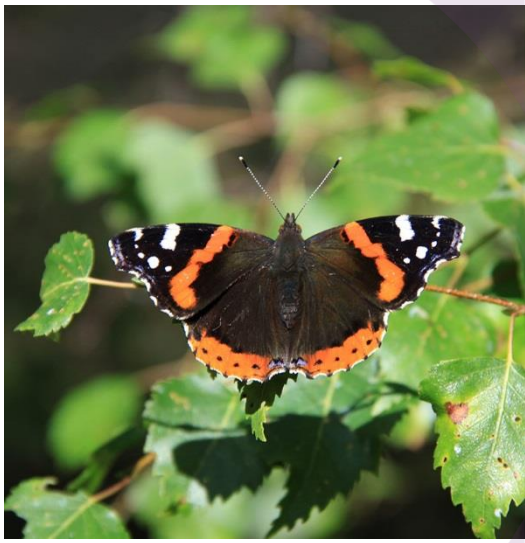
London Borough of Bexley

Level 1 Strategic Flood Risk Assessment



Wood Environment & Infrastructure Solutions UK Limited – November 2020

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Document revisions

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1	Draft report	January 2019
2	Final Report	July 2019
3	Revised Final Report	November 2019
4	Date on front page updated	January 2020
5	Maps A4 and A9 and paragraph 3.4.3 updated.	February 2020
6	Paragraph 6.3.11 updated in line with EA comments	July 2020
7	Text, maps and figure numbers updated inline with LBB comments.	November 2020

Contents

1. Introduction

1.1 Overview

1.1.1 This report provides an update to the Level 1 Strategic Flood Risk Assessment (SFRA) for the London Borough of Bexley (LBB). The LBB requires a comprehensive SFRA to support the production of a new Local Plan, and to inform planning decisions.

1.1.1 The National Planning Policy Framework (NPPF) requires local planning authorities to assess the risk of flood in their areas through undertaking an SFRA[1].

1.1.2 The SFRA is intended to inform the development of policies related to flood risk management and the allocation of land for future development. This is achieved through a thorough analysis of flood risk within the Borough, enabling a more informed response to development proposals and planning, and helping to identify strategic solutions to flood risk.

1.1.3 Level 1 and 2 SFRAs were produced by Entec (now Wood) in 2010 and 2014 respectively, and now require an update to take into account newly available data and updates to legislation, planning policy and strategy.

Purpose of the Level 1 SFRA

1.1.4 A SFRA is produced with the purpose of providing an evidence base to support spatial planning decisions at a Borough wide scale. The Level 1 SFRA is intended to:

- Identify main rivers and flood zones within the Borough;
- Assess the potential impact of climate change on flood risk;
- Identify areas at risk from other sources of flooding such as surface and groundwater;
- Identify flood risk management measures including their location and standard;
- Provide guidance on the application of the Sequential Test; and
- Provide guidance on flood risk management through the design process.

1.1.5 Changes and additions to legislation, planning policy and strategy since the SFRA of 2011 are accounted for within this update, such as the National Planning Policy Framework (NPPF) and National Planning Practice Guidance (NPPG).

1.1.6 The SFRA takes account of newly available data such as updates to the Environment Agency's (EA's) updated Risk of Flooding from Surface Water (RoFSW), the LBB Preliminary Flood Risk Assessment (PRFA), the LBB Local Flood Risk Management Strategy (LFRMS), the Charlton to Bexley Riverside Integrated Water Management Strategy (IMWS), the London Regional Flood Risk Appraisal (RFRA), and specific flood studies such as on the Danson Lake. Additionally, updates to the Environment Agency flood zone mapping are included and supplemented with the results from localised flood risk studies.

[1] NPPF - Paragraph: 001 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/740441/National_Planning_Policy_Framework_web_accessible_version.pdf

1.1.7 The SFRA provides an updated review of the flood risk within the Borough, enabling strategic planning for the allocation of potential future development and underpinning any amendments to planning policy.

1.1.8 The SFRA provides updated guidance to prospective developers who will require a site-specific Flood Risk Assessment (FRA) to support a planning application. This includes guidance on the appropriate use of Sustainable Drainage Systems (SuDS).

1.2 Scope of Level 1 update

1.1.9 The scope of the update was agreed with LBB representatives at a meeting in February 2018. The objectives of the SFRA update are to account for new policy and strategy, and update the Borough-wide mapping and assessment with recent flood risk datasets including detailed hydraulic modelling outputs.

1.1.10 To that end, this update will include the following:

- An appraisal on the future pressures on flood risk as a result of new development and climate change, to allow the application of the Sequential Test; and
- An update to the national flood risk policy guidance and sustainable drainage recommendations.

1.1.11 The sequence of tasks undertaken in this SFRA update was as follows:

- Inception meeting with the LBB;
- Data request to stakeholders;
- Collation and review of data;
- Mapping of available flood sources and flood risk; and
- Update of reporting.

1.2 Using the SFRA

1.2.1 The SFRA is a tool to inform the spatial planning process and guide safe development, from a flood risk perspective. The information has been presented in such a way to facilitate this objective. Appendix A is a key component of the report, as it includes detailed mapping sufficient to inform the application of Sequential Test.

1.2.2 For the purposes of informing the Sequential Test, the key pieces of information are:

- Figure A5 in Appendix A in conjunction with Table 5.1, showing flood zones and detailing appropriate land uses by zone;
- Section 5 – Information to support the Sequential Test; and
- Sections 6 and 7 – Guidance on appropriate flood risk management.

1.3 Report structure

1.3.1 The structure of this report is aligned with delivering the key aim of providing information to perform the Sequential Test. As such, the report comprises the following sections:

- Section 1 – provides an overview of the SFRA, its purpose and structure. The introduction is also designed to provide guidance on how to extract the most information from the SFRA;
- Section 2 – sets the SFRA within national and local planning policy, in light of multiple changes in recent years;
- Section 3 – provides an overview of all the sources of flood risk that have been identified within the LBB;
- Section 4 – provides an assessment of the potential impacts of climate change in the LBB;
- Section 5 – describes flood risk management in the LBB through the planning process
- Section 6– details how flood risk can be managed through the design process;
- Section 7 – outlines the principles of sustainable surface water management in the LBB; and
- Section 8 - describes the need for Flood Risk Assessments and processing windfall site applications.

2. Background information and flood risk policy

2.1 Geographical context

2.1.1 The London Borough of Bexley covers an area of 64 square kilometres (25 square miles) in South East London, shown on Figure A1 (Appendix A). It consists of several different communities whose boundaries mostly disappeared during the 1930s with their rapid growth and consequent merging. There are striking differences between areas in the Borough, from the rural surroundings and activities of the LBB's Green Belt, to the large areas of industry and business in Belvedere and Erith.

2.1.2 The London Borough of Bexley is predominantly a residential area. Over half the homes were built between the First and Second World Wars, mainly for people working in industry along the Thames, and in central London. Over many years, the LBB has become closely linked socially and economically with adjoining Boroughs and Districts.

2.1.3 Figure A1 in Appendix A provides an overview of the geography of the Borough. The underlying base geology is presented in Figure A2 and the Superficial Geology is presented in Figure A3. The topography of the Borough is illustrated in Figure A4 and is derived from Environment Agency LiDAR data (Light Detection and Ranging). The Environment Agency Flood map for Planning (Flood Zones) provide a useful initial indication of potential fluvial and tidal flood risk zones (see Figure A5).

2.2 Flood risk and planning policy

2.2.1 This SFRA has been prepared in accordance with national planning legislation and policy guidance. The planning process is driven by legislation and guidance developed at a national, regional and local level, of which flood risk is just one of many factors requiring consideration when making decisions relating to land use and development.

2.2.2 The challenge and measure of success for a SFRA is to develop pragmatic principles for steering future development towards areas of lower flood risk within the context of, and in adhering to other planning policies and local drivers.

2.2.3 There have been significant changes to the policy framework used in informing SFRAs since the previous Level 1 SFRA was published in 2010. At the national level, Planning Policy Statement 25 (PPS25) was replaced with the National Planning Policy Framework (NPPF) in 2012. At the local level, the LBB Local Flood Risk Management Strategy (LFRMS) was developed in 2017, providing local flood risk management coordination. The Thames and North Kent Catchment Flood Management Plans (CFMPs) give an overview of flood risk across each catchment and recommend ways of managing those risks now and over the next 100 years. The Thames River Basin Management Plan (RBMP) ensures the protection and improvement of the water environment.

2.2.4 Flood policy at the local level is informed by both regional and national policy, and should be compliant with the national legislation.

National planning policy

NPPF (2018) and NPPG (2018)

2.2.5 National planning policy is set out in the NPPF, published by the Government in 2012 and revised in 2018[2]. The NPPF is accompanied by online National Planning Practice Guidance (NPPG), published in 2018[3], which provides further guidance on specific issues such as flood risk. The NPPF and NPPG supersedes PPS25 and its associated planning practice guidance.

2.2.6 The NPPF covers a full range of planning issues, focusing on the core issue of sustainable development. Highlighted issues are the re-use of previously developed land of low environmental value, promoting economic growth, and transitioning to a low carbon future, with full consideration of any flood risk.

2.2.7 Local Planning Authority (LPA) planning processes are underpinned by NPPF which dictates that:

2.2.8 "Local Plans should apply a sequential, risk-based approach to the location of development to avoid where possible flood risk to people and property and manage any residual risk, taking account of the impacts of climate change, by:

- applying the Sequential Test;
- if required, applying the Exception Test;
- safeguarding land from development that is required for current and future flood management;
- using opportunities offered by new development to reduce the causes and impacts of flooding; and
- where climate change is expected to increase flood risk so that some existing development may not be sustainable in the long-term, seeking opportunities to facilitate the relocation of development, including housing, to more sustainable locations."

2.2.9 The Sequential and Exception Tests are detailed in Sections 5 and 6 of this SFRA.

Flood Risk Regulations (2009) and Flood and Water Management Act (2010)

2.2.10 The Flood Risk Regulations (2009) place responsibility for the management of localised flood risk upon Lead Local Flood Authorities (LLFAs), in this case the London Borough of Bexley.

2.2.11 The management of all flood risk outside of flooding from main rivers, the sea and reservoirs rests with the LLFA.

2.2.12 The duties for the LLFA, as described in the Water Management Act (2010) are as follows:

- Develop, maintain, apply and monitor a Local Flood Risk Management Strategy (LFRMS);
- Investigate and report flooding incidents from any source;
- Establish and maintain a register of structures or features that are likely to have a significant effect on flood risk;

2 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/740441/National_Planning_Policy_Framework_web_accessible_version.pdf

3 https://www.gov.uk/government/collections/planning-practice-guidance

- Designate structures and features that affect flood risk, thereby requiring the owner to seek consent for any alterations to or removal of the structure; and
- Perform consenting of works on ordinary watercourses.

SuDS

2.2.13 As of April 2015[4], LLFAs have the responsibility for ensuring any Sustainable Drainage Systems (SuDS) are of appropriate design standards and have clear arrangements for maintenance over the development's lifetime. The LBB must therefore be consulted to provide technical advice on all new major developments, defined as residential development of 10 dwellings or more, or with a site area of 0.5 hectares or more, and non-residential development where floor space created is 1,000 m^2 or more, or with a site area of 1 ha or more.

Regional Policy

The London Plan

2.2.14 The London Plan (2016)[5] is the overall strategic plan for London, setting out an integrated economic, environmental, transport and social framework for the development of London over the next 20-25 years. The themes of Flood Risk Management and Sustainable Drainage are brought out through two specific policies, providing guidance on how these issues will impact planning decisions. The policies are:

Policy 5.12 – Flood Risk Management

Strategic

A. The Mayor will work with all relevant agencies including the Environment Agency to address current and future flood issues and minimise risks in a sustainable and cost effective way.

Planning decisions

B. Development proposals must comply with the flood risk assessment and management requirements set out in the NPPF and the associated technical Guidance on flood risk1 over the lifetime of the development and have regard to measures proposed in Thames Estuary 2100 (TE2100) and Catchment Flood Management Plans.

C. Developments which are required to pass the Exceptions Test set out in the NPPF and the Technical Guidance will need to address flood resilient design and emergency planning by demonstrating that:

a) the development will remain safe and operational under flood conditions

b) a strategy of either safe evacuation and/or safely remaining in the building is followed under flood conditions

c) key services including electricity, water etc will continue to be provided under flood conditions

d) buildings are designed for quick recovery following a flood.

[4] http://www.parliament.uk/documents/commons-vote-office/December%202014/18%20December/6.%20DCLG-sustainable-drainage-systems.pdf

[5] https://www.london.gov.uk/sites/default/files/the_london_plan_2016_jan_2017_fix.pdf

D. Development adjacent to flood defences will be required to protect the integrity of existing flood defences and wherever possible should aim to be set back from the banks of watercourses and those defences to allow their management, maintenance and upgrading to be undertaken in a sustainable and cost effective way.

LDF preparation

E. In line with the NPPF and the Technical Guidance, boroughs should, when preparing LDFs, utilise Strategic Flood Risk Assessments to identify areas where particular flood risk issues exist and develop actions and policy approaches aimed at reducing these risks, particularly through redevelopment of sites at risk of flooding and identifying specific opportunities for flood risk management measures.

Policy 5.13 – Sustainable Drainage

Planning decisions

A. Development should utilise sustainable urban drainage systems (SUDS) unless there are practical reasons for not doing so, and should aim to achieve greenfield run-off rates and ensure that surface water run-off is managed as close to its source as possible in line with the following drainage hierarchy:

1) store rainwater for later use
2) use infiltration techniques, such as porous surfaces in non-clay areas
3) attenuate rainwater in ponds or open water features for gradual release
4) attenuate rainwater by storing in tanks or sealed water features for gradual release
5) discharge rainwater direct to a watercourse
6) discharge rainwater to a surface water sewer/drain
7) discharge rainwater to the combined sewer.

Drainage should be designed and implemented in ways that deliver other policy objectives of this Plan, including water use efficiency and quality, biodiversity, amenity and recreation.

LDF preparation

B. Within LDFs boroughs should, in line with the Flood and Water Management Act 2010, utilise Surface Water Management Plans to identify areas where there are particular surface water management issues and develop actions and policy approaches aimed at reducing these risks.

2.2.15 The new Draft London Plan (consolidated changes version July 2019[6]) contain two similar policies SI12 flood risk management and SI13 Sustainable drainage. The theme of the flood risk management policy is very similar to that of the current policy, with the addition of a policy around use of natural flood management methods to offer multiple benefits including recreation and habitat as well as flood risk management. The theme of the sustainable drainage policy is also broadly similar, with stronger wording around the refusal of development proposals for impermeable surfacing.

[6] https://www.london.gov.uk/sites/default/files/draft_london_plan_-_consolidated_changes_version_-_clean_july_2019.pdf

Local policy

Local Plan

2.2.16 A new development plan for long term investment and growth in the LBB is being prepared for the next 20 years, up to 2040. This is one of the drivers for updating the SFRA. An updated assessment of flood risk at the strategic scale will help inform development considered within the Plan. Although not finalised at the time of writing, the LBB have been able to provide policy approaches specific to development for setback from watercourses, as follows:

- Proposed policy DP33 Blue corridors, waterways and waterfront development, part 1(e), sets a requirement for providing 'suitable' setbacks, with Paragraph 6.77 noting that the EA requires undeveloped buffer zones; and
- Proposed policy DP36 Flood risk management, Part 3, includes a specific requirement for new development in riverside locations, and Paragraphs 6.109 to 6.112 discuss riverside development with 6.110 specifying that the width of land to be safeguarded should be 'at least 16 metres.

2.2.17 The LBB have also put in place a SuDS policy, which is as follows:

- The London Borough of Bexley expects all site drainage to achieve greenfield runoff rates for flood events up to and including 1 in 100 years plus 40% climate change;
- Permeable paving should be considered as the more viable and environmentally friendly option for hardstanding's, e.g. car parks;
- Drainage Strategies must be accompanied by suitable maintenance management plans;
- All developments, big or small, whether increasing or decreasing the impermeable area of the site, must provide sustainable drainage in line with all national, regional and local policies;
- Steeply sloping sites should consider the nature of water flow across the site to provide suitable SuDS; both surface water and groundwater flow should be considered;
- Applications should follow the FEH statistical method to estimate greenfield runoff rates. IH124 methods will be considered for smaller single dwelling sites; and
- Development sites should show aspects of water reuse mechanisms for either indoor or outdoor purposes.

Reference should also be made to the LBB Sustainable Drainage Design and Evaluation Guide[7].

Local Flood Risk Management Strategy (2017)

2.2.18 The Local Flood Risk Management Strategy (LFRMS) (2017)[8] sets out how flood risk is managed in the LBB, defines who is responsible for water from different sources and presents an action plan to reduce flood risk. The LFRMS confirms the LBB as the statutory consultee for major planning applications. SuDS are expected in all developments and are mandatory for large developments. The LFRMS also defines the goal of achieving greenfield runoff rates for all development.

[7] LBB Sustainable Drainage Design and Evaluation Guide available at https://www.bexley.gov.uk/services/planning-and-building-control/planning-policy/supplementary-planning-documents-spds
[8] https://www.bexley.gov.uk/sites/bexley-cms/files/Local-Flood-Risk-Management-Strategy.pdf

Integrated Water Management Strategy (2017)

2.2.19 The Charlton to Bexley Riverside Integrated Water Management Strategy (IWMS) (2017) sets out a series of water management and sustainability objectives, including measures that provide a clear framework for developers and other stakeholders. The aim is to provide spatial planning and technical recommendations on managing flood risk, as well as water security, water quality and drainage challenges. The key flood risk recommendations pertinent to the LBB opportunity areas studied in the Strategy are that new properties should achieve greenfield runoff rates, providing attenuation in line with the SuDS hierarchy.

Preliminary Flood Risk Assessment (2011)

2.2.20 The Preliminary Flood Risk Assessment (PRFA) (2011)[9] for the LBB is a high level screening exercise that compiles information on significant local flood risk. The PRFA did not identify any past floods that are considered to have had significant harmful consequences, but predicts that future flood risk is likely to be high, with approximately 10,600 properties at potential risk of flooding from a 1 in 200 (0.5%) annual probability rainfall event.

[9] https://webarchive.nationalarchives.gov.uk/20140328170848/http:/cdn.environment-agency.gov.uk/flho1211bvkp-e-e.pdf

3. Overview of flood risks

3.1 Introduction

3.1.1 This section of the report outlines the context of the LBB SFRA and describes the underlying data and flood-based assessments that have informed the study. The Level 1 assessments are not location or site-specific, rather they involve an assessment of each identified source of risk across the whole Borough, updated since the previous SFRA in 2010 with newly available flood risk information.

3.2 Responsibility for flooding associated with watercourses

3.2.1 The LBB as the LLFA are responsible for managing flood risk from local sources within the Borough boundary, such as surface water, groundwater and ordinary watercourses.

3.2.2 Flooding from main rivers, the sea and from reservoirs are the responsibility of the Environment Agency.

3.2.3 In England the Environment Agency retains permissive powers to carry out maintenance and improvement works on watercourses classified as Main River. These are usually larger streams and rivers, but also include smaller watercourses of strategic drainage importance. A main river is defined as a watercourse shown as such on a main river map, and can include any structure or appliance for controlling or regulating the flow of water in, into or out of a main river.

3.2.4 A map showing the extent of main rivers and ordinary watercourses in the Borough is provided in Figure A1 of Appendix A. The main rivers in the Borough are the Wyncham Stream, River Shuttle and River Cray, with the River Thames forming the northern boundary. A small network of ordinary watercourses are largely in the north of the Borough, around Thamesmead, Erith, Belvedere and Slade Green.

3.2.5 Riparian landowners also hold a responsibility for watercourses. Riparian owners should familiarise themselves with their responsibilities at https://www.gov.uk/guidance/owning-a-watercourse. Responsibilities include reporting incidents, preventing pollution, protecting wildlife and letting water flow naturally by:

- keeping any trash screen, weir, mill gate or other structure clear; and
- removing blockages, fallen trees or overhanging branches from their watercourse, or cutting back trees and shrubs on the bank, where safe and possible:
  - not obstructing or affecting a public right of way of navigation; or
  - reduce the flow or cause flooding to other landowners' property.

3.2.6 With regards flood risk riparian landowners must:

- get a Flood Risk Activity Permit (FRAP) to build anything in or around the watercourse;
- not build anything which could divert water and increase flood risk to other people's property;
- be aware that something on their land (such as a wall) may constitute a flood defence and therefore a FRAP will be required to:
  - change, remove or build any flood defence on their land; and

- do any work within 8 metres of a flood defence, or within 16 metres of a tidal flood defence.

3.3 Historic flooding

Fluvial/Tidal

3.3.1 In the LBB, the only recorded flood incident from the Thames held by the Environment Agency is that associated with the 1953 tidal event. This was an event which affected much of eastern and south eastern England. The extent of this flood even can be seen in Figure A7 in Appendix A, which provides a clear indication of the potential flood risk along the Thames Estuary. Historic flood events have also been recorded on the rivers Cray and Shuttle in 1968 and again on the upper River Cray in 1977.

Surface water

3.3.2 The LBB's record of reported flooding incidents is displayed in Figure A8 in Appendix A, and indicates the majority of causes were reported as "surface water" and "blocked gully". The PFRA notes several instances of surface water flooding in the LBB, two of which are considered to be sufficiently important to be distinguished from other past floods with lesser consequences. These are the past floods at Battle Road (discussed below), where basement flooding is reported to occur, also affecting transport and properties, and at Apperfield Road, which reportedly floods 3-4 times a year due to the limited capacity of the surface water sewer. Less severe surface water flooding is reported to have occurred on Dulverton Road, Brooklands Avenue, Woodlands Avenue, Halfway Street and Corbylands Road. Crayford town centre is also noted to have a history of surface water flooding.

3.3.3 The London Borough of Bexley database for historical flooding identifies Battle and Pembroke Road in Belvedere area as having the most flooding events reported in the Borough. Battle Road (near the junction with Lower Road) predominantly suffers from highway flooding which is both frequent and significant in nature. Residents in Pembroke Road have suffered internal property flooding on several occasions, and some of these properties also have basements which flood. Additionally, Pembroke Road also suffers from highway flooding. It is critical that there is no increase in surface water from new developments within this area and all opportunities to reduce runoff are seized. As such, developers are strongly urged to contact the LBB as Lead Local Flood Authority prior to acquisition and development of sites within this area. The Battle Road Flood Working Group meeting in 2018 determined that there are likely to be a number of causes including mixed ownership, lack of maintenance, loss of certain drainage assets, tide locking of the outfall, lack of capacity and unknown connectivity[10].

Sewer

3.3.4 Thames Water's sewer network is displayed on Figure A9, showing the arrangement of drainage infrastructure across the Borough.

3.3.5 Table 3.1 shows the historic flood events associated with this sewer network as recorded by Thames Water. The majority of flood events are external flooding events, so flooding that does not enter the property. The post code areas DA7 (Bexleyheath and Barnehurst), and DA15 (Blackfen and Sidcup) have historically suffered the most property flooding (internal and external).

[10] Source: Thames Water discussion.

Table 3.1 Thames Water DG5 data for the London Borough of Bexley[11]

Post code area	Internal flooding to property			External flooding property/areas			Grand Total
	AI (2 in 10 AEP)	BI (1 in 10 AEP)	CI (1 in 20 AEP)	AE (2 in 10 AEP)	BE (1 in 10 AEP)	CE (1 in 20 AEP)	
DA1 1	0	0	1	0	0	1	**2**
DA1 3	0	0	1	0	0	0	**1**
DA1 4	0	0	0	1	2	6	**9**
DA14 4	0	0	10	2	1	2	**15**
DA14 5	0	0	0	0	1	0	**1**
DA14 6	0	0	5	0	0	0	**5**
DA15 7	0	0	4	1	14	2	**21**
DA15 8	0	0	3	0	5	9	**17**
DA15 9	0	0	0	0	2	1	**3**
DA16 1	0	0	0	0	0	1	**1**
DA16 2	0	0	0	0	4	4	**8**
DA16 3	0	0	0	3	2	0	**5**
DA17 5	1	0	4	0	1	1	**7**
DA17 6	0	0	2	0	4	1	**7**
DA5 1	0	0	0	0	1	2	**3**
DA5 2	0	0	6	1	0	1	**8**
DA5 3	0	0	2	0	1	2	**5**
DA6 7	0	0	0	0	0	2	**2**
DA6 8	0	0	0	0	0	0	**0**
DA7 4	0	0	1	0	0	2	**3**
DA7 5	0	4	9	1	9	5	**28**
DA7 6	1	2	0	0	5	8	**16**
DA8 1	0	0	0	0	3	5	**8**
DA8 2	0	0	0	0	0	1	**1**
DA8 3	0	0	1	0	1	2	**4**
SE2 0	0	0	0	0	1	1	**2**
SE2 9	0	0	2	0	0	9	**11**
SE28 8	0	0	0	0	0	2	**2**
SE9 2	0	0	0	0	0	1	**1**
SE9 3	0	0	0	0	0	0	**0**
Grand Total	**2**	**6**	**51**	**9**	**57**	**71**	**196**

Table notes: The categories A, B and C relate to the likely frequency of flooding for each particular property. For example AI 1 in 10 AEP means that the property is likely, on average, to be flooded internally once every ten years. AEP = Annual Exceedance probability, the probability in any given year.

Groundwater

3.3.6 Historic groundwater flooding is reported in the PFRA at Thamesmead only, where issues with standing water are thought to be caused by the interaction of high groundwater levels and limited capacity sewers. Where, groundwater flooding occurs it can also reduce the capacity in sewers as such exacerbating flooding.

3.4 Fluvial risk and flood zones, including additional hydraulic modelling

3.4.1 Flood Zones are described throughout this SFRA and they refer to flood extent datasets held by the Environment Agency. The published datasets are updated to capture any refinements as a result of detailed hydraulic modelling projects commissioned by the EA.

3.4.2 NPPG definitions of the Flood Zones are presented below:

[11] Provided by Thames Water March 2019.

- **Zone 1**/Low Probability
  Land having a less than 1 in 1,000 (0.1%) annual probability of river or sea flooding. (Shown as 'clear' on the Flood Map in Figure A5 – all land outside Zones 2 and 3).
- **Zone 2**/Medium Probability
  Land having between a 1 in 100 and 1 in 1,000 (1% - 0.1%) annual probability of river flooding; or land having between a 1 in 200 and 1 in 1,000 (0.5% - 0.1%) annual probability of sea flooding. (Land shown in light blue on the Flood Map in Figure A5).
- **Zone 3a**/High Probability
  Land having a 1 in 100 (1%) or greater annual probability of river flooding; or Land having a 1 in 200 or greater annual probability of sea flooding. (Land shown in dark blue on the Flood Map).
- **Zone 3b**/The Functional Floodplain
  This zone comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. (Not separately distinguished from Zone 3 on the Flood Map).

3.4.3 Figure A5 (in Appendix A) illustrates the extent of Flood Zones 2 and 3. These outlines are based on the latest EA Flood Map for Planning.

3.4.4 The Flood Zones shown on the Environment Agency's Flood Map for Planning (Rivers and Sea) do not take account of the possible impacts of climate change and consequent changes in the future probability of flooding. Reference should therefore also be made to the Strategic Flood Risk Assessment when considering location and potential future flood risks to developments and land uses.

3.4.5 Flood Zones are created without accounting for the presence of flood defences. The Flood Zones are intended to provide an appreciation of potential flood risks that exist, and indicate the areas which should be considered in the planning process. The EA maps do, however, show the areas that benefit from the presence of defences in a 1 in 100 (1%) chance of flooding each year from rivers, or a 1 in 200 (0.5%) chance of flooding each year from the sea.

3.4.6 Flood Zone 3 is typically subdivided into Zones 3a and 3b through use of detailed hydraulic modelling. Detailed hydraulic models exist for the Rivers Cray, Shuttle and Darent, and for these rivers a range of events have been modelled to assess the various flood extents. Detailed modelling outputs are also available for the open watercourses and ditches within the Marsh Dykes region, assessing the fluvial risk only. Figure A6 in Appendix A shows the Functional Floodplain or Flood Zone 3b. This has been defined using the 1 in 20 (5%) flood extent as a basis, whilst taking into account local circumstances and excluding existing development and infrastructure. In line with NPPG (Table D.3, Appendix D) only essential infrastructure (pending application of the Exception Test) and water compatible uses are permitted in Flood Zone 3b.

3.5 Surface water risk

3.5.1 Surface water flooding is the term applied to flooding when intense rainfall overwhelms the ability of the land to infiltrate water, or in urban areas for the sewers and road drains to drain the water away, resulting in surface water runoff and consequent flooding. It is a particular problem in urban areas where the excess water will often travel along streets and paths, between and through buildings and across open space. It can result in indiscriminate flooding to properties when not controlled. The high profile flooding across the UK in the summer of 2007 was largely attributed to

excess runoff where the capacity of the drains was exceeded by intense summer rain storms and led to the Government commissioning the independent Pitt Review in 2008**.**

3.5.2 The EA released the Risk of Flooding from Surface Water (RoFSW) map in 2013. This mapping (although still considered indicative only) represents a significant improvement on the previous surface water flood maps, improving the modelling techniques and underlying dataset and incorporating locally produced mapping where available. In addition to the RoFSW map, several detailed pluvial hydraulic models exist which provide flood extents, including models at Marsh Dykes, Crayford, Darent Industrial Estate and the Wyncham Stream. This SFRA has merged the RoFSW and more detailed modelled extents to provide an overview of surface water flood risk across the LBB in Figure A10 in Appendix A.

Marsh Dykes

3.5.3 The surface water drainage network in the northern part of the Borough is a complex system comprising piped networks, open ditches and pumps. A piped surface water drain system collects water from the Abbeywood and Belvedere and discharges into open ditches in Erith Marshes. The water levels in the Marshes are maintained by pumping stations and a weir at Great Breach pumping station. Two pumping stations are in place in Erith Marshes, these are located on Great Breach Dyke (adjacent to the eastern boundary of the Crossness Sewage works) and at Green Level. This complex interaction is compounded by the multiple owners of the system components (Thames Water, London Borough of Bexley, Environment Agency and the land owner).

3.5.4 The southern edge of the Marshes was highlighted by the LBB as being at particular risk of surface water flooding. This location is where the piped drainage network discharges into ditches and dykes. Flooding issues in this area are associated with a culvert which runs under the railway line. LBB believe this culvert restricts the conveyance of the surface water drainage ditch, and subsequently during periods of high discharge rates, the water levels in the ditch increase and cause surface water drains to surcharge in the area around Abbeywood Station (Station Road and Lower Road). There are also perceived to be under capacity issues associated with the Thames surface water drainage network in this area.

3.5.5 A detailed hydraulic model was built for the Marsh Dykes study by the Environment Agency[12]. The model covers an area which includes the previous Erith Marshes and Thamesmead Canals study areas. The Marsh Dykes has a complex land drainage system and that is reflected in the modelling study. The study includes the main river network, the surface water drainage network, the combined sewer network draining to Crossness Sewerage Treatment Works, and the interaction with the tidal River Thames through the three gravity outfalls and the four pumping stations. The study had three purposes: -

1. to provide mapping of flood extents for fluvial and surface water flooding across the Marsh Dykes catchment including projected climate change.
2. to provide a flood model that can be used later as a base case against which to test options for possible changes to the operation of the system.
3. to undertake limited scenario testing of some options including : -
    a) having the existing sediment 'wished away' and also the sediment depth increased by 150mm and by 300mm.
    b) each pumping station being turned off in turn to see what they are protecting.

[12] Environment Agency, 2020 – Marsh Dykes hydraulic modelling

c) an assessment of the spare storage capacity (or void) in the system that could allow some areas of development to drain to the lakes and canals without attenuation without increasing flood risk.

3.5.6 Figure A17 in Appendix A shows the extent of flood risk across the Marsh Dykes area predicted now and in the future (assuming a 40% increase with climate change) for a 1 in 100 (1%) annual probability event.

Wyncham Stream

3.5.7 The LBB commissioned a detailed hydraulic model study of the Wyncham Stream in 2018[13]. The Wyncham Stream is a small tributary of the River Shuttle which flows through a heavily urbanised catchment. However it is surface water flooding events that pose the greatest risk in this small catchment. In times of flooding, the runoff generated from the catchment overwhelms the sewer system within the catchment which results in surface water flooding. The level of risk is heightened when these events occur in conjunction, resulting in a greater flood extent and/ or severity. For instance, prolonged periods of rainfall can result in localised surface water flooding, which can in turn result in exceedance of the sewer capacity. As rainwater will also enter the river network as overland flow, there is potential for the Wyncham to breach its banks and cause significant flooding.

3.5.8 The area can be divided into a north and south systems, separated by the Sidcup to New Eltham railway line. The surface water network collects run-off from the highways, roofs and curtilage areas and drains via gravity to the Wyncham Stream. The surface water system is mainly located within the public highways and ranges in size from 100mm diameter pipes serving properties to 1500mm diameter at locations where they discharge into the Wyncham Stream.

3.5.9 Historic flood records for the period 1993-2015 show a high concentration of flood incidents focused around Dulverton Road, Brooklands Avenue, Woodlands Avenue, Halfway Street and Corbylands Road. Halfway Street in particular is associated with recurrent flooding from blocked gullies.

3.5.10 Figure A16 in Appendix A shows the extent of flood risk across the Wyncham area predicted now and in the future (assuming a 40% increase with climate change) for a 1 in 100 (1%) annual probability event.

Crayford

3.5.11 A detailed hydraulic model of Crayford was developed in 2015[14] to further inform surface water risk in Crayford, and was used in this SFRA to indicate areas susceptible to surface water flooding now and in the future accounting for climate change. Surface Water flood risk is extensive across Crayford and impacts on a number of properties, including a large number of residential properties, to varying depths. There are some clearly defined flow routes shown by the modelling including:

- Martens Grove;
- Watling St;
- Gravel Hill;
- Crayford High Street;

[13] London Borough of Bexley, 2018 – Wyncham Stream Flood Project
[14] London Borough of Bexley, 2015 – Crayford Integrated Drainage Study

- Station Road across to Dale Road to the railway; and
- Windsor Drive.

3.5.12 Generally, the flooding is shallow, with isolated pockets of 'ponding'. The deepest pockets of surface water flooding affecting clusters of residential properties occur around:

- Broomfield Road/ Faygate Crescent area;
- Rochester Drive;
- Old Road;
- Manor Close;
- Windsor Drive/ Roman Road; and
- Andrew Close.

3.5.13 Figure A16 in Appendix A shows the extent of flood risk across the Crayford area predicted now and in the future (assuming a 40% increase with climate change) for a 1 in 100 (1%) annual probability event.

Darent Industrial Estate

3.5.14 A detailed hydraulic model of the Darent Industrial Estate was developed by the Environment Agency in 2018[15] to better understand the flood risks affecting the area and produce costed options for flood reduction measures. The baseline modelling undertaken was used in this SFRA to indicate areas susceptible to surface water flooding now and in the future accounting for climate change.

3.5.15 The modelling covers the Crayford Marshes, the Darent Industrial Estate and associated access roads. The Crayford Marshes are formed of a complex ditch and dyke network which discharges under gravity via the Crayford Sluice into the Tidal River Thames and is tide locked twice daily. There is a flap valve at the end of the network which prevents backflow from the River Thames into the Crayford Marshes.

3.5.16 The study concluded there are a number of flood mechanisms in the Darent Industrial Estate and Crayford Marshes area which influence the frequency and severity of flooding:

- During the winter months, due to the nature of the marshland, the ground is highly saturated and therefore all rainfall ponds instantly on the surface. During the summer months the marsh dries out and is able to absorb large volumes of rainfall with little surface water flooding. Although during the summer months there is heavy reed growth within the river channels and across the marshland which can have a significant impact on the conveyance of flow. This is exacerbated by the twice daily tide locking of the marsh network.
- Issues with the Darent industrial Estate Drainage system which could include:
  - Rainfall exceeding the capacity of the drainage network and water is unable to enter and flow through the system quickly enough;
  - Rainfall unable to enter and flow through the drainage network due to failure of the drainage system through either collapse of pipes or blockage of pipes due to sediment build up;

[15] Environment Agency, 2018 – Darent Industrial Estate Flood Study

- Rainfall entering and flowing through the drainage network cannot discharge freely to the river network due to siltation of the river channel and/or high water levels within the channel; and
- Drainage network already full of water due to high water levels in the river channel backing up through the estate.

- Persistent fly tipping within the Crayford Marshes and Darent Industrial Estate area, along the roadside ditches result in blockages which increase the permanent water level within the channel network. This results in a loss of channel capacity during rainfall events and causes frequent flooding.

3.5.17 Figure A16 in Appendix A shows the extent of flood risk across the Darent Industrial Estate area predicted now and in the future (assuming a 40% increase with climate change) for a 1 in 100 (1%) annual probability event.

3.6 Tidal flood risk

3.6.1 Tidal flooding and the resultant tidal flood zones in LBB are associated with the River Thames. By virtue of this, only the portion of the Borough along the low lying land adjacent to the Thames is affected.

3.6.2 This part of London benefits from the protection offered by the Thames tidal defences, which currently offer protection against the 1 in 1000 (0.1%) annual probability flood. The potential for defence failure means that despite this level of protection, these areas are not free from the risk of flooding. There remains a residual risk - being the risk that which exists despite the presence of flood defence measures reducing the actual risk, i.e. the flood defences.

3.6.3 Residual risk of flooding behind defences is either associated with the structural failure or the over topping of flood defences. This SFRA focuses on the consequence of a structural failure in flood defences, as NPPF does not require events with magnitude greater than the 1 in 1000 (0.1%) annual probability (which would be needed to overtop the defences) to be considered in the sequential approach to spatial planning. However, structural failure in flood defences can occur irrespective of the magnitude of an event and as such the associated risk is assessed. It is understood that the likelihood of a structural failure in maintained flood defences is low. The probability increases as the magnitude of the tidal event increase. The SFRA does not focus on the probability of failure, but rather the consequence of failure during the 1 in 200 (0.5%) annual probability and 1 in 1000 (0.1%) annual probability (plus climate change – year 2115) events.

3.6.4 Any future tidal flood risk as a result of sea level rise, leading to direct overtopping of the existing Thames defences, would result in less severe flooding than seen in the breach modelling study. As such, the breach modelling discussed in the following section can be considered to represent the worst tidal flood risk.

3.6.5 There is no undefended tidal flood risk in the Borough, with the exception of a small area of land that exists between the high water mark and the flood defence crest along the edge of the Crayford Marsh Embayment, as shown in Figure A11 indicating the Areas Benefitting from Flood Defences (ABDs) layer.

Breach modelling

3.6.6 A Thames Estuary Breach Assessment[16], covering a study area from the Thames Barrier to Gravesend and Tilbury was undertaken in 2018, and the breach extents provided by the EA for inclusion within this SFRA.

3.6.7 The modelling simulated continuous tidal breaches along the entire extent of the modelled area. All downriver breach locations along the Thames are equitably modelled, to ensure a consistent approach across London. For hard and composite defences breaches were set at 20m wide; for soft defences, breaches were 50m wide. In both cases, the defence breach scour distance was assumed to extend into the floodplain by the same distance as the breach width. Based on the 2008 TE2100 in-channel levels, the 1 in 200 (0.5%) and 1 in 1000 (0.1%) annual probability tidal events were modelled for all breach locations down river of the Thames Barrier. These were modelled for the 2014 (present day) epoch, as well as 2100 epoch which included allowances for climate change. The model was designed for catchment wide flood risk mapping, it was not created to produce flood levels for specific development sites within London. If development sites fall within these areas of risk a more detailed breach assessment specific to the development location will need to be undertaken.

3.6.8 Figures A12 and A13 in Appendix A show the breach flood extents for the 1 in 200 (0.5%) and 1 in 1000 (0.1%) annual probability events respectively, for both the 2014 (present day) and 2100 epochs. These figures can be used to define the locations at residual risk from defence failure along the River Thames.

3.6.9 The figures demonstrate that a large extent of the northern areas of the Borough are at potential risk of flooding from failure of the Thames tidal defences. Thamesmead, Belvedere and areas of Slade Green are at particular risk.

3.6.10 Appendix C provides further figures showing the maximum depths, elevations and flood hazards from each of the events.

3.7 Other sources of flooding

Groundwater

3.7.1 The PFRA applied a mapping technique to identify the areas within the LBB with the greatest potential for elevated groundwater. The following four data sources were used to create the Increased Potential for Elevated Groundwater (iPEG) map:

- British Geological Survey (BGS) Groundwater Flood Susceptibility Map;
- Jacobs Groundwater Emergence Maps;
- Jeremy Benn Associates Groundwater Flood Map; and
- Environment Agency Groundwater Hazard Maps.

3.7.2 The iPEG map (created for inclusion in the PFRA and included within this SFRA as Figure A14 in Appendix A) shows those areas within the LBB where there is an increased potential for groundwater to rise sufficiently to interact with the ground surface or be within 2m of the ground surface.

[16] Environment Agency, 2018 – Thames Estuary Breach Assessment

3.7.3 The map indicates that elevated groundwater from permeable superficial soils are located in the lower Thamesmead area of the LBB, and shows elevated groundwater from consolidated aquifers along the eastern edge of the LBB boundary.

3.7.4 The other potential source of groundwater related flooding is where superficial sand and/or gravel deposits are perched on the clay strata. In these instances the local sand/gravel aquifer can become saturated during prolonged intense rainfall and result in flooding at the surface. Any site specific FRAs should consider this potential risk through a review of local superficial and solid geology.

Reservoirs and Dams

3.7.5 The largest body of open water within the Borough is Danson Park reservoir, which is located on a tributary of the River Shuttle, in the centre of the Borough. The reservoir receives discharge from the local surface water drainage network. It has been reported that foul water can also surcharge from sewer system during periods of intense rainfall and route is to the reservoir (a known issue, raising water pollution concerns). The capacity of the reservoir was reduced in the years following the Second World War as building rubble was deposited in the lake, however it remains sufficient to facilitate recreational water sport activities and water levels are maintained at a consistently high level to enable this.

3.7.6 The crest of Danson Dam runs parallel with Danson Road and stands in the order of 7 to 8m higher than the road. The reservoir is drained through a chamber built into the dam wall which collects water and routes it into a culvert which routes flow into the River Shuttle. This path follows the natural low point in the topography and as such reflects the potential flow route of flood waters should the integrity of the dam be compromised. An overflow spillway is built into the dam structure and is designed to be effective when the water levels in the dam reach a critical level so as to avoid structural damage to the dam wall. The spill way is understood to discharge onto Danson Road.

3.7.7 The risk of flooding from reservoirs[17], maximum depth map is shown in Figure A15 in Appendix A. Failure of the Danson Dam is predicted to cause flooding onto Danson Road, and then follow a path southeast towards the River Shuttle, after which the flood extent follows the route of the Shuttle and then the River Cray after their confluence.

3.7.8 Potential flood risks posed by Danson Dam are monitored by the LBB. The dam is subject to regular inspections to assess its structural integrity. The LBB have an Emergency Procedure Strategy for the dam if the water levels begin to rise, to limit the risk of flooding to residents downstream of the dam. The dam is subject to the controls enforced by the Reservoirs Act, which limits the data that can be published in this publicly available document.

3.7.9 As part of the LBB's monitoring of the Dam, the Danson Lake Flood Study (2018)[18] assessed inflows, outflows and water levels for a range of extreme flood conditions, following a recommendation made in the Section 10 Inspection Report of 2017. The key conclusions of the report were as follows:

- that flood estimates derived in the 2018 study were larger than those used for the 2017 inspection and in a 1993 study;
- the current spillway is insufficient to meet the standard recommended for a Category A dam; and

[17] Accessed online via the Environment Agency Spatial Data Catalogue January 2019.
[18] Danson Lake Flood Study, Black & Veatch for the London Borough of Bexley, 2018

- options to lower peak water levels, such as removing spillway banks and re-opening old spillways may have a modest impact on peak water levels, but the solution is likely to require some measures to protect the dam against overtopping flows.

Southern Outfall Sewer

3.7.10 It has historically been considered that the Southern Outfall Sewer is a raised structure, located within the linear embankment locally known as 'The Ridgeway'. A review of Thames Water Sewer data, as part of the Erith Marshes Study (Entec 2009), revealed that the Southern outfall sewer is in fact buried 2-3m underground. The effluent is raised to the surface at Crossness Sewerage Works by pumps. The Ridgeway is in fact a relic of the times when the pumps were steam powered and required a coal supply, as this embankment is actually a disused railway line. As such a breach in the Southern Outfall Sewer is unlikely to present a risk to the LBB, however, the residual risk of pump failure cannot be discounted, and will be included in the evaluation of any sites that require assessment in the Level 2 SFRA.

3.8 Flood management infrastructure

3.8.1 Figure A11 (in Appendix A), details the location of the raised flood defences in the Borough. The defences presented in Figure A11 are regularly visually inspected by the Environment Agency to ensure they remain fit for purpose. As the defences are only visually inspected some uncertainty remains around the condition of buried elements of defences. All Thames tidal defences currently offer a 1 in 1000 (0.1%) annual probability standard of protection. The Environment Agency should be consulted for defence standard information when preparing site specific FRAs. The areas benefiting from the Environment Agency defences (ABDs) are also shown on Figure A11[19]. Please note that not all flood defences have associated ABDs, this reflects the current availability of mapping data and does not imply that other defences do not benefit areas. An ABD designation does not imply that flood risk has been completely removed, as there remains a residual risk associated with defence failure of the defences.

[19] accessed via the EA Spatial Data Catalogue in December 2018.

4. Climate change

4.1.1 Climate change is cited, by the IPCC (2018)[20] and CCC (2017)[21], as being one of the most significant threats to the long-term sustainability of our environment. It is essential that the likely impact of climate change on the extent of the future Flood Zones is considered if development is to be sustainable over the long term.

4.1.2 The current extents of Flood Zones 2 and 3 are critical to the site allocation process, but a view as to how these extents may change in the future is of importance. NPPF notes that the implications of climate change could mean that a site currently located within a lower risk zone could be reclassified as lying within a higher risk zone at some point in the future.

Climate change policy

4.1.3 The NPPF provides guidance on how the planning system should minimise vulnerability and provide resilience to the impacts of climate change. Flood Risk Assessments should demonstrate how flood risk will be managed over the development's lifetime, taking climate change into account.

4.1.4 The climate change allowances provided by the Environment Agency and included in NPPG set out estimates of climate change allowances to be used in Strategic Flood Risk Assessments and site specific Flood Risk Assessments.

- Peak river flow climate chance allowances are specific to each river basin district. The main rivers in the Borough fall into the **Thames River Basin District.**
- Peak rainfall intensity allowances apply across the entirety of England.

4.1.5 Both allowances guidance provide climate change uplifts for periods of time over the next century. Table 4.1 and Table 4.2 below set out the estimates for climate change impacts on river flows and rainfall, reproduced from NPPF.

Table 4.1 Peak river flow allowances

River Basin District	Allowance category	Total potential change anticipated 2015 - 2039	Total potential change anticipated 2040 - 2069	Total potential change anticipated 2070 - 2115
Thames	Upper end	25%	35%	70%
	Higher central	15%	25%	35%
	Central	10%	15%	25%

[20] IPCC, 2018. Global Warming of 1.5 ºC. Intergovernmental Panel on Climate Change. https://www.ipcc.ch/sr15/
[21] CCC, 2017. UK Climate Change Risk Assessment. Committee for Climate change. https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-2017

Table 4.2 Peak rainfall intensity allowances

Applies across all of England	Total potential change anticipated 2015 - 2039	Total potential change anticipated 2040 - 2069	Total potential change anticipated 2070 - 2115
Upper end	10%	20%	40%
Central	5%	10%	20%

Assessment of climate change impacts

4.1.6 Managing climate change and the associated heightened flood risks are key components of NPPF. This SFRA assesses climate change at the strategic scale by considering its impacts resulting in increased flood extents. All Flood Risk Assessments to be undertaken within the Borough should take into account climate change for at least the next 100 years, unless it can be demonstrated that the development will have lifespan of less than 100 years in which case a shorter horizon would be considered acceptable, upon agreement with the Environment Agency. The lifespan of developments are typically 50-60 years for commercial, and 100 years for residential.

Pluvial

4.1.7 Where detailed hydraulic models to assess surface water flood risk exist, the potential impacts of climate change on flood risk predictions have been represented by applying the "upper end" climate change uplift of 40%. This is limited to the Crayford, Wyncham Stream and Marsh Dykes areas of the borough, shown in Figures A16 and A17 respectively. The Marsh Dykes modelling data provides a combined flood risk extent, including both pluvial and fluvial flood risk sources.

4.1.8 Elsewhere, the EA RoFSW mapping has been used as a proxy to indicate areas potentially susceptible to climate change, as shown in Figure A18. The difference in extent between the 1 in 100 (1%) annual probability event and the 1 in 1,000 (0.1%) annual probability event is highlighted, acting as a proxy in lieu of detailed hydraulic analysis with climate change uplift.

4.1.9 In Figures A16, A17 and A18, areas potentially susceptible to climate change are those that show a flood extent when the climate change allowance is applied, but do not under the present day 1 in 100 (1%) annual probability event. Figure A18 in particular demonstrates that there may be areas of Belvedere, Thamesmead and Slade Green at increased risk of pluvial flooding when an allowance for climate change is added.

Fluvial

4.1.10 As in the pluvial climate change assessment, detailed fluvial hydraulic models of the Rivers Cray and Shuttle have been used to identify areas of floodplain potentially susceptible to climate change. This has been assessed by comparing the extents of the 1 in 100 (1%) and the 1 in 100 (1%) plus a 25% climate change uplift annual probability events.

4.1.11 Figure A19 shows the difference in flood extent between the events. Areas of the River Cray floodplain between Bexley and Crayford appear to be susceptible to fluvial climate change, with some increased areas of flood extent at this location.

4.1.12 The results shown in Figure A19 are from the EA's Darent and Cray modelling update (2018), and show the defended flood extents, rather than the undefended extents shown in the EA's Flood Map for Planning.

4.1.13 Similarly, detailed fluvial hydraulic modelling of the Marsh Dykes region has been used to assess areas potentially vulnerable to climate change. The extents of the 1 in 100 (1%) and 1 in 100 (1%) plus 40% climate change uplift events have been compared in Figure A20.

4.1.14 The results shown in Figure A20 are from the EA's Marsh Dykes hydraulic modelling study (2020), and also show the defended flood extents rather than the undefended extents.

4.1.15 For the ordinary and unmodelled watercourses in the Borough, Figure A21 provides an indicative assessment of areas potentially vulnerable to climate change, by using the pluvial assessment as a proxy for watercourses without detailed hydraulic modelling or EA flood mapping. This is intended to provide an indication of whether an area may be susceptible to climate change, and does not replace the requirement for detailed assessment as part of a FRA.

Spatial planning response

4.1.16 All flood risk assessments should factor in an assessment of climate change. If sites are located in, or partially within Flood Zones 2 or 3 then the FRA should assess how the 1 in 100 (1%) annual probability flood extent will be affected by climate change following guidance laid down in NPPF and on advice from the Environment Agency. Figures A16-A21 can be used to provide information on areas potentially vulnerable to climate change for spatial planning purposes, however, for site specific FRAs, full assessment of climate change impacts should be considered.

5. Flood risk management through planning

5.1 Introduction

5.1.1 The approach to the sustainable management of flood risk through the planning process supported in this SFRA follows the sequential risk based approach advocated by NPPF. This chapter discusses how flood risk can be managed through the spatial planning process. Avoidance is the principal method of managing flood risk through the spatial planning process and is discussed further in this chapter. If, in exceptional circumstances, development is proposed in areas of flood risk, Chapter 6 proposes guidance on managing the risk through site layout and building design.

5.2 Sequential approach

5.2.1 Through the planning process, NPPF aims to reduce the flood risks faced by future developments, and advocates a risk avoidance approach to spatial planning. The flood risk tables from NPPG on Flood Risk and Coastal Change have been reproduced in Appendix D of this SFRA for reference purposes. A sequential risk-based approach to determining the suitability of land for development in flood risk areas is central to the Policy Statement and should be applied at all levels of the planning process.

5.2.2 Application of the sequential approach to spatial planning reinforces the most effective risk management measure – that of avoidance. NPPF states that application the Sequential Test at the Local Development Document level, will help ensure that development can be safely and sustainably delivered.

5.2.3 The sequential approach offers a simple decision making tool that is designed to ensure that areas of little or no risk of flooding are developed in preference to areas at higher risk. NPPF notes that LPAs should make the most appropriate use of land to minimise flood risk, by planning the most vulnerable development in the lowest known risk areas. However, it is recognised that there are cases when development within higher risk zones is unavoidable.

Sequential test

5.2.4 The Sequential Test[22] is a decision making tool designed to ensure that areas at little or no risk of flooding are developed in preference to areas of higher risk. It is a key component of the hierarchical approach to avoiding and managing flood risk.

5.2.5 The EA's Flood Map for Planning is shown on Figure A5 in Appendix A. Table 5.1 presents details of land use types appropriate[23] for each zone. Further guidance on the appropriateness of land use types for each zone are presented in Table D.2 (in Appendix D). There are several key points that should be considered when applying the Sequential Test, these are outlined below.

- Increasing the vulnerability of a site by proposing an alternative use of a higher vulnerability (even if consistent with the risk) is considered an increase in flood risk and not in line with the principles of NPPF;
- The most vulnerable land uses should be allocated first, in areas of least risk;

[22] NPPF Paragraph: 019

[23] Appropriate = as defined by Table D.2 in Appendix D of this report, reproduced from NPPF

- Placing less vulnerable uses in low risk areas and thus reducing the amount of available space for more vulnerable uses in the lower risk zones is not appropriate. Such a situation can only be considered if it can be demonstrated that the only suitable site for the low vulnerability land-use is in the area of low risk; and
- If land in Flood Zone 3 has to be utilised, development should be steered towards the areas of lowest hazard within that zone. The information presented in Section 3 can be used to inform this process.

Data to support allocation of the sequential test

5.2.6 Flood risk classifications defined for the Borough are presented in Figure A6 (in Appendix A). This is a combination of the EA's Flood Map for Planning Zones 2 and 3, and the functional floodplain extent, derived using the 1 in 20 (5%) annual probability event provided through detailed hydraulic modelling as a basis and excluding areas of developed land. Table 5.1 presents guidance on appropriate land use guidance for each of the flood risk zones. Figure A6 and Table 5.1 can be used to guide the decision making process when the Borough is presented with windfall sites.

Table 5.1 Attribution of Flood Risk to Development Sites

Environment Agency Flood Zone Name	Probability	LBB Flood Zone Designation	NPPF Land use Guidance
Flood Zone 3b	Functional Flood Plain	Zone 3b	Only the water compatible uses and essential infrastructure listed in Table D.2 (Appendix D) should be permitted in this zone. Development should be designed and constructed in such a way to: • remain operational and safe for users in times of flood; • result in no net loss of floodplain storage; • not impede water flows; and • not increase flood risk elsewhere Essential Infrastructure in this zone should pass the Exception Test. All development proposals in this zone should be accompanied by a FRA.
Flood Zone 3a	High	Zone 3a	Water compatible and less vulnerable uses of land listed in Table D.2 are appropriate in this zone. More vulnerable and Essential infrastructure in this zone would require an Exception Test. All development proposals in this zone should be accompanied by a FRA.
Flood Zone 2	Medium	Zone 2	Water compatible, less vulnerable and more vulnerable uses of land and essential infrastructure in Table D.2 are appropriate in this zone. Subject to the Sequential Test being applied, the highly vulnerable uses in table D.2 are only appropriate in this zone if the Exception Test is passed. All development proposals in this zone should be accompanied by a FRA.
Flood Zone 1	Low	Zone 1	All uses of land are appropriate in this zone. Other sources of flooding should be reviewed. FRAs are required for sites over

Environment Agency Flood Zone Name	Probability	LBB Flood Zone Designation	NPPF Land use Guidance
			1ha and Drainage Impact Assessments are required for sites over 0.25 ha (See Section 5.1).

Guidance for zones 3b, 3a, 2 and 1 based on Table D.1 in Appendix D.

Other sources of Flooding

5.2.7 NPPG requires that the sequential approach to locating development in areas at lower flood risk should be applied to all sources of flooding. Alongside the Flood Map for Planning (Figure A5 in Appendix A), this therefore means that the following should be considered:

- the potential extent of surface water flow routes and ponding areas (Figure A10, Appendix A);
- the potential for groundwater emergence (Figure A14, Appendix A); and
- the risk of flooding from reservoirs (Figure A15, Appendix A).

5.2.8 This sequential approach of allocating development to areas at least risk of flooding can therefore be applied beyond the fluvial and tidal risk, ensuring sites at least risk of flooding from all sources are selected for development before those at greater risk.

6. Flood risk management through design

6.1 Introduction

6.1.1 Flood risk management by design should only be considered after the sequential approach has been applied to development proposals. The sequential approach is applicable both in terms of site allocation and site layout. Only when it has been established that there are no suitable alternative options in lower risk areas, should building design solutions be considered to facilitate development in flood risk areas.

6.1.2 The sequential approach to land use planning on sites can mitigate some of the flood risks, however, there will be instances where a level of risk remains. In these circumstances, flood risk management through design is required. This would need to be addressed as part of site-specific FRA.

6.1.3 Should the Sequential Test demonstrate that no alternative sites exist, the Exception Test can be applied to demonstrate that the sustainability benefits of the development to the community outweigh the flood risk.

6.2 Exception test

6.2.1 The Exception Test recognises that there will be some exceptional circumstances when development within higher risk zones is unavoidable. The allocation of necessary development must still follow the sequential approach and where exceptions are proposed, the Exception Test must be satisfied.

6.2.2 Flood mitigation measures should be considered as early as possible in the design development process to reduce and manage the flood risks associated with development. This section describes how flood risk can be managed through development design.

6.2.3 If the Sequential Test shows that it isn't possible to use an alternative site, the Exception Test is required if the development is classified as:

- highly vulnerable and in flood zone 2;
- essential infrastructure in flood zone 3a or 3b; and
- more vulnerable in flood zone 3a.

Passing the Exception Test

6.2.4 NPPF states that the Exception Test should only be undertaken after the Sequential Test has been applied. The successfully applied Sequential Test must demonstrate that there are no other reasonably alternative sites available in zones of lower flood risk. This is an essential evidence base and should be considered a prerequisite for any development proposed in a zone of flood risk.

6.2.5 Once the Sequential Test has been applied and passed, NPPF requires the following criteria to be met to pass the Exception Test:

- it must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a Strategic Flood Risk Assessment where one has been prepared; and

- 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.

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

Flood Risk Assessment requirement of the Exception Test

6.2.7 The Exception Test requires a FRA, demonstrating that the proposed development will be safe, without increasing the flood risk elsewhere. To achieve this, NPPF identifies a number of factors which need to be considered:

- Safe access and egress;
- Operation and maintenance;
- Design of development to manage and reduce flood risk wherever possible;
- Resident awareness;
- Flood warning; and
- Evacuation procedures and funding arrangements.

These key aspects are expanded in Section 6.3, where flood risk management is discussed in terms of design and emergency responses.

6.3 Development controls

6.3.1 Under exceptional circumstances, following the application of the Sequential Test, where development is proposed in areas of flood risk, it will be necessary for the design to incorporate certain flood risk management elements. The following paragraphs describe some of these control measures.

Development adjacent to a main river

6.3.2 Figure A1 (in Appendix A), illustrates the extent of the Environment Agency's main rivers and ordinary watercourses. To ensure that flood risk is considered as part of a development along the banks of any of these watercourses, a buffer zone along both banks is required.

Fluvial watercourses or fluvial defences

6.3.3 For any proposed development that is adjacent to a fluvial main river or ordinary watercourse, an offset of 8 metres from the closest point of any built structure, to the watercourse would be expected. For open channels, this should be measured from the top of bank of the river channel. For any culverted watercourses, this should be measured from the outward face of the culvert. This may require applicants to carry out some site investigations to establish where the culvert is located.

6.3.4 The Environment Agency requires unimpeded access to fluvial main rivers to carry out any emergency works, or to carry out any maintenance to the channel. It is likely that culverts will need to be replaced in the future, so it is very important to secure this offset during the development stage to reduce the risk of any complications.

6.3.5 Including this offset in any development plans will also increase the opportunities to provide environmental enhancements along the river channels. There may also be scope to open up culverted watercourses to 'daylight' the rivers and improve the amenity of the area.

Tidal main river or tidal defence

6.3.6 Future developments located next to the Thames Tidal Flood Defences will need to provide 16m between the proposed development and the landward extent of the flood defence. This is to allow machinery to be able to access the defence for maintenance/emergency repairs. In addition to this, developers will have to either raise the Thames Tidal Flood Defences in line with TE2100 as part of their development, or alternatively, demonstrate that the TE2100 crest raising can be done in the future without undue cost and difficulty. Having developments too close to the defence can seriously hinder the ability to raise flood defences in the future and may result in a much more costly solution.

6.3.7 On sites which include the Thames Tidal Flood Defences the developer is expected to demonstrate that the defence structures have a lifetime of no less than that of the development without needing a major intervention.

6.3.8 It is not always obvious where the landward extent of the flood defence will be as these are often buried underground. There are a number of different types of flood defence along the stretch of the River Thames through the London Borough of Bexley, some including different elements buried underground. The Environment Agency does not have accurate drawings of all of the flood defences, so the applicant may need to carry out intrusive site investigations to determine the exact location of any buried elements of the flood defence.

Flood Risk Activity Permits (FRAPs)

6.3.9 A Flood Risk Activity Permit (FRAP) will be required under the Environmental Permitting (England and Wales) Regulations 2016 if you want to do work:

- Within, over or under a main river;
- Within 8m of the bank of a main river, or 16m if it is a tidal main river; and
- Within 8m of any flood defence structure or culvert on a main river, or 16m on a tidal main river.

6.3.10 This may include any site investigations to establish where the buried elements of the flood defence are, so we recommend that developers contact the Environment Agency as soon as possible regarding whether they need a permit and what to consider in preparation for a permit during the planning stage. Further guidance on applying for Flood Risk Activity Permits can be found on the following link https://www.gov.uk/guidance/flood-risk-activities-environmental-permits.

Development in flood risk areas

6.3.11 Development within a fluvial flood risk area will be subject to Development Controls, including:

- All new developments are required to provide safe access and exit during a flood. Measures by which this will be achieved should be clear in the site-specific FRA. Safe access and exit is required to enable the evacuation of people from the development, provide the emergency services with access to the development during a flood and enable flood defence authorities to carry out necessary duties during the period of flood. A safe access or exit route is a route that is safe for use by occupiers without the intervention of the emergency services.

- The specification of finished floor levels:
  - Where highly vulnerable, more vulnerable, essential infrastructure development are permitted finished floor levels should be set to based on the source of risk:
    - In areas of fluvial or surface water flood risk finished floor levels should be set above the 1 in 100 (1%) annual probability plus 35% climate change flood level, plus an appropriate freeboard allowance (300 mm if the site is behind fluvial defences and 600mm if not).
    - In areas of tidal residual flood risk only, finished floor levels of sleeping accommodation need to be raised above the 1 in 200 (0.5%) annual probability for the 2115 epoch, which includes an allowance for climate change.
  - Where water compatible and less vulnerable development are permitted finished floor levels can be set at ground level although ideally less vulnerable land uses should also have floor levels that do not flood and this arrangement should be sought wherever possible.
- No increase in building footprint - The footprint of buildings should not be increased post re development without mitigation to compensate for lost floodplain storage space. Such schemes should be discussed in detail with the LPA and the Environment Agency.
- Provision of compensatory storage - Compensatory storage will be required if the proposed development increases the built footprint in the floodplain. The resulting loss of floodplain storage will require compensation, through the lowering of land levels elsewhere within the site. Compensation should be provided for flood events less than and including the 1 in 100 (1%) annual probability plus 35% climate change event. Storage should be provided on a level for level and volume for volume basis, so that the behaviour of the floodplain during a flood event remains unchanged. Compensatory storage area should utilise space outside the 1 in 100 (1%) annual probability plus 35% climate change extent, but which can become hydraulically connected to the floodplain. All proposals requiring compensatory storage should be discussed with the LPA and the Environment Agency.

Development in areas designated as the functional floodplain (Zone 3B)

6.3.12 NPPF states that only water compatible uses will be permitted in the functional floodplain, providing there is no reduction on flood conveyance or flood storage. Less vulnerable, more vulnerable and highly vulnerable uses are not permitted in Zone 3b. Essential infrastructure may be permitted providing the Exception Test is satisfied. However, given the limited extent of the functional floodplain shown in Figure A6 in Appendix A, it is recommended that development is not permitted in Zone 3b.

Development in surface water flood risk areas

6.3.13 NPPF requires that all sites over 1 hectare include a site-specific FRA, and all sites of any size in Flood Zones 2 and 3. However, due to the metropolitan nature of Bexley it is recommended that all sites over 0.25 hectares undertake a FRA, including a Drainage Impact Assessment as part of a Planning Application. These Drainage Impact Assessments should be inclusive of a consideration of surface water drainage and measures to mitigate against any potential increase in run off. In addition to this, Figure A10 should be reviewed to assess whether the site is within a zone of potential surface water flood risk. As part of these assessments, Thames Water should be contacted to discuss the proposed method of managing surface water. Guidance on the minimum requirements for site specific FRAs can be found in Section 8.2.

6.3.14 Site specific FRAs should consider the local drainage infrastructure in detail. When preparing site specific FRAs the impact of blocked drains and the likely consequences should be established. If necessary it might be appropriate to slightly raise ground floor levels to reduce potential damages. This is not a requirement of NPPF, it is just a means of reducing the impact of a potential risk. Such mitigation should be supported by evidence to demonstrate that surface water flow routes are not altered to the extent that the risk of flooding is made worse elsewhere.

6.3.15 An area identified at risk from surface water flooding, either from flood mapping or from historical records, should not be excluded from development solely on that basis. Surface water flooding can often be carefully managed and good site design may not only reduce the risk of flooding on site but could also help alleviate flooding problems downstream from the development.

6.3.16 The management of runoff during the construction period is an important consideration, particularly for large sites and details of measures to mitigate for this phase of development are required as part of an FRA. The Water Framework Directive (WFD) places specific requirements on the management of non-point source pollution such as that from construction site silts. Methods to reduce the volume of solids (and runoff) leaving the site include:

- Phased removal of surface vegetation at the appropriate construction phase;
- Provision of a grass buffer strip around the construction site and along watercourses;
- The covering of stored materials;
- Ensuring exposed soil is re-vegetated as soon as feasibly possible;
- Protection of storm water drain inlets; and
- Silt fences, siltation ponds and wheel washes.

Consideration of climate change

6.3.17 Managing climate change and the associated heightened flood risks are key components of NPPF. Site specific FRAs should take into account climate change, for at least the next 100 years, unless it can be demonstrated that the development will have lifespan of less than 100 years in which case a shorter horizon would be considered acceptable, upon agreement with the LPA and the Environment Agency.

6.3.18 The potential impacts of climate change on rainfall and river flows in Bexley have been strategically assessed as part of this Level 1 SFRA. Further detail is provided in Section 4.

6.3.19 In line with the principals of risk avoidance, site layout should seek to avoid the predicted flood extents. If this is not possible, risk management should be undertaken through design. As such it is recommended that finished floor levels for more vulnerable or highly vulnerable land use types of a site should reflect the 1 in 100 (1%) annual probability plus climate change flood level, plus an appropriate freeboard allowance.

Freeboard allowance

6.3.20 Predicted flood water levels alone, are not necessarily sufficient to inform finished floor levels. An additional freeboard may be required to account for uncertainties and in tidal area, the action of waves. In all instances, the Environment Agency should be consulted to establish the necessary freeboard allowance for the proposed development. The Environment Agency's current position is that freeboard allowance for fluvial flood risk is typically 300 mm if the site is behind fluvial defences and 600mm if not. However, LBB are at liberty to request additional freeboard as they see fit.

6.3.21 In areas of residual (tidal) risk, the breach model is deemed to be conservative enough to not require additional freeboard.

Basements

6.3.22 NPPF classes self-contained basement dwelling (i.e. with no internal access to upper floors) as 'highly vulnerable', and as such not permitted in flood zone 3a or 3b. Highly vulnerable development is permissible in flood zone 2 subject to the successful application of the exception test.

6.3.23 Basements are likely to be susceptible to groundwater and sewer flooding, and these sources must be considered as part of any FRA. Additionally, it is recommended that all basement developments include, within their proposal, protection to the property by installing, for example, a non-return valve or other suitable device to avoid the risk of backflow at a later date, on the assumption that the sewerage network may surcharge to ground level during storm conditions.

6.3.24 The LBB does not have a specific Supplementary Planning Document for Basement planning permission, however, it is recommended that habitable rooms in basements should not be permitted in Flood Zones 2 or 3. Adaptation of existing properties, to include a basement for habitable rooms should be discouraged in Flood Zones 2 and 3. It is however recognised that the implementation of this may be challenging, as basement development is sometimes classified as Permitted Development when within the bounds of the existing building.

6.3.25 If a basement is proposed in an area adjacent to a river or flood defence structure the footprint of a basement should not extend closer to the river or flood defence than the above ground structure. Basements cannot encroach towards, or be connected to the river bank or flood defences in anyway as this may compromise river banks and flood defences and make the basement part of the bank or defence structure. The nearest part of a basement must be set back, as above ground structures, by 8m of the bank of a main river or 16m if it is a tidal main river, to allow space for future works.

6.3.26 Basements for less vulnerable uses or non-habitable rooms must be designed with safe internal escape. In areas of surface water or fluvial flood risk safe internal escape should be to a location above the 1 in 100 (1%) annual probability plus climate change water level. In areas of tidal residual risk safe internal escape should be to a location above the 1 in 200 (0.5%) annual probability plus climate change water level. Each application should be discussed with the LPA and the Environment Agency. Site specific analysis should accompany any proposal, to demonstrate that a proposed basement would not impede the flow of groundwater in such a way that the risk of groundwater flooding elsewhere is increased.

Voids and stilts

6.3.27 The Environment Agency is against the use of voids and stilts in areas of flood risk where the voids under buildings are proposed to offer flood storage in the event of a flood.

6.3.28 To ensure flood storage is retained the functionality of the voids would need to be maintained to ensure they remain clear of all debris. Voids under buildings are not policed therefore their maintenance for flood storage cannot be guaranteed in the future. Voids remain at risk of future residents of developments sealing up the voids and as a result obstructing the flood storage and deflecting flood flows to neighbouring landowners.

6.3.29 In the LBB, therefore, there is a presumption against the use of voids and stilts as part of a new developments, and planning applications for developments which utilise voids and stilts to manage flood risk will only be accepted in exceptional circumstances.

Access and egress

6.3.30 In exceptional circumstances, pending successful application of the Sequential Test, development may be proposed in areas of flood risk. In such an event, safe escape routes to outside the flood risk zone should be incorporated into site designs to facilitate safe evacuation of the site. Additional detailed modelling of watercourses may be required to provide the necessary flood levels and speeds of onset and flood hazard classifications needed to inform safe evacuation routes. Safe routes should be identified both inside and beyond the site boundary of the new development. Even where a new development is above the floodplain and is considered to be acceptable with regard to its impact on flood flows and flood storage, it should be demonstrated that the routes to and from the development are also safe to use. Safe escape routes should be intuitively designed, so that they remain logical routes of escape during a flood event. In many cases, the adaptation of the normal access an egress routes so that they remain safe is the preferable option, rather than the engineering of routes specifically for use in flood events. Where possible, new development should aim to provide dry escape for the lifetime of the development.

6.3.31 London Borough of Bexley provides guidance on evacuation in the emergency planning section of their website[24].

Building design

6.3.32 The final step in the flood risk management hierarchy is to mitigate through building design. NPPF considers this as the least preferred option and should not be used in place of the sequential approach to land use planning on a site.

6.3.33 The Department for Communities and Local Government has published guidance on improving the flood performance of new buildings. The guide identifies a hierarchy of building design which fits within step 5 of the flood risk management hierarchy of NPPF (assess, avoid, substitute, control and mitigate). This is set out below:

- Flood avoidance:

  Constructing a building and its surrounds (at site level) to avoid it being flooded (e.g. by raising it above the flood level).

- Flood resistance:

  Constructing a building in such a way to prevent flood water entering the building and damaging its fabric.

- Flood resilience:

  Constructing a building in such a way that although flood water may enter the building its impact is reduced (i.e. no permanent damage is caused, structural integrity is maintained and drying and cleaning are facilitated).

- Flood reparable:

  Constructing a building in such a way that although flood water enters a building, elements that are damaged by flood water can be easily repaired or replaced.

6.3.34 The EA Guidance on Flood Risk Assessment: Local Planning Authorities[25] sets out to help the designer determine the best option or design strategy for flood management at the building site level, based on knowledge of basic flood parameters (e.g. depth, duration and frequency), these factors would normally be determined by the site specific FRA during the planning application

[24] https://www.bexley.gov.uk/services/emergency-planning/evacuation-advice
25 https://www.gov.uk/guidance/flood-risk-assessment-local-planning-authorities

process. Depending on these parameters (in particular depth) and after utilising options for flood avoidance at site level, designers may opt for a water exclusion strategy or a water entry strategy, as illustrated in .

Figure 6.1 Flexible and risk averse approaches to flood risk management and safe development

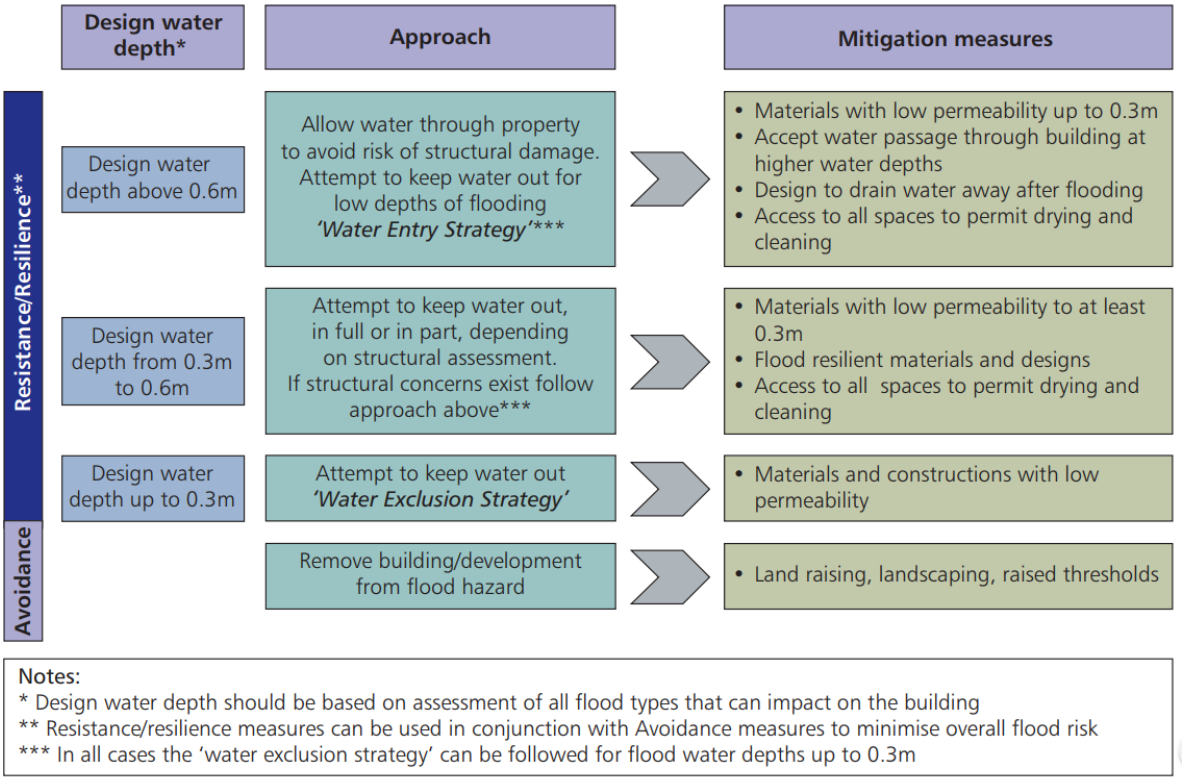

Figure taken from "Improving the Flood Performance of New Buildings – Flood Resilient Construction"[26]

6.3.35 In a Water Exclusion Strategy, emphasis is placed on minimising water entry whilst maintaining structural integrity, and using materials and construction techniques to facilitate drying and cleaning. This strategy is favoured when low flood water depths are involved (up to a possible maximum of 0.6m).

6.3.36 In a Water Entry Strategy, emphasis is placed on allowing water into the building facilitating draining and consequent drying. Standard masonry buildings are at significant risk of structural damage if there is a water lever difference between outside and inside the building of about 0.6 m or more. This strategy is therefore favoured when high flood water depths are involved.

Resilience and resistance

6.3.37 Building resilience in Thamesmead/Erith Marshes and Crayford Marsh embayments is a fundamental aspect to any developing proposal. Buildings must retain structural integrity in the event of a flood. Residual flood depths over the embayment have been estimated to be consistently in excess of 2m, as shown in Figures C1-4 in Appendix C. It is thought that standard masonry buildings are at significant risk of structural damage if there is a water level difference between outside and inside of in excess of 0.6m. Water entry strategies are favoured in these situations which promote flood resilience rather than flood resistance.

26 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/7730/flood_performance.pdf

6.3.38 The 'Improving the Flood Performance of New Buildings' report should be consulted for flood resilience design guidance. A summary of mitigation measures which should be considered at the detailed design stage for developments where the flood depths are expected to exceed 0.6m are:

- Accept water passage through building at higher water depths;
- Attempt to keep water out for low depths of flooding;
- Materials with a low permeability at lower levels;
- Design to drain water away after flooding; and
- Access to all spaces to permit drying and cleaning.

6.3.39 The impact the flood waters will have on the structural integrity of the buildings must be considered at the detailed design phase. It must be demonstrated that the buildings will remain safe in the event of a breach in the flood defences during a high tidal event.

Flood risk management through emergency response

6.3.1 The Environment Agency will issue flood warning advice if the river or tide levels reach a point at which the risk of flooding is considered significant. This will provide the community time to prepare and if necessary be evacuated. The Environment Agency provides flood warnings for the LBB for the following areas that include:

- Tidal Thames from Erith High Street to Thamesmead;
- Tidal Thames from Dartford Creek to Erith High Street;
- River Cray;
- River Shuttle; and
- River Darent.

6.3.2 In the event of a breach the principal escape route in the proposed development, if not located near a safe, dry evacuation route, should be internally upwards to higher floors. This completely precludes the installation of any single storey ground floor residential units which are not situated above the predicted 2115 1 in 200 (0.5%) annual probability modelled flood water level. The risk of defence failure is reduced by a programme of defence inspection and maintenance carried out by the Environment Agency.

6.3.3 Fire escape routes are a fundamental component of building regulations. These well sign-posted, communal routes could be utilised in the event of a flood, but in reverse direction. Buildings will therefore require a flood evacuation procedure designed to move people upwards to safe levels. This is of particular importance for those land uses which are below the predicted flood water level (e.g. shops, offices or gyms) and these developments should be supported with a detailed evacuation plan for moving people to safety. Internal safe refuge should be provided for all occupied land uses above the design flood level.

7. Sustainable surface water management

7.1 Introduction

7.1.1 Sustainable Drainage Systems (SuDS) are an approach to managing surface water that replicates natural drainage. The key objectives are to manage the flow rate and volume of runoff at the source, to reduce risk of flooding and improve water quality. From 6 April 2015, the Planning Practice Guidance for Flood Risk and Coastal Change (PPG) was amended to provide a stronger emphasis on the usage of SuDS. LPAs are required to ensure that SuDS are incorporated in all major development plans where appropriate, and make sure that there are arrangements in place for ongoing maintenance over a development's lifetime.

7.1.2 LLFAs are statutory consultees for surface water drainage, and are required to take account of new "non-statutory" national SuDS standards that have been introduced[27] as part of the update to NPPG.

7.1.3 From a drainage perspective, these FRAs and Drainage Impact Assessments need to detail how surface water is currently managed on site and how it is proposed to be managed post development. The discharge route (e.g. surface water drains or an open watercourse) should be detailed and it is important that there is evidence of either Thames Water or Environment Agency consultation which includes approval of the discharge. These assessments should describe how current run off rates and volumes are managed, for brownfield site development this should include details of how rates and volumes will ideally be reduced, keeping to greenfield runoff rates as advocated by the London Plan. If a reduction in runoff rates and volumes is not proposed the assessment must provide evidence to explain why this cannot be achieved.

7.1.4 London Borough of Bexley's position is that greenfield runoff rates should be met on all sites, including brownfield redevelopment. As the Lead Local Flood Authority, LBB will be required to act as the SuDS approval body.

NPPF and NPPG SuDS Advice

7.1.5 The NPPF and its associated NPPG advises that developers should use SuDS to manage runoff at source, replicate the natural hydrological cycle as closely as possible and reduce the pressure on downstream drainage networks, thus helping to manage flood risk to downstream development. SuDS should be incorporated into the site layout as an integral part of the development. Preference should be given to open-air SuDS formed as part of the development's green space to maximise the benefits SuDS can provide by improving water quality, and providing for amenity, recreation and wildlife. The PPG acknowledges that SuDS may not be applicable for all sites, for instance if there are pre-existing concerns about flooding. However, SuDS ought to be provided unless it is demonstrated that they are not appropriate (from a geotechnical or hydrological perspective) for a particular development.

7.1.6 When planning SuDS, the developer must consider construction, operation and maintenance requirements, both above and below the ground surface. The capacity of the system should be designed to take into account the design storm, allowances for future climate change, and likely changes in impermeable area over the lifetime of the development (the Local Authority SuDS Officer Organisation[28] practice guidance specifies a range of allowances for future urban creep). The

[27] https://www.gov.uk/government/publications/sustainable-drainage-systems-non-statutory-technical-standards - Non-statutory technical standards for sustainable drainage systems
[28] http://www.lasoo.org.uk/non-statutory-technical-standards-for-sustainable-drainage

suitability, or otherwise, of SuDS for a particular site is determined by the LPA, in consultation with the LLFA.

7.1.7 Early engagement with LBB is recommended to ensure development compliance, ideally at acquisition stage. London Borough of Bexley provide specific guidance on SuDS, aimed at developers and describing the design stages of sustainable drainage in their "Sustainable drainage design and evaluation guide"[29]. All SuDS need to comply with LBB SuDS Policy:

- Bexley council expects all site drainage to achieve greenfield runoff rates for flood events up to 1 in 100 years plus 40% climate change.
- Permeable paving should be considered as the more viable and environmentally friendly option for hardstanding's, e.g. car parks.
- Drainage Strategies must be accompanied by suitable maintenance management plans
- All developments, big or small, whether increasing or decreasing the impermeable area of the site, must provide sustainable drainage in line with all national, regional and local policies.
- Steeply sloping sites should consider the nature of water flow across the site to provide suitable SuDS system, both surface water and groundwater flow should be considered.
- Applications should follow the FEH statistical method to estimate greenfield runoff rates. IH124 methods will be considered for smaller single dwelling sites.

7.1.8 If it can be demonstrated that there are no suitable alternatives, Thames Water may permit connection to their assets for the disposal of surface water runoff. This would require confirmation from the LBB that it is not possible to manage surface water runoff via a soakaway, and from the EA to say that a connection to a watercourse is not possible. The application should be made to Thames Water directly, providing a site location plan indicating:

- The type of connection (surface water should be connected to either a surface water or combined sewer);
- The location of the connection (mapping available for purchase online via Thames Water);
- The size of the proposed connection;
- The size of the sewer;
- The level of connection;
- The method of connection;
- The type of sewer being proposed (e.g. clayware); and
- Details of planning conditions where applicable.

7.2 What is sustainable surface water management and where should it be applied?

7.2.1 The applicability of SuDS techniques for use on potential development sites should, as far as is practicable:

- Store rainwater for later use;

29 London Borough of Bexley, 2018. Sustainable drainage design and evaluation guide. http://online.flipbuilder.com/mccloy.consulting/dvqw/mobile/index.html#p=2

- Use infiltration techniques, such as porous surfaces in non-clay areas;
- Attenuate rainwater in ponds or open water features for gradual release;
- Attenuate rainwater by storing in tanks or sealed water features for gradual release;
- Discharge rainwater direct to a watercourse;
- Discharge rainwater to a surface water sewer/drain; and
- Discharge rainwater to the combined sewer.

7.2.2 Wherever possible, SuDS are designed to provide environmental enhancement by improving water quality, biodiversity, and landscape and amenity value. Although SuDS are generally designed at the site-specific scale, they should also give consideration to their ability to provide larger scale benefits to the wider area.

7.2.3 The main driver for incorporation of SuDS into new and existing developments is at national level, from the NPPF, with accompanying guidance being provided by the Department for the Environment, Food and Rural Affairs (Defra). LLFAs provide local guidance on how developers should incorporate SuDS into development, including detail on what information should be provided and how it should be presented for planning as detailed in the LBB Sustainable drainage design and evaluation guide[29].

7.2.4 The design and implementation of sustainable drainage solutions should be factored into the design of any new development. This follows best practice, but also it is a fundamental requirement of NPPF that new development does not result in an increase in surface water run-off rates post development.

7.3 Appropriate use of SuDS

7.3.1 The selection of appropriate SuDS is dependent upon many key influences, including:

- local hydrology and hydrogeology;
- ground contamination;
- depth of water table;
- soil permeability;
- ground stability;
- sensitivity of receiving waterbody (either surface water or groundwater);
- size of contributing site;
- development type, density and required layout; and
- requirements for local flood risk management.

7.3.2 The CIRIA SuDS Manual (2015) identifies four processes that can be used to manage and control runoff from developed areas. Each option can provide opportunities in varying degrees for storm water control, flood risk management, water conservation and groundwater recharge:

- Infiltration;
- Detention/attenuation;
- Conveyance; and

- Water harvesting.

7.3.3 Proposed and existing land-uses are thought to be a significant factor in deciding appropriate SuDS techniques, as these influence the volume of water required to be attenuated. Existing or historic land uses have the potential to influence the choice of SuDS techniques by informing the likelihood of pollution and potential contamination issues. Indications of the most suitable techniques for individual sites cannot be made at a strategic level, however, since these will be governed by site specific characteristics and other considerations. Therefore, site specific FRAs will provide the required recommendations.

7.3.4 Table B1 (in Appendix B) CIRIA (2015) provides a summary of influential site characteristics which should be assessed at the site specific level.

Source Protection Zones

7.3.5 The Environment Agency has defined Source Protection Zones (SPZs) for 2,000 groundwater sources such as wells, boreholes and springs used for public drinking water supply. SPZs are further subdivided into the following categories:

- SPZ1 (Inner SPZ – 50 day travel time or 50 metres): designed to protect against the effects of human activity which might have an immediate effect upon the source. SPZ1 was originally based on the need to protect against biological contaminants;
- SPZ2 (Outer SPZ – 400 day travel time or at least 25% of the recharge catchment area): designed to provide protection against slowly degrading pollutants; and
- SPZ3 (Catchment SPZ): covers the complete catchment area of the groundwater source.

7.3.6 There are a number of SPZs in the Borough, which will act as a constraint when considering the suitability of infiltration SuDS. The SPZs are shown in Figure A22 of Appendix A. Zones 1 to 3 cover approximately half of the Borough. The coverage is focussed in the south and east of the Borough around four zones of SPZ1 which exist in the Shuttle Valley. Two are to the south of Crayford, one to the north east of Sidcup and a small zone exists near Foots Cray. Surrounding and connecting the zones of SPZ 1 is a zone of SPZ 2 which extends across the Borough to the west. SPZ 3 envelopes zones 1 and 2 and extends the SPZ distinction further north and westwards from the SPZ 2 boundary.

7.3.7 The SPZ designations require the EA to be consulted if SuDS techniques are proposed to discharge to groundwater in these zones.

7.4 Management of construction site runoff

7.4.1 Construction site runoff is an important area of catchment hydrology, causing local short-term but potentially significant changes in local flood risk.

7.4.2 The clearance of vegetation (and modifications to drainage infrastructure on brownfield sites) may lead to increased runoff above pre-construction rates. The management of runoff during the construction period is an important consideration particularly for large sites and details of measures to mitigate for this phase of development are required as part of an FRA. The WFD places specific requirements on the management of non-point source pollution such as that from construction site silts. Methods to reduce the volume of solids (and runoff) leaving the site include:

- Phased removal of surface vegetation at the appropriate construction phase;
- Provision of a grass buffer strip around the construction site and along watercourses;

- The covering of stored materials;
- Ensuring exposed soil is re-vegetated as soon as feasibly possible;
- Protection of storm water drain inlets; and
- Silt fences, siltation ponds and wheel washes.

7.5 Using the SFRA to inform SuDS suitability

7.5.1 Infiltration/discharge to groundwater SuDS techniques are considered amongst the most sustainable solutions as maintenance requirements are comparatively low and the systems do not discharge to watercourses or the sewage undertakers piped drainage network.

7.5.2 The following figures in Appendix A can be used to inform SuDS suitability:

- Figure A14 – Indicates where groundwater levels are potentially nearer the surface. In areas where the water table is near the surface (<5m) the practicality of discharging to groundwater is limited, as such the feasibility of such schemes must be demonstrated;
- Figure A22 – Source Protection Zones. Less suitable in zones 1, 2 and 3 and should have Environment Agency consent. Pollution control measures will be required;
- Figure A23 – Infiltration Potential. Higher potentials are areas where the soils/geology will more likely allow greater rates of infiltration. The areas of 'no data' are characterised by London Clay, according to the 1:50,000 scale BGS Geology mapping. London Clay typifies by low infiltration rates.
- Figure A24 – Groundwater Vulnerability. Less suitable in areas of high vulnerability, pollution control measures will be required; and

7.5.3 The SFRA mapping does not preclude the need to undertake site specific investigations and consultation with the LLB. Issues of ground contamination, ground water pollution and technical feasibility will all have to be addressed at the site specific level.

8. Flood Risk Assessments and windfall sites

8.1 Site specific Flood Risk Assessments

8.1.1 Table 8.1 provides a clear instruction to developers and Planning Officers as to when a Flood Risk Assessment (FRA) is required. Should any one of the criteria listed in Table 8.1 apply to the site in question then a FRA needs to be prepared to accompany a planning application. The NPPF should provide the basis for establishing the scope of the FRA and the Environment Agency should also be consulted.

Table 8.1 When is a FRA required?

Criteria Requiring a FRA or further investigation	FRA Required (Yes/No)	Scope of the FRA or further investigation
In Fluvial Flood Zone 3b	Yes	Follow the requirements of NPPF
In Fluvial Flood Zone 3a	Yes	Follow the requirements of NPPF
In Fluvial Flood Zone 2	Yes	Follow the requirements of NPPF
Greater than 1 hectare in Fluvial Flood Zone 1	Yes	Follow the requirements of NPPF
Greater than 0.25 hectare	Drainage impact assessment required	For all sites over 0.25 hectare in Flood Zone 1 an assessment of surface water drainage will be required with any planning application. This assessment should review the potential to incorporate sustainable drainage techniques and attenuate flows in line with the Borough's aspirations.
Within 8m of the bank top of a main river?	Consult Environment Agency	Development will require an Environment Agency Flood Risk Activity Permit in these areas
Within 16 m of a flood Defence	Consult Environment Agency	Development will require an Environment Agency Flood Risk Activity Permit in these areas

8.2 Minimum requirements for a Flood Risk Assessment

8.2.1 Having determined that it is required, a FRA should be structured as follows, guidance on what LBB expect to see in a site specific FRA is outlined in the following sections, which is based on guidance provided in NPPF[30]:

- Section 1 – Development Site Context.
- Section 2 – The Development Proposal.
- Section 3 – Assessment of Flood Risk.
- Section 4 – Managing flood risk and proposed mitigation measures.
- Section 5 – Sustainable drainage proposal.

[30] https://www.gov.uk/guidance/flood-risk-assessment-for-planning-applications

Section 1 - The Site Context

8.2.2 A description of the current site location should be provided, including a location plan showing:

- Street names;
- Any rivers, streams, ponds, wetlands or other bodies of water; and
- Other geographical features, for example railway lines of local landmarks such as schools or churches.

8.2.3 A site plan should be provided, including details of the current land use/function of the site, supported by maps and/or photographs.

Section 2 - The Development Proposal

8.2.4 This should consist of a description of the development proposal, including a site plan showing:

- Your development proposal;
- Existing and proposed finished floor levels; and
- Any structures that could affect water flow, for example bridges, embankments.

8.2.5 For development in Flood Zone 1, a survey should be provided, showing:

- Existing site and floor levels; and
- The proposed development site and floor levels.

8.2.6 For development in Flood Zones 2 and 3, surveys should also show a cross-section of the site showing local ground levels, finished internal floor and (where relevant) access/egress road levels. Indicate peak flood water levels (which can be obtained from the EA – see Section 9.2.12) on these drawings to demonstrate that an appropriate freeboard allowance has been incorporated into the design. The EA need to be able to compare the finished floor levels and flood levels directly on a drawing.

Section 3 Assessment of Flood Risks

8.2.7 In addition to the information provided within this SFRA, contact the EA for further detailed information about flood risk in your area. The EA can provide a range of "products" or packages of information to assist with the FRA[31]:

8.2.8 The product required is dependent upon the development size and flood zone it is in:

- Non-domestic extensions with a footprint of less than 250 square metres and all domestic extensions:
  - flood zones 2 and 3 use product 3;
  - flood zone 3 in an area behind raised flood defences use product 8; and
  - flood zone 1 use product 1.
- Applications with a site area less than 0.25 hectare:
  - flood zone 3 choose from products 4, 5, 6, or 7;

[31] https://www.gov.uk/guidance/flood-risk-assessment-for-planning-applications#get-information-to-complete-an-assessment

- flood zone 3 in an area behind raised flood defences use product 8; and
- flood zones 1 and 2 use product 3.

- Applications with a site area greater than 0.25 hectare:
  - flood zones 2 and 3 choose from products 4, 5, 6 or 7;
  - flood zone 3 in an area behind raised flood defences use product 8; and
  - flood zone 1 use product 3.

8.2.9 The EA product can be used in conjunction with this SFRA to form the information base of the FRA. Contact should also be made with the EA for advice on what to do if the development is within 20m of a main river.

8.2.10 For development in Flood Zones 2 and 3, contact should be made with LBB to check whether a Sequential Test has been applied for the site. If not, this will need to be carried out prior to the FRA.

8.2.11 Flooding from all sources should be assessed (for example surface water and groundwater), as well as from rivers and the sea, including a consideration for climate change.

8.2.12 Development in Flood Zones 2 and 3 also requires an assessment of what the risk would be to the development in the event of a flood. An estimate of the following is required:

- The level for the site relative to a flood event, i.e. the 1 in 100 (1%) annual probability river flood level or the 1 in 200 (0.5%) annual probability tidal flood level;
- The duration of a flood;
- The rate of surface water runoff;
- The order in which areas of the site would be flooded; and
- Consequences for people living on or using the site.

8.2.13 The information might be available from the EA or LBB, or a flood risk specialist can be used to calculate the estimates.

Section 4 – Managing Flood Risk and Proposed Mitigation Measures

8.2.14 Development in Flood Zones 2 and 3 requires consideration of mitigation and resilience measures that could be applied, including:

- details of existing flood resistance and resilience measures on your site – information from the EA or LBB; and
- the capacity of drains or sewers (existing and proposed) on your site – information from Thames Water.

8.2.15 Additionally, details of how the proposed design will mitigate flood risk should be demonstrated, including details of how people will leave buildings safely during a flood, and how:

- Raised flood embankments or changes to ground levels could affect water flow; and
- Your development could affect rivers and their floodplain or coastal areas.

8.2.16 Sites within the functional floodplain (water compatible development or essential infrastructure developments that have met the requirements of the exception test) must also show that they have been designed to:

- stay safe and operational during a flood;
- avoid blocking water flows or increasing flood risk elsewhere; and
- avoid loss of floodplain storage (i.e. loss of land where flood waters used to collect).

Section 5 - Sustainable drainage proposal

8.2.17 Surface water runoff should be assessed, including:

- an estimate of the rates and volumes of surface water run-off from your development site currently.
- details of existing methods for managing surface water runoff, for example drainage to a sewer;
- your plans for managing surface water and for making sure there's no increase in the volume of surface water and rate of surface water runoff; and
- Proposed discharge locations (e.g. watercourse or Thames Water sewer).

8.2.18 Plans for managing surface water runoff should be in line with the guidance in Section 7 of this SFRA, and with sustainable drainage principles[32].

8.2.19 With the necessary requirements above satisfied, the FRA should be submitted with the planning application to LBB, who, in conjunction with the EA (if in Flood Zones 2 or 3) will review the FRA and advice whether it is satisfactory.

8.3 Windfall sites

8.3.1 Windfall sites refer to sites which become available for development unexpectedly, and are therefore not included as allocated land in a planning authority's development plan.

8.3.2 It is highly likely that there will always be windfall development, and these sites will need to be assessed. The Local Plan will identify the target areas for growth and redevelopment. The appropriateness for sites outside these areas will need to be addressed on a site by site basis. Proposed windfall development should pass the Sequential Test and Exception Test if required. Additionally, the sequential approach to flood risk management will be required within the development site, and this will need to be addressed within the development proposals and accompanying FRAs.

[32] http://www.susdrain.org/delivering-suds/using-suds/suds-principles/suds-principals.html

9. Recommendations for the new emerging Local Plan

9.1.1 The following is a list summarising the key recommendations that should be considered when preparing the new Local Plan:

- Ensure the sequential approach advocated in NPPF is followed, managing flood risk through avoidance where possible, and if you can't avoid ensure the development is resilient to flooding;
- Apply the sequential approach to all sources of flooding, not just tidal and fluvial, to ensure that sites selected for development are at the lowest possible risk of flooding;
- Reserve land in Flood Zone 1 for essential infrastructure and where possible highly vulnerable and more vulnerable land uses;
- Ensure basement development intended for dwelling is directed to Flood Zone 1, in line with Section 6.3 of this SFRA;
- Consider requiring all new developments greater than 0.25 hectare in size to have a flood risk and drainage impact assessment accompanying the planning application, as discussed in Section 6.3;
- To further reduce flood risk having followed the sequential approach, it is recommended that particular consideration is given to flood resilience during any development design;
- Site design in floodplains should facilitate safe escape, access and egress. Only in exceptional circumstances where this cannot be demonstrated should the emergency plan be to reside in situ and escape upwards in a building;
- Ensure new developments include a detailed evacuation plan that clearly outlines how people can easily leave to safety or move upwards from the lower floors to safety;
- An emergency evacuation procedure should be implemented for those sites which can feasibly be designed to allow for evacuation out of the flood risk zone;
- In line with Section 6.2, position all more vulnerable land uses above the predicted 2115 (0.5% AP event) flood water level in the Thamesmead/Erith Marshes and Crayford Marsh embayments, shown on Figure C7 in Appendix C;
- New developments should seek to meet the greenfield run-off rates as advocated in the London Plan, IWMS and LFRMS;
- All new development should, where feasible, attempt to reduce surface water run-off by sustainably managing run-off on site;
- It is also recommended that development immediately behind the flood defences be designed in such a way as to easily facilitate the raising and re-engineering of the tidal flood defences. For all development applications immediately behind flood defences, consultation with the Environment Agency should be sought.

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Appendix A
Figures

Figures supplied separately.

Appendix B
SuDS guidance

Table B.1 SuDS suitability and site characteristics

SuDS Group	Technique	Soils		Area draining to a single SuDS component		Minimum depth to water table		Site slope		Available head	
		Impermeable	Permeable	0 – 2 ha	> 2 ha	0 – 1 m	> 1 m	0 – 5%	> 5 %	0-1 m	1 – 2 m
Retention	**Retention pond**	Y	Y[1]	Y	Y[5]	Y[2]	Y[2]	Y	Y	Y	**Y**
	Subsurface storage	Y	Y	Y	Y[5]	Y[2]	Y[2]	Y	Y	Y	**Y**
Wetland	**Shallow wetland**	Y[2]	Y[4]	Y[4]	Y[6]	Y[2]	Y[2]	Y	N	Y	**Y**
	Extended detention wetland	Y[2]	Y[4]	Y[4]	Y[6]	Y[2]	Y[2]	Y	N	Y	**Y**
	Pond/wetland	Y[2]	Y[4]	Y[4]	Y[6]	Y[2]	Y[2]	Y	N	Y	**Y**
	Pocket wetland	Y[2]	Y[4]	Y[4]	N	Y[2]	Y[2]	Y	N	Y	**Y**
	Submerged gravel wetland	Y[2]	Y[4]	Y[4]	Y[6]	Y[2]	Y[2]	Y	N	Y	**Y**
	Wetland channel	Y[2]	Y[4]	Y[4]	Y[6]	Y[2]	Y[2]	Y	N	Y	**Y**
Infiltration	**Infiltration trench**	N	Y	Y	N	N	Y	Y	Y	Y	**N**
	Infiltration basin	N	Y	Y	Y[5]	N	Y	Y	Y	Y	**N**
	Soakaway	N	Y	Y	N	N	Y	Y	Y	Y	**N**
Filtration	**Surface sand filter**	Y	Y	Y	Y[5]	N	Y	Y	N	N	**Y**
	Sub-surface sand filter	Y	Y	Y	N	N	Y	Y	N	N	**Y**
	Perimeter sand filter	Y	Y	Y	N	N	Y	Y	N	Y	**Y**
	Bioretention/filter strips	Y	Y	Y	N	N	Y	Y	N	Y	**Y**
	Filter trench	Y	Y[1]	Y	N	N	Y	Y	N	Y	**Y**

SuDS Group	Technique	Soils		Area draining to a single SuDS component		Minimum depth to water table		Site slope		Available head	
		Impermeable	Permeable	0 – 2 ha	> 2 ha	0 – 1 m	> 1 m	0 – 5%	> 5 %	0-1 m	1 – 2 m
Detention	**Detention basin**	Y	Y[1]	Y	Y[5]	N	Y	Y	Y	N	**Y**
Open channels	**Conveyance swale**	Y	Y	Y	N	N	Y	Y	N[3]	Y	**N**
	Enhanced dry swale	Y	Y	Y	N	N	Y	Y	N[3]	Y	**N**
	Enhanced wet swale	Y[2]	Y[4]	Y	N	Y	Y	Y	N[3]	Y	**N**
Source control	**Green roof**	Y	Y	Y	N	Y	Y	Y	Y	Y	**Y**
	Rainwater harvesting	Y	Y	Y	N	Y	Y	Y	Y	Y	
	Permeable pavement	**Y**	**Y**	**Y**	**Y**	**N**	**Y**	**Y**	**N**	**Y**	**Y**

Y = Yes

N = No

Y[1] = with liner

Y[2] = with surface baseflow

Y[3] = Unless follows contours

Y[4] = With liner and constant surface baseflow, or high ground water table

Y[5] = possible, but not recommended (appropriate management train not in place)

Y[6] = Where high flows are diverted around SuDS component

Additional policy and general guidance on SuDS and drainage include the following:

- National Planning Practice Guidance, 2016;
- Water Framework Directive (200/60/EC);
- Highways Act, 1980;
- Town and Country Planning Act, 1990;
- Town and Country Planning Act, 1990 (amended) NB covers S106 Agreements;
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Appendix C
Breach modelling depths, elevations and hazard figures

Separately supplied are figures showing the maximum depths, elevations and hazard from the EA's Thames Estuary Breach Assessment (2018).

Appendix D
Tables reproduced from NPPF

Table D.1 Flood zones

Zone 1 Low Probability

Definition

This zone comprises land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%)

Appropriate uses

All uses of land are appropriate in this zone.

FRA requirements

For development proposals on sites comprising one hectare of above the vulnerability to flooding from other sources as well as from river and sea flooding, and the potential to increase flood risk elsewhere through the addition of hard surfaces and the effect of the new development on surface water run-off, should be considered in a FRA. This need only be brief unless the factors above or other local considerations require particular attention.

Policy aims

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

Zone 2 Medium Probability

Definition

This zone comprises 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 flooding (0.5% – 0.1%) in any year.

Appropriate uses

Essential infrastructure and the water-compatible, less vulnerable and more vulnerable uses, as set out in Table 2, are appropriate in this zone. The highly vulnerable uses are only appropriate in this zone if the Exception Test is passed.

FRA requirements

All development proposals in this zone should be accompanied by a Flood Risk Assessment.

Policy aims

In this zone, developers and Local Authorities should 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 sustainable drainage systems.

Zone 3 – High probability

Definition

This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.

Appropriate uses

The water-compatible and less vulnerable uses of land (Table 2) are appropriate in this zone. The highly vulnerable uses should not be permitted in this zone. The more vulnerable uses and essential infrastructure should only be permitted in this zone if the Exception Test is passed. Essential infrastructure permitted in this zone should be designed and constructed to remain operational and safe for users in times of flood.

FRA requirements

All development proposals in this zone should be accompanied by a Flood Risk Assessment.

Policy aims

In this zone, developers and Local Authorities should 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 sustainable drainage systems;
- Relocate existing development to land in zones with a lower probability of flooding; and
- Create space for flooding to occur by restoring functional floodplain and flood flow pathways and by identifying, allocating and safeguarding open space for flood storage.

Table D.2 NPPF Flood Risk Vulnerability Classification

Essential Infrastructure	• Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk, and essential utility infrastructure, including electricity generating power stations and grid and primary substations and water treatment works that need to remain operational in times of flood.
Highly Vulnerable	• Police stations, Ambulance stations and 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
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 and cafes; hot food takeaways; offices; general industry; storage and distribution; non–residential institutions not included in 'more vulnerable'; and assembly and leisure. • Land and buildings used for agriculture and forestry. • Waste treatment (except landfill and hazardous waste facilities). • Minerals working and processing (except for sand and gravel working). • Water treatment plants which do not need to remain operational during times of flood. • Sewage treatment plants (if adequate pollution control measures 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. • MOD defence installations. • Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location. • Water-based recreation (excluding sleeping accommodation). • Lifeguard and coastguard stations. • Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms. • Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan.

Table D.3 Flood Risk Vulnerability and Flood Zone "Compatibility"

Flood Risk Vulnerability classification (See Table D.2)		Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone (see Table D.1)	Zone 1	✓	✓	✓	✓	✓
	Zone 2	✓	✓	Exception Test required	✓	✓
	Zone 3a	Exception Test required	✓	×	Exception Test required	✓
	Zone 3b "Functional floodplain"	Exception Test required	✓	×	×	×