise have discharged into the River Thames. Annually, it is designed to capture 16 million tonnes of sewage which is collected from the lowest point of the Thames Tideway Tunnel. The sewage and rainwater is pumped up to Beckton Sewage Treatment Works. Subsequently, clean water is discharged into the Thames. To date, it has cut waste flowing into the Thames by 40%.

9 Burst water main flood risk

9.1 Overview

A burst water main can occur at any time and can have a serious impact on both property and infrastructure.

Any pipe burst can result in flooding of roads and property however the locations that are most at risk are considered to be low points in the topography along roads and tunnels, and locations where large water mains run along streets and open spaces. This is because flood water accumulates at low points and burst flows are much larger for larger pipes.

Thames Water undertook a review of bursts on their trunk main network following a series of incidents in 2016 (Thames Water, 2017b). This review came to the following findings regarding the causes of bursts;

> *'there is no single common cause of the bursts. Whilst age and condition of the pipes is an underlying factor in the eight high-profile failures, there were no systematic failings that could be said to have consistently caused or enabled the bursts.'*

At present no assessment of the risk of water main burst flooding has been undertaken as it has not been possible to obtain water main asset information, such as pipe sizes and locations. Therefore as a pre-cautionary approach and in the absence of 2d modelling or data from Thames Water, any infrastructure or property in the vicinity of the areas at high risk (low points and large water mains) can be assumed to be at high risk from this source.

Good management of the infrastructure itself is the key to minimising the threat of flooding from these sources.

9.2 The water main system

The Thames Water mains water distribution network in London dates from Victorian times and is the oldest network in the UK, with an average age of 70 years. Two-thirds of their water mains have been in use for more than 50 years and the frequency of water mains bursting has increased dramatically in recent years. This water distribution network also covers the City of London.

Thames Water outlines their plans to improve their distribution network in order to reduce leakage and the risk of burst mains; this is set out in their Water Resources Management Plan 2020 – 2100. The programme to replace the oldest and leakiest pipes has already begun and replacement of trunk mains started in 2020. Thames Water will make use of the latest technology to monitor and manage the performance of their system and to reduce losses of water. Information from 'smart' meters will help target key locations to improve performance. Improved knowledge of deterioration rate of trunk mains and improved monitoring will help, to better predict and prevent these bursts.

10 Groundwater flood risk

10.1 Overview

Groundwater flooding is usually caused when the level of water within the rock or soil rises significantly following long periods of abnormally high rainfall. It can cause significant damage to property and infrastructure. The two most vulnerable settings for groundwater flooding are chalk and river valleys which are underlain by permeable superficial deposits. LLFAs are responsible for managing groundwater flood risk.

In January 2014, extensive groundwater flooding occurred in the South East of England. Exceptional rainfall was unable to infiltrate into already saturated ground and ran off into watercourses. Whilst rivers returned to normal, groundwater levels continued to rise for weeks/ months in some areas; within Hampshire, groundwater levels rose more than 30m. Groundwater flooding in the City of London is less likely as groundwater levels are maintained artificially low.

This section outlines the conceptual ground modelling study which was undertaken as part of the Level 1 SFRA (Mouchel Parkman, 2007) and which is still considered to be an adequate assessment of groundwater flood risk within the City of London.

For the purpose of this SFRA, as no new information is available, the previous mapping of groundwater flood risk from the Level 1 SFRA and the Drain London SWMP (Halcrow, 2011) is still the most relevant information available.

10.2 Groundwater risk

It is not always possible to accurately map the groundwater level due to interactions between rainfall, the local variations in geology within the same strata, tide levels and underground obstructions. However, as there is a strategic understanding of the groundwater regime within the London Basin, a certain degree of confidence can be placed on determining the areas considered to be most at risk of experiencing groundwater flooding.

The City of London is underlain by two natural aquifers: River Terrace Deposits, and Upper Chalk.

The chalk aquifer is located approximately 68m below ground level, below a layer of London Clay. The chalk aquifer is heavily managed throughout the London Basin, with groundwater levels maintained between -30m AOD and -50m AOD by the General Aquifer Research Development and Investigation Team (GARDIT). The Level 1 SFRA mapped groundwater levels in the chalk aquifer. Although it only provided an assessment of groundwater levels, as opposed to groundwater flood risk, it showed that the chalk layer is confined beneath a low-permeability clay layer. Subsequently the groundwater flood risk from the chalk aquifer is considered to be low.

The River Terrace Deposits comprises a sand and gravel aquifer with high porosity and high permeability. It is at a relatively shallow depth and provides a large storage volume below ground and in the vicinity of the River Thames.

Groundwater levels within the River Terrace Deposits are unknown. Four potential flood risk mechanisms have been identified for this aquifer:

- Prolonged and above average rainfall in the River Terrace Deposit outcrop;
- High tide levels;
- Leaky drains and sewers; and,
- Basements/ foundations interrupting groundwater flow paths.

The Drain London SWMP provided an estimation of the areas considered to be most at risk from groundwater flooding within the River Terrace Deposits (Figure 33014-COL-5010 – Increase Potential for Elevated Groundwater). This is based on geology and topography. The mapping shows areas where the aquifer is at its thinnest in depth, most notably within the lower lying areas within the City of London. In these areas, basements are more likely to obstruct groundwater flows which will increase the risk of flooding to these buildings.

Typically the areas, where the aquifer is thinnest in depth, cover a small area of the City of London and are primarily covered by impermeable surfaces such as buildings and roads. In these areas, rainwater cannot infiltrate into the ground and subsequently raise groundwater levels. The main cause for rising groundwater levels is therefore caused by sewers leaking and the lateral transmission of high-water levels from the River Thames. Due to the impermeable surfaces in these areas, groundwater flooding is most likely to affect basements and utilities that are not waterproofed properly.

In addition to the natural geology beneath the City of London, there can be a substantial depth of made ground that comprises material that has been deposited as a result of human occupation and development since settlement by the Romans in the 1st century AD. This material which sits above the other geologies is highly variable but can hold perched groundwater and therefore pose a risk of groundwater flooding to basements and other buried structures.

Groundwater flood risk is not expected to increase in the short to medium term. However, climate change is likely to increase the existing groundwater flood risk due to higher rainfall, and increased leakage from drains and sewers infiltrating into ground. Sea level rise will increase the water level within the River Thames which will also increase groundwater levels, although this will dissipate with distance from the river. Additionally, the defence improvements by the TE2100 Plan and Thames Barrier may help to mitigate this.

11 Consequence of flood risk

11.1 Overview

The City of London due to its topography is at relatively low risk of flooding in comparison to some other parts of London. As a result, the consequences of flooding are limited to specific areas that are generally defined as the lower parts in the landscape. The key areas where the consequences of flooding could be greatest are Thames Riverside (where the fluvial flood risk is the highest) and Farringdon Street where the natural topography leads to the greatest risk of surface water and sewer flooding.

The consequences of flood risk are heavily dependent upon the severity of the extreme event and can affect individuals directly and indirectly. Failure of drainage assets can exacerbate flooding considerably.

Flood waters can damage residential and commercial properties, particularly if they have a basement and water is able to rapidly enter from the street. Flooding can also damage critical infrastructure such as sub-stations or water supply assets which may leave many properties without electricity or water. These direct consequences of flooding are restricted to a relatively small geographical area in the City of London. For these locations the consequences of flooding can be minimised through the implementation of appropriate resistance and resilience measures.

High flood depths and fast flowing water can result in the loss of life or severe injuries. Diseases can be spread by combined foul and surface water as a result of surcharging sewers.

Indirect effects of flooding can be caused by road traffic disruption; within the City of London, the main transport routes likely to be affected as a result of flood water are Farringdon Street and Victoria Embankment. Alternatively flooding of rail infrastructure including underground stations or overground railway lines or stations would have a significant impact on the functioning of the City of London. Flooding of commercial properties can result in disruption to critical commercial activities, including trading and communications infrastructure and could result in significant financial and reputational loss, as well as a loss of customers. Other utility infrastructure, such as electricity supplies, can be vulnerable to flooding leading to widespread disruption if key assets such as sub-stations are affected. This could have a negative economic impact to the City of London, the wider London economy and the nation as a whole.

Finally, indirect effects can be caused by the inconveniences of recovery after a flood event and the increased vulnerability of affected people.

11.2 Properties at risk of flooding

As part of the 2017 SFRA, the numbers of properties likely to be affected by flooding, within high-risk areas, have been assessed for the following sources: Tidal/Fluvial Flood Zones 2 and 3, groundwater, surface water and Tidal/Fluvial breach modelling. These numbers are conservative as individual properties may not flood based on their threshold levels which have not been accounted for in the calculations. However, it does give an indication of the estimate for the potential consequences. The results are shown in Table 6.

Table 6: Properties at direct risk of flooding

	Residential	Commercial	Total
Flood Zone 2*	64	78	141
Flood Zone 3*	64	69	133
Groundwater#	81	695	776
Surface Water 1 in 30 Annual Probability**	18	40	58
Surface Water 1 in 100 Annual Probability**	34	73	107
Tidal/Fluvial Breach Modelling (Present Day)##	46	33	79
Tidal/Fluvial Breach Modelling (2100)##	56	70	126

* based on Environment Agency fluvial and tidal flood zones.

based on the 'increased potential for groundwater' maps from the SWMP.

** based on the SFRA surface water modelling for the given probability event.

based on the Thames Tidal Upriver Breach Inundation Assessment.

The distribution of the properties at direct risk from flooding from the various sources are shown in Figures 33014-COL-801 - Figures 33014-COL-807, in Appendix A.

In addition to the properties at direct risk of flooding, there are a significant number of properties on upper floors whose access would be compromised by flooding of ground floor and basement properties beneath them. The numbers of properties at risk of loss of access/egress are shown in Table 7.

Table 7: Properties at risk of lost access/egress due to flooding

	Residential	Commercial	Total
Flood Zone 2*	520	19	539
Flood Zone 3*	517	15	532
Groundwater#	700	291	991
Surface Water 1 in 30 Annual Probability**	175	12	187
Surface Water 1 in 100 Annual Probability**	197	20	217
Tidal/Fluvial Breach Modelling (Present Day)##	450	7	457
Tidal/Fluvial Breach Modelling (2100)##	474	20	494

* based on Environment Agency fluvial and tidal flood zones.

based on the ‘increased potential for groundwater’ maps from the SWMP.

** based on the SFRA surface water modelling for the given probability event.

based on the Thames Tidal Upriver Breach Inundation Assessment.

11.3 Impacts on critical infrastructure

To assess the impact of flooding on critical infrastructure, the following assets at risk from flooding in the present-day scenario have been identified:

- Major roads (A roads);
- Railway lines and stations;
- Docklands Light Railway and stations;
- Underground stations (The London Underground Comprehensive Review of Flood Risk (London Underground, 2016) found that the most significant source of flood risk to underground stations is from burst water mains, this is not included in Table 8 as a quantitative assessment of this risk was not possible);
- Medical centres i.e. hospitals and GP surgeries;
- Educational centres i.e. schools, universities and libraries;
- Police stations; and,
- Electricity sub-stations.

The assets at risk are identified in Figure 33014-COL-808 – Critical Infrastructure in Appendix A, and the number of different types of assets at risk at different annual probability events for the present day is given in Table 8.

Table 8: Critical infrastructure at risk of flooding

	Flood Zone 2*	Flood Zone 3*	Groundwater#	Surface Water 1 in 30 Annual Probability**	Surface Water 1 in 100 Annual Probability**	Tidal/Fluvial Breach Modelling (Present Day)##	Tidal/Fluvial Breach Modelling (2100)##
Roads	Victoria Embankment / Upper Thames Street / Blackfriars Underpass (A3211), Queen Street Place (A300)	Victoria Embankment / Upper Thames Street / Blackfriars Underpass (A3211), Queen Street Place (A300)	Farringdon Street (A201), Poultry / Mansion House Street (A40), London Wall (A1211), Princes Street/Moorgate (A501)	Farringdon Street (A201), Victoria Embankment / Blackfriars Underpass (A3211)	Farringdon Street (A201), Victoria Embankment / Blackfriars Underpass (A3211)	Victoria Embankment / Blackfriars Underpass (A3211)	Victoria Embankment / Blackfriars Underpass (A3211)
Railway and DLR	None	None	Moorgate Station, Liverpool Street Station	None	None	Blackfriars Station	Blackfriars Station
Underground stations	Blackfriars	Blackfriars	Moorgate, Bank, Cannon Street, Liverpool Street	0	0	Blackfriars	Blackfriars
Medical centres	0	0	6	0	0	5	5
Educational centres	0	1	3	0	0	0	1

	Flood Zone 2*	Flood Zone 3*	Groundwater#	Surface Water 1 in 30 Annual Probability**	Surface Water 1 in 100 Annual Probability**	Tidal/Fluvial Breach Modelling (Present Day)##	Tidal/Fluvial Breach Modelling (2100)##
Police stations	0	0	1	0	0	0	0
Electricity sub-stations	4	3	5	2	3	2	5
Fire stations	0	1	0	0	0	0	1
Ambulance stations	0	0	0	0	0	0	0

* based on Environment Agency fluvial and tidal flood zones.

based on the 'increased potential for groundwater' maps from the SWMP.

** based on the SFRA surface water modelling for the given probability event.

based on the Thames Tidal Upriver Breach Inundation Assessment.

Table 9: Economic impacts of surface water flooding

Location	Average annual damage (£)			Present value damage (£)		
	Residential	Commercial	Total	Residential	Commercial	Total
Farringdon Street	0	391,500	**391,500**	0	12.473,500	**12,473,500**
New Bridge Street	3,900	463,200	**467,100**	169.100	9,066,700	**9,235,800**
Victoria Embankment	32,700	91,200	**123,900**	715,900	3,178,000	**3,893,900**
Thames Riverside	56,800	150,600	**207,400**	1,966,100	5,636,400	**7,602,500**
Total	**93,400**	**1,096,500**	**1,189,900**	**2,851,100**	**30,354,600**	**33,205,700**

11.4 2017 Economic assessment of flood risk impacts

An assessment of the economic impacts from flooding as a result of flooding from surface water sources was undertaken as part of the 2017 SFRA (when compared to the 2012 SFRA assessment) using the approaches outlined by the Flood and Coastal Erosion Risk Management – A Manual for Economic Appraisal (Flood Hazard Research Centre, 2013). This has assessed the impact of flooding on properties, costs to the emergency services and the cost of evacuation of residents and the working population. This has been based on the flood depths that the surface water modelling outputs from the 2012 SFRA indicates that the properties will experience. The present day, Average Annual Damages and Present Value Damages over the next 100 years are summarised in Table 9 for the City of London for the surface water hotspot areas.

Although not considered in this assessment, it is likely that the indirect impacts to the economy due to disruption to the large work force and nature of work undertaken in the City, will be larger than the figure calculated. Additional economic impacts that have not been valued but would increase the total damages include road traffic disruption, delays to railway services, disruption to businesses and risk to life.

12 Review of flood risk assets

12.1 Overview

Under the Flood and Water Management Act, all LLFAs are required to keep an asset register which will include all structures or features that are considered to have a significant effect on flood risk within their area. The asset register should be completed in accordance with regulations made by the Secretary of State and must be available for inspection at all reasonable times. Alongside the public register the LLFA must keep a record of the ownership of each asset and the state of repair of the structure. The asset register is a live document and should be updated as LLFAs:

- Respond to flood incidents;
- Conduct investigations; and,
- Carry out maintenance works on assets.

The Environment Agency has produced an example template for an asset register which has been used as a basis for the City of London's asset register. It has been created in GIS so that a user can locate and query assets within a spatial environment.

12.2 Identification of assets

Information about the City of London's Flood Risk Asset Register can be found on the City of London website.

Assets are identified using data obtained from the Environment Agency, Thames Water and the surface water modelling outputs.

The Environment Agency produces the National Flood and Coastal Defence database (NFCDD) which catalogues features and structures that influence fluvial and tidal flooding. It is provided in a GIS format: polylines identify defences (walls and embankments) whilst points identify structures (i.e. weirs and sluices).

Thames Water has produced an Infoworks hydraulic model which includes dimensions of pipes and other structures. It is also provided in GIS format. For the purposes of the City of London asset register, the City of London sewers plus a 200m buffer have been included in the database.

The surface water and sewer flooding model (obtained from Thames Water) includes structures and features above the ground which have a significant effect on surface water flooding, including gullies. These have been identified by post processing the results and analysing the flow patterns.

The records of asset ownership and state of repair are regularly reviewed and updated but not published.

12.3 Current policy of flood defences

The majority of the assets identified in the City of London's asset register (except gullies) are the responsibility of the Environment Agency and Thames Water.

The Environment Agency is committed to maintaining and improving the flood defences along the River Thames to ensure that the level of protection is maintained for a flood event with a 0.1% annual probability of occurrence. Until 2069, their focus will be on increasing the crest level of defences to take into account the effects of climate change. Additionally, opportunities offered by redevelopment will be used to set back defences from the river's edge which will allow more space for flood waters to flow. However, due to the highly developed nature of the City of London (which includes historic buildings and landmarks), such opportunities will be limited. As part of the TE2100 Plan it is anticipated that major flood defence works will be required. Further information and consultation is required to inform the final option decision.

Thames Water is committed to reducing the risk of sewer flooding within London. This will be done by increasing sewer capacity, upgrading sewer treatment works and offering mitigation measures to homes at risk. In order to protect London against increasing sewer flooding as a result of Climate Change, Thames Water have raised the design standards for new sewers and are developing innovative solutions to increase capacity. Furthermore, in partnership with the London Borough's, Thames Water is managing flood risk from sewers through new development by:

- Ensuring that there is sufficient capacity within sewers before connecting a new development;
- Protecting green spaces which have the potential for infiltration;
- Participating in the production of SWMP's, helping to identify flooding hotspots and providing strategies for reducing flood risk; and,
- Promoting the use of SuDS.

Additionally, the Thames Tideway scheme will reduce the number of overflow events into the River Thames to approximately 3 or 4 per year which will improve water quality by capturing most of the pollution which would otherwise end up in the River Thames. The combined sewer overflow (CSO) at Blackfriars within the City of London will be captured as part of the Thames Tideway scheme.

In addition to this, Thames Water is willing to provide funding contributions to schemes where surface water flows to the combined sewer system are reduced, which links well with LLFA's SuDS retrofitting schemes and surface water flood alleviation schemes.

12.4 Condition of assets

The asset register contains minimal information in relation to the condition of assets, with the exception of the walls and embankments along the River Thames which form part of the NFCDD database from the Environment Agency. The condition of the defences is categorised as 'excellent', 'good', 'fair', 'poor' and 'very poor' on a scale of 1 (very poor) to 5 (excellent). Within the City of London boundary in December 2022 all assets were categorised as 'fair' and 'good'.

It is worth noting that assets without a condition rating are part of formal, active systems which undergo ongoing maintenance and improvements.

13 Policy, guidance and engineered solutions – fluvial and tidal

13.1 Overview

This section outlines the currently adopted and potential solutions for managing fluvial and tidal flood risk within the City of London at a local scale, using engineered solutions, or at a strategic scale, through policy changes or development. The solutions focus on new development and retrofitting of existing development to improve the existing situation.

13.2 Background

The Environment Agency is responsible for ensuring the integrity of the existing defences along the River Thames. Riparian owners have a legal responsibility to maintain their defences. Under the terms of the Thames River (Prevention of Floods) Acts 1879 – 1962, the statutory flood defence levels must be maintained at all times, with temporary works when necessary. In order to carry out certain works that will directly affect the existing flood defences, or are within 16m of the structures, a Flood Risk Activity Permit is required from the Environment Agency.

The City of London riverside is split into a number of ownerships and includes a variety of defence types. The Thames Estuary including the area covered by the Square Mile is susceptible to sea level rise and the Thames Estuary 2100 (TE2100) Plan sets a strategic direction for managing this within the region. In the City of London it is anticipated that the river flood defences will need to be raised by up to a meter over the coming century.

13.3 Current Framework

Riverside Strategy

In response to the TE2100 Plan the City of London Corporation adopted a Riverside Strategy in November 2021. This strategy sets out a vision for the future riverside and how to use the Riverside Strategy Approach principles (Figure 2) set out in the TE2100 Plan to provide wider holistic benefits as part of defence raisings. The strategy identifies four mechanisms for delivering defence raising (development, cyclical replacement, major works and direct intervention) and outlines a number of principles on how the river defences and adjoining spaces should be designed.

The Riverside Strategy is tied to the timings of the TE2100 Plan. At present the planning policy in relation to new development on the riverside is that developments should be able to demonstrate that future raising of any associated flood defence is possible. The TE2100 Plan is currently undergoing a 10-year review and an updated Plan is due to be published in 2023. This review is likely to bring forward the raising deadlines.

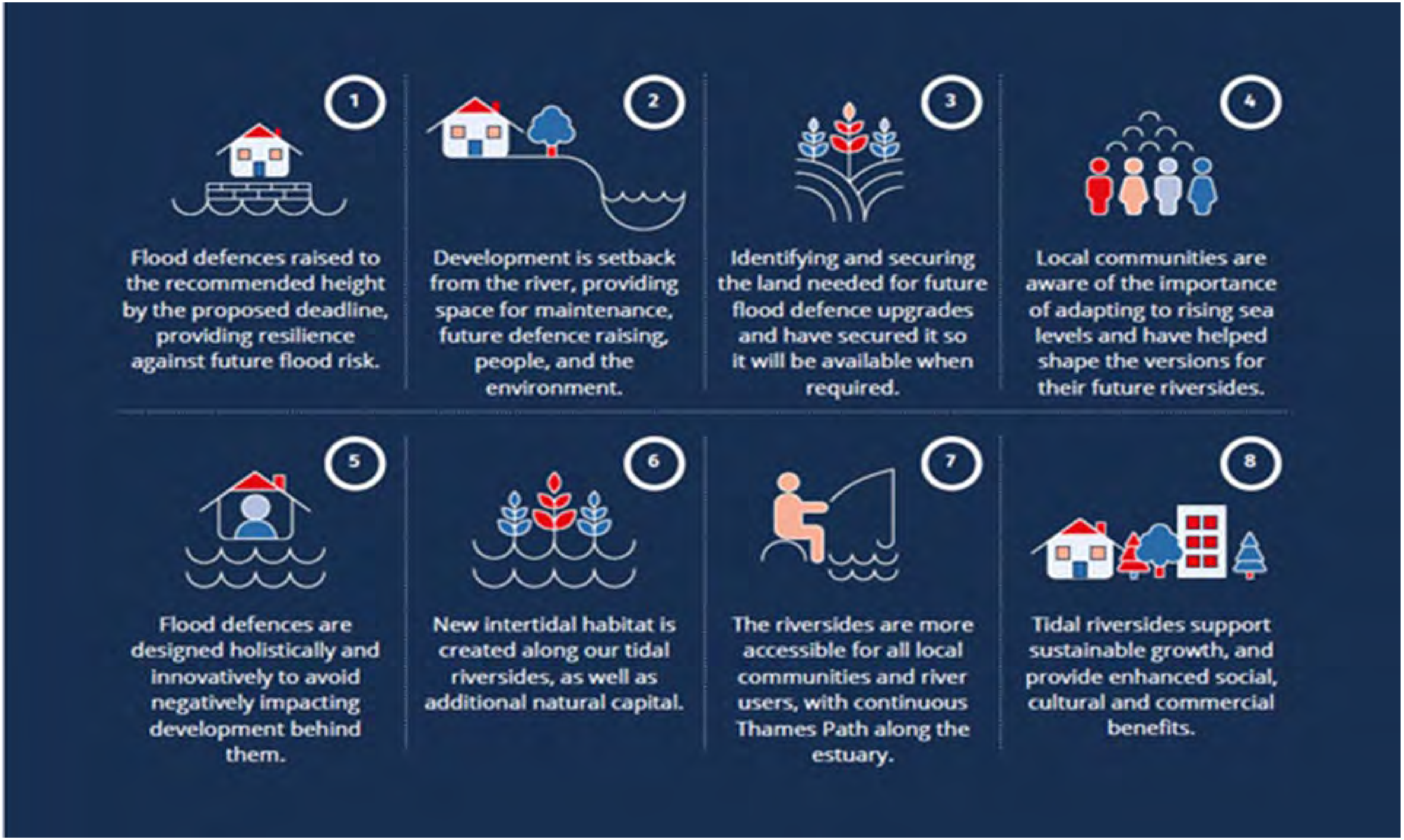


Figure 2: Riverside Strategy Approach Principles - Environment Agency

Local Plan

The City of London Local Plan 2015 contains a number of policies which seek to reduce fluvial and tidal flood risk. It is recommended that future iterations continue to do so. The Local Plan sets a number of expectations including:

- Requiring all developments within the City Flood Risk Area to submit a site-specific flood risk assessment.
- Requiring developments to not further encroach upon the river, unless for a specific marine use.
- Encouraging new development to move buildings away from the edge of the river.
- Requiring new development to ensure that any flood defences is in a good or fair state of repair ahead of construction.
- Locating the most vulnerable uses in parts of the development least at risk.
- Identifying safe access and egress routes.

The Lead Local Flood Authority are consultees on all planning applications within the City Flood Risk Area.

It is worth noting that at the time of preparing this SFRA for the City of London, the Local Plan is being updated and subsequently the above policies may be revised.

Environment Agency Policy in relation to basement breach flood risk

Basements for dwellings are categorised as highly vulnerable by the NPPF and subsequently are not allowed in Flood Zone 3 and must pass the Exception Test to be constructed in Flood Zone 2.

The City of London has a significant number of basements; however these are principally in commercial buildings and classified as less vulnerable. As such they are acceptable in all Flood Zones with the exception of Flood Zone 3.

The Environment Agency have stated that they will object to all development with areas with a sleeping risk use below the breach level of the Thames, unless it can be shown that the areas are protected by a permanent fixed barrier.

Irrespective of their usage, basement flooding is likely to result in severe economic damage. There is a need for a change in attitude of basement use for vulnerable assets. It is important that developers, building owners, commercial occupiers and residents (where applicable) are aware that although the probability of a defence breach or defence overtopping is very low, the consequences could be very high and that comprehensive flood resilience measures can mitigate this risk. Details of appropriate resistance and resilience measures that could be used to mitigate this risk are included in Section 13.4.

13.4 Recommendations

The following recommendations are proposed for development within the Tidal Breach Flood Extent in Flood Zone 3 and for riparian sites:

Flood Defences

- Where feasible development should raise adjacent defences to at least the first stage of the TE2100, as a minimum the ground on the landward side of the defence should be raised to the level required for TE2100 to maintain views over a future flood defence.
- Where feasible works to new flood defences should be designed in accordance with the principles of the Estuary Edges guidance.

Land Use

- Any proposals for the re-development of highly vulnerable land uses such as self-contained basement dwellings, emergency command centres and power stations (sub-stations) should where possible be located/re-located outside of the modelled tidal breach flood extent. No basement development or extension of existing basements are to be permitted in the Tidal Breach Flood Extent.
- Proposed development types or changes in land use (identified in the NPPF and the Environment Agency's Flood Risk Standing Advice as requiring an FRA) within the tidal flood extent should pass the Exception Test. This will include a detailed Flood Risk Assessment that considers all sources of flood risk.
- Proposed developments within areas at risk of tidal breach flooding will need to use flood resilient construction measures.

Flood Resistance Measures

- Flood resistant buildings with appropriate measures to prevent the ingress of water should be designed in the areas likely to be inundated (especially in areas at the highest risk of surface water flooding and tidal flood risk). Current guidance states that flood resistance measures are effective up to 600mm above a property's threshold level.
- Approaches could include the following:
    - External walls: careful consideration of materials using low permeability materials to limit water penetration (avoiding using timber frame and cavity walls). Consider applying a water-resistant coating.
    - Doors: flood resistant doors should be used to prevent water ingress; these should be designed to withstand 600mm of flood water and withstand damage from floating debris.
    - Windows: flood resistant windows should be used if they are to be located below the maximum water level expected for the 1 in 200 annual probability tidal flood event. These windows should be water tight and be able to withstand the high pressure exerted on

them, when submerged under flood water (and the impact from debris contained in the water).
    - Air vents: should not be located below the maximum water level expected for the 1 in 200 annual probability tidal flood event and should be set at a suitable high level to mitigate against surface water flooding (the level of which may be dependent on improved surface water software/methodologies or studies carried out at a higher resolution).
    - Drainage systems and pipes: Fit anti-flooding devices to drainage systems to prevent surcharged flooding through toilets. These devices act as one-way valves, preventing contaminated flood water backing up into the buildings through the toilets.

Flood Resilience Measures

- Flood resilient buildings (constructed from water resistant materials where applicable) should be designed in the areas likely to be inundated (especially in areas at the highest risk of surface water flooding and tidal flood risk) to minimise the consequences of flooding and facilitate recovery from the effects of flooding sooner than for conventional buildings.
- Approaches could include the following:
    - Floors: although access to the lower ground basement levels should be set above the maximum water level expected for the 1 in 200 annual probability tidal flood event, the lower ground level should still avoid use of chipboard floors. Use of concrete floors with integrated and continuous damp-proof membrane and solid concrete floors are preferable.
    - Internal walls: avoid the use of gypsum plaster and plasterboard at the lower ground level; use more flood resistant linings (e.g. hydraulic lime, ceramic tiles). Avoid use of stud partition walls.
    - Fitting, fixture and services: if possible, locate all fittings, fixtures and services above the maximum water level expected for the 1 in 200 annual probability tidal event and at a suitable height to minimise damage by flood waters. Avoid chipboard and MDF (Medium Density Fibreboard). Consider the use of removable plastic fittings. Use solid doors treated with waterproof coatings. Avoid fitted carpets. Locate electrical, gas and telephone and digital/IT equipment and systems above the design flood level.

Levels of Floors and Thresholds/Openings

- No self-contained residential basement development will be granted planning permission within the Tidal Breach Flood Extent.
- More vulnerable basements will not be considered within the Tidal Breach Flood Extents unless the entrance to these basements have threshold levels (entrances, windows, vents etc.) that are 300mm above the maximum water level expected for the 1 in 200 annual probability tidal

breach flood event scenario (this level will be site specific and will require consultation with the Environment Agency).

- Access to the ground level of new ‘more vulnerable’ developments (please refer to Table 3 for more information) within the modelled tidal breach flood extents, should have threshold levels designed to a level agreed with the Environment Agency. Ideally this should be 300mm above the maximum water level expected for the 1 in 200 annual probability tidal flood event (this level will be site specific).

Recommendations for Evacuation Access and Egress

- In addition, for planning permission to be granted for developments within the tidal breach there will need to be an agreed Flood Evacuation Plan as set out in Chapter 4 and Appendix D.

14 Policy, guidance and engineered solutions - surface water and sewer flood risk

14.1 Overview

This section outlines the currently adopted and potential solutions for managing surface water and sewer flood risk within the City of London at a local scale, using engineered solutions, or at a strategic scale, through policy changes or development. The solutions focus on new development and retrofitting of existing development to improve the current situation.

14.2 Background

The City of London in its role as the LLFA has responsibility for the management of surface water flood risk. Thames Water as the Sewerage Undertaker are responsible for the management of sewer flooding from their network within the City of London. Management of surface water runoff within the City of London is closely linked to the operation and maintenance of the highway drainage assets (gullies and pipes), and how these connect to and interact with the Thames Water combined sewer system. The City of London is vulnerable to sewer surcharge as a result of actions taken outside of the City's boundary in the wider Thames Water combined sewer catchment. Figures 33014-COL-603 and 33014-COL-604 shows the extent of the sewer catchments that drain through the City of London where surface water management activities could impact on the risk of flooding in the City.

Sustainable Drainage Systems (SuDS) offer the key mechanism by which surface water can be managed, both as part of new development within the City of London and through retrofitting to reduce flood risk elsewhere. The following sections provide information on how SuDS should be promoted and managed to reduce surface water flood risk wherever possible and combined with water re-use, as well as providing additional benefits including water quality treatment, water conservation, amenity and biodiversity.

For areas identified as at risk from surface water flood risk, there are a range of potential options to manage this risk. Options to reduce the risk of flooding could include retrofitting SuDS solutions on buildings and if space allows at ground level. Further details of potential SuDS measures that could be implemented are included in the subsequent parts of Section 14.4. In addition the viability of options for increasing the capacity of highways drainage and the combined sewer system should be considered to increase the rate at which water can be conveyed away from the risk areas. This could include larger sewer pipes, below ground tank storage and additional road gullies. If these potential solutions are not considered viable then individual property owners could consider the use of resistance and resilience measures to reduce the risk to their own property. In addition hybrid solutions incorporating elements of any of these options should be considered, including the potential for resistance and resilience measures to complement more strategic options such as retrofit SuDS and upgrades to the sewer systems.

14.3 Current Framework

Local Plan

The use of Sustainable Drainage Systems (SuDS) for management of surface water runoff from new development is promoted by the City of London through planning policy. Policy CS18 of the Local Plan requires Reducing rainwater run-off, through the use of suitable SuDS, such as green roofs and rainwater attenuation measures throughout the City. In addition there are several Development Management policies that give greater detail on the management of surface water and SuDS. Policy DM18.2 (Sustainable Drainage Systems) states that:

1. The design of the surface water drainage system should be integrated into the design of proposed buildings or landscaping, where feasible and practical, and should follow the SuDS management train and London Plan drainage hierarchy.
2. SuDS designs must take account of the City's archaeological heritage, complex underground utilities, transport infrastructure and other underground structures, incorporating suitable SuDS elements for the City's high density urban situation.
3. SuDS should be designed, where possible, to maximise contributions to water resource efficiency, biodiversity enhancement and the provision of multifunctional open spaces.

The Lead Local Flood Authority are a statutory consultee for sustainable drainage on all Major Developments within the City of London.

It is worth noting that at the time of preparing this SFRA for the City of London, the Local Plan is being updated and subsequently the above policies may be revised.

London Plan

The London Plan focuses on making new development as sustainable as possible for example through Policy SI 13 Sustainable drainage. This includes the London Drainage Hierarchy.

SI 13 requires that Lead Local Flood Authorities should identify – through their Local Flood Risk Management Strategies and Surface Water Management Plans – areas where there are particular surface water management issues and aim to reduce these risks. Due to the combined sewer network the entire City of London is considered to have surface water management issues and as such all development is expected to incorporate sustainable drainage where feasible.

The London Plan requires that development proposals should aim to achieve greenfield run-off rates and ensure that surface water run-off is managed as close to its source as possible. There should also be a preference for green over grey features, in line with the following drainage hierarchy:

1. rainwater use as a resource (for example rainwater harvesting, blue roofs for irrigation)
2. rainwater infiltration to ground at or close to source
3. rainwater attenuation in green infrastructure features for gradual release (for example green roofs, rain gardens)
4. rainwater discharge direct to a watercourse (unless not appropriate)
5. controlled rainwater discharge to a surface water sewer or drain
6. controlled rainwater discharge to a combined sewer.

In addition to meet the policy, development proposals for impermeable surfacing should normally be resisted unless they can be shown to be unavoidable, including on small surfaces such as front gardens and driveways. Drainage should be designed and implemented in ways that promote multiple benefits including increased water use efficiency, improved water quality, and enhanced biodiversity, urban greening, amenity and recreation.

Other sustainable drainage guidance

SuDS design must also comply with the Non-statutory Technical Standards for Sustainable Drainage Systems (DEFRA, 2015). Additional useful documentation on the use of SuDS within London can be found in:

- Transport for London's 'SuDS in London – a guide'; and,
- The London Sustainable Drainage Action Plan 2016 (Greater London Authority, 2016).
- The SuDS Manual (CIRIA, 2016)

City of London physical constraints

Opportunities for infiltration SuDS (e.g. soakaways) are expected to be limited due to the local bedrock geology (i.e. clay) and the density of urban development including underground development. If applicants wish to use infiltration as the destination for surface water runoff adequate proof that it is possible should be provided. This should include the results on infiltration testing at the site during winter conditions (December to March), groundwater monitoring over the same period and prove that infiltration will not affect the stability of new buildings on the site or buildings and other structures such as roads on adjacent land. In addition the applicant must prove that infiltration will not mobilise contaminants held in the ground as a result of previous uses of the site that could lead to a detrimental impact on groundwater quality.

Development located along the River Thames should discharge surface water runoff directly (in some cases with some treatment – oil interceptors) into the river where feasible and appropriate subject to obtaining the necessary permits (e.g. Environment Agency). Discharging surface water runoff directly into the River Thames helps in reducing the amount of surface water discharged into the public drainage network; it can also be cost effective as no surface water attenuation is required apart from that necessary to manage tide locking. This is also consistent with the London Sustainable Drainage Action Plan which explains that for residential locations next to the Thames, tidal rivers or docks, a relatively easy approach is to divert rainwater into the river or dock. This is not normally considered to be a form of sustainable drainage. However for the heavily urbanised areas of London it is a more sustainable approach to managing rainwater that would otherwise be carried into the combined sewer system. Any discharge directly to the River Thames should incorporate appropriate water quality treatment features to ensure that pollutants are not discharged into the river.

14.4 Recommendations

The following recommendations are relevant to any development within the City of London, they have been split into recommendations for Major and Minor Development. They include specific recommendations for development within surface water flood risk areas. This section includes further recommendations on appropriate sustainable drainage options and future policy suggestions.

Major Developments

Major Developments are classified as:

- The provision of a building or buildings where the floor space to be created by the development is 1,000 square metres or more; or,
- Development is carried out on a site having an area of more than 1 hectare; or,
- The provision of dwellinghouses where:
    - The number of dwellinghouses to be provided is more than 9;
    - The development is to be carried out on a site having an area of 0.5 hectares or more.

The planning applications for Major Development should be accompanied by an outline surface water drainage strategy, as part of a site-specific Flood Risk Assessment where appropriate. The strategy must demonstrate the sustainable management of surface water runoff incorporating best practice and in line with the above policies and the London Plan recommendations. The strategy must be developed in consultation with the City of London Corporation in their role of Lead Local Flood Authority. A pre-application discussion should be held with the LLFA team to enable a suitable solution for drainage of the site to be developed.

The City of London Corporation manages the local sewer network under contract on behalf of Thames Water and should be contacted to understand capacity constraints within the public sewer network (if applicable). Requests for information of and further details on new connections to the combined sewer system in the City of London and any pre-development enquiry can be submitted to (drainage.services@cityoflondon.gov.uk). It is recommended that expected foul water discharge rates are factored in when submitting a pre-development enquiry to the City of London Corporation in order to better understand the impact that the development might have on public drainage infrastructure.

In high-risk surface water zones, the finished ground floor level shall be set to 0.3m above the 1 in 100 annual probability peak water level taking account of climate change. If this is not feasible then the ground floor shall be flood resilient up to 0.6m above floor level. For new basements these shall be protected by the surrounding building (including the entrance) by a threshold set to 0.3m above the 1 in 100 annual probability peak water level taking account of climate change. If this is not feasible the basement shall be flood resilient up to 1m above basement floor level. An evacuation plan shall be required for all basements within high-risk surface water flood zones. The measures on flood resistance and resilience covered in Section 13.4 provide useful guidance.

In addition, for planning permission to be granted for developments within the City Flood Risk Area there will need to be an agreed Flood Evacuation Plan as set out in Chapter 4 and Appendix D.

Minor Developments

Minor Developments are classified as any planning application which does not fulfil the indicators given for Major Developments in the section above.

The City of London expects applicants to seek opportunities for the use of SuDS in these developments as far as is feasible. At the planning stage a short drainage statement should be produced (as part of the site-specific flood risk assessment if that is required). The statement should follow the requirements of the above policy and explain:

- How surface water runoff will be managed at the site;
- Where runoff will be discharged and the proposed discharge rates; and,
- The SuDS measures which are being proposed and the reason for the choice.

In addition Minor Developments should follow Policy CS18 and DM18.2.1 from the Local Plan, and the general recommendations of the London Plan.

In high-risk surface water zones, the finished ground floor level shall be set to 0.3m above the 1 in 100 annual probability peak water level taking account of climate change. If this is not feasible then the ground floor shall be flood resilient up to 0.6m above floor level. For new basements these shall be protected by the surrounding building (including the entrance) by a threshold set to 0.3m above the 1 in 100 annual probability peak water level taking account of climate change. If this is not feasible the basement shall be flood resilient up to 1m above basement floor level. An evacuation plan shall be required for all basements within high-risk surface water flood zones. The measures on flood resistance and resilience covered in Section 13.4 provide useful guidance.

In addition, for planning permission to be granted for developments within the City Flood Risk Area there will need to be an agreed Flood Evacuation Plan as set out in Chapter 4 and Appendix D.

Public realm improvements

Public realm improvements often create opportunities for retrofitting sustainable drainage systems into the built environment. Through the City Corporation's Cool Streets and Greening programme, part of the Climate Action Strategy, different SuDS measures and techniques are being piloted. Based on this work and industry best practice all public realm schemes should seek to maximise sustainable drainage in line with what is feasible on individual sites and the primary objectives of the schemes being implemented.

SuDS appropriate for the City of London

For a full review of the range of SuDS options available please refer to wider literature (e.g. the SuDS Manual); in this section we provide an outline summary of the SuDS which are generally expected to be more appropriate for the City of London.

Although many different types of SuDS exist, the most appropriate solutions depend on the nature of the development proposed and need to take into account local conditions, opportunities and constraints. On this basis for the City of London some SuDS are expected to be more appropriate than others.

Rainwater harvesting
Rainwater harvesting is the collection of rainwater runoff and its re-use as a supply of water for various purposes including commercial, residential and industrial. As explained in the SuDS Manual Rainwater harvesting can meet part of a development's water demand in favour of sustainability and reduce the volume of runoff from a site. Through 'smart water' technologies it is now also possible to combine rainwater harvesting and surface water runoff attenuation: this allows limiting peak and volumetric discharge rates while conserving water for re-use.

Green/blue roofs
Green roofs are areas of living vegetation, installed on the top of buildings or on terraces throughout buildings, and can provide multiple benefits including

biodiversity and water quality enhancement, improved building performance, reduce urban heat island effect and reduced runoff (both in terms of peak runoff rate and overall volume discharged). Their performance in terms of runoff attenuation depends on several factors including depth and slope.

A blue roof is a roof design that is intended to store water and can include open water surfaces, storage within or beneath a porous medium or modular surfaces; a green roof which includes a reservoir storage zone beneath the growing medium can also be called a blue roof.

Green/blue roofs are an appropriate solution for dense urban environment and can be used for many of the commercial buildings being developed in the City. Their use is consistent with the Local Plan Policy CS19: Open Space and Recreation.

Further information can be found in the City of London Local Plan Monitoring Report – Green Roofs.

Permeable/porous pavements
Permeable or porous pavements allow a suitable surface for pedestrian or vehicle access while also allowing water to infiltrate through the surface into the underlying storage layers. The surface can be formed of block paving with gaps between the blocks or porous surfaces such as specially designed asphalt. Water can be stored in the underlying layers attenuating flows and allowing for water quality treatment.

The generally accepted guidance for the design of permeable pavements is provided by Interpave (Interpave, 2010). The design of permeable pavements is dependent upon the following factors:

- The loading that they need to be able to withstand;
- If water is expected to infiltrate into the ground below the pavement or if it is stored and then transferred into either the next element of the SuDS treatment train or the sewer system;
- The level of the groundwater and whether this is a limiting factor for the depth of the pavement; and,
- The amount of water that needs to be stored within the pavement.

Rain gardens
Rain gardens are a combination of natural processes and storage units that not only provide more surface water capacity within the network but also treat the runoff from the roads to improve water quality overall.

In addition, their installation provides additional amenity and improvements to the streetscape through increased vegetation.

Tree planting and pits
Trees in the context of the City of London can be used as standalone features within soil-filled tree pits, tree planters or structural soils. Tree pits and planters

can be designed to collect and attenuate runoff by providing additional storage within the underlying structure.

The tree planting zone should be designed to be as large as possible to accommodate the largest tree size, which will increase its capacity to manage runoff. That being said, any tree pit or planter should provide adequate soil volume.

Retrofit SuDS

Good opportunities exist within the public realm for SuDS. SuDS can be introduced adopting an 'opportunistic' approach (i.e. introducing SuDS when works are needed irrespective) or a more strategic retrofitting of SuDS. Key for the implementation of SuDS in the public realm is a strong partnership between the various stakeholders involved; including but are not limited to the City of London Corporation (Highways and LLFA functions), The Mayor of London and Transport for London, Environment Agency, businesses, developers, landowners, Thames Water, and local residents. Useful information on how to ensure the future implementation of SuDS throughout London is contained within the London Sustainable Drainage Action Plan.

Opportunities to retrofit SuDS and their suitability in certain locations is typically dependent upon the following criteria:

- Availability of space at ground level to provide SuDS storage;
- Constraints posed by buried utility pipes and cables to storage of water below ground level and achieving a feasible connection to the combined sewer system; and,
- Acceptability of SuDS solutions given historic landscape designations such as Conservation Areas.

Further general recommendations

- Building owners and occupiers should undertake an assessment of surface water flood risk for all basements that contain highly valuable items.
- It is recommended that the City of London Corporation maximises opportunities for redirecting runoff from roof down pipes to open spaces, to form a visually attractive safe water environment or to use for storage and re-use in small City of London gardens and open spaces. Only excess volumes should be returned to the combined sewer system.
- Where pumping is proposed as part of a surface water drainage system sufficient safeguards should be provided such that continued service can be guaranteed or sufficient attenuation provided to accommodate the worst-case scenario for a 24-hour pump failure.

15 Policy, guidance and engineered solutions – groundwater flood risk

15.1 Overview

This section outlines the currently adopted and potential solutions for managing groundwater flood risk within the City of London at a local scale, using engineered solutions, or at a strategic scale, through policy changes or development.

15.2 Background

The City of London in its role as the LLFA has responsibility for the management of groundwater flood risk in the Square Mile. In reality due to the geology of the City of London this situation is much more complex as outlined in Chapter 10.

Basements are particularly vulnerable to groundwater flooding. In general, the groundwater levels within the chalk aquifer underneath the City of London are 30-60m below ground level (bgl); they are expected to remain at this level due to GARDIT (for more information refer to Chapter 10). The risk of groundwater flooding to property from this aquifer is considered to be low. However, much of the superficial deposits within the City of London are River Terrace Deposits. The levels of the River Terrace Deposits are likely to coincide with basements and subsequently could result in perched groundwater flood risk. It is therefore recommended that where possible new basements or enlarged basements are avoided where there are permeable superficial deposits. Where basement construction, or other underground development, cannot be avoided (i.e. underground stations), the walls must be fully waterproofed to prevent seepage and must have adequate pumped drainage and ventilation.

Groundwater is a constraint when considering the suitability of SuDS features. Infiltration SuDS are not suitable where soil has insufficient capacity. Additionally, an increase in infiltration may increase flood risk to the surrounding properties due to recharging groundwater and causing groundwater levels to rise. It is recommended that site investigations and infiltration testing is undertaken for individual developments prior to the detailed design of SuDS features.

15.3 Recommendations

For sustainable drainage schemes

Due to its highly developed nature, there are a number of additional considerations to take into account when determining SuDS feasibility within the City of London:

- There are archaeological remains present under many areas which may be uncovered during construction. Archaeological investigations may be required prior to the installation of SuDS features;

- There is extensive utility infrastructure under the City of London's streets including electricity and telecommunications cables, gas, water and sewerage pipes, underground railway lines, pipe subways, and tunnels that are both operational and redundant. Surveys must be undertaken prior to excavation; and,
- Security bollards and basements create further constraints extending under pavements and incorporating extensive underground structures. 136 streets within the City of London have Special Engineering Difficulties (i.e. underground stations or tunnels) which make excavation difficult or are so full of utility infrastructure that they are considered 'full'.

General further recommendations

To avoid increasing groundwater flood risk within the City of London, the following recommendations are proposed in the areas identified at risk from the Drain London SWMP (Figure 33014-COL-501 – Increase Potential for Elevated Groundwater):

- GARDIT to continue to maintain groundwater levels in the London Basin;
- Thames Water to continue to maintain and renovate the sewers to reduce the risk of leakage;
- Basements and underground utilities to be waterproofed where possible;
- If required, pumps can be installed to remove flood water;
- Relocate sensitive uses within buildings to higher floors.

16 Forward look

16.1 Overview

Due to the cyclical nature of flood risk management and the associated framework of policy and guidance it can be anticipated that there will be significant changes relevant to the content of this SFRA. In addition, a number of physical changes are likely to have an impact on the outputs and mapping. These changes will occur ahead of the next planned SFRA update in 2027. It is therefore recommended that that this SFRA is used in line with the most up-to-date documents and any emerging relevant information. This chapter therefore introduces known or likely changes to consider, this list should be assumed to be incomplete.

16.2 Expected policy updates

City of London Local Plan

The City of London Local Plan is due to be updated. This is likely to include a refresh of the flood risk, sustainable drainage and climate resilience policies.

TE2100 Plan 10 Year Review and update

The Thames Estuary 2100 Plan is currently undergoing a 10-year review which will result in an update to the plan. This is likely to include changes to the proposed raising deadlines; bringing them earlier as well as changes to how objectives and outcomes are defined. The expected publication is spring/summer 2023.

Schedule 3 Flood and Water Management Act 2010

In January 2023 the Secretary of State for the Environment announced the intention to implement Schedule 3 of the Flood and Water Management Act. This is likely to see the establishment of SuDS Approval Bodies (SABs), whose agreement would be required for all new development. A consultation will be held on the proposal in 2023 with the required Statutory Instrument to enact the schedule laid in parliament before 2024.

Thames Water Drainage and Wastewater Management Plan

Thames Water have been preparing their Drainage and Wastewater Management Plan. This will set out their approach for long-term planning in managing their wastewater network. This will be published in May 2023.

National Flood Risk Assessment 2 (NaFRA2)

The Environment Agency are currently developing the second cycle of national flood risk assessments. This includes the creation on a New National Model (NNM) for flood risk which will be used to develop new Risk of Flooding from Surface Water (RoFSW) and Risk of Flooding from Rivers and Sea (RoFRS) mapping.

16.3 Expected physical changes

Thames Tideway Tunnel

The Thames Tideway Tunnel is due to be completed ahead of the next planned SFRA review. The primary aim of the sewer is to reduce combined sewer overflow discharges into the Thames.

Impact of SuDS policy

By 2027 the LLFAs sustainable drainage role will have been in force for twelve years. At the current rate of approvals, approximately 12% of the Square Mile will be covered by a scheme with planning approval incorporating SuDS, with half of these schemes expected to have finished construction by this time.

16.4 Possible policy updates

London Plan

It is possible that a new London Plan will be being developed or be adopted before the SFRA is next reviewed.

Co-ordinated surface water management plan for London

Following the Summer 2021 flooding experienced in other parts of London there has been steps taken to setting up a London wide co-ordinated strategy for managing surface water flood risk. Further progress is expected on this.

16.5 Future SFRA review

The City Corporation is committed to increasing climate resilience of the Square Mile. The SFRA is a key document to understanding flood risk in the City of London. The SFRA is due to be reviewed every five years with the next review due to begin in 2027. Earlier reviews may be required subject to changes to the statutory duties for managing flood risk or as a consequence of experiencing major flooding.

17 Conclusion

This 2023 SFRA review has assessed the latest and most up-to-date information on the risk of flooding to the City of London from all sources. No additional flood modelling was undertaken as part of this review. The review has been informed by recent updates to policy and guidance from national Government and other relevant organisations such as the Environment Agency and Defra. Significant changes since the previous SFRA (published in 2017) include:

- Updated guidance from the Environment Agency on appropriate allowances for climate change that should be used when assessing flood risk;
- The National Planning Policy Framework has updated its guidance on flood risk and climate change, including expanding which sources of flood risk need to be considered in applying the Sequential and Exception Tests.
- Development of recommendations from previous SFRAs including the adoption of the City of London Riverside Strategy and the proposed Flood Evacuation Plan guidance.
- A review of recent flooding within the City of London.
- An expansion of guidance on flood resistance/resilience approaches and sustainable drainage options available to minor developments and for use within the public realm.

In addition to the changes above the document has been reformatted to improve legibility and to assist with understanding. This has included creating a dedicated chapter on the Sequential and Exception Tests and grouping sources of flood risk which have shared characteristics in how they impact the Square Mile, such as flooding from surface water and sewer flooding.

The fluvial and tidal flood zones have not changed since the 2012 SFRA with the southern part of the City of London in the immediate vicinity of the River Thames, being the only area at risk. The City of London is protected by the flood defence walls along the River Thames and the Thames Barrier. Since the last SFRA review the City of London Riverside Strategy has been adopted and sets out a long-term policy for managing these assets.

A review of the surface water flood risk modelling available has concluded that the modelling undertaken for the 2012 SFRA remains the best available assessment of risk, providing a conservative approach due to the large uncertainty in prediction. The significant risk areas within the City of London remain as Farringdon Street, New Bridge Street, Victoria Embankment and St Paul's Walk.

Information on the risk of flooding from groundwater sources remains limited; the GARDIT scheme which maintains groundwater levels in the deep chalk aquifer below London ensures that the risk of flooding from this source remains low. However there is a risk of flooding from groundwater in superficial deposits and made ground near to the surface which sits on top of clay. This may arise from leaking pipes or high-water levels in the River Thames.

Basements are particularly vulnerable to high groundwater levels, and these are numerous throughout the City of London.

To manage the risk of surface water flooding in the City of London this SFRA provides details of the potential approaches that could be used including retrofit SuDS, and property level resistance and resilience measures. SuDS and water re-use continue to be promoted in new development and the City of London Corporation will do this through planning policy.

Acronym guide

ADEPT – Association of Directors of Environment, Economy, Planning & Transport

AEP - Annual Exceedance Probability

AOD – Above Ordinance Datum

bgl – Below ground level

CDAs – Critical Drainage Areas

CSOs – Combined sewer overflows

Defra - Department for Environment, Food & Rural Affairs

DWMP – Drainage and Wastewater Management Plan

EA – Environment Agency

FEP – Flood Emergency Plan

FRA – Flood Risk Assessment

FRCC PPG – Flood Risk and Climate Change Practice Planning Guidance

FRMP – Flood Risk Management Plan

GARDIT – General Aquifer Research Development and Investigation Team

GIS - Geographic Information System

GLA – Greater London Authority

LLFA – Lead Local Flood Authority

LFRMS – Local Flood Risk Management Strategy

MLWL – Maximum Likely Water Level

MMO – Marine Management Organisation

NaFRA2 – National Flood Risk Assessment 2

NFCDD – National Flood and Coastal Defence Database

NPPF – National Planning Policy Framework

PLA – Port of London Authority

PRFA – Preliminary Flood Risk Assessment

RBMP – River Basin Management Plan

RMA – Risk Management Authority

SAB – SuDs Approval Body

SFRA – Strategic Flood Risk Assessment

SuDS – Sustainable Drainage System

SWMP – Surface Water Management Plan

TE2100 Plan – Thames Estuary 2100 Plan

TW – Thames Water Utilities Limited

WCC – Westminster City Council

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