PARSONS BRINCKERHOFF

LONDON BOROUGH OF BARKING AND DAGENHAM STRATEGIC FLOOD RISK ASSESSMENT

LEVEL 1

August 2017

One borough; one community;

London's growth opportunity

London Borough of Barking & Dagenham

lbbd.gov.uk

LONDON BOROUGH OF BARKING AND DAGENHAM STRATEGIC FLOOD RISK ASSESSMENT (SFRA) LEVEL 1

London Borough of Barking and Dagenham

Job Number 3514006A

Prepared for
London Borough of Barking and Dagenham
Town Hall
1 Town Square
Barking
IG117LU

Prepared by
WSP | Parsons Brinckerhoff
Kings Orchard
1 Queen Street
Bristol
BS2 0HQ
0117 933 6200

Report Title	**:**	**London Borough of Barking and Dagenham Strategic Flood Risk Assessment (SFRA) Level 1**
Report Status	**:**	**Final**
Job No	**:**	**3514006A**
Date	**:**	**August 2017**

DOCUMENT HISTORY AND STATUS

Document control			
Prepared by	David Fahey / Simon Olivier	**Checked by** *(technical)*	Andrew Lee
Approved by	Jonathan Ralph	**Checked by** *(quality assurance)*	Joanna Goodwin

Revision details			
Version	**Date**	**Pages affected**	**Comments**
1.0	June 2015	-	First issue – draft issued for review by the London Borough of Barking and Dagenham and Environment Agency
2.0	July 2015	-	General updates throughout report following Council review.
3.0	June 2016	-	General updates throughout report following Environment Agency review. Issued as final.
4.0	August 2016	-	Minor updates throughout report following final review by LBBD. Issued as final.
5.0	February 2017	-	General updates throughout report following Environment Agency review and updated climate change mapping for the Mayes Brook and Beam River. Issued as final.
6.0	March 2017	-	Modelling of lower extents of Mayes Brook completed
7.0	June 2017	-	Local plan period amended. Issued as final
8.0	August 2017	-	Minor updates throughout report following final review by Environment Agency. Issued as final.

CONTENTS

APPENDIX N: FLOOD WARNING AND ALERT AREAS (FLUVIAL & TIDAL)

APPENDIX O: EXISTING VULNERABLE LAND USES AND EMERGENCY SERVICES

GLOSSARY

CFMP	Catchment Flood Management Plans. A CFMP is a high level strategic planning tool which explores and defines long-term sustainable policies for flood risk management.
Core Strategy	The Core Strategy is the primary document in the Barking and Dagenham Local Plan and sets out the Councils long-term vision, spatial strategy and core policies for shaping the future development of Barking and Dagenham up to 2025.
Critical Drainage Area (CDA)	A discrete geographical area (usually a hydrological catchment) where multiple and interlinked sources of flood risk (surface water, groundwater, sewer, main river and/or tidal) cause flooding during severe weather thereby affecting people, property or local infrastructure.
DCLG	Department for Communities and Local Government
De facto Flood Defence	A structure that provides a flood defence function, however has not been built and/or maintained for this purpose (e.g. boundary wall).
Defra	Defra (Department for Environment, Food and Rural Affairs) is a UK Government Department. The overarching challenge for Defra is to enable everyone to live within our environmental means by tackling climate change internationally and through domestic action to reduce greenhouse gas emissions, and to secure a healthy, resilient, productive and diverse natural environment.
Development	The carrying out of building, engineering, mining or other operations, in, on, over or under land, or the making of any material change in the use of a building or other land.
Development Plan Document (DPD)	DPD's are a series of documents that form the Local Plan for Barking and Dagenham. They set out the planning policies of the Borough and are subject to independent examination.
DG5 Register	A water-company held register of properties which have experienced sewer flooding due to hydraulic overload, or properties which are 'at risk' of sewer flooding more frequently than once in 20 years.
Drain London	Forum founded in 2007 to assess flood risks associated predominantly with surface water flooding across all London Boroughs.
DTM	Digital Terrain Modelling. DTMs are topographic models of the bare earth that can be manipulated by computer programs. DTM files contain elevation data of terrain in a digital format that relates to a rectangular grid. Vegetation, buildings and other cultural features are removed digitally - leaving just the underlying terrain.
Flood and Water Management Act 2010	Part of the UK Government response to Sir Michael Pitt's report on the Summer 2007 floods, the aim of which is to clarify the legislative framework and responsibilities for managing flood risk in England.
Flood Risk Regulations 2009	Transposition of the EU Floods Directive into UK law. The EU Floods Directive is a piece of European Community (EC) legislation to specifically address flood risk by prescribing a common framework for its measurement and management.
Flood Map for Planning Rivers and	Defines flood zones based on annual probability of flooding from fluvial and tidal sources to inform development planning and flood risk assessment. Nationally consistent delineation of 'high', 'medium' and 'low' flood risk updated by the Environment Agency as deemed appropriate, typically on a quarterly basis.

Sea) Flood Zone Map	
Flood Zone 1 Low Probability	This zone comprises land assessed as having less than a 1 in 1000 (0.1%) annual probability of flooding from rivers or the sea in any year.
Flood Zone 2 Medium Probability	This zone comprises land assessed as having between a 1 in 100 (1%) and 1 in 1000 (0.1%) annual probability of flooding from rivers, or between a 1 in 200 (0.5%) and 1 in 1000 (0.1%) annual probability of flooding from the sea in any year.
Flood Zone 3a High Probability	This zone comprises land assessed as having a 1 in 100 (1%) or greater annual probability of flooding from rivers or a 1 in 200 (0.5%) or greater annual probability of flooding from the sea in any year.
Flood Zone 3b Functional Floodplain	This zone comprises land where water has to flow or be stored in times of flood. SFRAs should identify this flood zone as land that would typically flood with an annual probability of 1 in 20 (5%) or greater in any year, or is designed to flood in an extreme (0.1%) flood, or at another probability to be agreed between the local planning authority and the Environment Agency, including water conveyance routes.
Fluvial	Of, relating to, or inhabiting a river or stream.
Formal Flood Defence	A structure built and maintained specifically for flood defence purposes
Greater London Authority (GLA)	A strategic citywide government for London consisting of a directly elected Mayor and a separately elected Assembly. It has strategic regional authority, with powers over transport, policing, economic development and fire and emergency planning.
Greenfield Land	Undeveloped land in an urban or rural area either used for agriculture, landscape design, or left to evolve naturally.
Habitable Room	A room used as living accommodation within a dwelling but excludes bathrooms, toilets, halls, landings or rooms that are only capable of being used for storage. All other rooms, such as kitchens, living rooms, bedrooms, utility rooms and studies are counted.
LDS	Local Development Scheme. The Local Development Scheme is a public statement of the Council's programme for the preparation of Local Development Documents that will form the Local Development Framework (LDF).
Lead Local Flood Authority (LLFA)	Local Authority responsible for taking the lead on local flood risk management as defined within the Flood and Water Management Act.
Local Development Framework (LDF)	Consists of a number of documents which together form the spatial strategy for development and the use of land.
Local Flood Risk Management Strategy	Document that sets out the way in which the LLFA will manage the local flood risks for the whole of their administrative area to meet the requirements of the Flood and Water Management Act.
Local Flood Risk Zone (LFRZ)	Term used in Barking and Dagenham Surface Water Management Plan to refer to flooding 'hot spots' that were identified within the Borough.

London Plan	The overall strategic plan for London. It sets out a fully integrated economic, environmental, transport and social framework for the development of London to 2036. It forms part of the Development Plan for Greater London.
LiDAR	Light Detection and Ranging. LiDAR is a technology that employs an airborne scanning laser rangefinder to produce detailed and accurate topographic surveys. LiDAR can be used to accurately measure the topography of the ground, even where overlying vegetation is quite dense.
Main River	Main rivers 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 the Flood Map for Planning (Rivers and Sea), and can include any structure or appliance for controlling or regulating the flow of water in, into or out of a main river. Main rivers are under the jurisdiction of the Environment Agency who have powers to carry out flood defence works to main rivers.
National Flood and Coastal Erosion Risk Management Strategy for England	This strategy outlines a national framework for managing the risk of flooding and coastal erosion. It aims to help risk management authorities and communities understand their roles and responsibilities and is particularly relevant to Lead Local Flood Authorities.
NPPF	National Planning Policy Framework. NPPF, published in March 2012 and supported by the on-line resource, Planning Practice Guidance 'Flood Risk and Coastal Change', that replaces previous guidance PPS25 Development and Flood Risk and provides the framework by which local authorities in England inform local planning policy and take decisions regarding planning and development within their administrative boundaries.
Ordinary Watercourse	An ordinary watercourse is every river, stream, ditch, drain, cut, dyke, sluice, sewer (other than a public sewer) and passage through which water flows that does not form part of a main river. The Lead Local Flood Authority, or Internal Drainage Board where relevant, has powers for ordinary watercourses that are similar to those held by the Environment Agency for main rivers.
OD (Ordnance Datum)	Ordnance Datum, or OD, is a vertical datum used by Ordnance Survey as the basis for deriving altitudes on maps. In Great Britain, the datum point against which all heights and altitudes are referenced is the mean sea level (MSL) at Newlyn, Cornwall, between 1915 and 1921.
One Dimensional River Model	A One Dimensional river model presumes that a river flows in a single plane, i.e. in a straight line. This is a simplistic approach to river modelling, but in most rural areas, one-dimensional models give good results.
Perched Groundwater Table	A perched water table is where groundwater 'sits on top' of an impermeable layer, normally as a result of rainfall directly onto a location.
Pluvial (flooding)	In hydrology, pluvial refers to any water that is brought about by precipitation. Pluvial flooding is usually associated with high intensity rainfall events (typically >30mm/h) but can also occur with lower intensity rainfall or melting snow where the ground is saturated, frozen, developed or otherwise has low permeability resulting in surface water flow and ponding in depressions in the topography.
Preliminary Flood Risk Assessment (PFRA)	A high level screening exercise to identify areas of significant flood risk and summarise the probability of harmful consequences of past (historical) and future (potential) flooding.

Previously Developed (Brownfield) Land	Land that is or was occupied by a building (excluding those used for agriculture and forestry). It also includes land within the curtilage of the building, for example, a house and its garden would be considered to be previously developed land.
Residual Risk	The risks remaining after applying the sequential approach and taking mitigating actions are known as the residual risks.
Risk of Flooding from Reservoirs Map	This map shows the area that could be flooded if a large reservoir were to fail and release the water it holds. A large reservoir is defined as one that holds over 25,000 m^3 of water.
Risk of Flooding from Surface Water Map	Defines areas at risk of flooding from surface water. The map defines areas based on the probability of a flood occurring in any given year and is based on the Environment Agency 'updated Flood Map for Surface Water' (uFMfSW) dataset.
SEA	Strategic Environmental Assessment. An SEA analyses the environmental effects of development policies, plans, programmes and other proposed strategic actions.
SUDS	Sustainable Drainage Systems. SUDS use techniques to control surface water runoff as close to its origin as possible, before it enters a watercourse or sewerage system. This involves moving away from traditional piped drainage systems to solutions that mimic natural drainage processes i.e. permeable and porous pavements.
Sustainable Drainage Systems – Non-statutory Technical Standards for Sustainable Drainage Systems	The non-statutory technical standards for sustainable drainage systems, published by Defra in March 2015, sets out the technical standards to which sustainable drainage systems should be designed and constructed. They should be used in conjunction with NPPF.
SoP	Standard of Protection. The SoP that a flood defence offers is expressed in terms of the likelihood of a particular flood event (or level) being equalled or exceeded in any given year. Therefore, if a flood defence offers a SoP of 1 in 50, it will take a 1 in 50 (or greater) flood event to overtop it.
Supplementary Planning Document (SPD)	Provides supplementary guidance to policies and proposals contained within Development Plan Documents. They do not form part of the development plan, nor are they subject to independent examination.
Surface Water Management Plan (SWMP)	A plan that assesses the risk of flooding from surface water flooding and outlines the preferred surface water management strategy in a given location. In this context surface water flooding describes flooding from sewers, drains, groundwater, and runoff from land, small watercourses and ditches that occurs as a result of heavy rainfall.
TE2100 Project	The Thames Estuary 2100 (TE2100) Project, led by the Environment Agency, was formed to develop a comprehensive action plan to manage flood risk for the Tidal Thames.
Threshold	The lowest point of the door entrance to the house.

Two Dimensional River Model	When studying urban and some particularly flat rural areas one-dimensional models may not prove accurate. They lack the ability to model flood patterns and the fact that flooding reacts in different ways to common features of the urban landscape. In such cases, a two-dimensional mathematical model should be used, which is capable of analysing flood patterns in more than one plane.
uFMfSW	The updated Flood Map for Surface Water is the third national surface water map produced Environment Agency. The uFMfSW assesses flooding due to rainfall for the 1 in 30 (3.3%), 1 in 100 (1%) and 1 in 1000 (0.1%) annual probability events and provides information relating to the likely flood extent, depth, velocity and hazard.
UKCIP	United Kingdom Climate Impacts Programme. UKCIP assists organisations, sectors and governments adapt to the changing climate through practice-based research, and by providing support and advice. UKCIP's work falls into three main categories: decision-making for adaptation; exchanging knowledge and ideas and creative adaptation.
Water Framework Directive	Introduces a holistic approach to the management of water quality and establishes a system for the protection and improvement of all aspects of the water environment including rivers, lakes, estuaries, coastal waters and groundwater.

EXECUTIVE SUMMARY

This SFRA has been commissioned by the London Borough of Barking and Dagenham to update the Level 1 SFRA published in 2008. Since 2008 new flood risk mapping information has been published by the Environment Agency and there have been significant changes to planning policies and guidance relevant to the management of flood risk, principally the NPPF and the supporting Planning Practice Guidance. This report updates the SFRA to reflect these changes and will inform the updated Barking and Dagenham Local Plan, currently under review by Barking and Dagenham, which will set out the future planning of the Borough between 2018 and 2033.

The Level 1 SFRA has been developed in accordance with the NPPF and in consultation with both the Council and the Environment Agency. It assesses the risk of flooding from all sources, now and in the future, taking account of the impacts of climate change, and assesses the impact that land use changes and development in the area will have on flood risk. Specifically the SFRA will be used to:

- Determine the variations in risk from all sources of flooding;
- Inform the sustainability appraisal of the Local Plan, so that flood risk is fully taken into account when considering allocation options and in the preparation of plan policies;
- Apply the Sequential Test and, where necessary, the Exception Test when determining land use allocations;
- Identify the requirements for site-specific flood risk assessments in particular locations, including those at risk from sources other than river and sea flooding;
- Set out the recommended approach to the management of flood risk that can be applied through the design and planning of development within the Borough;
- Determine the acceptability of flood risk in relation to emergency planning capability;
- Consider opportunities to reduce flood risk to existing communities and developments.

The SFRA has built upon existing knowledge, underpinning the delineation of the Borough into zones of 'high', 'medium' and 'low' probability of flooding. Collectively these flood zones will be used to provide a reliable and thorough evidence base for the development of fluvial and tidal flooding related policy and the allocation of sites for future housing and employment uses.

The most significant sources of flood risk in Barking and Dagenham are typically associated with fluvial and tidal sources of flooding. Many parts of the Borough are shown to benefit from flood defences although there are a small number of areas not benefitting from defences. When assessing the flood risk in areas benefitting from flood defences it is necessary to assess the risk posed by a breach of the defences which can result in large areas being inundated quickly.

In recent years greater consideration has been given to the potential risks posed by local sources of flooding. Significant areas of the Borough have been identified as being at risk of surface water flooding and these are highlighted in the SFRA. While there are very few recorded incidents of groundwater flooding in Barking and Dagenham a number of areas susceptible to groundwater flooding have been identified based on the underlying geology and subsoils.

The SFRA also makes a number of recommendations for development control policies that should be used by both the Council and prospective developers to meet their obligations under the NPPF throughout the planning cycle.

SECTION 1

INTRODUCTION

1 INTRODUCTION

1.1 Overview

1.1.1 Parsons Brinckerhoff was appointed by the London Borough of Barking and Dagenham to prepare an update of the Level 1 Strategic Flood Risk Assessment (SFRA), published in 2008. Similar language and layout has been maintained in this report for consistency and continuity with the 2008 SFRA. This report assesses the risk of flooding in Barking and Dagenham from all sources, now and in the future, taking account of climate change, and assesses the impact that land use changes and development in the area could have on flood risk.

1.1.2 Significant improvements and updates to the fluvial and tidal flood modelling in the Borough have been undertaken since the production of the 2008 SFRA. The Flood Map for Planning (Rivers and Sea) is typically updated by the Environment Agency on a quarterly basis, giving a more accurate representation of fluvial and tidal flood risk. Fluvial Flood Risk Mapping Studies for the Beam, Ingrebourne and Mayes Brook and Lower Roding River were completed in 2013 and 2009 respectively.

1.1.3 The risk of flooding due to breach of the River Thames tidal flood defences in Barking and Dagenham has also been updated. The breach modelling along the River Thames flood defences undertaken as part of the 2008 SFRA was superseded by the Environment Agency in 2017 on completion of the Thames Tidal Breach Modelling. The Environment Agency modelling (2017) also considers breaches of the western embankment of the River Roding, but not breaches of the eastern embankment. The most recent data for breaches of the eastern embankment remains the same as the modelling undertaken as part of the previous Barking and Dagenham SFRA (2008) and is reproduced within this SFRA update.

1.1.4 Updated climate change recommendations were published by the Environment Agency in February 2016 and these are discussed within the SFRA update. The hydraulic models of the Mayes Brook, Gores Brook, Beam River and Wantz Stream have been updated to reflect the changes that these recommendations have on fluvial flood extents within Barking and Dagenham. The Environment Agency are due to update their hydraulic model of the Lower Roding and Loxford Water in December 2017 and, as such, updated modelling of these watercourses has not been undertaken at this time.

1.1.5 The knowledge and understanding of the risk of flooding from surface water in Barking and Dagenham has been improved by the publication of the Environment Agency's Risk of Flooding from Surface Water map in 2010 and subsequently updated in 2013, and also the production of the Surface Water Management Plan (SWMP) in 2012 as part of the Drain London programme. The SWMP has developed a detailed understanding of surface water flood risk in the Borough, and made recommendations for surface water management to improve emergency and land use planning, and enable better flood risk and drainage infrastructure investments.

1.1.6 A Level 2 SFRA has been completed for the strategic development sites identified by the Council. The Level 2 SFRA provides a more detailed assessment of the flood risk at the strategic development sites where it is not possible to allocate all proposed development and infrastructure in accordance with the Sequential Test described in the NPPF. In these cases the Level 2 SFRA applies the Exception Test in accordance with the NPPF.

1.2 Local Context

1.2.1 The London Borough of Barking and Dagenham is in East London and fronts onto the northern bank of the River Thames, downstream of the Thames Barrier. It is bordered to the west, north and east by the London Boroughs of Newham, Redbridge and Havering, respectively. See Appendix A for a map of the Borough.

1.2.2 Barking and Dagenham covers an area of 37.8 km^2 (3778 hectares). The Beam River defines much of the Borough of Barking and Dagenham's eastern boundary, while the River Roding (known in its lower reaches as the Barking Creek) defines the south-west. Other watercourses that flow within Barking and Dagenham, or adjoin watercourses within the Borough, are: Loxford Water, Gores Brook, Mayes Brook and The Ship and Shovel Relief Sewer. See Appendix B for a map of Barking and Dagenham's watercourses.

1.2.3 Barking and Dagenham has a population of approximately 185,911 which reside in approximately 69,681 households. This gives an average household size of 2.67 persons per household[1].

1.2.4 The latest available data indicates that Barking and Dagenham is largely urban in character, with over 2,300 hectares of land classified as urban. There are significant areas of industrial land in the Borough. Over 1,100 hectares (33%) of the Borough is classified as green space which contains areas of wildlife habitat, including Eastbrookend Country Park and the Chase, Beam Parklands and the River Thames.

1.2.5 Whilst the physical size of the Borough is relatively small compared to other counties and boroughs throughout England, the population density within the Borough is relatively high with over 5,000 people per square kilometre.

1.2.6 Industry in Barking and Dagenham is split between services (80% of all employment), utilities (5% of all employment), manufacturing (5% of all employment) and construction (10% of all employment)[1].

1.2.7 The Environment Agency's Risk of Flooding from Rivers and Sea dataset, published in 2015, is an assessment of flood risk for England produced using local data and expertise. It determines the chance of flooding from rivers and the sea taking account of flood defences and the condition they are in. The dataset divides the floodplain into 50m x 50m cells with each allocated as high, medium or low flood risk (see Table 1.1). All properties not within these flood risk categories are at very low risk with a 1 in 1000 (0.1%) or less annual probability of flooding. The dataset also identifies the number of properties in each of the flood risk categories in each postcode unit in England. A summary of the properties at risk in Barking and Dagenham is included in Table 1.1.

[1] Source: 2011 Census

Table 1.1: Risk of Flooding from Rivers and the Sea statistics for the London Borough of Barking and Dagenham[2]

Risk category	Number of properties at risk (residential and non-residential)
Low Between 1% (1 in 100) and 0.1% (1 in 1000) chance of flooding each year	7,660
Medium Between 3.3% (1 in 30) and 1% (1 in 100) chance of flooding each year	1,319
High Greater than 3.3% (1 in 30) chance of flooding in any year	356
Total number of properties at risk	**9,335**

1.2.8 The consequences of flooding depend greatly on the development density of an area. The impact of an increase in fluvial or tidal flood extents or an increase in surface water runoff in densely developed areas such as Barking and Dagenham is greater than for the same increase in less densely developed areas given the number of properties and people and the extent of infrastructure that will likely be affected.

1.2.9 The greatest source of flood risk to Barking and Dagenham, and arguably the greatest risk to the greater London area, is the River Thames. The natural floodplain of the River Thames within London is now almost fully developed and land within the south of Barking and Dagenham that adjoins the River Thames is heavily dependent upon manmade flood defences to protect it against the risk of flooding.

1.2.10 Substantial investment has been committed to the protection of London, both now and into the future, as set out by the TE2100 Strategy (Environment Agency). Details of the TE2100 Strategy are included in Section 3.3.

1.2.11 Other significant rivers located within Barking and Dagenham that present a potential risk of flooding to property and infrastructure include:

- The River Roding – forming the Borough's south-western boundary.
- Barking Creek – the lower stretches of the River Roding prior to discharge to the River Thames.
- Loxford Water – forming part of the Borough's north-western boundary.
- Mayes Brook – flows through the west of the Borough to confluence with the River Roding / Barking Creek. The upper reaches of Mayes Brook (within the London Borough of Redbridge) are predominantly culverted. The Brook is believed to start at Chadwell Heath in the north of Barking and Dagenham.
- Ship and Shovel Relief Sewer – a manmade relief channel that flows from west to east within the south of Barking and Dagenham to carry flow from Mayes Brook to Gores Brook when levels are high in the Mayes Brook.

[2] Contains public sector information licensed under the Open Government Licence v2.0

- Buzzard Mouth Creek – flows south through the Barking Riverside and Creekmouth areas in the south of the Borough to discharge to the River Thames.
- Gores Brook – flows through Goresbrook Park in the south-east of Barking and Dagenham and passes through Dagenham Docks to discharge to the River Thames. Gores Brook receives flow from the Mayes Brook (via the Ship and Shovel Relief Sewer) when water levels are high in the Mayes Brook.
- Wantz Stream - short stretch of watercourse in the east of Barking and Dagenham that discharges to the Beam River. Land adjacent to the Wantz Stream is known as the Beam Parklands (formerly Dagenham Washlands).
- Dagenham Breach – short stretch of watercourse in the south-east of Barking and Dagenham that discharges to the Beam River.
- Beam River – forming the eastern boundary of Barking and Dagenham and discharges to the River Thames.

1.2.12 As is the case in many areas of England, an ever increasing 'squeeze' is evident through competing needs for government funding for flood defence and an increasing potential risk of flooding due to pressure for future development and the impacts of climate change. For this reason, a key focus of the Thames CFMP is the need to proactively deliver a reduction in flood risk through the planning process – in simple terms, guiding vulnerable development away from areas that are most at risk, and adopting sustainable design techniques. This philosophy is also clearly evident within other strategic studies developed by the Environment Agency relating more widely to the River Thames, in particular the TE2100 Strategy, as well as in other national, regional and local legislation and planning policy as discussed in Section 3.

1.2.13 Barking and Dagenham are required to prepare a strategy for local flood risk management to meet the requirements of the Flood and Water Management Act. A Local Flood Risk Management Strategy (LFRMS) will be produced by Barking and Dagenham Council to set out the overarching objectives of the Council with regards to managing flood risk and the proposed methods by which this will be achieved. The LFRMS is due to be published in April 2016.

1.2.14 Barking and Dagenham has also been defined as a Flood Risk Area in accordance with the Flood Risk Regulations and therefore required to prepare a flood risk management plan. The Council are contributing to the Thames Flood Risk Management Plan (FRMP) that will set out actions to be taken forward within the Borough over the next six years. The Thames FRMP was published in March 2016.

1.3 Future Development in Barking and Dagenham

1.3.1 Barking and Dagenham is undergoing its most extensive programme of regeneration since the Borough was urbanised and industrialised. The regeneration programme includes the construction of over 30,000 new residential units, commercial properties, community facilities and transport infrastructure at the following key regeneration sites identified by the Council:

- Barking Town Centre
- Barking Riverside
- Creekmouth
- Thames Road

- Dagenham Dock
- Ford Stamping Plant and Beam Park
- Chadwell Heath
- Wantz Industrial Estate
- Dagenham East
- Rippleside
- Dagenham Leisure Park
- Barking and Dagenham College
- Marks Gate

1.3.2 The regeneration of Barking Town Centre, in the east of the Borough, includes provision for approximately 4,000 new homes. Planning permission for up to 950 dwellings was granted in 2011 at Fresh Wharf Estate, adjacent to the A406 on the west of the Barking Town Centre key regeneration area.

1.3.3 The Barking Riverside development is part of the Thames Gateway development project in East London and was granted planning permission in 2007. It is one of the largest brownfield developments in the UK and is located in the south of the Borough, adjacent to the River Thames. The development comprises the construction of approximately 10,800 homes, 64,000m^2 of commercial floor space, transport infrastructure and supporting community facilities including healthcare, schools, open space and public squares. Over 650 homes have been completed with a further 698 units due for completion by 2017.

1.3.4 Flood risk was one of the key constraints in the regeneration of Barking Riverside and as part of the proposed management measures the level of the development areas has been raised to protect future residents from fluvial flooding from the Thames and the existing creeks. Flood compensation areas are incorporated into the parklands to reduce the risk of fluvial flooding due to the tide-locking of the creeks.

1.3.5 Aside from the Barking Riverside development, two other brownfield areas adjacent to the River Thames have been identified for regeneration. Creekmouth, to the west of Barking Riverside, and Dagenham Dock, to the east, have been identified for the construction of residential properties and the development of 'green industries' respectively. Planning permission has also been permitted for the construction of 276 residential units adjacent to the Thames Road key regeneration area.

1.3.6 A more detailed assessment of flood risks at the key regeneration sites identified by the Council is provided in the accompanying Level 2 SFRA.

SECTION 2

SFRA APPROACH

2 SFRA APPROACH

2.1 The Need for the SFRA

2.1.1 The London Borough of Barking and Dagenham are required to prepare a Strategic Flood Risk Assessment in accordance with National Planning Policy Framework (NPPF) to support their Local Plan and inform development control within the Borough.

2.1.2 Barking and Dagenham are currently reviewing their Local Plan which will set out the future planning of the Borough between 2018 and 2033 responding to the opportunity that Barking and Dagenham has some of the most untapped potential for growth in London. The Local Plan will promote development at the key regeneration sites discussed in Section 1.3, subject to review of constraints and opportunities, as well as set out objectives and policy requirements for all other development in the Borough including other windfall sites that may come forward.

2.1.3 The SFRA is a living document that is amended periodically to reflect changes in flood risk data, changes in legislation and changes in planning policy. This SFRA provides an update to the previous SFRA published in 2008. Similar language and layout has been maintained in this report for consistency and continuity with the 2008 SFRA.

2.2 Approach to Completing the SFRA

2.2.1 This SFRA was completed via the key tasks as listed below:

- Review of changes in key national, regional and local planning policy and strategies that are relevant to the management of flood risk within Barking and Dagenham;
- Consultation with relevant authorities for the purpose of discussing current and future flood risk, obtaining relevant datasets, and understanding development control and flood management requirements;
- Review of available data sets to understand historic, current and future flood risks within the Borough from all sources of flooding;
- Interpretation of available data to understand the risk of flooding to people and property for the purpose of informing development control;
- Recommendation of measures to ensure the sustainable management of flood risk within the Borough through the development and re-development of sites.

2.2.2 The SFRA has been reviewed and approved by the Environment Agency as a statutory consultee under the NPPF.

2.3 Proposed Use of the SFRA

2.3.1 This SFRA assesses the risk of flooding from all sources, now and in the future, taking account of the impacts of climate change, and assesses the impact that land use changes and development in the area will have on flood risk.

2.3.2 In relation to the Local Plan, the SFRA will be used to:

- Determine the variations in risk from all sources of flooding;
- Inform the sustainability appraisal of the Local Plan, so that flood risk is fully taken into account when considering allocation options and in the preparation

of plan policies, including policies for flood risk management to ensure that flood risk is not increased;

- Apply the Sequential Test and, where necessary, the Exception Test when determining land use allocations;
- Identify the requirements for site-specific flood risk assessments in particular locations, including those at risk from sources other than river and sea flooding;
- Determine the acceptability of flood risk in relation to emergency planning capability;
- Consider opportunities to reduce flood risk to existing communities and developments through better management of surface water, provision for conveyance and provision of storage for flood water.

2.3.3 The SFRA comprises a Level 1 and Level 2 SFRA. The Level 1 SFRA, which is this document, provides sufficient information to principally enable the Sequential Test to be applied. The Level 1 SFRA also provides guidance to developers within Barking and Dagenham in regard to how flood risk should be considered within planning applications for new and re-developed sites and the expectations of the Council in terms of development control.

2.3.4 The Level 1 SFRA is supported by a Level 2 SFRA that provides a more detailed assessment of flood risk at the strategic development sites discussed in Section 1.3. Where it is not possible to allocate all proposed development and infrastructure in accordance with the Sequential Test as described in the NPPF, the Level 2 SFRA applies the Exception Test in accordance with the NPPF.

SECTION 3

POLICY FRAMEWORK

3 POLICY FRAMEWORK

3.1 Introduction

3.1.1 This section provides a brief overview of the strategy and policy context relevant to flood risk in the London Borough of Barking and Dagenham. The SFRA is a key point of reference to the Council in developing their flood risk policies, and this part of the document is designed to facilitate policy development.

3.1.2 The success of the SFRA is heavily dependent upon the Council's ability to implement the recommendations put forward for future sustainable flood risk management, both with respect to planning decisions and development control recommendations (refer Section 7). A framework of national and regional policy and strategy directives are in place, providing guidance and direction to local planning authorities. Ultimately however, it is the responsibility of the Council to establish robust policies and strategies that will ensure future sustainability with respect to flood risk.

3.2 National Planning Policy and Strategy

National Planning Policy Framework

3.2.2 The National Planning Policy Framework (NPPF) was published in 2012 and sets out the Government's planning policies for England and provides a framework within which local councils can produce their own plans that better reflect the specific needs of their communities. The NPPF and accompanying Planning Practice Guidance has superseded Planning Policy Statement 25: Development and Flood Risk.

3.2.3 Section 10 of the NPPF requires Local Plans to be supported by Strategic Flood Risk Assessments and requires Local Authorities to develop policies to manage flood risk from all sources. In the preparation of a SFRA the Environment Agency and any other relevant flood risk bodies should be consulted. 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 into account the impacts of climate change. In general, these requirements will be met by:

- Applying the Sequential Test and, if necessary, 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;
- 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.

3.2.4 Development should be steered to areas with the lowest probability of flooding and should not be allocated or permitted in areas where there are reasonably available sites appropriate for the proposed development in areas with a lower probability of flooding. The Sequential Test is used as the principal step to identify preferred locations, i.e. those not exposed to the risk of flooding.

3.2.5 If, following the application of the Sequential Test, it is determined that development cannot be located in an area with a lower probability of flooding and is deemed

necessary in a flood zone the Exception Test can be applied. For the Exception Test to be passed:

- 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.

3.2.6 The Planning Practice Guidance provides guidance on the implementation of the planning policies set out in the NPPF including a framework for the production of a SFRA.

3.2.7 The NPPF also promotes the use of sustainable drainage systems (SUDS) and sets out the preferred hierarchy for surface water management, stating that surface water should be infiltrated to ground in the first instance. If infiltration is not a feasible means of managing surface water runoff, the preferences are (in order of priority) discharge to a surface water body, discharge to a surface water or highways drainage system, and discharge to the combined sewerage network.

Flood Risk Regulations 2009

3.2.8 The Flood Risk Regulations transposes the European Commission (EC) Floods Directive (2007/60/EC) into domestic law in England and Wales and implements its provisions.

3.2.9 The key objective of the Floods Directive is to coordinate the assessment and management of flood risks within Member States. Specifically it requires LLFAs of Member States to assess if all watercourses and coast lines are at risk from flooding, map the flood extent and assets and humans at risk in these areas, and take adequate and coordinated measures to reduce this flood risk. In particular it places duties on the LLFAs to prepare a number of documents including:

- A Preliminary Flood Risk Assessment Report that identifies Flood Risk Areas that warrant further examination through the production of maps and management plans.
- Flood Hazard and Flood Risk Maps that summarise identified local flood risks and flood hazards within the Flood Risk Areas.
- Local Flood Risk Management Plans that set out the actions and measures that will be taken to manage identified flood risks within the Flood Risk Areas.

3.2.10 The London Borough of Barking and Dagenham PFRA was published in 2012 and confirmed the extent of the defined Flood Risk Areas against the Environment Agency's indicative Flood Risk Area that broadly covers London. The Council have also contributed to the Thames Flood Risk Management Plan that was published by the Environment Agency in March 2016.

Flood and Water Management Act 2010

3.2.11 The Flood and Water Management Act implements the recommendations from Sir Michel Pitt's Review of the floods in 2007 and places a series of responsibilities on local authorities with the primary aim of improving flood risk management.

3.2.12 Sir Michael Pitt's review stated that "the role of local authorities should be enhanced so that they take on responsibility for leading the co-ordination of flood risk management in their areas". The Act provides for this through the new role of the LLFA.

3.2.13 LLFAs are responsible for a number of important aspects in coordinating the management of local flood risk, including:

- The investigation of flood incidents: a duty to investigate and record details of significant flood events within the LLFA administrative area. This includes identifying which organisations have flood risk management functions and what will be done to investigate flood incidents, notifying risk management organisations where necessary and publishing the results of any investigations carried out.
- Asset Register: a register of structures or features which are considered to have an effect on flood risk, including details on ownership and condition as a minimum must be maintained. The register must be available for inspection by the Secretary of State.
- Sustainable Drainage Systems (SUDS) Approving Body: under Schedule 3 of the Act, the LLFA would be the designated SUDS Approving Body (SAB) for any new drainage system, and therefore must approve, adopt and maintain any new sustainable drainage systems (SUDS) within their area. Schedule 3 has not yet been enacted in full and full implementation is still in question. However, as of the 6th April 2015, LLFAs have a duty to review and comment on the management of surface water relating to planning applications for major development[3] and that the proposals are in accordance with the Non-Statutory Technical Standards for Sustainable Drainage Systems[4].
- Local Flood Risk Management Strategy (LFRMS): a requirement to develop, maintain, apply and monitor a local strategy for flood risk management in the LLFA area. This local strategy must build upon national and local information and will use consistent risk-based approaches across local authority areas and catchments.
- Powers to Undertake Works: powers to undertake works to manage flood risk from surface runoff and groundwater, consistent with the LFRMS for the area.
- Powers to Designate: alongside the Environment Agency, the LLFA now has power to designate structures and features that affect flooding or coastal erosion. This will safeguard assets that are relied upon for flood or coastal erosion risk management.

National Strategy for Flood and Coastal Erosion Risk Management

3.2.14 The Environment Agency's National Strategy for Flood and Coastal Erosion Risk Management (FCERM) sets out how the Environment Agency intends on meeting their obligations under the Flood and Water Management Act to 'develop, maintain, apply and monitor a strategy for flood and coastal erosion risk management in England'.

3.2.15 The National Strategy describes what needs to be done by all organisations involved in flood and coastal erosion risk management. These include local authorities, internal

[3] As set out in Article 2(1) of the Town and Country Planning (Development Management Procedure) (England) Order 2010

[4] Non-Statutory Technical Standards for Sustainable Drainage Systems, DEFRA, March 2015

drainage boards, water and sewerage companies, highways authorities, and the Environment Agency.

3.2.16 The National Strategy also sets out a statutory framework that will help communities, the public sector and other organisations to work together to manage flood and coastal erosion risk. It will make sure that risks are managed in a co-ordinated way across catchments and along each stretch of coast. This includes the development of the LFRMS by LLFAs, as well as the Environment Agency's strategic overview of all sources of flooding and coastal erosion.

3.2.17 The measures set out by the LLFA within their LFRMS should therefore be compatible with the Environment Agency's National Strategy.

3.2.18 The National Strategy states that the Government will work with individuals, communities and organisations to reduce the threat of flooding and coastal erosion by:

- Understanding the risks of flooding and coastal erosion, working together to put in place long-term plans to manage these risks and making sure that other plans take account of them;
- Avoiding inappropriate development in areas of flood and coastal erosion risk and being careful to manage land elsewhere to avoid increasing risks;
- Building, maintaining and improving flood and coastal erosion management infrastructure and systems to reduce the likelihood of harm to people and damage to the economy, environment and society;
- Increasing public awareness of the risk that remains and engaging with people at risk to encourage them to take action to manage the risks that they face and to make their property more resilient;
- Improving the detection, forecasting and issue of warnings of flooding, planning for and co-ordinating a rapid response to flood emergencies and promoting faster recovery from flooding.

3.2.19 The Barking and Dagenham SFRA therefore contributes to meeting these strategic goals through the understanding and communication of risks within the Borough, and through informing appropriate development.

<u>Sustainable Drainage Systems – Non-Statutory Technical Standards for Sustainable Drainage Systems</u>

3.2.20 The Non-Statutory Technical Standards for Sustainable Drainage Systems, published by DEFRA in March 2015, set out the core technical standards for sustainable drainage systems proposed within England. These standards should be used in accordance with the NPPF and Planning Practice Guidance.

3.2.21 Whilst the standards should be considered for new and existing development of any size within Barking and Dagenham, they are considered to be of particular importance to major development as set out in the Town and Country Planning (Development Management Procedure) (England) Order 2010, incorporating:

- Mineral working sites;
- Waste sites;

- Developments of 10 dwellings or more, or residential development with a site area of 0.5 hectares or greater;
- Building(s) where the proposed flood space in 1,000m^2 or more; or
- Any development with a site area of 1 hectare or greater.

3.2.22 The standards include guidance on flood risk within a development boundary and beyond the boundary, peak flow and runoff volume control and the structural integrity of SUDS.

3.2.23 As discussed above, LLFAs now have a duty to review and comment on the management of surface water relating to planning applications for major development and to ensure that the proposals are in accordance with the Non-Statutory Technical Standards for Sustainable Drainage Systems.

3.3 Regional Planning Policy and Strategy

The London Plan, 2011 (including alterations adopted in March 2015)

3.3.2 The London Plan (including alterations adopted in March 2015) is the adopted regional spatial strategy that covers the London Borough of Barking and Dagenham and includes a number of flood risk policies relevant to the area. The key policies relate to flooding; flood risk management; sustainable drainage; rising groundwater; and climate change.

3.3.3 Chapter 5 sets out the range of policies that underpin London's response to climate change, including underlying issues of resource management. Paragraph 5.54 identifies London as being prone to six sources of flooding: tidal, fluvial, surface water, sewer, groundwater and reservoir flooding and the Plan acknowledges that climate change will increase the probability of flooding from all these sources except perhaps groundwater. Subsequent paragraphs therefore indicate that the management of flood risk is extremely pertinent to London.

3.3.4 Policy 5.12 "Flood Risk Management" refers to the need for carrying out strategic flood risk assessments in order to identify locations suitable for development, which should be carried out in line with NPPF. This policy also highlights criteria for managing flood risk where development has been permitted in areas at risk of flooding. One criterion states the need to set back permanent development from flood defences to allow for the management, maintenance and upgrading of flood defences to be carried out in a sustainable and cost effective way. This is a potential issue for Barking and Dagenham as there are a number of flood defences located in the Borough, such as the Thames Tidal Defences, behind which significant development is proposed. The London Borough of Barking and Dagenham will need to ensure that any new development near to the defences is set back from them, and that any new development does not undermine or breach the defences.

3.3.5 Policy 5.13 "Sustainable Drainage" seeks to ensure that surface water runoff is managed close to its source and recommends that rainwater harvesting and sustainable drainage systems (SUDS) are promoted for new developments unless there are practical reasons for not doing so. It also identifies that developers should aim to achieve Greenfield runoff from their site. Sustainable drainage techniques are identified as one of the keys to ensuring that long-term flooding risk is managed. Thus it is important that local planning policy provides clear guidance relating to sustainable drainage within emerging development areas in Barking and Dagenham.

3.3.6 The Regions housing targets over the plan period are given in Policy 3.3 "Increasing Housing Supply" and the subsequent Table 3.1 of the Plan. These state that the Mayor will see a minimum provision of 42,000 additional homes per year from all sources in London. Within the Borough of Barking and Dagenham a minimum ten year target (2015 – 2025) of 12,355 and an annual monitoring target of 1,236 additional housing is sought per year.

3.3.7 The policies mentioned above will need to be considered when the Borough is considering how to allocate land, in particular, in order to meet development pressures such as the need for additional housing.

Supplementary Planning Guidance – Sustainable Design and Construction[5]

3.3.8 Clause 3.4 (Flooding) and Clause 4.6 (Water Pollution) of the Supplementary Planning Guidance (SPG) set out a series of standards that are to be sought through local planning policy. These are key to the framework within which the development control recommendations within the Barking and Dagenham SFRA have been developed.

3.3.9 The Mayor's priorities relating to flood risk management identified in the SPG are:

- Through their LFRMS boroughs should identify areas where there are particular surface water management issues and develop policies and actions to address these risks.
- Developers should maximise all opportunities to achieve greenfield runoff rates in their developments.
- When designing their schemes developers should follow the drainage hierarchy set out in London Plan Policy 5.13.
- Developers should design SUDS into their schemes that incorporate attenuation for surface water runoff as well as habitat, water quality and amenity benefits.
- Developments in areas at risk from any form of flooding should include flood resistance and resilience measures in line with industry best practice.
- Developments are designed to be flexible and capable of being adapted to and mitigating the potential increase in flood risk as a result of climate change.
- Developments should incorporate the recommendation of the TE2100 plan for the future tidal flood risk management in the Thames Estuary.
- Where development is permitted in a flood risk zone, appropriate residual risk management measures are to be incorporated into the design to ensure resilience and the safety of occupiers.
- Developments should maximise all opportunities to achieve an 8m setback on fluvial watercourses between built development and watercourses, flood defences and culverts.

[5] Mayor of London (April 2014)

- Development should maximise all opportunities to achieve a 16m setback on tidal watercourses between built development and watercourses and flood defences.

- All sources of flooding need to be considered when designing and constructing developments.

The Sub-Regional Development Framework: East London

3.3.10 The Sub-Regional Development Framework (SRDF) for East London was published in 2006 by the Mayor of London. The Framework is not a planning policy document in itself but a complementary aid to the London Plan in identifying issues which might be addressed in the London Plan review or Local Development Frameworks. Within the development control process, the SRDF may be used as a material consideration in the determination of planning applications. Amended sub-regional groupings are being considered as part of future alternations to the London Plan, however the Mayor has advised that the information contained in these SRDFs will remain valuable.

3.3.11 In discussing flood risk, the SRDF cites good practice examples such as the Millennium Dome and the Olympic site of how development can achieve sustainable flood defences. Likewise it encourages innovative building and site designs that do not depend on flood barriers for protection and impose restrictions on a site's accessibility, natural environment and aesthetic value.

3.3.12 Key infrastructure issues surrounding the Opportunity Areas of Barking Riverside (formerly Reach)[6] and London Riverside[7] in Barking and Dagenham are set out in the SRDF. It is highlighted that Barking Riverside, the site for a proposed 10,000 residential unit new community development, lies within the Tidal Thames flood plain and is also at risk from fluvial flooding. The western parts of London Riverside, a site earmarked for up to 9,000 residential units, may also be subject to flood risk. The Framework repeats NPPF advice and the London Plan policies by emphasising the need to examine future flood risk management and consider mitigation measures in the development of these sites.

Regional Flood Risk Appraisal

3.3.13 The RFRA, published in 2009, is a strategic overview of flood risk across London. It does not represent a detailed analysis of flood risk in relation to any particular areas or sites. It contains a series of recommendations which are either region wide or applicable to boroughs in undertaking their SFRA to accompany emerging Local Development Documents. The RFRA will remain a live document with regular updates to reflect the changing position in relation to both climate change and development pressure and policy responses. The RFRA should be useful to spatial planners, developers, infrastructure and utility operators and emergency planners. It is a specific aim of the RFRA to bring spatial planners and emergency planners into closer communication.

3.3.14 The RFRA provides the following recommendations of specific relevance to the London Borough of Barking and Dagenham:

[6] Mayor of London (2006), pg A25, Annex 2, The Sub-Regional Development Framework: East London, GLA

[7] Mayor of London (2006), pg A29, Annex 2, The Sub-Regional Development Framework: East London, GLA

- Recommendation No. 1 – All Thames-side planning authorities should consider in their SFRAs and put in place DPD policies to promote the setting back of development from the edge of the Thames and tidal tributaries to enable sustainable and cost effective upgrade of river walls/embankments in line with London Plan Policy 5.12, CFMPs and TE2100.

- Recommendation No. 4 – Boroughs at confluences of tributary rivers with the River Thames should pay particular attention to the interaction of fluvial and tidal flood risks.

- Recommendation 5 – Developments all across London should reduce surface water discharge in line with the Sustainable Drainage Hierarchy set out in Policy 5.13 of the London Plan.

- Recommendation 6 – Regeneration and redevelopment of London's fluvial river corridors offer a crucial opportunity to reduce flood risk. SFRAs and policies should focus on making the most of this opportunity through appropriate location, layout and design of development as set out in PPS 25 (now superseded by NPPF) and the Thames CFMP. In particular opportunities should be sought out to:

    - Set back developments from the river edge to enable sustainable and cost effective flood risk management options

    - Ensure that buildings with residual flood risk are designed to be flood compatible or flood resilient

    - Use open spaces within developments which have a residual flood risk to act as flood storage areas

- Recommendation 8 – Organisations responsible for development with large roof areas should investigate providing additional surface water runoff storage.

- Further strategic recommendations are provided for key development types throughout the region including (for example) schools, hospitals and emergency services. These recommendations focus heavily upon ensuring that the risk of flooding is minimised through the design process.

3.3.15 The RFRA deliberately crosses the boundary between land use planning and emergency planning, which has been done to stimulate greater links between these disciplines. The London Resilience Team has recently published its London Strategic Flood Plan (LSFP). This seeks to co-ordinate emergency services and emergency planners across London in the event of a major flood. This is the first time it has been updated since the opening of the Thames Barrier. It will be important to foster links between the RFRA and the LSFP.

Thames Catchment Flood Management Plan

3.3.16 Catchment Flood Management Plans (CFMPs) are a planning tool through which the Environment Agency aims to work in partnership with other key decision-makers within a river catchment to explore and define long term sustainable policies for flood risk management.

3.3.17 The CFMP for the River Thames catchment was published by the Environment Agency in 2009. Four overarching key messages have been highlighted by the CFMP:

- Flood defences cannot be built to protect everything;
- Climate change will be the major cause of increased flood risk in the future;
- The floodplain is our biggest asset in managing flood risk;
- Development and urban regeneration provide a crucial opportunity to manage the risk.

3.3.18 The CFMP divides the Thames catchment into 43 sub-areas with one of six policy options for the management of flood risk applied to each sub-area. The Beam and Ingrebourne Rivers have been classified as part of the "London catchments" sub area and are subject to Policy Option 4. The objective of Policy Option 4 is to "take further action to sustain the current level of flood risk into the future (responding to the potential increases in risk from urban development, land use change and climate change" and is applied to areas of low, moderate or high flood risk.

3.3.19 The Lower River Roding is within the "heavily populated floodplain" sub-area. Policy Option 5 is the preferred policy for this sub-area and aims to "take further action to reduce flood risk". This Policy Option is applied to areas of moderate to high flood risk.

3.3.20 Specific messages have been provided for characteristic reaches along the River Thames and its tributaries. The lower reaches of the River Roding and the Beam River are classified as 'Generally urban areas with some river flood defences". The specific messages from the Thames CFMP for these reaches are:

- Redevelopment rates in some areas are very high and offer the opportunity to reduce the risk and the current reliance on flood defences. This includes making the urban environment more resilient and with a layout that offers more options for managing future flood risk and the impacts of climate change.
- Generally the existing river corridors in these areas provide an opportunity to be able to adapt to the impacts of climate change and the Environment Agency is seeking to safeguard them from inappropriate development. The Environment Agency are seeking to maintain existing assets at least until redevelopment takes place.
- Climate change will mean that the Environment Agency need to adapt the existing defences over time. Rather than replacing them like for like, the Environment Agency will be seeking a different combination of flood storage, river defences and floodplain attenuation.
- Some of the areas are susceptible to rapid flooding from thunderstorms. Emergency response and flood awareness are particularly important.

Thames Estuary 2100 Plan

3.3.21 The Thames Estuary 2100 Plan (TE2100) is a strategic flood risk management plan for London and the Thames Estuary through to the end of the century. TE2100 covers the tidal portion of the Thames and its floodplain from Teddington in the west to Sheerness / Shoeburyness in the east. While the plan focuses primarily on tidal flooding, other sources of flooding including high river flows and surface water flooding are also considered.

3.3.22 The broad objectives of TE2100 are:

- To manage the risk of flooding to people, and minimise the adverse impacts of flooding to property and the environment;
- To adapt to the challenges that the Thames Estuary will face from climate change;
- To support and inform the land use planning process to ensure appropriate, sustainable and resilient development in the Tidal Thames floodplain;
- To protect the social, cultural and commercial value of the tidal River Thames, its tidal tributaries and its floodplain;
- To enhance and restore estuarine ecosystems to contribute to biodiversity targets and maximise the environmental benefits of natural floods.

3.3.23 The TE2100 Plan divides the Thames Estuary into 23 geographical areas, known as policy units. Each policy unit has been assessed for the appropriate level of flood risk management and five policies for the management of flood risk have been developed. One policy has been applied to each policy unit with Policy No. 4 applied to the Borough of Barking and Dagenham. This policy aims to:

- Take further action to keep up with climate change and land use change so that flood risk does not increase.

3.3.24 Policy units with similar characteristics and requiring a similar type and range of actions have been grouped together into action zones. Action Zone 0 incorporates the entire estuary and includes 15 recommendations for the estuary, divided into 3 time periods; first 25 years, middle 15 years and up to 2100. The recommendations are summarised below:

- To maintain, operate, modify and improve the Thames Barrier or new Barrier and other active defences across the lifetime of the plan;
- To implement four intertidal habitats along the estuary, although noting that none of the sites identified for habitat creation are located within Barking and Dagenham;
- To implement the TE2100 “end of the century” option between 2050 and 2070. The decision on the option will not be made until 2050 but the two ‘front runners’, improving the existing system and a new barrier at Long Reach, have been highlighted;
- Development of a land strategy for the Thames Estuary to safeguard land which may be needed for future flood risk management, to co-ordinate planning and ensure that the benefits of the habitat creation schemes are maximised, develop a programme of investigations and remedial works with the objective of removing the constraints to flood risk management caused by contamination and to bring together the various strategic plans and vision statements in the estuary;
- Agree partnership arrangements for floodplain management;
- To monitor and maintain the TE2100 Plan;

- To formalise TE2100 Legacy handover arrangements;
- To prepare Riverside Strategies for each local authority.

3.3.25 The Borough of Barking and Dagenham is located within Action Zone 4 – East London downstream of the Thames Barrier for which 11 actions have been identified:

- TE2100 Plan to inform the development and revision of local authority SFRAs and flood plans;
- To agree a programme of floodplain management including localised flood protection, resilience and local emergency plans for vulnerable key sites;
- To agree partnership arrangements and principles to ensure that new development in this zone is safe, and that where possible, the application of NPPF reduces the consequence flood risk – particularly in areas where large numbers of people congregate or there is aggregation of flood risk;
- To review and maintain from 2035 to 2049, the partnership arrangements and principles for development and flood risk management established in the first 25 years of the TE2100 Plan;
- To review and maintain from 2050 and into the 22nd century, the partnership arrangements and principles for development and flood risk management established in the middle years of the TE2100 Plan;
- To maintain, enhance and improve or replace, the river defence walls and active structures through East London downstream of the Thames Barrier during the first 25 years of the TE2100 Plan from 2010 to 2034;
- To maintain, enhance and improve or replace the river defence walls and active structures through East London downstream of the Thames Barrier during the 15 year period of the Plan from 2035 to 2049;
- To implement the TE2100 “end of the century” option between 2050 and 2070;
- To maintain, improve and enhance or replace the river defence walls and active structures in East London downstream of the Thames Barrier post 2050 and into the 22nd century;
- To agree a programme for managing flooding from other sources in the defended tidal floodplain;
- To agree a programme for habitat enhancement and replacement and implement habitat improvement and replacement schemes up to 2050.

3.4 Local Planning Policy

Barking and Dagenham Local Plan

3.4.2 The Barking and Dagenham Local Plan is currently being reviewed and will set out the future planning of the Borough between 2018 and 2033 responding to the fact that Barking and Dagenham has some of the most untapped potential for growth in London. The updated Local Plan will be informed by this SFRA.

3.4.3 The current Barking and Dagenham Local Plan consists of a series of documents called Development Plan Documents (DPDs). The most important of these is the Core Strategy. The Borough Wide Development Policies, the Site Specific Allocations and the Barking Town Centre Area Action Plan DPDs support the strategic objectives set out in the Core Strategy and provide further detail on how development should be shaped.

3.4.4 The current Core Strategy sets out the Councils' long-term vision, spatial strategy and core policies for shaping the future development of Barking and Dagenham up to 2025, however this will be updated in the revised Local Plan 2018 - 2033. The Core Strategy is a key document within Barking and Dagenham's Local Plan and the strategic objectives of the Core Strategy follow the principals of NPPF by stating:

> "Reducing the risk of flooding for people and property by guiding development to areas where flood risk can be avoided or alleviated and ensuring new development provides for flood control measures where appropriate."

3.4.5 The main policy concerning flood risk is Policy CR4: Flood Management that states "development that places people and property at risk from flooding or which would have an adverse impact on watercourses will not be permitted. The impacts of climate change and any potential displacement of flood risk into other areas must be taken into account."

3.4.6 Two other policies in the Core Strategy refer to flood risk. Policy CM1: General Principles for Development which states "development should take account of natural constraints, particularly the risk of flooding…" and Policy CR1: Climate Change and Environmental Management states "the Council will manage flood risk so that people and property will not be placed at risk of flooding."

3.4.7 The Borough Wide Development Policies DPD reflects the spatial vision and objectives, and complements the proposed core policies set out in the Core Strategy Preferred Options Report. The DPD offers detailed guidance on thematic issues including flood risk. Preferred Policy Option BR4: Water Resource Management specifically addresses flood risk related requirements. It cites SUDS in reducing flood risk and managing surface runoff.

Barking and Dagenham Local Flood Risk Management Strategy

3.4.8 In accordance with the Flood and Water Management Act and Flood Risk Regulations, Barking and Dagenham are required to prepare a strategy for local flood risk management. A single, combined LFRMS will be produced by Barking and Dagenham Council to set out the overarching objectives of the Council with regards to managing flood risk and the proposed methods by which this will be achieved.

3.4.9 The LFRMS is due to be published in April 2017 and is will include the following key information:

- The vision and objectives of the Council with regards to the management of flood risk within the Borough;
- A summary of relevant risk management authorities within Barking and Dagenham and their role in regard to flood and coastal erosion risk management;
- Proposed methods and measures that the Council will implement to achieve their vision and objectives, including the identification and prioritisation of communities at risk, and the identification and prioritisation of measures to address significant risks;
- An action plan for measures to be taken forward.

SECTION 4

DATA COLLECTION

4 DATA COLLECTION

4.1 Overview

4.1.1 A considerable amount of information has been collated to inform the analysis (and delineation) of flood risk throughout the London Borough of Barking and Dagenham, including (but not limited to):

- Historical river flooding information;
- Information relating to localised flooding issues (surface water, groundwater and/or sewer related), collated in consultation with the Council, Environment Agency and Thames Water;
- Locality and condition of raised flood defences;
- Environment Agency Flood Maps;
- Detailed hydraulic modelling studies for the Lower Roding, Beam, Ingerbourne and Mayes Brook, and Thames Breach Modelling;
- Surface Water Management Plan (SWMP);
- Preliminary Flood Risk Assessment (PFRA); and
- Topography (LiDAR).

4.1.2 This data has been sourced from key stakeholders, as highlighted below. The interpretation of this data to inform the delineation of zones of 'high', 'medium' and 'low' probability of flooding, in accordance with NPPF, is explained in Section 5. The findings of this interpretation are outlined in Section 6.

4.2 Consultation

4.2.1 Consultation has formed a key part of the data collation phase for the Barking and Dagenham SFRA. The following key stakeholders have been comprehensively consulted to inform the current investigation:

<u>London Borough of Barking and Dagenham</u>

4.2.2 Consultation has been undertaken with a number of departments within the London Borough of Barking and Dagenham to understand the Council's approach to flood risk management and aspirations for future development. This has included:

- Development planning officers to discuss the formulation of the updated Local Plan, development control priorities for all proposed development within the Borough, and the key regeneration sites that form the focus of the Level 2 SFRA;
- Flood risk and asset management officers to discuss historic flood events, known flooding hot spots, recent flood improvement and alleviation works, and proposed or planned flood improvement and alleviation works;

- Emergency planning and response officers to discuss existing plans and protocols before, during and after a flood event, as well as to understand recommendations and requirements for new development.

Environment Agency

4.2.3 Consultation has been undertaken with the Environment Agency primarily to:

- Obtain the most up-to-date available flood risk modelling and mapping;
- Discuss the findings of flood and breach modelling studies;
- Discuss historic flood events and known flooding hot spots;
- Obtain information regarding the location, nature and standard of protection of existing flood defence infrastructure;
- Discuss recent flood improvement and alleviation works, and proposed or planned flood improvement and alleviation works;
- Obtain other data sources required to inform this SFRA, such as the Thames CFMP and TE2100 technical reports.

4.2.4 In addition, the Environment Agency is a statutory consultee under NPPF and therefore must be satisfied with the findings and recommendations for sustainable flood risk management into the future. The Environment Agency has therefore been consulted during the development of the SFRA to review and comment on the findings of the SFRA, discuss potential flood risk mitigation and management measures, and provide comment on the Council's subsequent development control and planning recommendations.

Thames Water

4.2.5 Thames Water is the incumbent sewerage provider for the area of Barking and Dagenham with responsibility for the management of urban drainage (surface water) and sewerage within the Borough. Thames Water was consulted to discuss the risk of localised flooding associated with the existing drainage/sewer system and provided records from the DG5 flood register for the past 10 years.

4.3 Environment Agency Flood Maps

4.3.1 The Environment Agency Flood Maps provide a comprehensive overview of flood risks from fluvial, tidal, surface water and reservoir sources, which are updated regularly following periodic review and/or following changes to flood management infrastructure.

Fluvial and tidal flood risk

4.3.2 The Environment Agency's Flood Map for Planning (Rivers and Sea) shows the natural floodplain, ignoring the presence of defences and, therefore, areas potentially at risk of flooding from rivers or the sea.

4.3.3 The Flood Map for Planning is principally used to inform land use planning and defines Flood Zones that align with the terminology of NPPF to indicate the predicted annual

probability of flooding from fluvial and tidal sources. In summary, all land within England is indicated to fall within one of the following Flood Zones:

- Flood Zone 1 (low probability) - less than 1 in 1000 (0.1%) annual probability of flooding from fluvial or tidal sources.
- Flood Zone 2 (medium probability) - between 1 in 100 (1%) and 1 in 1000 (0.1%) annual probability of flooding from fluvial sources, or between 1 in 200 (0.5%) and 1 in 1000 (0.1%) annual probability of flooding from tidal sources.
- Flood Zone 3 (high probability) - greater than 1 in 100 (1%) annual probability of flooding from fluvial sources, or greater than 1 in 200 (0.5%) annual probability of flooding from tidal sources.

4.3.4 The Flood Zones have been produced from a combination of a national generalised computer model, more detailed local modelling (if available), and some historic flood event outlines (only in Flood Zone 2). Within the tidal reaches of the River Thames (including the London Borough of Barking and Dagenham) the flood map has been developed on the basis of detailed two dimensional modelling (as discussed in Section 4.5).

4.3.5 The Environment Agency's Risk of Flooding from Rivers and the Sea map illustrates similar extents of fluvial and tidal flooding to that illustrated within the Environment Agency's Flood Map for Planning (Rivers and Sea), but delineates the likelihood of flooding from rivers and the sea whilst considering the presence and effect of all flood defences and predicted flood levels. It describes the probability of flooding in accordance with one of four categories:

- High - greater than 1 in 30 (3.3%) annual probability of flooding from fluvial or tidal sources.
- Medium - less than 1 in 30 (3.3%) but greater than 1 in 100 (1%) annual probability of flooding from fluvial or tidal sources.
- Low - less than 1 in 100 (1%) but greater than 1 in 1000 (0.1%) annual probability of flooding from fluvial or tidal sources.
- Very Low - less than 1 in 1000 (0.1%) annual probability of flooding from fluvial or tidal sources.

4.3.6 It is important that users of these resources do not confuse the description of risk within the Environment Agency's Risk of Flooding from Rivers and the Sea map with the mapped zones as provided within the Environment Agency's Flood Map for Planning (Rivers and Sea).

4.3.7 Many smaller watercourses are not illustrated within the Flood Map for Planning (Rivers and Sea) or the Risk of Flooding from Rivers and the Sea map, usually due to the size of the watercourse catchment (catchments with a size of less than 3km^2 are unlikely to be included). Flooding from smaller watercourses not included on the Flood Map for Planning or the Risk of Flooding from Rivers and the Sea map is likely to be best represented by the Environment Agency's Risk of Flooding from Surface Water map as discussed overleaf.

4.3.8 The Environment Agency's knowledge of the floodplain is continuously being improved by a variety of studies, detailed models, data from river flow and level monitoring

stations, and actual flooding information. They have an on-going programme of improvement, and updates are made on a quarterly basis where more accurate information is available.

Flood Warning

4.3.9 The Environment Agency's Flood Warning map indicates those areas that benefit from the Environment Agency's flood warning schemes. The schemes have been set up for a number of areas that are considered to be at particular risk from flooding. These areas are called Flood Warning Areas. Within these areas, the Environment Agency can warn residents in advance that flooding may be likely and of how severe the flooding could be.

Surface Water Flood Risk

4.3.10 The Environment Agency's Risk of Flooding from Surface Water map shows the approximate areas that would flood as a result of rainfall being unable to soak into the ground or enter a drainage system, leading to overland flow. As with the Environment Agency's Risk of Flooding from Rivers and the Sea map, the probability of flooding from surface water is defined as being high, medium, low or very low.

4.3.11 The surface water maps have been produced by the Environment Agency using a combination of a national generalised computer model, and improved using information from the LLFAs where it is available. As such depending on the location the modelling may not accurately represent all flow paths (for example pipe drainage systems or small culverts on watercourses may not be included). The purpose of the map is to highlight those areas potentially at risk of flooding. Where flooding is shown, this should prompt further consideration of the actual risk. Further discussion of the limitations of this data is provided in Section 5.3. Periodic updates of the maps are issued as more accurate information becomes available.

4.3.12 The surface water maps also provide a good indication of fluvial flood risk associated with smaller watercourses not included in the Environment Agency's Flood Map for Planning (Rivers and Sea) or the Environment Agency's Risk of Flooding from Rivers and the Sea map.

Reservoir Flood Risk

4.3.13 The Environment Agency's Risk of Flooding from Reservoirs map shows the likely extent of flooding in the event of reservoir failure. Although the likelihood of such an occurrence is low, as all large reservoirs are stringently governed under the Reservoirs Act 1975, a large volume of water could escape with little or no warning if a failure were to occur. As such, following a recommendation in the Pitt Review, the Environment Agency completed a programme of breach assessments to ascertain the areas at potential risk.

4.4 Surface Water Management Plan

4.4.1 The Barking and Dagenham Surface Water Management Plan (SWMP) was completed in 2011 as part of the Drain London Project. The project sought to gain an understanding of the causes and effects of surface water flooding within the Borough, and derive a method of managing the identified risk for the long term.

4.4.2 In order to assess the risk of flooding 2D pluvial modelling was completed. The output from the model was then used to subdivide the Borough into critical drainage areas

runoff catchment areas, and Local Flood Risk Zones (LFRZs) flooding hotspots which in turn were used to define 'Policy Areas' reflecting strategic issues and recommendations. It should be noted that the critical drainage areas as defined in the SWMP are different to those defined by the Environment Agency; there are no Environment Agency designated Critical Drainage Areas in the Borough.

4.4.3 In addition to the surface water mapping, an increased Potential for Elevated Groundwater map (iPEG) was developed. The purpose of this mapping was that it would be used in conjunction with the surface water maps to identify where groundwater may emerge and, if so, the flow route the water may take.

4.5 Historical Flooding

4.5.1 Details of historic flooding have been obtained through a review of previous flood risk assessment documents prepared by or on behalf of LBBD that summarise flood risk from all sources of flooding; and new data provided by LBBD, the Environment Agency and Thames Water for the production of this SFRA. This study has been informed through direct consultation with key staff at LBBD that may build on information that was provided in previous reports.

4.6 Detailed Hydraulic Modelling

4.6.1 Breach analysis considering the impact of a sudden failure of the River Thames defences was published by the Environment Agency in 2017[8]. This model supersedes the modelling undertaken as part of the previous Barking and Dagenham SFRA (2008). The Environment Agency modelling (2017) also considers breaches of the western embankment of the River Roding, but not breaches of the eastern embankment. The most up to date data for breaches of the eastern embankment comes from the modelling undertaken as part of the previous Barking and Dagenham SFRA (2008) and should still be used in the assessment of flood risk in this area until such a time as more up-to-date modelling data is available.

4.6.2 Detailed modelling studies have been conducted on some of the watercourses in Barking and Dagenham on behalf of the Environment Agency. The Lower Roding Flood Risk Mapping, undertaken by Capita Symonds in 2009, and the Beam, Ingrebourne and Mayes Brook Flood Mapping Study, undertaken by Halcrow in 2013, have provided detailed fluvial flood extents for some of the watercourses in Barking and Dagenham. In addition, the Environment Agency TE2100 project has investigated the risks of flooding associated with the River Thames at a more detailed level to inform the flood risk management strategy for the area up to the year 2100.

4.6.3 The Mayes Brook model was re-run as part of this update to the SFRA to inform the mapped extents of Flood Zone 2 and 3a and 3b with updated climate change recommendations as published by the Environment Agency in February 2016. The model hydrology was amended to reflect changes in peak flow rates of 25%, 35% and 70% to reflect the Central, Upper Central and Upper End allowances for the 2070 to 2115 epoch respectively. Similar updates were also undertaken for the Beam River, Wantz Stream and Gores Brook by Jacobs on behalf of the London Borough of Havering. The Environment Agency are due to update their hydraulic model of the Lower Roding and Loxford Water in December 2017 and, as such, updated modelling of these watercourses has not been undertaken at this time.

[8] Note that this SFRA is informed by hydraulic modelling completed by the EA in 2015. Correspondence received from the EA in 2017 confirmed that their latest Thames breach modelling was published in June 2017 and that this incorporated the 2015 data which remains the same for Barking and Dagenham.

4.6.4 A MIKE 11 model was created for the Buzzard Mouth Creek watercourse in 2004 to support the planning application for the Barking Riverside development. It is likely that after this period of time that the model would not be suitable for use in future development planning.

4.6.5 It should be noted that the detailed hydraulic models developed on behalf of the Environment Agency assume 'typical' conditions within the respective river systems that are being analysed. The predicted water levels may change if the operating regimes of the rivers involved are altered (e.g. engineering works which may be implemented in the future), if culverts become blocked, or if the condition of the river channel is allowed to deteriorate.

4.6.6 Furthermore, an assessment is being completed by Mott MacDonald on behalf of the GLA in support of the Beam Park development. The Environment Agency has indicated that the storage volume of the Washlands area within their model is currently being under represented, and therefore the new assessment may indicate a smaller flood extent in the region. It is recommended that once complete this information is used to inform the risk of flooding from the Beam River for development within that area.

4.7 Flood Defences

4.7.1 Flood defences are typically raised structures that alter natural flow patterns and prevent floodwater from entering property in times of flooding, but can also be other measures such as flood storage areas and mechanical pumps. They are generally categorised as either 'formal' or 'informal' defences. A 'formal' flood defence is a structure that was built specifically for the purpose of flood defence and is maintained by its respective owner, which could be the Environment Agency, Local Authority or an individual. An 'informal' flood defence is a structure that has not been specifically built to retain floodwater and is not maintained for this specific purpose, but may afford some protection against flooding. These can include boundary walls, industrial buildings, railway embankments and road embankments situated immediately adjacent to rivers.

4.7.2 Plate 4.1 shows a typical tidal defence on Barking and Dagenham's River Thames frontage. It shows steel sheet piling with a sloped rock revetment.

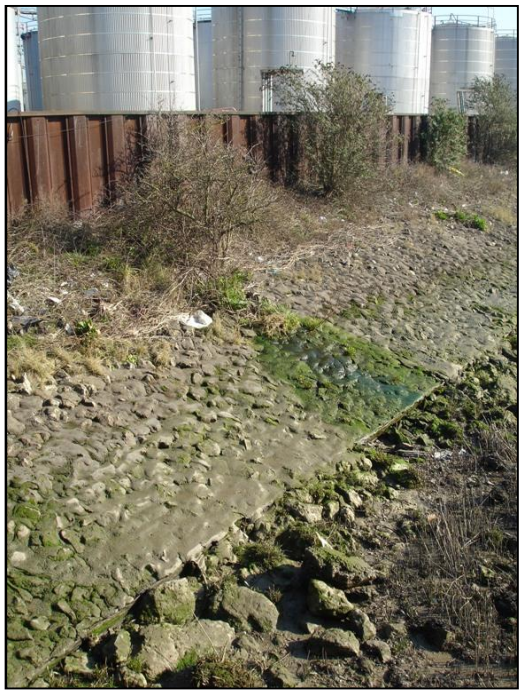

Plate 4.1: Typical Thames Tidal Defence in Barking and Dagenham

4.7.3 Formal defences are also present on the larger rivers and tributaries of the River Thames, such as the Barking Barrier on the River Roding and the defences and washlands that exist on the Beam River upstream of its confluence with the Thames. A map of defences, structures and flood storage areas can be seen in Appendix C. Improvements to the defences along the River Roding were made in 2011 and the flood storage at the Washlands was also increased by 25,000m^3 to 475,000m^3 in that year.

4.7.4 Information pertaining to the flood defences within the Borough was provided by the Environment Agency, extracted from the National Flood and Coastal Defence Database (NFCDD). This information includes details of the location, type and standard of protection (SoP) afforded by the flood defences within the Borough and against what type of event (tidal or fluvial) the defences provide protection. This information has been taken into account during the assessment of flood risk within the SFRA as discussed in Section 6.

4.7.5 Further information has been provided by the Environment Agency regarding the condition of flood defences as inspected in 2015-2016. The information provided grades flood defence assets from one to five, with one being 'Very Good' and five being 'Very Poor'. Generally the flood defence assets protecting Barking and Dagenham are in good condition; of the 120 flood defence assets surveyed, 105 were classified as being 'Good' or 'Very Good'.

4.7.6 During the most recent inspections undertaken by the Environment Agency in 2015-2016, three of the surveyed flood defence assets were graded as 'Poor' (described as having 'defects that would significantly reduce the performance of the asset') and one of the surveyed flood defence assets was graded as 'Very Poor' (described as having 'severe defects resulting in complete performance failure').

4.7.7 Two of the 'Poor' assets are located opposite each other on either side of the River Roding approximately 6.5km upstream from the confluence with the Thames

(Environment Agency asset numbers 8742 and 15371). The other 'Poor' asset is located on the River Thames at the confluence with the River Beam (Environment Agency asset number 7391).

4.7.8 The asset classified as 'Very Poor' is located on the River Thames, 2.2km downstream of the confluence with the River Roding (Environment Agency asset number 14860). The condition of flood defence assets should be considered by those bringing sites forward for development during the site selection, masterplanning, detailed design and (where necessary) emergency planning stages, with the most up to date information to be requested from the Environment Agency at the time of the assessment.

4.7.9 The railway lines in the Borough may act as informal raised flood defences altering the risk of flooding from what would naturally occur if they were not present. It is important to recognise that local roads and/or rail lines that have been constructed on raised embankments may alter overland flow routes, and as such may have a localised effect upon the risk of flooding (in particular the railway line between Barking and Elm Park Stations). Informal flood defences should be carefully reviewed in a local context as part of a detailed site based flood risk assessment.

4.8 Topography and Geology

4.8.1 Detailed topographic information has been provided by the Environment Agency for the Borough in the form of LiDAR. LiDAR enables the development of a detailed Digital Elevation Model (DEM) that provides a three dimensional representation of the Borough.

4.8.2 Geological information has been retrieved from the British Geological Society (BGS), providing an overview of soils and substrate.

SECTION 5

DATA INTERPRETATION

5 DATA INTERPRETATION

5.1 Introduction

5.1.1 The data captured from key sources to inform the development of the Barking and Dagenham SFRA is outlined in Section 4. This section provides an overview of how this data was interpreted to meet the requirements of NPPF and the supporting Planning Practice Guidance. The findings of these analyses are presented in Section 6.

5.2 Delineation of the NPPF Flood Zones (Fluvial and Tidal Flooding)

5.2.1 To inform the planning process, it is necessary to review flood risk across the Borough, categorising the area in terms of the likelihood (or probability) that flooding will occur.

5.2.2 The definitions of these flood zones are summarised in Section 4.3 with further details of each category provided below. Specifically, the zones discussed below relate to those illustrated within the Environment Agency's Flood Map for Planning (Rivers and Sea) as these align with the requirements of NPPF.

Delineation of Flood Zone 3b Functional Floodplain

5.2.3 Flood Zone 3b Functional Floodplain is defined as those areas in which *"*water has to flow or be stored in times of flood*"*. Areas subject to flooding in the 1 in 20 (5%) or greater annual probability event or areas designed to flood in an extreme 1 in 1000 (0.1%) annual probability event have been delineated as Flood Zone 3b Functional Floodplain.

5.2.4 The NPPF Planning Practice Guidance highlights the importance of considering existing land use when delineating areas that are to be treated as 'functional floodplain' for planning purposes. The Guidance states "areas which would naturally flood, but which are prevented from doing so by existing defences and infrastructure or solid buildings, will not normally be identified as functional floodplain."

5.2.5 Within Barking and Dagenham, the majority of rivers have been subject to detailed hydraulic modelling and areas identified as Functional Floodplain are indicated to generally be restricted to the river channel or areas between the river channel and the flood defences, as shown on the flood risk mapping in Appendix D. Rivers within Barking and Dagenham are generally very well defended as discussed in Section 6. The detailed modelling outputs developed by the Environment Agency, where available (refer Section 4.5), have been adopted for the delineation of Flood Zone 3b Functional Floodplain within the Borough of Barking and Dagenham.

5.2.6 There are a number of minor watercourses and drainage ditches, particularly in the southern areas of the Borough, that have not been subject to detailed hydraulic modelling. These watercourses have a very small catchment and are unlikely to have a notable fluvial flood risk associated with them. It is recommended that consideration is given to the Environment Agency's Risk of Flooding from Surface Water map to understand the likely flood risk associated with these features.

Delineation of Flood Zone 3a High Probability

5.2.7 Flood Zone 3a High Probability is defined as those areas of the Borough that are situated within the 1 in 100 (1%) fluvial or 1 in 200 (0.5%) tidal (whichever is greater) annual probability flood extent.

5.2.8 Detailed modelling for both defended and undefended scenarios are available for the Beam River and Ingrebourne Marshes and Lower Roding River (refer Section 4.6). For the defended scenarios, the presence of flood defences has been taken into account within the analysis of flood risk. For the undefended scenario, the presence of flood defences has not been taken into account within the analysis of flood risk and therefore this represents a more 'natural' floodplain should the defences not be present. Areas that are protected by flood defences are therefore illustrated as those areas 'between' the defended and undefended flood zones.

5.2.9 The outlines from the undefended scenario were used to create the Environment Agency's Flood Map for Planning. The predicted flood extent for the undefended scenario is used as the primary means of assessing flood risk to any proposed development and therefore forms the mapped Flood Zone 3a extents. However, as part of detailed assessment of flood risk to proposed development, consideration can be given to the presence of flood defences and an assessment of residual flood risk can be made taking into account potential flood defence failure and/or lack of investment in future years.

5.2.10 The mapped Flood Zone 3a High Probability within the southern part of Barking and Dagenham (that is defended against flooding from the River Thames) has been sub-delineated into zones of 'hazard' (reviewing the potential risk to life), considering the impact of a failure of the River Thames defences. This is discussed further in Section 5.4.

Delineation of Flood Zone 2 Medium Probability

5.2.11 Flood Zone 2 Medium Probability is defined as those areas of the Borough that have between a 1 in 100 (1%) and a 1 in 1000 (0.1%) annual probability of fluvial flooding, or between a 1 in 200 (0.5%) and a 1 in 1000 (0.1%) annual probability of tidal flooding. In this instance, Flood Zone 2 Medium Probability is defined in accordance with the Environment Agency's Flood Map for Planning (Rivers and Sea), which shows undefended flood extents that are also combined with historic flood extents.

Delineation of Flood Zone 1 Low Probability

5.2.12 Flood Zone 1 Low Probability is defined as those areas of the Borough that are situated above (or outside of) the 1 in 1000 (0.1%) annual probability flood extent. This incorporates all land that is outside of the identified Flood Zone 2 and Flood Zone 3 (a and b) flood risk areas as defined above.

5.3 Localised Flooding Issues

5.3.1 The risk of flooding from other (non-fluvial or tidal related) sources is an important consideration in the planning of new development. This can include flooding associated with surface water runoff, groundwater emergence, surcharging of the below ground sewerage network, and risks associated with the failure of reservoirs and other manmade structures. It can also include flooding associated with minor watercourses and drainage ditches that are not considered within the analysis of fluvial and tidal flood extents due to the size of catchment that they drain.

Surface Water

5.3.2 Given the heavily urbanised character of much of the Borough, it is inevitable that localised flooding problems arising from under capacity drainage and/or sewer systems will occur, particularly given the mounting pressure placed upon ageing systems as a

result of climate change. Furthermore, gullies are generally designed for the 1 in 5 annual probability event, sewer systems are generally designed to cater for the 1 in 30 annual probability event, and highway soakaways are generally designed for only the 1 in 10 annual probability event. Storms over and above these design events will exceed the drainage system, resulting in overland flow, often in an uncontrolled manner resulting in localised flooding. Information on reported incidents over the last ten years has been provided by Thames Water to try and identify known and/or perceived problem areas relating to the sewer system, however the information provided is very general (see Appendix H).

5.3.3 The Environment Agency's Risk of Flooding from Surface Water map provides information relating to flood depth, flood hazard and the main flow paths through the Borough, and has been used to identify the main areas in which surface water flooding may be a problem.

5.3.4 With the Risk of Flooding from Surface Water map, the Environment Agency provides a suitability classification that gives an indication of the scale at which the data is applicable. The majority of the Borough, from approximately south of the A1083 Green Lane, is classified as "County to Town", which indicates that the information in this area is suitable for identifying areas at risk of flooding and approximate flood extents, but is unlikely to be reliable for local or property level assessments. The majority of the area to the north of the A1083 Green Lane is classified as "National to County" which is a more broad scale assessment and therefore can be used to identify vulnerable areas, but the predicted extents may be less reliable.

5.3.5 The surface water flood map describes the probability of flooding in accordance with one of four categories:

- High - greater than 1 in 30 (3.3%) annual probability of flooding.
- Medium - less than 1 in 30 (3.3%) but greater than 1 in 100 (1%) annual probability of flooding.
- Low - less than 1 in 100 (1%) but greater than 1 in 1000 (0.1%) annual probability of flooding.
- Very Low - less than 1 in 1000 (0.1%) annual probability of flooding.

5.3.6 These maps highlight where surface water is likely to flow overland to local depressions in topography and, whilst the flow paths are of importance, it is often the final resting place that is at greatest flood risk.

5.3.7 Further information relating to surface water flooding is provided in the Barking and Dagenham Surface Water Management Plan (SWMP) which identifies the critical locations within the Borough at risk from surface water flooding. The Environment Agency's Risk of Flooding from Surface Water map is currently deemed the best available information; however a comparison between the two datasets indicates that they are in close agreement and therefore the Local Flood Risk Zones (LFRZs), or flooding hotspots, identified within the SWMP have been used to identify specific areas at significant risk. The delineation of the LFRZs was based the 1 in 100 (1%) annual probability rainfall event modelled flood extents.

5.3.8 A number of the LFRZ areas are located within Flood Zones 2 and 3 and therefore a detailed flood risk assessment will be required for any potential new development at these locations to address the risk from fluvial and tidal flooding. However at some

locations, due to the presence of flood defences, the risk from surface water may be more significant. Therefore in completing the flood risk assessment the potential risk of surface water flooding should be fully addressed.

Groundwater

5.3.9 The local geology provides an indication of the likely susceptibility (or otherwise) to groundwater emergence. Areas of highly permeable gravel geology situated near a river may be more likely to experience groundwater emergence that could lead to groundwater flooding as the local water table rises following a rainfall event.

5.3.10 Where the Borough of Barking and Dagenham overlays London Clay the risk of groundwater emergence will typically be low. However, where alluvial drift deposits, such as gravels, sit over the impermeable clay geology a perched water table can occur. This can lead to groundwater emergence.

5.3.11 Areas characterised by alluvium and river terrace deposits can also be at risk of groundwater emergence. There is evidence within adjoining Boroughs of groundwater emergence occurring some distance from the Thames and its tributaries as a result of water finding a pathway through the gravels when river levels are high. A large proportion of the River Thames corridor is characterised by gravely soils referred to as 'Thames Gravels' and there are large swathes of gravel deposits throughout Barking and Dagenham. As water levels within the river rise, the water table rises within the gravel layer, resulting in groundwater flooding within overbank areas. Also, in other parts of London, areas characterised by these gravel deposits have been noted for their shallow groundwater table and perched groundwater tables. These areas respond rapidly to rainfall and can cause minor groundwater emergence.

5.3.12 The iPEG maps produced as part of the SWMP provide information relating to areas at risk of ground water emergence. The map was produced using four data sources: the Groundwater Flood Susceptibility Map (British Geological Society), Groundwater Emergence Maps (Defra), Groundwater Flood Map (JBA consulting) and the Areas Susceptible to Groundwater Flooding dataset (Environment Agency). The iPEG maps shows the areas within the Borough where there is an increase potential for groundwater to rise sufficiently to interact with the ground surface or to within 2m of the ground surface. Properties within these areas could be expected to experience anything from groundwater emergence into cellars and underground services to surface water flooding and incursion into properties.

5.3.13 It should be recognised that although the iPEG map may provide an indication of where ground water may emerge, once at the surface the resultant flow is likely to follow the topography. It is therefore not necessarily those areas susceptible to groundwater emergence that are at risk, but the areas that are located downhill of those areas susceptible to groundwater emergence. It is the intention of the SWMP that these maps are reviewed alongside the surface water maps in order to identify areas that may be at risk.

5.3.14 The risk of groundwater flooding is highly variable and heavily dependent upon local conditions at any particular time and, therefore, it is not possible to sensibly develop a strategic map of 'groundwater risk' as part of the SFRA process. However during the completion of any detailed flood risk assessment it is recommended that the iPEG maps are referenced to identify areas that may be at an increased risk.

Ordinary Watercourses

5.3.15 The potential localised flooding issues associated with the surcharging of the many smaller watercourses and drainage ditches located within Barking and Dagenham (particularly in the land to the south of the A13) are not illustrated within the Environment Agency's Flood Map for Planning (Rivers and Sea) and are therefore not categorised into one of the fluvial and tidal flood zones. This is usually due to the size of the watercourse/drainage ditch catchment as catchments with a size of less than $3km^2$ are unlikely to have been modelled. The assessment of the risk of flooding from these features will need to be undertaken on a site-by-site basis and is likely to comprise a predominantly qualitative analysis of likely risk, often associated with the blockage of channels and culverts within close proximity of the proposed scheme area. The Environment Agency's Risk of Flooding from Surface Water map, as discussed above, is likely to provide a good estimation of likely flow routes and potential flood extents that can be taken into consideration during development control and developing planning. However, consultation should be undertaken with the Council and, where necessary, the Environment Agency to determine the need for quantitative analysis of minor watercourses in areas that are deemed to be at significant risk.

Reservoirs

5.3.16 The Environment Agency's Risk of Flooding from Reservoirs map shows the likely extent of flooding in the event of reservoir failure. The key purpose of these maps is to highlight those areas where developers and the public need to be aware of the potential risks should a breach of a reservoir occur and therefore the actions that should be taken. The maps provide information of the extent, depth and velocity of flow that in turn can inform an assessment of hazard.

Surcharging of Sewerage Systems

5.3.17 Flood risks associated with the potential surcharging of the sewerage network is extremely hard to predict and there are currently no datasets available that provide an indication of areas that may be at risk of flooding from the sewerage network. Thames Water provided records from their DG5 flood register for the past 10 years that indicates the number of flooding issues that have been recorded within postcode areas. The register therefore provides an indication of historic flood events and, subsequently, an indication of where flooding may reoccur – but this data is not detailed enough to inform a site-specific flood risk assessment and therefore inform site-specific flood resistance and resilience measures. Instead, it is recommended that consideration is given to the Environment Agency's Risk of Flooding from Surface Water map, as discussed above, as this will provide an indication of likely flow routes should surcharging of the sewerage system occur.

5.4 Assessment of Flood Risk (Flood Hazard)

5.4.1 The assessment of flood risk has thus far considered the likelihood of flooding within the Borough. Of equal importance, however, is the potential impact (or consequence*)* that flooding could have within the Borough. For example, will the flooding simply result in shallow ponding for a short period of time, causing a temporary disruption to traffic? Or will deep fast flowing floodwaters inundate areas of the Borough without warning, posing an immediate and very real risk to life?

5.4.2 Research has been carried out into the risk posed to pedestrians during flash flooding[9,10]. This research has concluded that the likelihood of a person being knocked over by floodwaters is related directly to the depth of flow, and the speed with which the water is flowing. This is referred to as 'Flood Hazard'.

5.4.3 For example, if a flood flow is relatively deep but is low energy (i.e. slow moving), then an average adult will be able to remain standing. Similarly, if the flow of water is moving rapidly but is very shallow, then once again an average adult should not be put off balance. If, however, the flow is both relatively deep and fast flowing, then a person will be washed off their feet, placing them at considerable risk. The safety risk associated with submerged hazards, such as an exposed drain, during flooding conditions (given the often murky nature of floodwaters) is also a consideration.

5.4.4 The Defra and Environment Agency document entitled 'Flood Risk to People' (FD2320) provides guidance to aid in the review of flood hazard within the UK. In order to assess the hazard associated with flooding, a Flood Hazard Rating can be calculated which is a function of the flood depth and flow velocity. The Flood Hazard Ratings are categorised within different levels of risk as follows:

- Very Low Hazard – Caution
- Moderate – Dangerous for some (includes children, the elderly and the infirm)
- High – Danger for most (includes the general public)
- Very High – Danger for all (includes the emergency services)

5.4.5 The risk to life (as a result of flooding) within the Borough of Barking and Dagenham has been assessed accordingly to inform the allocation of land within the Borough for future development. A brief summary of the findings is presented below:

Flood Hazard due to Flood Defence Failure

5.4.6 Flood defences are typically raised structures that alter natural flow patterns and divert floodwater away from areas of habitation in times of flooding. Raised defences exist along the Thames frontage, the Barking Creek and the River Roding, providing protection against tidal and fluvial flooding (discussed in greater detail in Section 6).

5.4.7 A failure of a raised flood defence could result in rapid inundation into the Borough, posing a potential risk to residents, pedestrians and property that may be in the path of the floodwaters. Deep, fast flowing water may threaten life, and this must be considered when planning future development. The accumulation of standing water as a result of breaching or overtopping also needs consideration. This can lead to flood risks associated with:

- safe access and egress to properties through flood water;
- interference with essential services and infrastructure; and/or

[9] Flood Risk Assessment Guidance for New Development (R&D Technical Report FD2320) Udale, Clarke, dyer, Scott - October 2005

[10] Flood Risks to People (R&D Technical Report FD2321/TR1 & TR2) Environment Agency and Ramsbottom et al., 2006

- the sudden inundation of basement dwellings.

5.4.8 The Environment Agency has undertaken hydraulic modelling to consider the velocity, depth and path of flood water should a failure of the Thames Tidal Defence occur. The time within which flood water can inundate the Borough following a breach failure is also a key consideration of the breach modelling. This model largely supersedes the modelling undertaken as part of the previous Barking and Dagenham SFRA (2008) and is included in Appendix G.

5.4.9 The Environment Agency modelling (2017) also considers breaches of the western embankment of the River Roding, but not breaches of the eastern embankment. The most up to date data for breaches of the eastern embankment comes from the modelling undertaken as part of the previous Barking and Dagenham SFRA (2008) and should still be used in the assessment of flood risk in this area until such a time that more up-to-date modelling data is available.

5.4.10 The use of this information in planning terms is outlined below.

River Thames, River Roding and Barking Creek

5.4.11 The southern part of the London Borough of Barking and Dagenham is situated within Zone 3a High Probability, which is currently defended against flooding from the River Thames. There remains a residual risk of failure of these defences and, therefore, it is essential that planning decisions are taken with due consideration to the scale (and variability) of this risk.

5.4.12 Raised defences are also present along the River Roding and Barking Creek. Breach modelling of these defences was carried out as part of the Environment Agency's Tidal Breach Modelling Study (2017) and the Barking and Dagenham SFRA Level 1 (2008). Two particular 'measures' of flood risk have been adopted to underpin the development of spatial planning and development control recommendations for the Borough.

5.4.13 The first is flood hazard, considering the potential risk to life should a failure of the flood defences occur as outlined above. The second is rate of inundation, considering the time available to warn residents and business owners of a pending flood following a failure of the River Thames defences and to allow them to react to the warning.

5.4.14 These have typically been delineated to show the predicted extent of flooding at 5, 10 15 and 20 hours after a failure has occurred. Mapping for breaches of the western embankment of the River Rodding show the predicted extent of flooding at 4, 8, 12, 16 and 20 hours after a failure has occurred.

The Beam River and Tributaries

5.4.15 Due to their type and size, the raised defences along the above-named watercourses are deemed unlikely to collapse in a catastrophic manner that would result in a sudden wave that may wash pedestrians off their feet. However any proposed development within close proximity of the defences must consider the potential risk of breach failure and/or overtopping within a localised context as an integral part of a site-specific flood risk assessment.

Structural Integrity of Flood Defences

5.4.16 The structural integrity of the existing flood defences is integral to the sustainability of development. It is recognised however that this will vary with time and proximity to the

river frontage. Consequently it is essential that detailed site-specific flood risk assessments for all potential future development within defended areas of the Borough consider both the likelihood and consequence of defence failure near the proposed site.

Flood Hazard due to Reservoir (or Other Water Storage Facilities) Failure

5.4.17 Structures such as raised reservoirs or raised canals (i.e. structures designed to hold, or capable of holding, water above the surrounding ground levels) can pose a significant flood risk if they were to fail.

5.4.18 The Water Act (2003) amended the Reservoirs Act (1975), requiring the preparation of dedicated Flood Plans for large raised reservoirs, to be prepared by the asset owner. A large raised reservoir is defined in the Act as a structure 'designed to hold, or capable of holding, more than 25,000m^3 of water above that level (the natural level of any part of the land adjoining it)'.

5.4.19 As of 2009 dedicated Flood Plans are required for all large raised reservoirs that may pose a risk to the Borough. A Flood Plan is a set of documents that describe the arrangements to be put into operation in response to a sudden large release of water from a reservoir that could pose a threat to property and life downstream. They include an assessment of the impacts of dam failure, a review of the measures that can be taken by the reservoir operator to prevent the catastrophic failure and an assessment of the emergency response mechanism required to minimise risk to life and property should a failure occur.

5.4.20 Reservoirs must undergo regular inspections to the requirements of the Reservoirs Act by suitably qualified engineers. On this basis therefore, the probability of structural failure of these reservoirs is considered to be low.

5.4.21 For reservoirs below the threshold of 25,000 m^3 (small reservoirs) there are different regulations governing safety, although the Environment Agency considers them to be a significant risk since there is no regulation equivalent to that afforded by the Reservoir Act. Where there is a workplace at risk from flooding from such a dam, the Health and Safety Executive is responsible under Health and Safety at Work Act. Where people are at risk, the Local Authority has a duty under clause 77 of 1984 Building Regulations to serve the owners notice if a small reservoir is deemed unsafe.

5.4.22 The Environment Agency's Risk of Flooding from Reservoirs Map indicates the west of the Borough between the River Roding and the A406 is at risk of flooding from the Basin reservoir in Wanstead and the Perch Pond Reservoir in Wanstead Park. The east of the Borough, in the vicinity of Choats Manor Way and the railway line, is shown to be at risk of flooding from the Washlands Flood Storage Area.

5.4.23 No specific information relating to the Mayesbrook Park and the Beam Washlands water storage areas is currently available, however the potential risk of flooding as a result of structural failure is certainly considered to be much less than the indicative scenarios set out within NPPF (i.e. 1 in 100 likelihood of occurring in any one year). This should not unduly influence the spatial planning process. Notwithstanding this, it is recommended that the potential risk of reservoir failure is communicated to the Local Resilience Forum by the Council for inclusion on the Community Risk Register. This will ensure that future planning is put into place to enable an effective response in case of a possible emergency.

Flood Hazard due to Surface Water

5.4.24 Although the risk to life is likely to be at its highest in the event of a failure of a raised flood defence, reservoir or similar due to the nature of their sudden onset, the risk from surface water flows can also be significant, in particular with regards to access and egress routes around the Borough.

5.4.25 The Environment Agency's Risk of Flooding from Surface Water map provides information relating to flood depth, flow velocity and the main flow paths through the Borough. In addition the SWMP provides flood hazard mapping, undertaken as described above, that can be used to inform development planning and design.

5.5 Potential Impacts of Climate Change on Flood Risk

5.5.1 Scientific consensus is that the global climate is changing as a result of human activity. While there remain uncertainties in how a changing climate will affect areas already vulnerable to flooding, it is expected to increase risk significantly over time. For the UK, projections of future climate change indicate that more frequent short-duration high-intensity rainfall events and more frequent periods of long-duration rainfall could be expected.

5.5.2 In February 2016 the Environment Agency published updated climate change advice to be taken into account in site-specific and strategic flood risk assessments[11]. This provides recommended national precautionary sensitivity ranges for changes to peak rainfall intensities, river flows, sea level rise, offshore wind speed and extreme wave height resulting from climate change for the next 100 years.

5.5.3 All new developments in Barking and Dagenham must consider the potential impacts of climate change on flood risk in accordance with the Environment Agency recommendations and over the lifetime of the development. For design purposes, it is recommended that for residential development a minimum of 100 years is considered, and that for commercial and industrial development a minimum of 60 years in considered.

5.5.4 A summary of the latest guidance is provided below and should be considered when reviewing the potential risk of flooding in future years within Barking and Dagenham. Reference should be made to the www.gov.uk website to fully understand how this guidance is to be interpreted.

Table 5.1 Recommended sea level allowances for London (relative to 1990 baseline)

Year	1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115	Cumulative rise 1990 to 2115
Net Sea Level Rise	4.0 mm/yr	8.5 mm/yr	12.0 mm/yr	15.0 mm/yr	1.21 m

Table 5.2 Offshore wind speed and extreme wave height allowance (relative to 1990 baseline)

[11] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Year	1990 to 2055	2056 to 2115
Offshore wind speed allowance	+5%	+10%
Offshore wind speed sensitivity test	+10%	+10%
Extreme wave height allowance	+5%	+10%
Extreme wave height sensitivity test	+10%	+10%

5.5.5 Note that the assessment of climate change on wind speed and wave height requires consideration of the single allowance for each epoch for wind speed and wave height in Table 5.2, and consideration of the 10% sensitivity allowance to understand the range of impacts.

Table 5.3 Recommended peak rainfall intensity allowances in small and urban catchments (relative to 1961 to 1990 baseline)

Year / Allowance category	2015 to 2039	2040 to 2069	2070 to 2115
Upper End	+10%	+20%	+40%
Central	+5%	+10%	+20%

5.5.6 Within Barking and Dagenham, it is expected that all drainage systems are designed for the Central category but that the performance of the system is assessed for the Upper End category to understand and manage residual risks, i.e. through the retention of surface water within the development boundary.

Table 5.4 Peak river flow allowances by river basin district (relative to 1961 to 1990 baseline)

Year / Allowance category	2015 to 2039	2040 to 2069	2070 to 2115
Thames Upper End	+25%	+35%	+70%
Thames Higher Central	+15%	+25%	+35%
Thames Central	+10%	+15%	+25%

5.5.7 The selection of the most appropriate allowance category will be determined through consideration of the flood zone and vulnerability classification of the development.

Detailed guidance has been provided by the Environment Agency via the www.gov.uk website.

5.5.8 A summary of this guidance is provided in Table 5.5 to inform the minimum requirements for the design of flood risk mitigation for different vulnerability classifications. This is a guide only and consultation must be undertaken with the Environment Agency and Barking and Dagenham Council to agree the most appropriate approach on a case-by-case basis. The Council are also likely to require that the development is 'tested' against higher allowance categories to understand and manage residual risks.

Table 5.5 Indicative guide to allowance categories appropriate to development vulnerability classification

	Flood Zone 1	Flood Zone 2	Flood Zone 3a	Flood Zone 3b
Essential Infrastructure	Central	Upper End	Upper End	Upper End
Highly Vulnerable	Central	Higher Central	Upper End	Upper End
More Vulnerable	Central	Central	Higher Central	Upper End
Less Vulnerable	Central	Central	Central	Higher Central
Water Compatible	Central	Central	Central	Central

5.5.9 Development within areas identified to be at risk or in close proximity to the current mapped fluvial flood extent (including sites that are currently located in the low risk Flood Zone 1) will need to take the new climate change allowances into account. The level of assessment required to consider the new climate change allowances will be dependent on the location, vulnerability and scale of the proposed development, as well as the nature of flood risk, and should be agreed on a case-by-case basis with the Environment Agency and Council. An indication of the level of technical assessment that may be considered appropriate for different types of development is provided in Table 5.6.

Table 5.6 Indicative guide to assessment approach

	Development Size	Flood Zone 2	Flood Zone 3a	Flood Zone 3b
Essential Infrastructure	**All**	Detailed	Detailed	Detailed
Highly Vulnerable	**Major - Large**	Detailed	Not appropriate	Not appropriate
	Major - Small	Intermediate	Not appropriate	Not appropriate
	Minor	Intermediate	Not appropriate	Not appropriate
More Vulnerable	**Major - Large**	Intermediate	Detailed	Not appropriate
	Major - Small	Intermediate	Detailed	Not appropriate
	Minor	Intermediate	Intermediate	Not appropriate
Less Vulnerable	**Major - Large**	Intermediate	Detailed	Not appropriate
	Major - Small	Intermediate	Intermediate	Not appropriate
	Minor	Intermediate	Intermediate	Not appropriate
Water Compatible	**All**	None	Intermediate	Detailed

Minor: 1-9 dwellings; residential site area less than 0.5 ha; retail, office or industrial site area under 1ha; gypsy/traveller site between 0 and 9 pitches.

Major (Small): 10 to 30 dwellings; retail, office or industrial site area 1ha to 5ha; gypsy/traveller site 10 to 30 pitches.

Major (Large): 30+ dwellings; retail, office or industrial site area 5ha+; gypsy/traveller site over 30+ pitches; any other development that creates a non-residential building or development over 1000 square metres.

5.5.10 A 'detailed' assessment will require hydraulic modelling to be undertaken to inform the development and the design of appropriate mitigation. This can be achieved by re-running one of the existing Environment Agency models or constructing a new model for this purpose. Detailed hydraulic models are available for the majority of watercourses within Barking and Dagenham including the Lower Roding, Loxford Water, Mayes Brook, Gores Brook, Beam River and Wantz Stream. However it is ultimately the developer's responsibility to obtain and provide data that is considered appropriate to the size, nature and location of the development.

5.5.11 Where hydraulic modelling is not considered proportionate to the size and/or vulnerability of the development, an 'intermediate' approach to the assessment of the potential impacts of climate change may be adopted. The Environment Agency recommends that indicative flood levels can be generated by using existing modelled flood and flow data to construct a stage-discharge rating curve and, from this, interpolating a flood level based on the required peak flow allowance to apply to the 'design flood' flow.

5.5.12 Where no modelling data is available a qualitative approach to the assessment of the potential impact of climate change may be adopted where appropriate. This approach is also recommended for development in Flood Zone 1, particularly for understanding the likely future extents of Flood Zone 2 and 3 and, subsequently, the potential need to undertake a more detailed assessment as outlined above. This must be agreed on a case-by-case basis with the Environment Agency and Council, but in the absence of an agreed approach the following information can be used as a guide to better

understand the extent and depth of flooding, whilst also considering local topography at the development site against predicted future flood levels:

- Assume that the current extent of Flood Zone 2 provides an indication of the future extent of Flood Zone 3 for the purposes of applying a sequential approach to development and assessing the suitability of development within the mapped flood zones.
- Assume that the recommended increase in peak river flow as summarised in Table 5.4 equates to an approximate rise in flood level of 300mm for up to a 25% increase in river flow, 450mm for up to a 35% increase in river flow, and 900mm for up to a 70% increase in river flow.
- Assume that the recommended increase in sea level rise over the lifetime of the development would be added to the existing predicted tidal flood depth in the absence of modelled data.

5.5.13 The recommendations discussed above will also apply to flooding from smaller watercourses that may not be included on the Environment Agency's Flood Map for Planning (Rivers and Sea) or Environment Agency's Risk of Flooding from Rivers and the Sea map due to their smaller catchment size, but which may have an associated floodplain as indicated by the flood extents as shown in the Environment Agency's Risk of Flooding from Surface Water map and LBBD SWMP. In this instance, the recommendations discussed in the paragraph above are considered applicable.

5.6 Climate Change within Existing Models

5.6.1 As discussed in Section 4.6, fluvial modelling of the Mayes Brook, Gores Brook, Beam River and Wantz Stream has been undertaken to include updated climate change allowances for changes in peak flow rates of 25%, 35% and 70% to reflect the Central, Upper Central and Upper End allowances for the 2070 to 2115 epoch respectively. The mapped outputs for these events are provided in Figures D3 and D4 in Appendix D.

5.6.2 Fluvial flooding of land within the south of the Borough, notably to the south of the A13, is dominated by the Lower Roding, particularly in the south-west in the vicinity of the lower reaches of the Mayes Brook. Modelling of the updated climate change extents has not been undertaken for the Lower Roding in this area but updated modelling of the Lower Roding and Loxford Water is, however, expected to be published by the Environment Agency in December 2017. If modelling of these or other watercourses is deemed required to inform the design of appropriate mitigation, it will be the responsibility of the developer to provide this.

5.6.3 The potential increase in sea level rise, offshore wind speed and extreme wave height is the same as that previously promoted by PPS25 and, later, the NPPF Planning Practice Guidance and is therefore likely to have little impact on previous mapped tidal flood extents, including breach mapping that include the potential effects of climate change.

5.6.4 The SWMP considered the impact of climate change on the predicted flood extents and depth of surface water flooding during the 1 in 100 (1%) annual probability event. This is presented in the mapped outputs of the SWMP and is considered most applicable to assessing the potential impacts of climate change on overland flow that is not associated with the potential fluvial extents of an unmapped watercourse. To consider the potential effects of climate change on smaller rainfall events, an alternative approach could be to adopt a method similar to that proposed for fluvial and tidal flood

risks; namely to assume that the existing 1 in 100 (1%) annual probability event will provide an approximation of the future 1 in 30 (3.3%) annual probability event.

5.7 Topography and Geology

Topography

5.7.2 The London Borough of Barking and Dagenham is largely flat with no rapid changes in slope. The lowest areas are those towards the River Thames, which are at 2m AOD (approx.) with some areas, such as Creekmouth, as low as 1m AOD. Away from these low-lying areas, towards Barking and north of the A13 and A1306, the ground rises gently and elevations increase to over 10m AOD. There are, however, low lying 'valleys' within this slightly higher land where flood water from the Thames can ingress. To the north of the Borough the land rises further still and ranges between 20 and 40m AOD. See Appendix K for a topographic map of Barking and Dagenham.

5.7.3 The relatively flat topography and urban nature of Barking and Dagenham results in flow patterns that are less likely to be dictated by the topography but more so by the built environment such as roads, buildings, walls and fences. However, there are a number of areas where overland flow paths are apparent on the Environment Agency Flood Risk from Surface Water map and in the SWMP.

Geology

5.7.4 The drift geology of the London Borough of Barking and Dagenham is characterised by alluvial and river terrace deposits, such as sands and gravels. The solid geology is predominantly London Clay, which lies under all of the Borough except for the very south where the solid geology is of Thanet Sand, the Lambeth Group (fine to medium grain sands with thin clay beds) and, below the Thames, Upper Chalk.

5.7.5 The impermeable nature of the geology within much of the Borough can increase the susceptibility of the area to surface water flooding following periods of heavy rainfall. Also, where permeable gravel deposits sit above impermeable clay layers, a perched water table can occur. This can lead to localised incidents of groundwater flooding.

5.7.6 The geology of the Borough will heavily influence the functionality of Sustainable Drainage (SUDS) techniques and should be carefully considered as part of the design process. Some infiltration techniques, such as soakaways, are unlikely to operate efficiently in areas overlaying impermeable soils. In these areas, engineered solutions (such as on-site attenuation prior to discharge to watercourse or surface water sewer off site) may be more suitable. This is discussed in greater detail in Section 7.

SECTION 6

FLOOD RISK IN THE LONDON BOROUGH OF BARKING AND DAGENHAM

6 FLOOD RISK IN THE LONDON BOROUGH OF BARKING AND DAGENHAM

6.1 Introduction

6.1.1 This section will firstly discuss the watercourses in the Borough of Barking and Dagenham, including their characteristics and flood defences. It will then consider historic flooding within the Borough before looking at specific flood risk to each of the character areas in turn and describe the general patterns of flood risk within each one, detailing which communities are at risk and, where possible, from what source.

6.2 The Rivers in the Borough of Barking and Dagenham

The River Roding and Barking Creek

6.2.2 The south-western boundary of Barking and Dagenham is defined by the course of the River Roding. The River Roding rises near Stanstead Airport and has a catchment area of over 380km^2. It flows either through or near to Epping, Uttlesford, Redbridge, Newham and, finally, Barking, before its confluence with the River Thames at Creekmouth, which is downstream of the Thames Barrier.

6.2.3 The lower, tidally-dominated, reach of the River Roding is known as the Barking Creek. This waterway is navigable for a short length up to Mill Pool. At the downstream limit of the Barking Creek is the 60-metre high Barking Barrier (see Plate 6.1), which was built to work alongside the Thames Barrier and over 36 other major industrial floodgates along the River Thames to protect London from tidal flooding. When the Barking Barrier is closed, it impounds flow on the River Roding in the Barking Creek. The Barking Barrier has vertical lifting gates, which are held out of the water when not in use and this allows commercial shipping to use the Barking Creek.

Plate 6.1: The Barking Barrier[12]

[12] Picture from www.geograph.org

6.2.4 The River Roding is tidally influenced by the River Thames for 9km upstream of the Barking Barrier. When the Barking Barrier is in use, its closure influences extreme water levels for up to 6km upstream (this is known as the backwater effect). Beyond this, extreme water levels are influenced by fluvial flows alone.

6.2.5 The upper reaches of the River Roding are predominantly rural with most of the surrounding land used for arable farming. However in contrast to this, the land surrounding the watercourse through the lower reaches of the river, which include the area of Barking and Dagenham, is highly urbanised.

6.2.6 The combination of heavy urbanisation and clay geology in Barking results in the River Roding exhibiting a flashy response to heavy rainfall events. The catchment is also prone to flooding after prolonged periods of heavy rain and large storm events.

6.2.7 As the River Roding enters its lower reaches it becomes increasingly tidally influenced. Flood defences are present on the lower 7km of the River Roding and Barking Creek, which are designed for tidal events up to the 1 in 1000 (0.1%) annual probability event[13] and fluvial floods, although a low point in the flood defences adjacent to Crows Road reduces the fluvial standard of protection as discussed below. The largest tidal events are dealt with by the Barking Barrier. The defences are also designed to provide sufficient storage for the fluvial flows while the Barking Barrier is shut due to high tidal levels. A fluvial event with a 1 in 2 (50%) probability in any one year can be stored within the Barking Creek in the event of the closure of the Barking Barrier[14].

6.2.8 The defence levels on the River Roding sit between 5.3m AOD and 6.5m AOD. These levels have important implications for the acceptability of development in the areas behind these defences and it is important that flood risk assessments produced for developments in these areas consider both the direct risk of flooding to the site from overtopping, as well as the residual risks from a breach in the defences.

6.2.9 The Lower Roding Regeneration Project, completed in 2006 and funded by the Environment Agency, consisted of environmental enhancement works, including flood defence improvements, along the Lower Roding. The project improved the flood defences at the Barking Barrier and improvements to the New England Embankment, near the Frogmore Estate and Gascoigne Road in Barking. The works included new sheet piling and concrete capping that has increased the defence level in this area from 5.7m AOD to 6.2m AOD.

6.2.10 Beckton Sewage Treatment Works (STW) is located on the right (western) bank of the lower reaches of the Barking Creek and is the largest in the U.K. processing the waste water of over 3 million people. In normal circumstances, the STW discharges directly to the River Thames at a point adjacent to the mouth of the River Roding. However, when tide levels are high in the Thames, the STW discharges into the River Roding via an auxiliary gravity outfall. When this occurs the discharge from Beckton STW can contribute a significant amount of flow to the River Roding. To quantify, flows during the 1 in 100 (1%) annual probability event on the River Roding is estimated to be 80m^3/s and the discharge from Beckton STW can supply an additional 25 m^3/s of flow[13]. Clearly, this has the potential to increase the probability of flooding significantly, especially when the Barking Barrier is closed due to high tide levels in the River Thames.

[13] According to the Environment Agency's National Flood and Coastal Defence Database (NFCDD)

[14] TE2100 –Technical Report EP4 – Tidal/Fluvial Interactions on the tributaries of the River Thames (HR Wallingford)

6.2.11 For the majority of the defences on the River Roding through the Borough the estimated Standard of Protection (SoP) from fluvial flooding is 1 in 1000 (0.1%) in any given year. However, the Lower Roding Flood Risk Mapping report identifies a low point in the flood defences adjacent to Crows Road, south of the railway line, where overtopping is predicted to occur between the 1 in 200 (0.5%) and 1 in 1000 (0.1%) annual probability event.

Buzzard Mouth Creek

6.2.12 The Buzzard Mouth Creek flows south through the Barking Riverside and Creekmouth areas in the south of the Borough and discharges to the River Thames via a sluice gate. The alignment of the watercourse has been amended as part of the Barking Riverside development to include the creation of floodplain storage compensation and enhance the amenity value of the watercourse. The site-specific flood risk assessment that was prepared to support the Barking Riverside development indicates that residual flood risks associated with this watercourse are minimal. Flooding within the vicinity of the Buzzard Mouth Creek will therefore be dominated by the Lower Roding and Thames watercourses.

The Mayes Brook and Loxford Water

6.2.13 The Mayes Brook, which flows through western Barking and Dagenham, is a tributary of the River Roding with a catchment area of just under 14km^2. Its confluence with the River Roding is controlled by a flapped outfall and penstock at Kingsbridge Sluice. This control structure is closed approximately 40% of the day to prevent tidal inundation of the upstream floodplains. Upstream of the Kingsbridge Sluice and downstream of the Barking Culvert is the Ripple Road Sluice, the operation of which effectively separates the Mayes Brook into two distinct areas of fluvial flood risk; those upstream of the Barking Culvert and those downstream of the Barking Culvert.

6.2.14 The Mayes Brook has designated areas of flood storage in the form of two reservoirs in Mayesbrook Park. In 2011 restoration works were undertaken in the reach upstream of the Mayes Brook reservoirs. These works included the introduction of a river meander and bank grading works to increase the available flood storage area by 1 ha. However, the reservoirs appear to have inadequate inlet structures, which are not adequate to cope with high flows. As a result, flood water is able to inundate informal reservoirs both adjacent to and downstream of the Mayesbrook Park reservoirs. Overall, the Mayes Brook has a flood scheme that provides a standard of protection up to the 1 in 30 (3.33%) annual probability flood event[13].

6.2.15 The Mayes Brook is connected to the Gores Brook (discussed below) via the Ship and Shovel Relief Channel. When flow levels are high on the Mayes Brook, a fixed weir on the left bank of the watercourse, downstream of the A13, is overtopped allowing water into the Relief Channel, thus providing flood relief downstream on the Mayes Brook. However, inspections in 1992 and 2006 of the culvert that passes under Renwick Road, approximately 1.2km downstream of the fixed weir, showed that it had completely silted up. This completely blocks any flow from the Relief Channel into the Gores Brook and means that the length of watercourse between the fixed weir and the Renwick Road culvert is acting as an additional flood storage area. Although this culvert has been blocked for some time and it is understood that there are no plans to unblock the culvert in the near future, it may not always remain blocked. It is important to note, however, that the flood mapping for this area may not reflect the reduced capacity of the watercourse.

6.2.16 Loxford Water is another tributary of the River Roding. Its course also defines part of Barking and Dagenham's western boundary. There are no control structures at the confluence of Loxford Water and the River Roding. A tidal sluice is present on Loxford Water 400m upstream from the confluence with the River Roding.

The Gores Brook

6.2.17 The Gores Brook drains a small catchment (approximately 12km^2) flowing in a southerly direction from its source near the Fenchurch Street railway line through Goresbrook Park down towards the southernmost part of the Borough before discharging to the River Thames at the Horseshoe Corner Sluice. As described above, it is linked to the Mayes Brook via the Ship and Shovel Relief Sewer. It has semi-natural channel for its entire course.

6.2.18 The Gores Brook and River Beam Flood Alleviation Scheme, completed in 2011, increased the fluvial SoP on the Gores Brook from a 1 in 10 (10%) annual probability flood event to a 1 in 150 (0.67%) annual probability flood event for the area south of the Goresbrook Park. This increase in SoP was achieved by the construction of a new pumping station, with a capacity of 6m^3/s, which operates when tide locking of the Gores Brook outfall, by the River Thames, and high fluvial flows in the channel occur at the same time. The Beam, Ingrebourne and Mayes Brook Flood Risk Mapping study indicates flooding of Goresbrook Park occurs for events with an annual probability of flooding of 1 in 30 (3.3%) or greater.

6.2.19 A review of the data included in the National Flood and Coastal Defence Database indicates that the SoP indicated on the Gores Brook does not take into account the 2011 improvements which are predicted to increase the SoP from approximately 10 years to 150 years. Developers should consult the Barking and Dagenham Council and the Environment Agency at the start of the design process when developing in this area.

6.2.20 Because it is tidally influenced, the Gores Brook can only discharge to the River Thames, under normal fluvial flow conditions, when tide levels recede to a level below that of the water in the Gores Brook. There is no storage area or flood plain associated with the Gores Brook, however the pumping station at the outfall operates when high fluvial flows coincide with the tide locking effects of the River Thames. Historically, the land surrounding the watercourse formed low-lying marshland and this would have accommodated flood flows from the Gores Brook (as well as the River Roding and, to a greater extent, the Beam River). However, a land-filling exercise in the vicinity of the Gores Brook took place between 1970 and 1985 removing all of the natural floodplain (an area of approximately 320,000m^2). The lowest lying land still existing in the area is within one of the Ford Motor Company's buildings where flooding has been reported a number of times[15].

6.2.21 During times of flood, the Gores Brook becomes hydraulically connected to the Beam River, which lies approximately 2km to the east, by the flow of flood water between the two watercourses.

The Beam River and Tributaries

6.2.22 The Beam River rises in Navestock near Romford in Essex where it is known as the Bourne Brook, before becoming the River Rom and finally the Beam River. It has a catchment area of 63km^2 and tributaries of significance to this study include the Wantz Stream and Dagenham Breach. It joins the River Thames at a point between the Ford

[15] Beam and Gores Brook Flood Risk Management Strategy, Environment Agency, June 2005.

Motor Company site and the Hornchurch Marshes where the outflow is controlled by flapped outfalls and a penstock, which become tide-locked when water levels in the River Thames are high.

6.2.23 In a normal tidal cycle the Beam River can only discharge to the River Thames for 3 hours either side of low tide[16]. There are raised defences on the Beam River for a distance upstream of the outfall, which are required to hold back waters when the tide-locked channel is storing water.

6.2.24 A pumping station with a capacity of 9.3m^3/s was constructed at the outfall of the Beam River to the River Thames in 2011 as part of the Gores Brook and River Beam Flood Alleviation Scheme. This pumping station alleviates the tidal-locking effect during times of high flow, and was designed to increase the current day SoP to 1 in 150 (0.67%) probability of flooding occurring in any one year as well as reduce the amount of bank overtopping[17]. However, the hydraulic assessment completed for the Beam, Ingrebourne and Mayes Brook FRM Study (2013) indicates that the SoP afforded by the pumping station may be lower with the Ford Stamping Plant site predicted to flood for an event with an annual probability of between 1 in 50 (2%) and 1 in 75 (1.33%) when combined with a Mean High Water Spring (MHWS) tide.

6.2.25 A study by Capita Symonds[18] has shown that if the tidal outfall to the River Thames was to fail, it would result in extensive flooding. Due to the low level of the Beam River, inundation would be very fast and last for a significant portion of the tidal cycle. Flood waters in the area between the A13 and new road could exceed 2m in depth.

6.2.26 Like the River Roding, the Beam is heavily urbanised in its lower reaches, resulting in a flashy response to storm events. Although it does flow through a green corridor between Dagenham and Hornchurch, much of which is public open space.

6.2.27 Some fluvial flood protection is provided by the Beam Washlands flood storage area, which is a statutory reservoir under the Reservoirs Act 1975. The storage capacity of the Washlands was increased by 25,000m^3 to 455,000m^3 in 2011. Downstream of the confluence of the Wantz Stream and Beam River, adjacent to the A1306, are sluices that are closed during periods of high river flow. This causes water to spill into the Beam Washlands, which is made up by the land lying adjacent to the Beam River and Wantz Stream upstream of the sluice (see Appendix C for the location of the Beam Washlands). When the Beam Washlands are full, they return water back to the Beam River via a spillway. However, the Thames CFMP has identified that improvements to the Washlands flood storage area might not be sufficient enough to offset increasing risk from rising tides.

6.2.28 Downstream of the Beam Washlands, a 7.9 hectare lake called the Dagenham Breach also provides flood storage for the River Beam. The Dagenham Breach was formed in 1707 due to a collapse in part of the River Thames' defences, which resulted in much of the land between the Beam River and Gores Brook being extensively flooded. The land remained inundated until the 1720s, when the breach was repaired. The current water body of the Dagenham Breach is much smaller than the original breach having been gradually filled in due to development needs in the early 20th Century. A single spill weir controls flow into the Dagenham Breach when river levels on the Beam River

[16] Thames CFMP – Beam Policy Unit

[17] Beam, Ingrebourne and Mayes Brook FRM Study (SE050), Environment Agency, October 2013

[18] Dagenham, Barking & Havering Strategic Flood Risk Assessment, Capita Symonds, February 2006.

are high enough. This same weir also regulates flow back into the River Beam, holding water levels high enough to sustain the ecology of the site.

6.2.29 No specific information relating to the Mayesbrook Park and the Beam Washlands water storage areas is currently available, however the potential risk of flooding as a result of structural failure is certainly considered to be much less than the indicative scenarios set out within NPPF (i.e. 1 in 100 likelihood of occurring in any one year).

The River Thames

6.2.30 The River Thames drains a catchment area of over 12,000km^2 (excluding the Medway) and it is tidally influenced for about 90km of its length, up to the town of Teddington in Middlesex.

6.2.31 The southern boundary of the London Borough of Barking and Dagenham sits immediately adjacent to the River Thames with the Borough situated within the lowermost reaches of the river. Historically, the River Thames floodplain in this area was substantially wider than it is today with the dense urban area of Greater London (including Barking and Dagenham) heavily constraining the river corridor as it winds its way towards the sea.

6.2.32 The River Thames has been heavily modified over time with the growth of London, including the construction of raised defences along much of its length. As a result, the direct risk to the London Borough of Barking and Dagenham as a result of fluvial flooding alone from the River Thames is negligible. However, should a fluvial flooding event on the Thames coincide with a particularly high tide, the London Borough of Barking and Dagenham could be at risk.

6.2.33 The primary risk of flooding within the London area is as a result of a surge tide. A surge occurs when a weather system within the North Sea creates gale force winds that blow in a southerly direction through the narrow stretch of sea between Great Britain and the continent. A ‘wedge’ of water is created, which increases in height as it progresses through the narrowing gap between the land masses that border the English Channel. Large tidally influenced river estuaries, particularly within the South East of England (including the River Thames), are susceptible to relatively large and rapid increases in river levels as the wave passes. Should this ‘surge’ coincide with a particularly high tide and/or intense rainfall in the upper catchment leading to significant fluvial flows, the River Thames within London becomes in effect a ‘basin’ with water approaching in both directions.

6.2.34 The highest recorded tidal flood levels in the River Thames occurred in 1953 and reached a height of 5.4m above the London Bridge Ordnance Datum point. With the impact of climate change, sea and tide levels are increasing and this means that the probability of tidal flooding over time gets ever greater in the communities that adjoin the River Thames.

6.2.35 Considerable investment has been made in the provision of the Thames Tidal Defences to protect Greater London (including Barking and Dagenham) from tidal flooding. It is essential, though, to appreciate that the flood defences are engineered structures that can only ever protect up to a point. They may malfunction and they have a finite structural life. There will, therefore, always be a residual risk of flooding within the Borough. The tidal defences downstream of the Thames Barrier are maintained to a minimum level of 7m AOD, which, at the current time, provides a SoP equivalent to a 1 in 2000 (0.05%) annual probability tidal event. With the anticipated sea level rise due to climate change, it is believed that by 2030 the SoP will decrease to approximately a

1 in 1000 (0.1%) annual probability of flooding and the Thames tidal defences will no longer meet their design requirements.

6.2.36 The future sustainability of London is clearly dependant to a large degree upon the retention of the River Thames Tidal Defences in the longer term. Decisions surrounding investment of this nature in future years cannot be predicted with any certainty, and therefore it is imperative that planning decisions are taken with a clear understanding of the potential risks posed to property and life should things ultimately go wrong.

6.3 Historical Flooding

6.3.1 A brief summary of recoded and known historic flooding events is provided in Table 6.1. The historical flood data available for Barking and Dagenham ranges from 1707 to 2016, however, only events assessed as likely to recur given the improvements made to the flood defences and drainage infrastructure in the Borough have been included in Table 6.1. A summary of historic flooding events that have occurred within Barking and Dagenham is also provided within the Borough's Preliminary Flood Risk Assessment (PFRA) that has been updated in 2017.

Table 6.1 Summary of historic flood events

Location and date	Source	Description
River Road area, 1949	Fluvial flooding from **Mayes Brook** (main river) with channel exceeding capacity.	The River Roding Catchment Board reported in 1949 that serious flooding took place on regular occasions in the Mayes Brook catchment and in particular the River Road and Clare [Gardens] areas.
Clare Gardens area, 1949	Fluvial flooding from **Mayes Brook** (main river) with channel exceeding capacity.	The River Roding Catchment Board reported in 1949 that serious flooding took place on regular occasions in the Mayes Brook catchment and in particular the River Road and Clare [Gardens] areas. The same report indicated that the inadequacy of the Barking Culvert at that time was the major cause of flooding in the upper Mayes Brook.
Westrow Drive, Salisbury Avenue and River Road areas, 1968	Fluvial flooding from **Mayes Brook** (main river) with channel exceeding capacity.	A report dated 14th/15th September 1968, published for the December Works Committee, describes how 2 inches of rain fell in 1.5 hours and a total of 2.25 inches of rain fell in 24 hours on the Mayes Brook catchment on 31st July 1968. This led to localised flooding in Westrow Drive, Salisbury Avenue and the River Road areas.
Clare Gardens and Westrow Drive areas, 1993	Fluvial flooding from **Mayes Brook** (main river) with channel exceeding capacity.	No further information available.

Location and date	Source	Description
Length of the River Roding, 2000	Fluvial flooding from the **River Roding** (main river), possibly tidally influenced, with channel exceeding capacity.	The most recent severe flooding to affect the River Roding catchment occurred in autumn 2000 when over 200 properties were affected along the whole length of the river. This flood event has been calculated to have approximately a 1.4% annual probability of occurrence. The worst hit areas were Ilford and Redbridge, which are outside of Barking & Dagenham. However, it is not unknown for flooding problems to affect the River Roding and Barking Creek within the Borough of Barking & Dagenham.
Beam Valley Country Park, 2000	Fluvial flooding from the **Beam River and Wantz Stream** (main rivers) with channel exceeding capacity.	Flooding in the Beam [Valley] Country Park from River Beam and Wantz Stream.
Land between Gores Brook and Beam River, dates unknown	Fluvial flooding from **Gores Brook** and **Beam River** (main rivers), possibly tidally influenced.	Known that the Gores Brook and Beam River have caused flooding problems in their lower reaches and have combined to inundate the Ford Motor Company's Stamping and Tooling plant building. However, no specific dates or return periods are available.
Rush Green, Gorseway, July 2012	Fluvial flooding from River Rom (main river).	Following a period of continual rainfall, the River Rom breached its banks and flooded the rear gardens and garages of a number of properties at Gorseway to a depth of approximately 100-300mm.
Parsloes Park area, dates unknown	Fluvial flooding and overland flow from **surface water drain** and **Gores Brook** (ordinary watercourse) with culvert exceeding capacity.	Gores Brook is fed by a surface water drain that crosses Parsloes Park from Parsloes Avenue, just to the west of Terrace Walk and this is prone to backing up, causing manholes to 'blow'. Barking and Dagenham Borough Council are aware of this issue and they have made enquiries about funding a scheme to have the culvert opened.
River Road, Creekmouth, dates unknown	Surface water flooding from insufficient capacity in **surface water drain**.	Frequent nuisance flooding believed to be due to lack of drainage capacity and insufficient cleaning. Some flooding to a small number of businesses. The industrial area at River Road is still a known problem area, with the deposition of mud from heavy duty vehicles reducing the capacity or causing blockages of highway gullies.
Chequers Lane, Dagenham Dock, dates unknown	Surface water flooding from insufficient capacity in **surface water drain**.	Frequent nuisance flooding believed to be due to lack of drainage capacity and insufficient cleaning. Some flooding to a small number of businesses.
Estuary Close, Renwick Road, 2014	Surface water flooding from a blockage in the surface water drain/channel.	Flooding causing structural damage to a property in Estuary Close due to road gullies surcharging due to a blockage in the surface water drain/pipe.

Location and date	Source	Description
Throughout Barking and Dagenham	Overland flow from **Thames Water sewerage network**.	Thames Water provided information extracted from their DG5 register of properties at risk of sewer flooding. The information is supplied as numbers of properties on the DG5 register considered to be at risk of flooding from sewers within each Postcode Sector, e.g. "RM5 2." Postcode sectors typically contain several thousand properties, and therefore the data provided in this manner only gives an approximate indication of areas at risk of sewer flooding. Additionally, many Postcode sectors overlap LLFA boundaries. In total there are 47 reported incidents of sewer flooding in Barking & Dagenham in the last 10 years. Note that the DG5 register does not include properties considered to be at risk in a 1 in >20 year (less than 5% Annual Event Probability) event.
Wards of Parsloes, Eastbury, Village and Chadwell Heath, dates unknown	**Groundwater** flood incident	Review of maps provided within the LBBD SWMP identifies four groundwater flooding events as identified by EA records of Groundwater Flood Incidents. No further information is available.
Multiple locations throughout Barking and Dagenham, June 2016	Predominantly attributable to **local sources of flooding**	Flooding throughout borough including at Valence Avenue, Westrow Drive, Heathway, Ripple Road, Saville Gardens, Felton Road, Movers Lane, River Road, Beresford Gardens, Cornwall Close, Lambourbe Road, Whiting Avenue, Woodbridge Road, Woodbridge Road and Halsham Crescent. Flooding mainly to carriageway but some internal property flooding also recorded.
Goresway, June 2016	Fluvial flooding from River Rom (main river)	River Rom burst banks and caused flooding of rear gardens.

6.3.2 Many of the flooding events listed above have not been captured within a mapped format. The Environment Agency has provided mapping of the 1968, 1974, 1987, 1992, 2000, 2003 and 2007 flood events, which can be seen in Appendix J. The most recent fluvial flood events on the River Rom in 2012 and 2016, at Goresway, and the multiple June 2016 flood events are also identified on the map. The location of these events are indicative and do not clarify the extent in which flooding occurred. It is often difficult to ascertain the cause of observed flooding, particularly after the flood waters have receded. Also, whilst detailed information relating to the precise location and depth of flooding is not always available, anecdotal information highlights the importance of careful and informed decision making when locating future development within a Borough.

6.3.3 Thames Water provided information extracted from their DG5 register of properties at risk of sewer flooding. The information is supplied as numbers of properties on the DG5 register considered to be at risk of flooding from sewers within each Postcode Sector, e.g. "RM5 2." Postcode sectors typically contain several thousand properties, and therefore the data provided in this manner only gives an approximate indication of areas at risk of sewer flooding. In total there are 47 reported incidents of sewer flooding

in Barking and Dagenham in the last 10 years. Refer to Appendix H for details of the DG5 register of properties at risk of sewer flooding in Barking and Dagenham.

6.3.4 Although the historical flood data for Barking and Dagenham provides valuable insight into areas that have previously been affected by flooding, the future flood risk in these areas could be affected by changes to infrastructure and development that have occurred since the reported flooding. Much of the historical flood data available ranges from 1707 to 1993 and the majority of this information is no longer applicable in assessing current and future flood risk due to improvements made to flood defences and drainage infrastructure in the Borough. Consultation should therefore always be undertaken with the relevant authorities and consideration given to current flood defence infrastructure when assessing the importance of historic flood events to the planning of new development.

6.4 Spatial Variations of Flood Risk in the Character Areas

6.4.1 For the purposes of reviewing the flood risk within Barking and Dagenham the Borough has been divided into six Character Areas as follows based around the 17 Wards (and as shown on map in Appendix L):

- Character Area 1: Alibon, Eastbrook and Heath
- Character Area 2: Abbey, Gascoigne and Thames
- Character Area 3: Chadwell Heath and Whalebone
- Character Area 4: Eastbury, Longbridge and Mayesbrook
- Character Area 5: Becontree, Parsloes and Valence
- Character Area 6: Goresbrook, River and Village

6.4.2 For consistency with the previous SFRA report the same Character Areas have been adopted. The following sections consider the spatial variations of flood risk from all sources (that are available) within each of these Character Areas in turn. This should be read in conjunction with the flood risk mapping in Appendix D and the maps of the Character Areas and flood risk in Appendix M.

Character Area 1: Alibon, Eastbrook and Heath

Fluvial and Tidal

6.4.3 Fluvial and tidal flooding in this character area is limited to the Eastbrook ward with the wards of Albion and Heath shown to be in areas of low risk from any fluvial or tidal flooding. The eastern boundary of the area, adjacent to the River Rom (upstream extents of Beam River), is within Flood Zone 3a, 3b and 2. The areas within the flood zones are predominantly open space with few properties shown to be at risk. The flood zones are well defined along the Beam River and River Rom and topography is the dominant factor in this area. The LiDAR data in this area confirms the areas within the flood zones are generally at a lower elevation than the adjacent developed areas, although flooding to rear gardens and garages of a number of properties along Gorseway has been known to occur when the River Rom bursts its banks.

6.4.4 The eastern boundary of this character area is within an Environment Agency Flood Warning Area.

Surface Water

6.4.5 The Risk of Flooding from Surface Water map indicates that during a rainfall event with an annual probability of 1 in 100 (1%) there would be a prominent flow path through the centre of the character area flowing in a southerly direction through Central Park, then parallel to A1112 before crossing Oxlow Lane and down to Reede Road. The SWMP highlights two LFRZ along this flow route where deep flooding is predicted at Sterling Industrial Estate and Pondfield Park. A LFRZ is also identified at Parsloes Park where flow appears to pond to the north of the railway embankment. For further details of these LFRZs refer to the Barking and Dagenham SWMP.

Groundwater

6.4.6 The iPEG map indicates the eastern boundary of the area, adjacent to the Beam River, the southern boundary and the centre of the area in the vicinity of the A1112 are located within areas where identified as having an increased potential for groundwater to interact with or rise to within 2m of the ground surface. For details of the iPEG map refer to Appendix I. Groundwater emergence could pose flood risk to basement or below ground structures, as well as generate overland flows that are likely to be similar in location to those discussed as part of the surface water flood analysis.

Defence or Reservoir Failure

6.4.7 This character area is not deemed to be at risk from a failure of raised flood defences.

6.4.8 The Environment Agency Risk of Flooding from Reservoirs Map indicates flood flows from a reservoir breach are indicated to be largely contained within the Beam River and with a similar extent to that shown in the fluvial and tidal flood zones.

Character Area 2: Abbey, Gascoigne and Thames

Fluvial and Tidal

6.4.9 Fluvial and tidal flooding affects a significant portion of this character area. The River Roding, Loxford Water, Mayes Brook and Gores Brook are the potential sources of fluvial flooding, and with the River Roding the primary source of flooding in the area. Flood Zone 3b is not particularly extensive and is generally contained within watercourse channels or behind flood defences. A small number of properties in the vicinity of Waverly Gardens are within Flood Zone 3b. However a significant proportion of the area is within Flood Zone 3a and benefits from flood defences. The hydraulic modelling completed for the Lower Roding Flood Risk Mapping study reflects the low point in the defences at Crows Road.

6.4.10 In the Abbey ward, Flood Zone 3a is limited to the north and west of the area in the vicinity of the railway line and River Roding respectively. The southern half of the Gascoigne ward is within Flood Zone 3a. The majority of the Thames ward is shown to be within Flood Zone 3a with the area of land around the Gores Brook that was raised between 1970 and 1985 and the land to the north of the Channel Tunnel Rail Link (CTRL), which encompasses Castle Green and Goresbrook Leisure Centre, shown to be within Flood Zone 1.

6.4.11 Development within close proximity of the Ship and Shovel Relief Sewer may need to take into consideration blockage of this watercourse that could cause localised flooding issues. The existing flood mapping for this area may not reflect the reduced capacity of the watercourse.

6.4.12 The majority of this character area with the exception of the land at the north eastern boundary, adjacent to Loxford Water, is within an Environment Agency Flood Warning Area.

Surface Water

6.4.13 As highlighted above the majority of this character area is shown to be within Flood Zones 2 and 3. However due to the presence of the flood defences the risk from surface water flooding may pose a more 'real' threat. Seven LFRZ's were identified in the SWMP within this character area.

6.4.14 The surface water mapping predicts significant depths of surface water ponding in the vicinity of Loxford Water and the River Roding in the north of the Abbey ward, Salisbury Avenue / Greenslade Road, Whiting Avenue, Greatfields Park, Wayside Commercial Estate and in the vicinity of Choats Road. A surface water flow path from Castle Green across the A13 and onto Renwick Road was also identified. For further details of these LFRZ's refer to the Barking and Dagenham SWMP.

6.4.15 The management of surface water runoff will be an important consideration within this character area given the potentially high risks as identified above. A number of minor watercourses and drainage ditches are also located within this character area that may need to be taken into consideration during site-specific flood risk assessments, particularly the consideration of blockages.

Groundwater

6.4.16 The iPEG map indicates the north western boundary of the area, adjacent to the River Roding and Loxford Water and the area in the vicinity of Greatfields Park, has increased potential for elevated groundwater. The area in the vicinity of Renwick Road in the south of the area is also shown to have increased potential. For further details of the iPEG map refer to Appendix I. Groundwater emergence could pose flood risk to basement or below ground structures, as well as generate overland flows that are likely to pond in areas of flat topography or be similar in location to those discussed as part of the surface water flood analysis.

Defence or Reservoir Failure

6.4.17 The Environment Agency breach analysis indicates that a significant proportion of this character area would be at a very high risk to life should a breach in the Barking Creek or Thames Defences occur. The areas shown to be at risk tend to coincide with the mapped extents of Flood Zone 2 and 3, however the area adjacent to the River Roding could also be at risk, as could the north of the Thames ward. The south east of the Thames ward is shown to be in Flood Zone 3 but is at low risk of flooding due to the breach of a flood defence.

6.4.18 The Environment Agency Risk of Flooding from Reservoirs Map indicates the west of the character area between the River Roding and the A406 is at risk of flooding from the Basin reservoir in Wanstead and the Perch Pond Reservoir in Wanstead Park. The east of the character area, in the vicinity of Choats Manor Way and the railway line, is shown to be at risk of flooding from the Washlands Flood Storage Area.

6.4.19 Emergency planning will be a key consideration within areas identified to be at risk from failure of flood defences or reservoir structures.

Character Area 3: Chadwell Heath and Whalebone

Fluvial and Tidal

6.4.20 This character area is located within Flood Zone 1.

Surface Water

6.4.21 The Barking and Dagenham SWMP identified two LFRZ's in this character area. Surface water modelling indicates that during a 1 in 100 (1%) annual probability rainfall event surface water ponding may occur in the Whalebone South area, specifically in Wadeville Avenue, Saville Road and Selinas Lane. Ponding to a lesser depth is also predicted to occur at Eastern Avenue (the A12) to the north. The management of surface water runoff will be a key consideration within this character area given its relative high elevation in the catchment and therefore potential impact on flood risk within areas at a lower elevation.

Groundwater

6.4.22 Two areas of increased potential for elevated groundwater are identified in this character area, at the eastern boundary in the vicinity of the A12 and in the south of the area in the vicinity of the railway line. For further details of the iPEG maps refer to Appendix I. Groundwater emergence could pose flood risk to basement or below ground structures, as well as generate overland flows that are likely to pond in areas of flat topography or be similar in location to those discussed as part of the surface water flood analysis.

Defence or Reservoir Failure

6.4.23 This character area is not deemed to be at risk from a failure of raised flood defences or reservoir failure.

Character Area 4: Eastbury, Longbridge and Mayesbrook

Fluvial and Tidal

6.4.24 Loxford Water in the north-west and Mayes Brook in the centre are the primary sources of fluvial flooding in this area. Flood risk within the south of this character area is dominated by the Lower Roding.

6.4.25 A number of properties in the vicinity of Westrow Drive are shown to be within Flood Zone 3b along with a section of Barking Industrial Park at the southern boundary of the area. Flood Zone 3a affects a significant number of properties in this area, particularly in the vicinity of Harrow Road, Blake Avenue, Weston Drive and Barking Industrial Park. Land adjacent to the lake in Barking Park is also within Flood Zone 3a, however no properties are affected. Flood Zone 2 impacts further properties in these areas. However, these areas are shown to benefit from flood defences on the River Thames, River Roding and Mayes Brook.

6.4.26 These areas are also within an Environment Agency Flood Warning Area.

Surface Water

6.4.27 A significant proportion of the predicted surface water flood extent aligns with the predicted fluvial flood zones from Mayes Brook and Loxford Water within this character area. However three LFRZ's identified in the SWMP lie outside the predicted fluvial flood extents.

6.4.28 Surface water ponding is predicted to occur to the west of Parsloes Park and in the Lodge Drive / Westrow Drive area. A surface water flow path crossing Ripple Road to the east of Lancaster Avenue / Harrow Road was also identified. For further information on these LFRA's refer to the Barking and Dagenham SWMP.

Groundwater

6.4.29 A number of areas including the land in the vicinity of the Mayes Brook in the centre of the character area, Parsloes Park in the east, the railway line in the south west, Barking Park in the northwest adjacent to Loxford Water and Woodbridge Road in the north are shown to have increased potential for elevated groundwater. For further details of the iPEG mapping refer to Appendix I. Groundwater emergence could pose flood risk to basement or below ground structures, as well as generate overland flows that are likely to pond in areas of flat topography or be similar in location to those discussed as part of the surface water flood analysis.

Defence or Reservoir Failure

6.4.30 The Environment Agency breach analysis indicates that part of this character area would be at a very high risk to life should a breach in the Barking Creek or Thames Tidal Defences occur. All of the areas shown to be at risk are in Eastbury and are typically to the south and west of the ward.

Character Area 5: Becontree, Parsloes, Valence

Fluvial and Tidal

6.4.31 This character area is predominantly located within Flood Zone 1 with the exception of the south west corner adjacent to Waterside Close which is located within Flood Zone 3a associated with the Mayes Brook. This area benefits from flood defences.

Surface Water

6.4.32 The majority of the surface water flooding within this character area during the 1 in 100 (1%) annual probability rainfall event is predicted to be contained to the roads. One LFRZ was identified within this character area in the SWMP located at Longbridge Road affecting properties in Lindsey Road, Fuller Road and Campden Crescent. For further details of this LFRZ refer to the Barking and Dagenham SWMP.

6.4.33 The management of surface water runoff will be a key consideration within this character area given its relative high elevation in the catchment and therefore potential impact on flood risk within areas at a lower elevation.

Groundwater

6.4.34 A significant portion of this character area is shown to be within areas with increased potential for elevated groundwater on the iPEG map including the south of the area in the vicinity of Parsloes Park, the east of the area in the vicinity of Valence Park and the

north east of the area in the vicinity of Winterbourne Road. For further details of the iPEG mapping refer to Appendix I. Groundwater emergence could pose flood risk to basement or below ground structures, as well as generate overland flows that are likely to pond in areas of flat topography or be similar in location to those discussed as part of the surface water flood analysis.

Defence or Reservoir Failure

6.4.35 This character area is not deemed to be at risk from a failure of raised flood defences or reservoir failure.

Character Area 6: Goresbrook, River and Village

Fluvial and Tidal

6.4.36 The sources of fluvial flooding in this character area are the Gores Brook, Wantz Stream, Beam River and Dagenham Breach which is a storage area linked to the Beam River. This area is also at risk from tidal flooding from the River Thames.

6.4.37 No properties in this area are within Flood Zone 3b as the extent of this zone is limited to the Beam River flood defences, the Dagenham Breach and the Beam Washlands. Significant parts of the character area are located within Flood Zone 3a with the industrial area between New Road and the River Thames and the residential properties in the vicinity of Oval Road North within the Flood Zone 3a extents. Further areas in the vicinity of Oval Road North and in the vicinity of Gores Brook are located within Flood Zone 2. However the majority of this character area at risk of fluvial or tidal flooding is protected by flood defences on the River Thames, Beam River and Gores Brook. These areas are also within an Environment Agency Flood Warning Area.

6.4.38 This area is also at risk of flooding due to a failure of the pumping stations described in Section 6.2. If the failure of the pumping stations were to coincide with the tide locking of the Gores Brook and Beam River outfalls and high fluvial flows, significant flooding could occur in the area.

Surface Water

6.4.39 A significant proportion of the predicted surface water flood extent aligns with the predicted fluvial flood zones within this character area with flooding associated with the flows on the Gores Brook, Wantz Stream, Beam River.

6.4.40 The surface water flood extent predicted for the 1 in 100 (1%) annual probability rainfall event indicates an overland flow route flowing in a southerly direction to the northern extent of the Wantz Stream. The SWMP highlights this area, in the vicinity of Ballards Road (at Shafter Road, Dewey Road and Sandown Avenue), as a LFRZ with several properties shown to potentially be at risk. A further three LFRZ's are identified in this character area with ponding predicted to occur in Goresbrook Park (upstream of the culvert under Goresbrook Road), behind the Beam Washlands defences and at numerous areas in the vicinity of the Ford Motor Works. For further details of these LFRZ's refer to the Barking and Dagenham SWMP.

Groundwater

6.4.41 The iPEG map indicates the eastern boundary of this area adjacent to the Beam River, the north of the area in the vicinity of the railway line, the area in the vicinity of Old Dagenham Park and the land in the vicinity of Gores Brook are within areas with

increased potential for elevated groundwater. For details of the iPEG map refer to Appendix I. Groundwater emergence could pose flood risk to basement or below ground structures, as well as generate overland flows that are likely to pond in areas of flat topography or be similar in location to those discussed as part of the surface water flood analysis.

Defence or Reservoir Failure

6.4.42 The Environment Agency breach analysis indicates that a significant proportion of this character area would be at a very high risk to life should a breach in the River Roding, Barking Creek or Thames Defences occur. The River ward is at the highest risk, with parts of the Gorsebrook and Village wards also affected.

6.4.43 The south of the character area, between New Road and Choats Manor Way and also immediately adjacent to the Washlands is shown to be at risk of flooding from the Washlands Flood Storage Area.

6.4.44 Emergency planning will be a key consideration within areas identified to be at risk from failure of flood defences or reservoir structures.

6.5 Impacts of Climate Change on Flood Risk

6.5.1 As discussed in Section 5.5, studies completed prior to the publication of the updated Environment Agency climate change guidance (February 2016) used previous climate change recommendations as included within PPS25 and, later, the NPPF Planning Practice Guidance. The potential increase in sea level rise, offshore wind speed and extreme wave height is the same as that previously promoted by these documents and is therefore likely to have little impact on previous mapped tidal flood extents. However, the potential increase in fluvial flood flows compared to previous recommendations could increase the mapped extents of fluvial flood risk during extreme events, as well as the associated flood hazard. The approach to considering the potential effects of climate change is discussed further in Section 5.5.

6.5.2 Updated guidance for considering the potential effects of climate change has been considered within the fluvial modelling of the Mayes Brook, Gores Brook, Beam River and Wantz Stream for the 1 in 100 (1%) annual probability event using the updated climate change recommendations. The outputs of this exercise are illustrated on maps D3 and D4 provided in Appendix D. Updated climate change analysis has not yet been undertaken for the other main rivers within Barking and Dagenham, including the Lower Roding which the Environment Agency are due to complete in December 2017. Users of this SFRA should undertake their own analysis (in accordance with the detailed and intermediate approach outlined in Section 6.4) of climate change effects in these areas.

6.5.3 The potential effects of climate change to tidal flood risks have been considered within the breach analysis of the Thames and Lower Roding flood defences as illustrated on the maps provided in Appendix G. It is recommended that users of this SFRA refer to these maps to understand the likely effects of climate change on tidal flood risk.

6.5.4 The Environment Agency has undertaken substantial investigations into the impacts of climate change within the Thames Estuary. Their Thames Estuary 2100 (TE2100) project developed a tidal flood risk management plan for London and the Thames Estuary through to the end of the century. This work has identified that the existing tidal defences are very effective with a greater safety margin than previously understood. When the potential impacts of climate change are considered, they do not expect any major upgrade to the current system of defences or a new major engineering project

within the estuary before 2030, when the SoP provided by the Thames Tidal Defences will be reduced to a 0.1% (1 in 1,000) annual probability event due to the effects of climate change. They have identified a need to continue to maintain defences and may need to improve many of the walls and embankments by 2050.

6.5.5 The SWMP has considered the potential impacts of climate change on surface water flood risk and reference should be made to the information provided within the SWMP. As discussed in Section 5.5, this is considered most applicable to surface water flooding that is not attributable to fluvial flooding from an unmapped watercourse.

6.5.6 It is important to recognise that those properties (and areas) that are currently at risk of flooding may be susceptible to more frequent, more severe flooding in future years. It is essential, therefore, that the development control process (influencing the design of future development within the Borough) carefully mitigates against the potential impact that climate change may have upon the risk of flooding to the property.

6.5.7 For this reason, all of the development control recommendations set out in Section 7 require all floor levels, access routes, drainage systems, infrastructure and flood mitigation measures to be designed with an allowance for climate change[19]. This provides a robust and sustainable approach to the potential impacts that climate change may have upon the Borough, ensuring that future development is considered in light of the possible increases in flood risk over time.

6.6 Residual Risk of Flooding

6.6.1 It is essential that the risk of flooding is minimised over the lifetime of the development in all instances. It is important to recognise that flood risk can never be fully mitigated and there will always be a residual risk of flooding. This residual risk is associated with a number of potential risk factors including (but not limited to):

- a flooding event that exceeds that for which the local drainage system has been designed;
- the residual danger posed to property and life as a result of flood defence failure;
- general uncertainties inherent in the prediction of flooding.

6.6.2 The modelling of flood flows and flood levels is not an exact science. Therefore, there are inherent uncertainties in the prediction of flood levels and frequency used in the assessment of flood risk. The adopted flood zones underpinning the Barking and Dagenham SFRA are largely based upon detailed river and/or breach modelling within the area. Whilst these provide a robust depiction of flood risk from a strategic perspective, all detailed modelling requires the making of core assumptions and the use of empirical estimations.

6.6.3 There are considerable residual risks associated with the failure or breach of the tidal defences or the failure of the Barking Barrier. By their nature these events cannot always be predicted, however measures can be taken (particularly at the design stage) to minimise their impacts on the communities that are affected. With reference to the breach modelling and rate of inundation mapping provided in Appendix G, developers

[19] All elements of design must account for the potential impact of climate change in predicted peak design water levels. The impacts of climate change should be assessed over the lifetime of the proposed development, and calculated in accordance with *"Climate change allowances for planners – Guidance to support the NPPF"* (or as otherwise advised by the Environment Agency).

should consider moving proposed developments to areas of the least hazard and should place an emphasis on flood resistance and resilience. Also, communities should be educated about the flood risks in their area and the awareness of the measures they can take to protect themselves. This way, should flooding through the failure or breach of a tidal defence occur, communities will be better prepared to deal with onset of flooding and will be able recover more quickly.

6.6.4 In urban areas, such as Barking and Dagenham, there is a residual risk of culvert blockage. The effects of culvert blockage can be severe and the remedial works can be costly. If culverts are within or near to a development site, the potential for culvert blockage and the consequence of such an event should be investigated in the site-specific flood risk assessment. If there is a residual risk of culvert blockage, developers should design flood resistance and resilience into their development proposal. The developer may also wish to install a trash screen onto the culvert (if one does not already exist) to minimise the risk of blockage and ease culvert maintenance. It is recommended that the installation of trash screens is only considered after alternative measures have been fully investigated and it can be shown that the benefits of installing a trash screen are significant and outweigh the risks. The installation of trash screens should be done in partnership with the Environment Agency and Council as LLFA to ensure that the design adheres to the requirements of the Trash Screen Design and Management Manual.

6.7 The Source – Pathway Receptor Model

6.7.1 The various ways in which flooding can occur are known as flood mechanisms. It is found helpful to consider this using the Environment Agency's Source-Pathway-Receptor approach, where:

- the source is where the floodwater originates from;
- the pathway is the route it is likely to take to cause flooding; and
- the receptor is the place of impact and is often where damage is realised.

6.7.2 The below tables give an overview of the source, pathways and receptors for each type of flooding mechanism.

1. Groundwater		
Source	**Pathway**	**Receptor**
Groundwater flooding occurs where the level of groundwater in the ground rises to within close proximity of the ground surface or above ground level, leading to flooding of basement structures and springs. Perched groundwater in shallow gravel layers is also a risk within Barking and Dagenham.	The pathway is where the geological boundary forming the base of the water bearing deposits emerges at the ground surface and/or causes flooding of basement structures.	Infrastructure located on or just down-slope of the geological boundary from which the springs originate, or buried structures and infrastructure.

2a. Overland flow – Permeable Geology Areas (Thanet Sand and Upper Chalk, for example)		
Source	**Pathway**	**Receptor**
In areas of natural permeable geology without urban infrastructure, the rainfall generally soaks into the permeable geology. Surface runoff only arises at times of extreme rainfall events when the rainfall exceeds the rate of infiltration by the water into the permeable geology. Runoff will increase where the permeable ground is covered by impermeable man made developments.	The runoff exceeding the permeable geology infiltration will tend to drain via natural valleys, but may be modified by local ditches and embankments.	Infrastructure in, and across, natural valleys.

2b. Overland flow – Impermeable Geology Areas (London Clay, for example)		
Source	**Pathway**	**Receptor**
On a natural clay catchment the rainfall tends to flow rapidly to ditches, drains and watercourses. These tend to be well defined but may be modified by land-use. In particular depressions may be formed where water is trapped and cannot escape. At times of more extreme rainfall events the rainfall runoff may flow down original flow pathways of natural valleys as well as coming out-of-bank resulting in surface water flooding.	Natural valleys. Depressions in urban areas resulting from placing of fill or other activities by man. In extreme floods this can include flood banks which trap water on the flood plain.	Infrastructure in, and across, natural valleys, and in man made depressions.

3. Foul sewer network – exceedance of the network capacity		
Source	**Pathway**	**Receptor**
Foul water networks are also developed in parallel with infrastructure development to carry waste from properties. Surface and groundwater infiltration into the sewer and surface water misconnections by property owners do cause capacity exceedance. Some flooding is also caused by local blockages.	The foul flood water from manholes will tend to follow the surface water flow paths and mix with surface water at variable depths and extents.	Infrastructure around, and down-slope of, manholes.

4. Watercourse (fluvial) flooding – exceedance of the watercourse capacity		
Source	**Pathway**	**Receptor**
Every watercourse (river, stream and ditch) has a finite capacity. Once the capacity of the structure is exceeded, water flows out of bank at low points. Typically, channels are enlarged and defences rose in response to actual flooding experience. However, the risk remains that the next flood will be higher than anything experienced previously and overtop defences or exceed the enlarged channel.	The flood water flowing out of bank will fill low-lying areas within the floodplain and in some cases, tend to follow the surface water flow paths with variable depths and extents.	Infrastructure along the sides of watercourses.

5. Tidal flooding (River Thames) – overtopping or breach of the defences		
Source	**Pathway**	**Receptor**
In tidal estuaries, such as that of the River Thames, adjacent land areas are at risk from extreme high tides and/or tidal surges (where a low pressure forms at sea and moves inland, bringing with it elevated sea and tide levels). Should the extreme high tide and/or tidal surge be higher than the local flood defences, overtopping will occur and, where the defences are of poor standard, the breach of the defences is also a risk, causing more rapid and dangerous inundation of low-lying areas.	The tidal flood water will penetrate through and fill low-lying areas within the floodplain in a sheet of water, with rapid inundation and greater depths close to the defences. Further away from the defences, the flood water will be shallower, but may be fast-moving.	Infrastructure, land and property behind the defences within the tidal Flood Zone.

6. Surface water drainage network – exceedance of the network capacity		
Source	**Pathway**	**Receptor**
Surface water networks are developed in parallel with infrastructure development, to replace surface water flow enabling that development to occur. Surface water drainage flooding occurs when the volume of surface water arising from rainstorms exceeds the capacity of the surface water drainage network, known as exceedance. Exceedance can occur from water which: a) Cannot get into the system because it is full; b) Spills out from man-holes due to upstream pressure in the pipeline known as surcharging.	The flood water from manholes will tend to follow the surface water flow paths at variable depths and extents. Except where there is contamination with foul sewage, or close to the source, it may be difficult to identify it as surface water drainage flooding.	Infrastructure around and down-slope of manholes and gullies.

SECTION 7

SUSTAINABLE MANAGEMENT OF FLOOD RISK

7 SUSTAINABLE MANAGEMENT OF FLOOD RISK

7.1 Overview

7.1.1 The sustainable management of flood risk is of key importance to new and existing developments. Significant advancements in the sustainable management of flood risk have occurred over recent years, from the publication of Planning Policy Statement 25: Development and Flood Risk through to more recent changes in legislation such as the National Planning Policy Framework, Flood and Water Management Act and Flood Risk Regulations. The sustainable management of flood risk is a statutory planning consideration that must be addressed as part of the planning approval process.

7.1.2 The potential impacts of flooding are wide ranging. The most commonly reported impacts are typically associated with damage to private property and the inconvenience and financial implications that this can cause. However, flooding can pose significant direct and indirect risk to loss of life, including that associated with the inability to evacuate those in need of emergency services. Flooding can also have significant economic implications, for example through damage to business premises or disruption to travel.

7.1.3 The most significant flood risk issues are typically associated with fluvial and tidal sources. However, in recent years greater consideration has been given to the potential risks posed by local sources of flooding such as surface water, groundwater and sewerage flooding. This is reflected in activities such as the preparation of the Surface Water Management Plan and the clarification of responsibilities in the Flood and Water Management Act and Flood Risk Regulations. The sustainable management of flood risk from these sources must therefore also be taken into consideration in the design of new or redeveloped sites and in the development control process.

7.1.4 Recent history has shown the devastating impacts that flooding can have on lives, homes and businesses. A considerable number of people live and work within areas that are susceptible to flooding and, ideally, development should be moved away from these areas over time. It is recognised, though, that this is often not a practicable solution. For this reason, careful consideration must be taken of the measures that can be put into place to minimise the risk to property and life posed by flooding. These should address the flood risk not only in the short term, but throughout the lifetime of the proposed development. This is a requirement of NPPF.

7.1.5 The primary purpose of the SFRA is to inform decision making as part of the planning and development control process, taking due consideration of the scale and nature of the flood risk affecting the Borough. Responsibility for flood risk management resides with a number of organisations, and indeed individual landowners, as outlined below.

7.2 Responsibility for Flood Risk Management

7.2.1 A number of organisations are responsible for managing the risk of flooding in England although there is no statutory requirement for the Government to protect property against the risk of flooding. However, the Government recognise the importance of safeguarding the wider community and in doing so the economic and social wellbeing of the nation. An overview of key responsibilities with respect to flood risk management is provided below.

Greater London Authority

7.2.2 The Greater London Authority (GLA) is responsible for producing a number of strategies relevant to managing flood risk, including the London Plan, Water Strategy and Climate Change Adaptation Strategy. The GLA should consider flood risk when reviewing strategic planning decisions including (for example) the provision of future housing and transport infrastructure. The GLA is responsible for developing a Regional Flood Risk Appraisal (RFRA) to inform the development (and distribution) of housing targets for boroughs throughout the Greater London area, as discussed in Section 3.

Environment Agency

7.2.3 The Environment Agency is responsible for taking a strategic overview of the management of all sources of flooding and coastal erosion throughout England – as set out within the National Flood and Coastal Risk Management Strategy discussed in Section 3. The Environment Agency also has operational responsibility for managing the risk of flooding from main rivers, reservoirs, estuaries and the sea, as well as being a coastal erosion risk management authority.

7.2.4 The Environment Agency assists the planning and development control process through the provision of information and advice regarding flood risk and flooding related issues. The Environment Agency is a statutory consultee for many developments located within areas potentially at flood risk, including development within the high risk Flood Zone 3 (excluding minor extensions and some change of use proposals), development greater than 1 hectare in size within the medium risk Flood Zone 2, and development within 20m of a main river. A full explanation of when the Environment Agency must be consulted is provided on the Government website www.gov.uk[20].

7.2.5 The Environment Agency is also responsible for flood forecasting and flood warning.

Lead Local Flood Authority

7.2.6 The Lead Local Flood Authority (LLFA) for an area is defined by the Flood and Water Management Act as the unitary authority or, if applicable, the county council for the area and, in this case, is the London Borough of Barking and Dagenham. The LLFA is responsible for managing the risk of flooding from local sources of flood risk, namely surface water, groundwater and ordinary watercourses. The LLFA is also responsible for the development, maintenance and application of a flood risk management strategy in their area and maintaining a register of flood risk assets.

7.2.7 As discussed in Section 3 LLFAs now have a duty to review and comment on the management of surface water relating to planning applications for major development and that the proposals are in accordance with the Non-Statutory Technical Standards for Sustainable Drainage Systems.

7.2.8 The LLFA is responsible for issuing consents for altering, removing or replacing certain structures or features on ordinary watercourses, and also play a lead role in emergency planning and recovery after a flood event.

[20] https://www.gov.uk/flood-risk-assessment-local-planning-authorities

Highways Authority

7.2.9 The local highways authority, in this case the London Borough of Barking and Dagenham, is responsible for managing flood risks associated with highways drainage systems serving all adopted roads and for the maintenance of highways drainage systems serving all adopted roads (excluding trunk roads managed by Highways England or Transport for London).

Local Planning Authority

7.2.10 The Local Planning Authority, in this case the London Borough of Barking and Dagenham, is responsible for carrying out a Strategic Flood Risk Assessment. The SFRA should consider the risk of flooding throughout the Borough and should inform the allocation of land for future development, development control policies and sustainability appraisals. During the determination of planning applications, the Local Planning Authority must ensure that consideration has been given to the management of flood risk, including the management of site generated surface water runoff, and that appropriate robust mitigation measures have been implemented where necessary. Local Planning Authorities also have a responsibility to consult with the Environment Agency when making planning decisions, as discussed above.

Water and Sewerage Authorities

7.2.11 The relevant water and sewerage authority, in this case Thames Water, is responsible for managing the risks of flooding from surface water and foul or combined sewerage systems that serve more than one property. Where there is frequent and severe sewer flooding (including those sites included on the DG5 Register) water and sewerage undertakers are required to address this through their capital investment plans.

Landowners and Developers

7.2.12 Landowners and developers have the primary responsibility for protecting their land and property against the risk of flooding but must not build defences that have an adverse impact to adjacent properties. They are also responsible for managing the drainage of their land without increasing flood risk elsewhere, and for the management of flood risks from private sewerage systems not adopted by Thames Water or the highways authority.

7.2.13 Any new development should be in accordance with the relevant local planning policies and relevant legislation, including National Planning Policy Framework.

7.2.14 Landowners that own land through which an ordinary watercourse or main river flows (including culverted watercourses) are the responsible 'riparian owner' for the watercourse. The Environment Agency has developed a guide entitled "Living on the Edge" that provides specific advice regarding the rights and responsibilities of riparian (riverside) land, as well as the Environment Agency and other bodies. The guide is a useful reference point outlining who is responsible for flood defence and what this means in practical terms. It also discusses how stakeholders can work collaboratively to protect and enhance the natural environment of our rivers and streams. This guide can be found at www.gov.uk[21].

[21] https://www.gov.uk/government/publications/riverside-ownership-rights-and-responsibilities

7.3 Planning and Development Control

Planning Solutions to Flood Risk Management

7.3.2 The risk of flooding is most effectively addressed through avoidance, which in very simple terms equates to guiding future development (and regeneration) away from areas at risk. Development that is sustainable for future generations is essential and it is widely recognised that the risk of flooding cannot be considered in isolation. There are many tests and measures of 'sustainability' that must be weighed in the balance when locating and designing future development.

7.3.3 NPPF endeavours to guide Local Planning Authorities and the Environment Agency in this decision making process and the Sequential and Exception Tests underpin the method by which flood risk should be taken into consideration as part of the planning process. The application of these tests within the London Borough of Barking and Dagenham is outlined below.

The Sequential Test

7.3.4 The ideal solution to effective and sustainable flood risk management is a planning led one, i.e. steer urban development away from areas that are susceptible to flooding.

7.3.5 NPPF advocates a sequential approach that will guide the planning decision making process (i.e. the allocation of sites) through the application of the Sequential Test. In simple terms, the Sequential Test aims to steer new development to areas with the lowest probability of flooding and requires planners to seek to allocate sites for future development within areas of lowest flood risk in the initial instance. Only if it can be demonstrated that there are no suitable sites within these areas should alternative sites (i.e. within areas that may potentially be at risk of flooding) be considered.

7.3.6 The most significant sources of flood risk considered during the development control process are typically associated with fluvial and tidal sources of flooding. Development should be steered to Flood Zone 1 in the first instance, and only if there are no reasonably available sites located in Flood Zone 1 should sites be considered in Flood Zones 2 and 3, supported by an appraisal of risk and the implementation of appropriate reduction and management measures.

7.3.7 Consideration should also be given to other local sources of flood risk including surface water, groundwater, surcharging of sewers, reservoirs and any other artificial sources. Whilst these sources of flood risk may have less influence over the suitability of land for development, it is essential that any new or redeveloped sites take these risks into account and, where necessary, protect the development against flood risk and ensure no increased flood risk elsewhere as a result of development.

7.3.8 The assessment of flood risk considers both the risk of flooding to a development site as well as the vulnerability of the proposed development to the impacts of flooding. Planning Practice Guidance to NPPF summarises the proposed vulnerability classification for different types of development to flood risk. Within a proposed development site, a sequential approach should be promoted that proposes to locate the most vulnerable areas of a development to those areas of the site that are at least flood risk. Similarly, the redevelopment of previously developed sites should aim to relocate vulnerable development to areas at lesser flood risk, using the redevelopment of the site to reduce existing flood risk.

7.3.9 It is important to recognise that the principles of the sequential approach are applicable throughout the planning cycle and refer equally to the forward planning process (delivered by Council as part of the LDF) as they do to the assessment of windfall sites. Where windfall sites come forward for consideration, it is essential that the developer considers the planning 'need' for the proposed site. The Council will assist where possible with supporting information, as it is their responsibility to carry out the Sequential Test.

The Exception Test

7.3.10 If, following application of the Sequential Test, it is not possible for the development to be located in zones with a lower probability of flooding, the Exception Test can be applied if appropriate. For the Exception Test to be passed:

- 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.

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

7.3.12 Planning Practice Guidance to NPPF provides recommendations on the compatibility of each vulnerability classification within each of the mapped fluvial and tidal Flood Zones and summarises where the Exception Test will be required, as shown in Table 7.1. It is, however, important to note that even where development is considered acceptable, the Sequential Test and sequential approach (as discussed above) should still be applied.

Table 7.1 Flood risk vulnerability and flood zone compatibility

EA Flood Zone	Essential Infrastructure	Water Compatible	Highly Vulnerable	More vulnerable	Less vulnerable
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	✓	Exception test required	✓	✓
Zone 3a	Exception test required	✓	×	Exception test required	✓
Zone 3b	Exception test required	✓	×	×	×

✓ Development considered acceptable

× Development considered unacceptable

7.3.13 Many parts of Barking and Dagenham are situated within the defended Flood Zone 3a. Significant regeneration of some of these areas, particularly at Barking Riverside and Dagenham Dock, has already begun with further regeneration and investment proposed. Prohibiting future development in these areas is likely to have a detrimental impact upon the future economic and social welfare of the community and,

consequently, there are clearly other non-flooding related planning 'needs' that warrant further consideration of these areas. It is also appreciated that further windfall sites that have not been identified by the Council as strategic development areas may also come forward as viable sites for development even if located in areas identified to be at risk. The Council and potential future developers are therefore required to work through the Exception Test for any site that falls into the categories summarised in Table 7.1.

7.3.14 For those sites that have been identified by the Council as a strategic development site, a more detailed assessment of flood risk is provided within the Level 2 SFRA. In these cases the Level 2 SFRA applies the Exception Test, where required, in accordance with the NPPF.

Flood Risk Assessment

7.3.15 As set out in the NPPF and as summarised within Environment Agency Standing Advice, local planning authorities should only consider development in flood risk areas where informed by a site-specific flood risk assessment.

7.3.16 The developer will be required to demonstrate within the site-specific flood risk assessment that the Sequential Test has been applied and, where appropriate, that the risk of flooding has been adequately addressed in accordance with NPPF. A detailed description of when a site-specific flood risk assessment is required and the required content of that assessment is provided in Section 7.5 and via information available at www.gov.uk[22].

7.3.17 An overview of flood risk throughout the Borough has been provided in Section 6 and the adjoining flood risk maps. Future planning decisions should consider the spatial variation in flood risk across the Borough, as defined by the delineated flood zone that applies at the specified site location, and apply the recommendations provided below accordingly. It is reiterated that NPPF applies equally to both allocated sites identified within the emerging LDF and future windfall sites.

Reducing Flood Risk through Development

7.3.18 It is crucial to reiterate that NPPF considers not only the risk of flooding posed to new development, but also seeks to positively reduce the risk of flooding posed to existing properties within the Borough. It is strongly recommended that this principle be adopted as the underlying 'goal' for developers and Council development control teams within the Borough.

7.3.19 Developers should be encouraged to demonstrate that their proposal will deliver a positive reduction in flood risk to the Borough, whether that be by reducing the frequency or severity of flooding (for example, through the introduction of SUDS), or by reducing the impact that flooding may have on the community (for example, through a reduction in the number of people within the site that may be at risk). This should not be seen as an onerous requirement, and if integrated into the design at the conceptual stage, will place no added demands upon the development and/or planning application process.

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

7.3.20 Possible risk reduction measures for consideration may include the following:

- The integration of SUDS to reduce the rate and volume of runoff from the site;
- A change in land use to reduce the vulnerability of the proposed development;
- A reduction in the building platform area;
- The raising of internal floor levels and flood proofing (within existing buildings) to reduce potential flood damage;
- The rearrangement of buildings within the site to remove obstructions to overland flow paths;
- The placement of buildings to higher areas within the site to limit the risk of flood damage;
- The integration of landscaping for flood storage and flood resilience;
- Improvements to existing water features and assets such as de-silting or unblocking of culverts and naturalisation of waterways;
- Improved management of watercourses, drainage features and culverts to reduce of flood risk associated with poor maintenance.

7.3.21 A recommendation from the SWMP was that policies on the use of soakaways, water butts, rainwater harvesting, permeable paving and green roofs should be linked to planning and building regulation such that they are applied proactively to any new development. Potential flood alleviation schemes where also identified and further details can be found in the SWMP report.

7.3.22 It is recommended that a clear statement is requested within each flood risk assessment that concisely summarises how the developer has strived to achieve a reduction in flood risk within the proposed (re)development. This may be specified as (for example) a reduction in flow from the site, a reduction in water levels within (or adjacent to) the site, or a reduction in the consequences of flooding.

Summary of Development Control Recommendations

7.3.23 A summary of key development control recommendations is provided in Table 7.2. These recommendations are discussed in greater detail in Sections 7.5 to Section 7.9 of this report.

Table 7.2 Spatial Planning and Development Control Recommendations

Policy Response	NPPF Flood Zone							Other Sources of Flood Risk
	Zone 3b Functional Floodplain	Zone 3a High Probability				Zone 2 Medium Probability	Zone 1 Low Probability	
		Undefended Fluvial and Tidal Flooding	Defended Fluvial and Tidal Flooding					
			Rate of Inundation <5 hours	Rate of Inundation 5 to 10 hours	Rate of Inundation >10 hours			
SPATIAL PLANNING RECOMMENDATIONS								
Land Use	Future development within Zone 3b should only be considered following application of the Sequential Test. Within a development site, a sequential approach should be adopted.	Future development within the undefended Zone 3a should only be considered following application of the Sequential Test. Within a development site, a sequential approach should be adopted.	Future development within the defended Zone 3a should only be considered following application of the Sequential Test. Within a development site, a sequential approach should be adopted.			Future development within the defended or undefended Zone 2 should only be considered following application of the Sequential Test. Within a development site, a sequential approach should be adopted.	N/A	Within a development site, a sequential approach should be adopted.
	Only development classified as water compatible and certain essential infrastructure that has to be located in Flood Zone 3b is considered acceptable. Essential infrastructure will be required to pass the Exception Test.	Only development classified as water compatible and less vulnerable is considered acceptable in the undefended Flood Zone 3a. Essential infrastructure development classified as more vulnerable may be accepted if it can successfully pass the Exception Test. Development classified as highly vulnerable should not be permitted.	Only development classified as water compatible and less vulnerable is considered acceptable in the defended Flood Zone 3a. Essential infrastructure development classified as more vulnerable may be accepted if it can successfully pass the Exception Test. Development classified as highly vulnerable should not be permitted.			All types of development, with the exception of highly vulnerable development, are considered acceptable in the defended or undefended Flood Zone 2. Development classified as highly vulnerable may be accepted if it can successfully pass the Exception Test.	All types of development are considered acceptable in Flood Zone 1, although consideration should still be given to other sources of flooding.	All types of development are considered acceptable for sites that are in Flood Zone 1 but may be at risk from other sources of flooding.
Important Considerations	Seek to relocate existing development to land with a lower probability of flooding. Do not impede flood flows and seek opportunities to reduce the overall level of flood risk in the area.	Seek to relocate existing development to land with a lower probability of flooding. Create space for flooding and seek opportunities to reduce the overall level of flood risk in the area.	Seek to relocate existing development to land with a lower probability of flooding. Seek opportunities to reduce the overall level of flood risk in the area and seek opportunities to improve existing flood defence.			Seek opportunities to reduce the overall level of flood risk in the area. Consider risks to access and egress for sites that are surrounded by the defended or undefended Flood Zone 3a or 3b.	Seek opportunities to reduce the overall level of flood risk in the area. Consider risks to access and egress for sites that are surrounded by the defended or undefended Flood Zone 2, 3a or 3b.	Consider risks to access and egress for sites that are surrounded by the defended or undefended Flood Zone 2, 3a or 3b.
DEVELOPMENT CONTROL RECOMMENDATIONS								
Detailed Flood Risk Assessment	Required for all development.	Required for all development.	Required for all development. The assessment of flood risk in areas that benefit from flood defences should include an assessment of risk following a breach in the flood defences.			Required for all development.	Required for all sites one hectare or greater, and/or if the development is within an EA critical drainage area, and/or if the development could be subject to other sources of flooding.	Required for all sites at risk of surface water flooding up to the 1 in 30 annual probability event, or at risk of flooding to a depth greater than 300mm during the 1 in 100 annual probability event, or in an area at risk of flooding from reservoirs.
Environment Agency Consultation	Required for all development.	Required for all development, excluding minor development and some change of use proposals unless these are within 20m of a main river.	Required for all development, excluding minor development and some change of use proposals unless these are within 20m of a main river.			Required for all development greater than 1 hectare or if the development is classified as essential infrastructure, highly vulnerable, a caravan site, is within 20m of a main river, or poses pollution risk.	Required for development located within 20m of a main river or if development is located in an EA designated critical drainage area.	Required for development located within 20m of a main river or if development is located in an EA designated critical drainage area.
Floor Level	Ground floor levels are to be situated a minimum of 0.3m above the 1 in 100 annual probability fluvial flood level or 1 in 200 annual probability tidal flood level, including allowance for climate change.	Ground floor levels are to be situated a minimum of 0.3m above the 1 in 100 annual probability fluvial flood level or 1 in 200 annual probability tidal flood level, including allowance for climate change.	Typically, ground floor levels are to be situated a minimum of 0.3m above the 1 in 100 annual probability fluvial flood level or 1 in 200 annual probability tidal flood level following a breach in the defences and including allowance for climate change.		Recommend ground floor levels are situated above or raised to a level above which the rate of inundation would be 10 hours or greater.	Ground floor levels are to be situated a minimum of 0.3m above the 1 in 100 annual probability fluvial flood level or 1 in 200 annual probability tidal flood level, including allowance for climate change, or set a minimum of 0.3m above adjacent ground level.	No minimum level required, although recommend ground flood levels are situated 150mm above adjacent ground level and consider other sources of flooding.	Recommend ground floor levels are situated 0.3m above adjacent ground level, or above the estimated flood depth.

Policy Response		NPPF Flood Zone							Other Sources of Flood Risk
		Zone 3b Functional Floodplain	Zone 3a High Probability				Zone 2 Medium Probability	Zone 1 Low Probability	
			Undefended Fluvial and Tidal Flooding	Defended Fluvial and Tidal Flooding					
				Rate of Inundation <5 hours	Rate of Inundation 5 to 10 hours	Rate of Inundation >10 hours			
DEVELOPMENT CONTROL RECOMMENDATIONS									
Site Access & Egress	Highly Vulnerable	N/A	N/A	N/A			Dry access should be provided above the 1 in 100 annual probability fluvial flood level (including allowance for climate change) or 1 in 200 annual probability tidal flood level (including allowance for climate change). Where this is not possible, safe access with 'very low' flood hazard should be demonstrated.	Dry access should be provided above the 1 in 100 annual probability fluvial flood level (including allowance for climate change) or 1 in 200 annual probability tidal flood level (including allowance for climate change). Where this is not possible, safe access with 'very low' flood hazard should be demonstrated.	Consideration should be given to the impact of flooding from other sources to the ability to provide safe access and egress, similar to those recommendations made for sites at risk from fluvial and tidal flooding.
	More Vulnerable	N/A	Dry access should be provided above the 1 in 100 annual probability fluvial flood level (including allowance for climate change) or 1 in 200 annual probability tidal flood level (including allowance for climate change). Where this is not possible, safe access with 'very low' flood hazard should be demonstrated.	Dry access should be provided above the 1 in 100 annual probability fluvial flood level (including allowance for climate change) or 1 in 200 annual probability tidal flood level (including allowance for climate change). Where this is not possible, safe access with 'very low' flood hazard should be demonstrated. Only where neither of these is feasible, a dedicated 'safe haven' should be provided. This may be provided in the form of a sheltered communal space within the building, accessed via internal stairs. It will be necessary to ensure that the safe haven is sufficient in size to safely house all residents/users of the building and consideration must be given to the needs of vulnerable and disabled users of the development.			Dry access should be provided above the 1 in 100 annual probability fluvial flood level (including allowance for climate change) or 1 in 200 annual probability tidal flood level (including allowance for climate change). Where this is not possible, safe access with 'very low' flood hazard should be demonstrated.	Dry access should be provided above the 1 in 100 annual probability fluvial flood level (including allowance for climate change) or 1 in 200 annual probability tidal flood level (including allowance for climate change). Where this is not possible, safe access with 'very low' flood hazard should be demonstrated.	
	Less Vulnerable	For water compatible and essential infrastructure only: Dry access should be provided above the 1 in 100 annual probability fluvial flood level (including allowance for climate change) or 1 in 200 annual probability tidal flood level (including allowance for climate change). Where this is not possible, safe access with no greater than 'moderate' flood hazard should be demonstrated.	Dry access should be provided above the 1 in 100 annual probability fluvial flood level (including allowance for climate change) or 1 in 200 annual probability tidal flood level (including allowance for climate change). Where this is not possible, safe access with no greater than 'moderate' flood hazard should be demonstrated.	Dry access should be provided above the 1 in 100 annual probability fluvial flood level (including allowance for climate change) or 1 in 200 annual probability tidal flood level (including allowance for climate change). Where this is not possible, safe access with no greater than 'moderate' flood hazard should be demonstrated. Only where neither of these is feasible, a dedicated 'safe haven' should be provided. This may be provided in the form of a sheltered communal space within the building, accessed via internal stairs. It will be necessary to ensure that the safe haven is sufficient in size to safely house all residents/users of the building and consideration must be given to the needs of vulnerable and disabled users of the development.			Dry access should be provided above the 1 in 100 annual probability fluvial flood level (including allowance for climate change) or 1 in 200 annual probability tidal flood level (including allowance for climate change). Where this is not possible, safe access with no greater than 'moderate' flood hazard should be demonstrated.	Dry access should be provided above the 1 in 100 annual probability fluvial flood level (including allowance for climate change) or 1 in 200 annual probability tidal flood level (including allowance for climate change). Where this is not possible, safe access with no greater than 'moderate' flood hazard should be demonstrated.	
Site Specific Emerg-ency Response Plan	Highly Vulnerable	N/A	N/A	N/A			Required to support all developments.	Not required.	Not required.
	More Vulnerable	N/A	Required to support all developments.	Required to support all developments and must consider the needs of vulnerable and disabled users of the development.			Unlikely to be required to support development.	Not required.	Not required.
	Less Vulnerable	For water compatible and essential infrastructure only: Required to support all developments.	Required to support all developments.	Likely to be required to support all habitable buildings and manned sites and must consider the needs of vulnerable and disabled users of the development.			Unlikely to be required to support development.	Not required.	Not required.

Policy Response		NPPF Flood Zone							Other Sources of Flood Risk
		Zone 3b Functional Floodplain	Zone 3a High Probability				Zone 2 Medium Probability	Zone 1 Low Probability	
			Undefended Fluvial and Tidal Flooding	Defended Fluvial and Tidal Flooding					
				Rate of Inundation <5 hours	Rate of Inundation 5 to 10 hours	Rate of Inundation >10 hours			
DEVELOPMENT CONTROL RECOMMENDATIONS									
Evacuation by Emergency Services (All Flood Risk Vulnerabilities)		Site specific emergency evacuation procedures must be in place to ensure that the risk to life is minimised should a flood event occur. Coordination with the emergency services will be required in the event of a flooding emergency.					Site specific emergency evacuation procedures likely to be only required for highly vulnerable development in Flood Zone 2.	Unlikely to be required, unless at significant risk from other sources such as reservoir failure.	Unlikely to be required, unless at significant risk from other sources such as reservoir failure.
Basement structures	Highly Vulnerable	N/A	N/A	N/A			Basements should be flood resistant, and must have an internal access to a higher floor situated a minimum of 0.3m above the 1 in 100 annual probability fluvial flood level or 1 in 200 annual probability tidal flood level with an allowance for climate change. Flood resilient design techniques should be adopted for all basement uses.	No restrictions, unless identified as at risk of flooding from other sources of flooding.	Where possible, prevent the overland flow of water entering the basement structure up to and including the 1 in 30 annual probability event.Consideration should be given to the impact of flooding from other sources to the ability to provide safe access and egress, similar to those recommendations made for sites at risk from fluvial and tidal flooding.
	More Vulnerable	N/A	Basements used as habitable areas and living accommodation are not considered appropriate in the undefended Flood Zone 3a.	Basements used as habitable areas and living accommodation are not considered appropriate in the defended Flood Zone 3a.					
	Less Vulnerable	For water compatible and essential infrastructure only: No basements are considered appropriate within Zone 3b Functional Floodplain.	Safe internal access must be provided to a level 0.3m above the 1 in 100 annual probability fluvial flood level or 1 in 200 annual probability tidal flood level with an allowance for climate change. Flood resilient design techniques must be used for all basements.	No basements are considered appropriate in the defended Zone 3a if the rate of inundation is less than 5 hours.	Basements should be protected with a continuous secondary fixed flood defence and must have internal access to a level 0.3m above the 1 in 100 annual probability fluvial flood level or 1 in 200 annual probability tidal flood level with an allowance for climate change. Flood resilient design techniques should be adopted for all basement uses.	Basements should be protected with a continuous secondary fixed flood defence and must have internal access to a level 0.3m above the 1 in 100 annual probability fluvial flood level or 1 in 200 annual probability tidal flood level with an allowance for climate change. Flood resilient design techniques should be adopted for all basement uses.			
Site Runoff		Development should result in no increase in the rate or volume of runoff when compared to the existing situation. Where possible, betterment should be provided. Runoff should be infiltrated to ground where site conditions permit. If this is not possible, consideration should first be given to discharging to a watercourse (unless contamination risks are too great) before consideration is given to discharging to the sewerage network. SUDS features should be used where feasible to promote water quality, amenity and biodiversity benefits. Proposed adoption and maintenance arrangements for all proposed drainage systems must be clarified.							
Buffer Zone		An 8m buffer from the top of bank or foot of a non-tidal river flood defence will be sought for all fluvial stretches of water. A 16m buffer from the top of bank or foot of defence wall will be sought for all tidal watercourses. A Flood Risk Activities Permit is likely to be required from the EA for any works within 8m of a main river (or flood defence structure) or within 16m of a tidal main river (or flood defence structure). Ordinary Water Consent is likely to be required for any works in close proximity to an ordinary watercourse (c. 8m). Buffer zones should be naturalised wherever possible.							
Flood Resilience/Resistance		For development within areas identified to be at risk of flooding, appropriate resistance and resilience measures should be incorporated to adequately protect the development from flooding in accordance with Section 7.6. Essential infrastructure should remain operational during flooding events.							
Flood storage compen-sation	Fluvial	Compensation for any loss of Zone 3b should be provided on a like-for-like basis.	Compensation for any loss of undefended Zone 3a should be provided on a like-for-like basis.	Compensation is not required in areas that are defended from fluvial flooding.	Compensation for any loss of Zone 2 is not required.	N/A	Compensation is not required.		
	Tidal	Compensation for loss of flood storage is not required.	Compensation for loss of flood storage is not required.	Compensation is not required in areas that are defended from tidal flooding.	Compensation for any loss of Zone 2 is not required.	N/A	Compensation is not required.		

7.4 SFRA Interpretation

7.4.1 This section of the SFRA provides further clarification of how flood risk will be taken into account in the spatial planning and development control process. It is also essential that all development within Barking and Dagenham takes into account other information provided within this SFRA, particularly the requirements of policy and legislation as summarised in Section 3, the assessment of flood risks as summarised in Section 6.4, and the recommendations for climate change as summarised in Section 5.5.

7.4.2 The Barking and Dagenham SFRA should be used by both the Council and prospective developers to meet their obligations under NPPF throughout the planning cycle.

7.4.3 It is essential that prospective developers consider the most up to date flood risk information that is available at the time of preparing their development plans. The information provided within this SFRA is the best available at the time of writing, but as discussed within this SFRA new hydraulic modelling is already planned and new datasets are sure to become available in the future. It is the developer's responsibility to ensure that the most up to date datasets are being used to inform proposed development.

Forward Planning

7.4.4 Figures D1 and D2 in Appendix D provides an overview of the spatial variation in fluvial and tidal flood risk throughout the Borough of Barking and Dagenham. Flood risk in the south of the Borough is dominated by the Roding and the Beam.

7.4.5 Consideration has been given to the updated climate change recommendations on fluvial flood risk associated with the Mayes Brook, Gores Brook, Beam River and Wantz Stream as presented within Figure D3 and Figure D4. However, flood risk within the south of the Borough is dominated by the Lower Roding. The Environment Agency are due to complete updated modelling of the Lower Roding in December 2017.

7.4.6 It is necessary to adopt a sequential approach when considering where land should be allocated for future development, and this is described in Section 7.3. Appendix D should be used to inform this sequential approach, although consideration should also be given to flood mapping available through the Environment Agency's website as this is typically updated more frequently than the SFRA. Furthermore, NPPF and the supporting Planning Practice Guidance provides clear guidance on permissible land use within areas potentially at risk from flooding, and this too is discussed in Section 7.3.

7.4.7 The southern section of the Borough of Barking and Dagenham adjacent to the River Thames is shown to be within the tidal flood risk area of the River Thames. However, this area is well defended by the River Thames Tidal Defences and, therefore, the primary risk of flooding within these areas is a residual risk (i.e. to be realised only should there be a failure of the River Thames defences). Given that this is the case, it is important that a more robust assessment of the 'real' risk to property and life is considered and that planning decisions are taken accordingly. Appendix G provides an overview of the variation in flood hazard within the defended (River Thames) area of the Borough. The Council should exercise a sequential approach within the high probability Flood Zone 3a, steering more vulnerable development away from areas of highest hazard. Section 7.3 provides further advice in this regard.

7.4.8 Whilst there is no particular constraint placed upon land use within areas of the low probability Flood Zone 1 within the Borough, it is strongly recommended that the Council takes due consideration of flooding from other sources (i.e. non fluvial) and, in particular, risks associated with surface water flooding as discussed in detail in the Barking and Dagenham SWMP and highlighted in Section 6. Many localised sources of flooding within Barking and Dagenham can be effectively managed through the design process. However, it is recommended that advice is taken from the Council to ensure that the severity of the local issue that may affect (or be exacerbated by) the proposed allocation is fully appreciated.

Development Control and Developers

7.4.9 It is important that the potential risk of flooding is considered as an integral part of all proposed development within the Borough. Appendix D and Appendix G provide a measure of the severity of flooding within any proposed development sites. These, along with data available through the Environment Agency website and Barking and Dagenham SWMP, should be used to trigger a more detailed assessment of flood risk-related issues within the site, as described in Section 7.3 and Section 7.5. Within defended areas[23], a detailed assessment of the potential impact of breach failure and/or defence overtopping will also be required.

7.4.10 The assessment of localised flooding related issues is essential for all proposed development, irrespective of its location and/or scale within the Borough and the SFRA provides a helpful tool to assist in this regard. Appendix F, Appendix I and Appendix K provide an overview of groundwater emergence, geology, topography and potential overland flow paths, respectively, within the Borough of Barking and Dagenham. The detailed flood risk assessment should use this information to assess (in a site based context) the potential risk of localised ponding, flash flooding and/or inundation from surface water or groundwater.

7.5 Detailed Flood Risk Assessment

7.5.1 As discussed in Section 7.3, local planning authorities should only consider development in flood risk areas where informed by a site-specific flood risk assessment. The requirements of a site-specific flood risk assessment have been clarified by the Environment Agency and are explained in detail on the www.gov.uk website[24]. A summary of the requirements of a site-specific flood risk assessment and development control policies for each identified Flood Zone is provided below.

Scope of the Detailed Flood Risk Assessment

7.5.2 As highlighted above, the SFRA is a strategic document that provides an overview of flood risk throughout the area for the purpose of informing the Sequential Test, Exception Test and site-specific flood risk assessments.

7.5.3 A site-specific flood risk assessment is required to support any planning application for development located within the medium risk Flood Zone 2 or high risk Flood Zone 3 excluding benefits that may be offered by flood defences. A site-specific flood risk

[23] The Environment Agency has prepared a dedicated map layer referred to as 'Areas Benefitting from Defence' as depicted on the Flood Map for Planning (Rivers and Sea) that can be accessed via the www.gov.uk website here: https://www.gov.uk/check-local-environmental-data. This relates purely to areas defended from flooding from the River Thames, though, and does not include the River Roding, Gores Brook or Beam River defences. Early advice should be taken from the EA as to whether or not a breach assessment is required.

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

assessment is also required for developments in the low risk Flood Zone 1 where the development is:

- 1 hectare of greater in area;
- Located in an area with critical drainage problems as notified by the Environment Agency;
- At risk of flooding from other sources of flooding (i.e. surface water, sewerage systems or reservoirs), including a change of use in development type to a more vulnerable class (e g. from commercial to residential).

7.5.4 The site-specific flood risk assessment should identify and assess the risks of all forms of flooding to and from the development and demonstrate how these flood risks will be managed so that the development remains safe throughout its lifetime, taking climate change into account. Those proposing developments in areas identified to be at risk of flooding should take advice from the local emergency planning department and emergency services when producing an evacuation plan for the development as part of the flood risk assessment.

7.5.5 Site-specific flood risk assessments for sites greater than 1 hectare in Flood Zone 1 and with no identified risks from other sources should focus on the sustainable management of surface water runoff generated by the proposed development and opportunities to reduce risk elsewhere.

7.5.6 Although the statutory requirement to complete a site-specific flood risk assessment is defined by the location of development in areas identified to be at risk and/or the size of the proposed development, the developer should demonstrate for all types of development that consideration has been given to all sources of flood risk including overland flow, groundwater, surcharging of sewers and other artificial sources. This may include consideration of runoff from areas of higher ground or from minor watercourses that may not be illustrated on published flood maps. It is recommended that the developer consults with the LLFA to discuss any known local sources of flood risk, including that derived from anecdotal evidence that may require further investigation.

7.5.7 For all proposed developments in Flood Zone 2 and Flood Zone 3, ignoring the presence of flood defences, the site-specific flood risk assessment should demonstrate the application of the Sequential Test and, if required, the Exception Test (if not already completed for the proposed development type within the identified site). It is important to note that prior to investing resources into carrying out a detailed flood risk assessment (in particular for major developments) developers should first contact the Council to discuss the Sequential Test. It is possible that the development may be inappropriate and be refused planning permission irrespective of any flood risk assessment.

7.5.8 In accordance with NPPF, the Sequential Test does not need to be completed for minor development or for a change of use (e.g. from commercial to residential) unless your development is a caravan, camping chalet, mobile home or park home site.

7.5.9 Within all site-specific flood risk assessments, the development should demonstrate that a sequential approach has been taken that aims to steer the most vulnerable types of development to those areas within the site that are at least flood risk.

7.5.10 The site-specific flood risk assessment should be commensurate with the risk of flooding to the proposed development. For example, where the risk of fluvial and/or tidal flooding to the site is negligible (e.g. Zone 1 Low Probability) and it is not indicated as being at risk of flooding from other sources or likely to impact on any known problem area off-site, there is little benefit to be gained in assessing the potential risk to life and/or property as a result of flooding. Rather, emphasis should be placed on ensuring that runoff from the site does not exacerbate flooding lower in the catchment. The particular requirements for flood risk assessments within each delineated flood zone are outlined below.

Proposed Development within Flood Zone 3b – the Functional Floodplain

7.5.11 The functional floodplain is defined as those areas where water has to flow or be stored in times of flood. It is typically defined as land which would flood with an annual probability of 1 in 20 (5%) or greater in any year but should take account of local circumstances.

7.5.12 Only development classified as 'water compatible' and certain essential infrastructure as defined by NPPF that has to be located in these areas should be permitted in Flood Zone 3b. A site-specific flood risk assessment will be required to support the planning application and this should demonstrate that the development will be designed and constructed 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.

7.5.13 For development proposed to be located within Flood Zone 3b, developers 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 with a lower probability of flooding.

7.5.14 Essential infrastructure in this zone will be required to pass the Exception Test and this should also be demonstrated within the site-specific flood risk assessment.

Proposed Development within Zone 3a - High Probability

7.5.15 Flood Zone 3 is defined as land assessed as having a 1 in 100 (1%) or greater annual probability of river flooding or a 1 in 200 (0.5%) or greater annual probability of flooding from the sea in any year. Within Barking and Dagenham, a significant proportion of land within the mapped Flood Zone 3a is protected by flood defences. Whilst the same key principles of development control will apply to both defended and undefended areas, the management of identified flood risks may differ.

7.5.16 Only development classified as 'water compatible' and 'less vulnerable' as defined by NPPF are considered appropriate in the defended and undefended Flood Zone 3a,

although development classified as 'essential infrastructure' and 'more vulnerable' is also considered acceptable subject to the successful application of the Exception Test. The redevelopment of brownfield land will be of key importance when demonstrating the wider sustainability benefits of development in Flood Zone 3a.

7.5.17 Development classified as 'highly vulnerable' is not considered appropriate in the defended or undefended Flood Zone 3a.

7.5.18 A site-specific flood risk assessment will be required to support the planning application for any development in the defended and undefended Flood Zone 3a. This should clearly summarise:

- the predicted fluvial and/or tidal flood risk within the development site, including the estimated flood levels, existing site topography and proposed development levels;
- the predicted duration, rate and order of inundation, hazard and consequences of flood risk;
- predicted flood risks from other sources of flooding, including surface water, groundwater, surcharging of sewers, reservoirs and other artificial sources;
- information of any known past flood events that effected the site;
- an assessment of the potential impacts of climate change over the life time of the development on all sources of identified flood risk;
- consideration of site access and egress routes and the risk of flooding to these routes during a flood event up to the 1 in 100 (1%) annual probability fluvial plus climate change event or the 1 in 200 (0.5%) annual probability tidal plus climate change event, taking into consideration the risk of the site within a 'dry island';
- an assessment of the impact of the development on flood risk elsewhere, including that associated with loss of flood plain storage (where appropriate) and site generated surface water runoff;
- proposed resistance and resilience measures that will be incorporated into the development to address identified flood risks and an assessment of any residual risks;
- application of the Sequential Test (if not assessed previously) and, where appropriate, successful application of the Exception Test.

7.5.19 It should be noted that any loss of flood plain storage within the undefended fluvial Flood Zone 3a up to the 1 in 100 (1%) probability annual year plus climate change event may need to be compensated for on a like-for-like basis to ensure no increased flood risk elsewhere as a result of development. This should be discussed with the Council and Environment Agency during the preparation of the flood risk assessment.

7.5.20 The assessment of flood risk as described above in areas that benefit from flood defences should include an assessment of risk following a breach in the flood defences, as informed by breach analysis completed by the Environment Agency. In areas of defended floodplain that have not yet been modelled for breach analysis, it may be

necessary to complete this to inform the assessment and this should be discussed with the Council and Environment Agency prior to completing the assessment.

7.5.21 Development proposed within Flood Zone 3a, including that within areas identified to benefit from flood defences, is likely to need to be supported by a flood evacuation plan and/or emergency response plan prepared in consultation with the local emergency planning department and emergency services. This should be determined within the site-specific flood risk assessment in consultation with the Council and Environment Agency.

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

7.5.23 For development proposed to be located within Flood Zone 3a, developers 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 with a lower probability of flooding;
- 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.

Proposed Development within Zone 2 - Medium Probability

7.5.24 Flood Zone 2 is defined as land assessed as having between a 1 in 100 (1%) and 1 in 1000 (0.1%) annual probability of river flooding, or between a 1 in 200 (0.5%) and 1 in 1000 (0.1%) annual probability of flooding from the sea in any year. Within Barking and Dagenham, the majority of land within the mapped Flood Zone 2 is protected by flood defences. The same key principles of development control will apply to both defended and undefended areas, although the management of identified flood risks may differ.

7.5.25 The majority of development is considered appropriate in the defended and undefended Flood Zone 2. Only development classified as 'highly vulnerable' as defined by NPPF is not considered appropriate in this flood zone unless subject to the successful application of the Exception Test. The redevelopment of brownfield land will be of key importance when demonstrating the wider sustainability benefits of development in Flood Zone 2.

7.5.26 A site-specific flood risk assessment will be required to support the planning application for any development in the defended and undefended Flood Zone 2. This should clearly summarise:

- the predicted fluvial and/or tidal flood risk within the development site, including the estimated flood levels, existing site topography and proposed development levels;
- the predicted duration, rate and order of inundation, hazard and consequences of flood risk;
- predicted flood risks from other sources of flooding, including surface water, groundwater, surcharging of sewers, reservoirs and other artificial sources;

- information of any known past flood events that effected the site;
- consideration of site access and egress routes and, in particular, that safe access and egress (including consideration of 'dry islands') is available up to the 1 in 100 (1%) annual probability plus climate change fluvial event and 1 in 200 (0.5%) annual probability plus climate change tidal event;
- an assessment of the potential impacts of climate change over the life time of the development on all sources of identified flood risk;
- an assessment of the impact of the development on flood risk elsewhere, including that associated with site generated surface water runoff;
- proposed resistance and resilience measures that will be incorporated into the development to address identified flood risks and an assessment of any residual risks;
- application of the Sequential Test (if not assessed previously) and, where appropriate, successful application of the Exception Test.

7.5.27 It is unlikely that development (other than highly vulnerable development) proposed within Flood Zone 2, including that within areas identified to benefit from flood defences, will need to be supported by a flood evacuation plan and/or emergency response plan prepared in consultation with the local emergency planning department and emergency services. However, the need for a flood evacuation plan and/or emergency response plan should be determined within the site-specific flood risk assessment in consultation with the Council and Environment Agency. Highly vulnerable development proposed within Flood Zone 2 is more likely to need to be supported by a flood evacuation plan and/or emergency response plan.

7.5.28 For development proposed to be located within Flood Zone 2, developers 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.

Proposed Development within Zone 1 - Low Probability

7.5.29 Flood Zone 1 is defined as land assessed as having less than a 1 in 1000 (0.1%) annual probability of flooding from rivers or the sea.

7.5.30 In accordance with NPPF, all types of development are considered appropriate in Flood Zone 1.

7.5.31 For all sites greater than 1ha in area located in Flood Zone 1, a site-specific flood risk assessment must be prepared to accompany the planning application. A site-specific flood risk assessment is also likely to be required for all sites of any size within Flood Zone 1 that:

- is in an area with critical drainage problems as notified by the Environment Agency;
- if the development could be subject to other sources of flooding (e.g. surface water flood risk), including a change of use to an existing development that makes it more vulnerable to flooding.

7.5.32 The need and scope of a site-specific flood risk assessment in Flood Zone 1 should be discussed and agreed with the Council as part of the pre-application and planning process. However, it is recommended that, at minimum, a site-specific flood risk assessment is provided for any development:

- indicated to be at risk of flooding from surface water sources up to and including the 1 in 30 (3.3%) annual probability event;
- indicated to be at risk of flooding from surface water sources to a depth greater than 300mm up to and including the 1 in 100 (1%) annual probability event;
- indicated to be at risk of flooding from reservoirs.

7.5.33 Information regarding the depth of predicted surface water flooding during the 1 in 100 (1%) annual probability event is available within the Surface Water Management Plan and Environment Agency website.

7.5.34 If deemed required, the site-specific flood risk assessment should clearly summarise:

- predicted flood risks from all sources of flooding, including surface water, groundwater, surcharging of sewers, reservoirs and other artificial sources;
- information of any known past flood events that effected the site;
- consideration of site access and egress routes and, in particular, that safe access and egress (including consideration of 'dry islands') is available up to the 1 in 100 (1%) annual probability plus climate change fluvial event and 1 in 200 (0.5%) annual probability plus climate change tidal event.
- an assessment of the potential impacts of climate change over the life time of the development on all sources of identified flood risk;
- an assessment of the impact of the development on flood risk elsewhere, principally that associated with site generated surface water runoff;
- if appropriate, application of a sequential approach to development layout.

7.5.35 For development proposed to be located within Flood Zone 1, developers 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.

Liaison with the Environment Agency and Lead Local Flood Authority

7.5.36 The Environment Agency is a statutory consultee for many developments located within areas potentially at flood risk and developers are advised to consult with the Environment Agency during the planning application process for the following developments:

- all development located within the high risk Flood Zone 3 (excluding minor extensions and some change of use proposals);
- all development of greater than 1ha in size and located within Flood Zone 2;

- development in Flood Zone 2 that is classified as:
    - essential infrastructure;
    - highly vulnerable;
    - more vulnerable and is a landfill or waste facility or is a caravan site;
    - less vulnerable and is one of the following: land or building used for agriculture or forestry; a waste treatment site; a mineral processing site, a water treatment plant; or a sewage treatment plant;
- all development within 20m of a main river.

7.5.37 A full explanation of when the Environment Agency must be consulted is provided on the Government website www.gov.uk[25].

7.5.38 To assist local planning authorities and developers, the Environment Agency has produced Standing Advice to inform on their requirements for developments not included within the list above. Full details of their Flood Risk Standing Advice can be found at www.gov.uk[25].

7.5.39 The Environment Agency is an excellent source of information to inform the development of the detailed flood risk assessments. The Customers and Engagement Team should be contacted as early as possible to source information relating to (for example) up to date mapped outputs, historical flooding, hydraulic modelling and topography (LiDAR). It is emphasised that the information provided within the SFRA is the best available at the time of writing. More up to date information may be available and contact should always be made with the Environment Agency at an early stage to ensure that the detailed site based flood risk assessment is using the most current datasets, avoiding unnecessary re-work.

7.5.40 It is recommended that developers consult with the LLFA, namely the Council for Barking and Dagenham, at an early stage of the planning application process to discuss any known flood risk issues at the proposed development site, the need and scope of a site-specific flood risk assessment and opportunities to reduce the overall flood risk in the area, including the sustainable management of surface water runoff.

7.5.41 Consultation with the Council is also recommended for any development within close proximity (recommended 8m from top of bank) of an ordinary watercourse. Consent for works within close proximity of an ordinary watercourse may require consent from the Council in accordance with the Land Drainage Act 1991.

7.5.42 For all development in areas identified to be at flood risk for which the Environment Agency are not a statutory consultee, consultation with the Council should be undertaken to agree site-specific flood resilience and resistance measures in accordance with Environment Agency Standing Advice.

7.5.43 It is strongly recommended that a draft of the detailed flood risk assessment is provided to the Council and, where appropriate, the Environment Agency for review and

[25] https://www.gov.uk/flood-risk-assessment-local-planning-authorities

comment before being submitted with the Planning Application, thereby reducing potentially costly delays to the planning process.

7.6 Resistance and Resilience Measures

7.6.1 For development within areas identified to be at risk of flooding, the developer will need to demonstrate that appropriate resistance and resilience measures have been incorporated to adequately protect the development from flooding. A range of possible measures is provided below.

7.6.2 The need for site-specific resistance and resilience measures for all developments will need to be agreed in consultation with the relevant authorities and tailored to site-specific conditions. For those developments that require Environment Agency statutory consultation, these measures should be agreed to meet Environment Agency requirements. For those developments for which Environment Agency Standing Advice applies, measures should be discussed and agreed with the Council as LLFA.

Raised Floor Levels (Freeboard)

7.6.3 The raising of floor levels within areas identified to be at risk of flooding from any source (i.e. including surface water and other local sources) can ensure that the risk to life, and damage to property, is minimised.

7.6.4 Typically, floor levels within new development should be situated a minimum of 0.3m above the predicted 1 in 100 (1%) annual probability design flood level for fluvial flooding scenarios, including an allowance for climate change effects. Within tidal areas, this should be taken as the 1 in 200 (0.5%) annual probability design flood level, including an allowance for climate change effects, calculated assuming a breach of the raised flood defences. The height that the floor level is raised above flood level is referred to as the 'freeboard' and is determined as a measure of the residual risks, confidence in flood data and vulnerability of development. Typically it is recommended that a minimum freeboard of 0.6m would be applied where there is uncertainty regarding predicted flood levels and/or for highly vulnerable development, where as a freeboard of 0.3m would be more applicable where a detailed and up-to-date hydraulic model exists and/or the development has low vulnerability.

7.6.5 In areas at risk of surface water flooding, it is recommended that floor levels within new development should be situated a minimum of whichever is higher of 0.3m above existing ground levels or 0.3m above the estimated flood depth, taking the potential effects of climate change into account.

7.6.6 For development for which Environment Agency Standing Advice applies, it is typical for ground floor levels to be a minimum of whichever is higher of 0.3m above the general ground level of the site or 0.3m above the estimated river or sea flood level as discussed above. If it is not possible to locate ground floor levels above the estimated flood level, resistance and resilience measures as discussed below should be considered.

Flood Resilience

7.6.7 If it is not possible to raise ground floor levels above the estimated flood level for the site, the following recommendations are included within Environment Agency Standing Advice:

- Water depth up to 0.3m:

- Design the proposed building or development to keep water out as much as possible. Do this by using materials that have low permeability (i.e. materials that water cannot pass through such as impermeable concrete).

- Water depth from 0.3m to 0.6m:
  - Design the proposed building or development to keep water out (unless there are structural concerns) by using materials with low permeability to at least 0.3m; using flood resilient materials (e.g. lime plaster) and design (raised electrical sockets); and making sure there's access to all spaces to enable drying and cleaning.

- Water depth above 0.6m:
  - Design the proposed building or development to allow water to pass through the property to avoid structural damage by using materials with low permeability to at least 0.3m; making it easy for water to drain away after flooding; and making sure there's access to all spaces to enable drying and cleaning.

7.6.8 Development located within the defended Flood Zone 3a may be at risk from sudden inundation following a breach of the flood defences, with an associated 'extreme' flood hazard due to the predicted depth and velocity of flood waters in some areas. If it is not possible to locate the ground floor level of the development above the predicted flood level, it is recommended that the developer strives to reduce the rate of inundation (i.e. through raising ground levels as high as practicable without increasing flood risk elsewhere) to 10 hours or greater to provide sufficient time to facilitate evacuation of the site. Access and evacuation is discussed in greater detail below.

Basements

7.6.9 Basements in areas of the London Borough of Barking and Dagenham that fall within Flood Zone 3b are not considered appropriate.

7.6.10 Within the undefended Flood Zone 3a, basements with a proposed use classified as more vulnerable and/or to be used as habitable areas and living accommodation are not considered appropriate. Basements with a proposed use classified as less vulnerable within the undefended Flood Zone 3a or within the defended Flood Zone 3a where the rate of inundation due to a breach of the defences is greater than 5 hours are considered acceptable, but must have a point of access that is situated 0.3m above the 1 in 100 (1%) annual probability fluvial flood level or 1 in 200 (0.5%) annual probability tidal flood level, plus climate change allowance. Basements in the defended Flood Zone 3a where the rate of inundation is less than 5 hours are not considered appropriate.

7.6.11 Within the medium risk Flood Zone 2, basements are considered appropriate, but must have a point of access that is situated 0.3m above the 1 in 100 (1%) annual probability fluvial flood level or 1 in 200 (0.5%) annual probability tidal flood level, plus climate change allowance.

7.6.12 It is particularly important to ensure that basements within areas benefitting from flood defences are provided within a 'continuous secondary fixed flood defence'. In practical terms, this may be a raised wall incorporated into the landscaping that will withstand the ponding of water (i.e. following a breach failure), and will prevent water surging into the basement area with little or no warning.

7.6.13 There are no restrictions on basements in Flood Zone 1, however the risk of flooding from other sources must be considered. Where possible, the overland flow of water entering the basement structure up to and including the 1 in 30 (3.3%) annual probability surface water flood event should be prevented from entering the basement structure. Consideration should also be given to the impact of flooding and the ability to provide safe access and egress up to and including the 1 in 100 (1%) annual probability surface water flood event.

Access and Evacuation

7.6.14 For developments located within Flood Zone 3 or areas at significant risk of flooding from other sources, developers will need to provide details of emergency escape plans for any parts of a building that are below the estimated flood level. This requirement also applies to any development located within a lower flood zone where vehicular access (particularly to enable access to emergence services and other key infrastructure) requires passage through an area at higher risk. The creation of 'dry islands' is of particular importance.

7.6.15 The definition of 'safe' access and egress is somewhat defined by the vulnerability of the proposed development and the ability of the users of that development to escape the identified risks. 'Flood hazard', as described in Section 5.4, is an important consideration in the assessment of risk.

7.6.16 For 'more vulnerable' development located in the defended or undefended high risk Flood Zone 3, or if the access route passes through this flood zone, it is recommended that dry access is provided above the 1 in 100 (1%) annual probability fluvial or 1 in 200 (0.5%) annual probability tidal flood level and allowing for the potential effects of climate change. Where this is not possible, it may be acceptable to demonstrate that a suitable access and egress routes subject to 'very low' flood hazard is available.

7.6.17 For 'less vulnerable' development located in the defended or undefended high risk Flood Zone 3, or if the access route passes through this flood zone, it is also recommended that dry access is provided above the 1 in 100 (1%) annual probability fluvial or 1 in 200 (0.5%) annual probability tidal flood level and allowing for the potential effects of climate change. However, where this is not possible, a viable access and egress route that is subject to 'moderate' flood hazard may be considered acceptable.

7.6.18 Within the defended Flood Zone 3a it may not always be possible to evacuate the site following a breach in the tidal flood defences, particularly for those developments that are at risk of rapid inundation. Where safe access cannot be provided, a sheltered communal space within the building, accessed via internal stairs, should be provided. It will be necessary to ensure the safe haven is sufficient in size to safely house all residents/users of the building and consideration must be given to the needs of vulnerable and disabled users of the development. At minimum, it is recommended that a safe haven is provided for all developments with a rate of inundation of less than 10 hours, with this area located a minimum of 0.6m above the 1 in 100 (1%) annual probability fluvial and 1 in 200 (0.5%) annual probability tidal flood level and allowing for the potential effects of climate change.

7.6.19 Consultation with the Environment Agency should be undertaken for all developments in Flood Zone 3a and 3b, during which time their requirements for safe access and egress should be established.

7.7 Sustainable Drainage Systems (SUDS)

7.7.1 Sustainable drainage systems, commonly referred to as SUDS, promote an improved approach to the management of surface water runoff that maximises the additional benefits that can be achieved when compared to traditional piped systems.

7.7.2 SUDS can comprise a wide range of drainage features that aim to mimic natural drainage systems more closely than traditional drainage systems whilst also improving the quality of our natural and surrounding environment.

7.7.3 The requirement to consider SUDS in all new and redeveloped sites in Barking and Dagenham is being driven by existing and increased local flooding, increased pollution of rivers, poor natural landscapes, declining biodiversity and uncertainty regarding the impact of climate change. In particular, traditional piped systems that collect runoff from hard paved surfaces such as roofs, roads and car parks have contributed to increased flood risk and pollution by:

- Increasing the volume and rate at which surface water is discharged to a receiving watercourse and therefore increasing fluvial flood risk;
- Surcharging during larger rainfall events, with water unable to discharge to the system or emerging through manholes and gullies in areas at lower elevation hence causing localised flooding;
- Partial or full blockage caused by sediment, debris or pipe collapse which can often go unnoticed until a large rainfall event causes flooding in upstream areas;
- Little to no treatment of surface water runoff, especially from vehicular areas, thereby conveying all pollutants to the natural environment;
- Increased discharge of surface water runoff to combined sewers or wastewater treatment works, resulting in more regular discharge of wastewater to the water environment via combined sewer overflows (CSOs) or insufficient capacity at the wastewater treatment works.

7.7.4 Increasing urban development is exacerbating existing issues. It is therefore essential that any new development in Barking and Dagenham looks to incorporate the principles of SUDS as much as practical to prevent further deterioration and help reverse this increasing trend.

7.7.5 The primary aims of SUDS are to reduce flood risks and improve the quality of water discharged to our rivers and aquifers, as well as enhance our open space to provide an improved environment for people and wildlife. Whilst the provision of a below ground tank may offer some benefit in terms of reduced flood risk, it offers little to improve water quality or enhance our landscape.

7.7.6 A brief description of the most common types of SUDS is provided in Table 7.3.

Table 7.3 Common types of SUDS components

SUDS type	SUDS component	Description
Ponds and wetlands	**Retention pond**	Ponds are used to store and treat water, providing a permanent water feature within the landscape. Additional storage is provided above the normal water level to attenuate runoff prior to a controlled discharge to a watercourse or sewer.
	Wetland	Wetlands are shallow vegetated water bodies with a permanent but typically varying water level. Specially selected plant species are used to filter the water. Water flows horizontally and is gradually treated before being discharged to a watercourse or via infiltration.
Storage	**Infiltration basin**	Infiltration basins provide temporary storage of surface water runoff prior to infiltration to ground. They are typically grassed depressions and can be integrated with amenity areas, with the majority of the infiltration basin remaining dry during smaller rainfall events.
	Detention basin	Detention basins are similar to infiltration basins but attenuate surface water runoff prior to a controlled discharge to a watercourse or sewer. The majority of the basin can remain dry during smaller rainfall events, although areas of the basin can be profiled to provide a permanent water feature or wetland area.
	Subsurface storage	Surface water runoff is stored in tanks, oversized pipes or geocellular blocks below ground. Surface water can be infiltrated to ground or discharged at a controlled rate to a watercourse or sewer.
Conveyance	**Swale**	Swales are vegetated shallow depressions designed to convey water to downstream SUDS components. They can be 'wet' where water is retained/conveyed above the surface or 'dry' where water is retained/conveyed in a gravel layer below the surface. Swales can be lined or unlined to promote infiltration.
	Filter strip	Filter strips are grassed or planted areas that runoff is allowed to flow across prior to entering another SUDS component to promote settlement and entrapment of silts.
	Filter drain/trench	Filter drains or trenches (sometimes referred to as French drains) are linear gravelled filled trenches that convey surface water to downstream SUDS components. The gravel can provide robust treatment of runoff. A perforated pipe is usually provided within the bottom of the trench to aid conveyance, although trenches can remain unlined to promote infiltration.
	Canals and rills	Canals and rills are essentially hard engineered open channels that convey water to downstream SUDS components. They can also provide some attenuation of runoff depending on their size and are most applicable to dense, urban environments. Planting can be incorporated to enhance their biodiversity and amenity benefits.

SUDS type	SUDS component	Description
Source control	**Green roof**	A green roof is a planted soil layer constructed on the roof of a building to create a living surface. Water stored in the soil layer, is absorbed by vegetation or lost through evaporation. Green roofs can also be predominantly un-planted and are referred to as 'brown roofs'.
	Rain water harvesting	Rainwater is collected from the roof of a building or other (relatively clean) surface and stored within an underground or above ground tank for treatment and reuse locally within non-potable applications. The benefits to flood risk, water quality, amenity and biodiversity are limited, but these systems offer other benefits to water resources, treatment and distribution.
	Permeable pavement	Paving which allows water to percolate through the surface and accumulate within the underlying granular sub-base. They can provide robust treatment of runoff from vehicular areas. Stored water can either be infiltrated to ground or discharged at a controlled rate to a watercourse or sewer.
	Soakaway	Soakaways allow surface water runoff to quickly infiltrate into permeable layers of soil. They commonly comprise below ground structures formed of precast manhole rings, gravel trenches or geocellular blocks.
	Bioretention/ rain gardens	Bioretention areas and rain gardens are vegetated areas that typically receive runoff directly from the surrounding area. They provide attenuation of flow and allow runoff to percolate through the substrate layers, thus providing robust treatment. Water is typically collected in a drainage layer at the base of the structure or overflows into a collector pipe prior to conveyance to a downstream SUDS component. These features can also remain unlined to promote infiltration.

7.7.7 SUDS are not a single solution but will comprise a number of the SUDS components discussed in Table 7.2, with water from one SUDS component flowing downstream to another SUDS component prior to infiltration and/or controlled discharge.

7.7.8 Chapter 6 of the Mayor's Draft Water Strategy (Rainwater in London) sets out a hierarchy for management of urban runoff as below:

"The Mayor applies the following hierarchy for the drainage of rainwater in the London Plan. The aim is to manage as much water as possible towards the top of the hierarchy:

- *Store rainwater for use later*
- *Use infiltration techniques, such as porous surfaces in non-clay areas*
- *Attenuate rainwater in ponds or open water features for gradual release*
- *Attenuate rainwater in tanks or sealed water features for gradual release*
- *Discharge rainwater direct to a watercourse*
- *Discharge rainwater to a surface water drain*
- *Discharge rainwater to the combined sewer"*

7.7.9 A similar hierarchy is promoted within the NPPF Planning Practice Guidance. It is recommended that developers are required to demonstrate that this hierarchy has been considered in the design of their storm water management system.

7.7.10 There is no 'one solution fits all' approach to SUDS. Each site will be presented with its own constraints and opportunities and it is the responsibility of the site's developer to implement the most appropriate solution for that site.

7.7.11 The reuse of previously developed 'brownfield' sites is promoted within the London Borough of Barking and Dagenham and, in many cases, this is essential. However this can pose contamination risks associated with site's history, particularly due to the Borough's industrial legacy. The use of infiltration features within contaminated sites can mobilise certain contaminants and subsequently pollute groundwater resources and surface water resources.

7.7.12 The responsibility for determining the extent of contamination rests with the developer who must also ensure that the drainage proposals are suitable for the site. It is recommended that on-site testing should always be undertaken prior to construction for any site considered to pose risk, and should be at the location of proposed drainage features and downstream of these features.

7.7.13 If soluble or mobile contaminants are found to be present, the use of infiltration systems are unlikely to be feasible and should not be promoted. Demonstration of an alternative drainage system will therefore be required. However, it should still be possible to maintain the principles of SUDS, for example through the use of lined SUDS features that store runoff and maximise other benefits such as water quality and amenity, and which can be used in conjunction with discharge to a watercourse or sewer.

7.7.14 If remediation of soils is required to enable development, this could adequately remove soluble or mobile contaminants and subsequently enable the use of infiltration techniques.

Design Considerations

7.7.15 Drainage systems should be considered at the earliest stages of a development design to influence the layout of the development and its associated roads, open space, play areas etc. This will reduce the need to try and 'squeeze in' SUDS at a later date, as well as maximise opportunities for multifunctional spaces such as landscaping, car parks and recreational space.

7.7.16 Key design principles that are promoted within Barking and Dagenham include:

- managing water on the surface and as close to the source of the runoff as possible;
- ensuring pollution is prevented at source, rather than relying on the drainage system to treat or intercept it;
- managing rainfall to protect people from flood risk and, where possible, reducing existing surface water flooding issues;
- taking account in designs of likely future pressures such as climate change and future urban development;

- using drainage components in series to achieve a robust surface water management system;
- maximising the delivery of benefits for amenity and biodiversity;
- seeking to make the best use of available land through multifunctional usage of public spaces and the public realm;
- performing safely, reliably and effectively over the period of the development's lifetime; and
- being affordable, taking into account both construction and long term maintenance costs and the additional environmental and social benefits afforded by the system.

Larger developments

7.7.17 Larger developments, and particularly strategic development sites, are likely to be required by the Council to go above and beyond the minimum requirements – for example by providing betterment over existing discharge rates and demonstrating an exemplar approach to the design and incorporation of SUDS. The requirement for betterment and going beyond the minimum requirements will be somewhat dependent on the size, nature and location of the development. However, providing betterment to the wider community will be an important factor in the successful delivery of these sites within Barking and Dagenham.

7.7.18 For large developments that are being constructed in phases, each phase of the development as well as the development as a whole must meet the standards as set out within this document and in national guidance.

7.7.19 Defra has recently published the Non-Statutory Technical Standards for Sustainable Drainage Systems (March 2015) and these set out the minimum requirements of SUDS in regard to the management of flood risk. In summary, the Standards require that the post-developed runoff rate for previously undeveloped (greenfield) sites is limited to the existing runoff rates for all events between the 1 in 1 (100%) and the 1 in 100 (1%) annual probability rainfall events. For previously developed (brownfield) sites, post-developed runoff should be limited as far as practical to the equivalent greenfield runoff rate and should never exceed the rate of discharge from the development prior to redevelopment. In catchments that contribute to significant downstream surface water flooding, restriction to equivalent greenfield rates may be a requirement of the Council to aid in reducing existing flood risks.

7.7.20 The Standards also require consideration of volume control as well as peak runoff. For previously undeveloped (greenfield) sites, the volume of runoff in the 1 in 100 year, 6 hour rainfall event should never exceed the greenfield runoff volume for the same event. For previously developed (brownfield) sites, the volume of runoff in the 1 in 100 year, 6 hour rainfall event should be restricted as far as practical to the greenfield runoff volume for the same event and should never exceed the runoff volume from the development prior to redevelopment.

Smaller developments

7.7.21 Many people associate SUDS with large, open green spaces and assume that SUDS require significant land take. Whilst many types of SUDS do fall into these categories,

such as wetlands and detention basins, it is still possible to achieve many of the principles of SUDS in even the most urban and dense of environments.

7.7.22 Many SUDS techniques can be combined with other green space requirements, such as formal and informal play areas and sports pitches. If necessary, a staged approach can be applied that stores surface water below ground during smaller rainfall events, for example up to the 1 in 30 year event, but during larger events surface water can be directed towards less vulnerable 'green' areas. These areas will only be required for storage during the most extreme events hence their use for flood storage is unlikely to significantly disrupt their primary use.

7.7.23 Similarly, an alternative approach could be adopted in urban and dense developments to maximise the use of SUDS techniques for the 'first flush' of surface water runoff prior to discharge to a below ground storage tank that could be located below a driveway, car park or public open space area. These techniques could include green roofs, rain gardens or bioretention areas incorporated into landscaped areas or adjacent to road verges. The use of SUDS upstream of below ground storage will provide treatment of runoff prior to discharge as well as provide enhanced landscape and biodiversity benefits.

7.7.24 Controlling runoff to greenfield rates can be problematic for smaller developments as this would result in the use of very small flow control structures that will be liable to blockage.

7.7.25 The Joint EA/DEFRA guidance Preliminary Rainfall Runoff Management for Developments (January 2012) states that it may be appropriate to size flow control devices to reduce peak flows below 5l/s as the risk of blockage at the outlet increases due to small diameter pipes below this rate. This could therefore negate the need for long term storage for smaller sites that will generate peak flow rates of less than 5 l/s. However, within the London Borough of Barking and Dagenham, a flow control device that reduces peak flows below 5 l/s is still acceptable and should be promoted when:

- A robust maintenance regime and appropriate maintenance contract is provided by the developer; and
- An appropriate overflow device can be included within the design that will direct flows to less vulnerable areas should the flow control device block and surcharge.

7.7.26 Reducing the flow rate to below 2l/s is, however, considered to pose greater risk and this would be considered an appropriate minimum discharge rate for most development unless robust controls are in place for managing residual risk.

7.7.27 Limiting surface water runoff and providing betterment as far as practicable will help address the significant surface water flood risks experienced in many of the urban areas.

7.7.28 Where the development is too small to warrant the use of storage features such as attenuation ponds and below ground storage, it is essential that SUDS techniques appropriate to the development are implemented to maximise the other benefits – principally slowing down the rate of discharge, maximising infiltration potential, improving resilience to climate change, providing treatment and enhancing biodiversity. These could include techniques such as rainwater harvesting, rain gardens, green roofs, filter strips, permeable paving, swales and filter drains.

For all developments

7.7.29 For all developments, no flooding of drainage systems, unless an area is designated to hold and/or convey water as part of the design, should occur on any part of the site up to and including the 1 in 30 (3.3%) annual probability rainfall event.

7.7.30 For events greater than the 1 in 30 (3.3%) annual probability event, flooding from the drainage system may be allowed to occur but only within areas designated to hold and/or convey water as part of the design. No flooding of any part of a building (including a basement) or any utility plant susceptible to water (e.g. pumping station or electricity substation) would be acceptable up to and including the 1 in 100 (1%) annual probability event. The design of the site must ensure that, so far as is reasonably practicable, flows resulting from rainfall in excess of a 1 in 100 (1%) annual probability rainfall event are managed in exceedance routes that minimise the risks to people and property.

7.7.31 Where the drainage system discharges to a surface water body that can accommodate uncontrolled surface water discharges without any impact on flood risk from that surface water body (for example, if the discharge is directly to the River Thames or downstream end of tidally influenced rivers) the peak flow control standards and volume control technical standards as set out within Defra's Non-Statutory Technical Standards for Sustainable Drainage Systems need not apply.

7.7.32 If surface water drainage systems have their outfall below the water level in the river they are discharging to, there are potentially at risk of surcharging if the water level in that river remains high enough for long enough that the sewer system is unable to drain. This process should be investigated by the developer of a site in any surface water drainage flood risk assessment.

7.7.33 The SUDS Manual (CIRIA C753, 2015) provides the basis for current design standards and methodology of construction and maintenance for SUDS in the UK. Developers are recommended to use the SUDS Manual when seeking further detailed guidance on the application of SUDS.

Adoption and Maintenance

7.7.34 The long term maintenance of surface water drainage systems is essential to their ability to manage flood risk and protect the natural water environment. Information regarding the proposed adoption and maintenance of surface water drainage systems must be submitted as part of the planning application.

Further Guidance

7.7.35 For more guidance on SUDS, the following documents and websites are recommended as a starting point:

- National Planning Policy Framework, Department for Communities and Local Government, 2012, and supporting Planning Practice Guidance
- Sustainable Drainage Systems – Non-Statutory Technical Standards for Sustainable Drainage Systems (Defra, March 2015)
- C753 - The SUDS Manual (Woods Ballard B, Wilson Udale-Clarke H, Illman S, Scott T, Ashley R, Kellagher R, 2015)

- Preliminary Rainfall Runoff Management for Developments (R&D Technical Report W5-074/A Revision D, Environment Agency and Kellagher R, 2005)
- BRE Digest 365 Soakaway Design (BRE, February 2016)
- C644 - Building Greener. Guidance on the use of green roofs, green walls and complementary features on buildings (Early P, Gedge D, Newton J, Wilson S, 2007)
- C635 - Designing for Exceedance in Urban Drainage – Good Practice (C Digman, D Balmforth, R Kellagher, D)
- www.ciria.org.uk/SUDS/

7.8 Local Community Actions to Reduce Flood Damage

7.8.1 There will always be a residual risk of flooding, whether that be from an event that is more extreme than that considered, or whether as a result of a flood defence system that fails unexpectedly. For this reason, flood resistance and flood resilience may need to be incorporated into the design of buildings.

7.8.2 In all areas at risk of flooding, a basic level of flood resistance and resilience will be achieved by following good building practice and complying with the requirements of the Building Regulations 2010[26]. The difference between 'resilience' and 'resistance' is:

- *Flood resistance*, or 'dry proofing', where flood water is prevented from entering the building. For example using flood barriers across doorways and airbricks, or raising floor levels.
- *Flood resilience*, or 'wet proofing', accepts that flood water will enter the building and allows for this situation through careful internal design for example raising electrical sockets and fitting tiled floors. The finishes and services are such that the building can quickly be returned to use after the flood.

7.8.3 Examples of both flood resistant and flood resilient design are given in Improving the Flood Performance of New Buildings (Flood Resilient Construction), CLG (2007).

7.8.4 Table 1.1 has shown that many homes within the Borough are at risk of flooding. Therefore, it is essential to ensure that there is a broad awareness of flood risk in the local community, which can be achieved through the provision of the knowledge (and tools) that will enable them to help themselves should a flood event occur.

7.8.5 It is recommended that the Local Authority seek to proactively raise awareness within the community with respect to flooding (and 'self help' flood risk reduction opportunities) through, for example, the circulation of a targeted newsletter to affected residents to coincide with the release of the Barking and Dagenham SFRA and inclusion within the forthcoming LFRMS and Thames FRMP.

[26] Department of Communities and Local Government

7.8.7 The 'flood proofing' of a property may take a variety of forms:

- For new homes and/or during redevelopment:
  - Raising of floor levels
  - The raising of floor levels above the anticipated maximum flood level ensures that the interior of the property is not directly affected by flooding, avoiding damage to furnishings, wiring and interior walls. It is highlighted that plumbing may still be impacted as a result of mains sewer failure.
  - Raising of electrical wiring
  - The raising of electrical wiring and sockets within flood affected buildings reduces the risks to health and safety, and reduces the time required after a flood to rectify the damage.
- For existing homes
  - Installation of flood boards
  - The placement of a temporary watertight seal across doors, windows and air bricks to avoid inundation of the building interior. This may be suitable for relatively short periods of flooding, however the porosity of brickwork may result in damage being sustained should water levels remain elevated for an extended period of time. This may lessen the effectiveness of flood proofing to existing properties affected by flooding from larger river systems such as the Thames.

7.8.8 Further guidance is provided by the National Flood Forum, www.nationalfloodforum.org.uk.

7.9 Emergency Planning

7.9.1 Developing in areas at known flood risk can pose risk to the users of those developments as well as risk to the developments themselves. For the majority of proposed developments in areas identified to be at fluvial or tidal flood risk, and in some cases from other sources of flooding, consideration will need to be given to emergency planning.

7.9.2 A relatively small proportion of the Borough is at risk of river flooding (as indicated by the NPPF flood risk zones in the adjoining maps) although significant risk following a breach of the Thames Tidal Defences is indicated within the south of the Borough. The majority of flooding will typically occur following relatively long duration rainfall events and, consequently, forewarning will generally be provided to encourage preparation in an effort to minimise property damage and risk to life. The risks following a breach of flood defences is highly dependent on the rate of inundation and the ability to respond to a flood event once the breach has been identified, however through the appropriate siting of development it should be possible to provide sufficient forewarning to enable safe evacuation. It is worth highlighting that the benefits of flood warning are often compromised to a large degree by the lack of take-up within the local community. This emphasises the extreme importance of raising local awareness with respect to the potential risks of flooding.

7.9.3 Areas suffering from localised flooding issues may also be at great risk. These areas are susceptible to flash flooding from storm cells that pass over the Borough, which results in high intensity, often relatively localised, rainfall. It is anticipated that events of this nature will occur more often as a result of possible climate change over the coming decades. Events of this nature are difficult to predict accurately and the rapid runoff that follows will often result in flooding that cannot be sensibly forewarned. All urbanised areas are potentially at some degree of risk of localised flooding due to heavy rainfall. The blockage of gullies and culverts as a result of litter and/or leaves is commonplace and this will inevitably lead to localised problems that can only realistically be addressed by reactive maintenance.

Risk Management Authority Responsibilities

7.9.4 Barking and Dagenham Council is designated as a Category 1 Responder under the Civil Contingencies Act (2004) and therefore has defined responsibilities to assess risk, and respond appropriately in case of an emergency, including (for example) a major flooding event. The Council's primary responsibilities are[27]:

- from time to time assess the risk of an emergency occurring;
- from time to time assess the risk of an emergency making it necessary or expedient for the person or body to perform any of his or its functions;
- maintain plans for the purpose of ensuring, so far as is reasonably practicable, that if an emergency occurs the person or body is able to continue to perform his or its functions;
- maintain plans for the purpose of ensuring that if an emergency occurs or is likely to occur the person or body is able to perform his or its functions so far as necessary or desirable for the purpose of:
    - preventing the emergency,
    - reducing, controlling or mitigating its effects, or
    - taking other action in connection with it.

7.9.5 This SFRA provides a concise summary of the possible sources of flooding within the Borough, and should be used to inform the assessment of flood risk in response to the requirements of the Act.

7.9.6 The Flood Forecasting Centre (FFC) is a partnership between the Environment Agency and Met Office and provides forecasts for all natural forms of flooding – river, surface water, tidal/coastal and groundwater. The FFC provides Category 1 and 2 responders with a daily Flood Guidance Statement to aid with emergency planning and resourcing decisions. The statement provides an overview of the flood risk for England and Wales across five days and identifies possible severe weather, which could cause flooding and significant disruption.

7.9.7 The Environment Agency constantly monitor rainfall, river levels and sea conditions to forecast the possibility of flooding, and if flooding is forecast, will issue Flood Warnings and Alerts. Flood Warnings are issued to specific areas where flooding is expected.

[27] Civil Contingencies Act 2004

Flood Alerts cover larger areas and are issued more frequently to areas when flooding is possible. Refer to Appendix N for details of the Flood Warning and Alert areas in Barking and Dagenham.

7.9.8 As water levels rise and begin to pose a risk to life and/or livelihood, it is the responsibility of the emergency services to coordinate the evacuation of residents. This evacuation will be supported by the Council. It is essential that a robust plan is in place that clearly sets out (as a minimum):

- roles and responsibilities;
- paths of communication;
- evacuation routes;
- community centres to house evacuated residents;
- contingency plans in case of loss of power and/or communication.

7.9.9 Barking and Dagenham is part of a Borough Resilience Forum that is chaired by the Police and contributed to by the Civil Protection Service. This is a multi-borough forum that feeds into Multi-Agency Flood Plan, led by the Police, which sets out the approach to managing a major flooding incident, such as a breach of the Thames Tidal Defences, should one occur.

7.9.10 To support the emergency planning process, Appendix O depicts the locations of vulnerable sites and emergency services and the Flood Hazard mapping in G provides an indication of flood hazard along key roads within the Borough, following a breach of the River Thames defences. The emergency planning team (and, indeed, prospective developers) may use this information to identify routes that may be susceptible to flooding following particularly heavy rainfall and/or a failure of the River Thames defences.

7.9.11 Floodplain management and emergency response activities must have a focus on key infrastructure such as the underground network and other properties that are below sea level. Emergency planning would include refuge areas in vulnerable areas, and aim to increase the number of people who sign up to Flood Warnings Direct[28]. Key challenges include instilling a culture of flood preparedness in the resident and visitor population without damaging confidence in London.

7.9.12 It is recommended that the Council advises the local Resilience Forum of the risks raised in light of the Barking and Dagenham SFRA, ensuring that the planning for future emergency response can be reviewed accordingly. This must include the planned development of the strategic development sites that will significantly increase the number of people located within areas to be at risk of flooding (principally following a breach in tidal flood defences) to ensure that Borough-wide emergency response plans cater for these new developments.

Developer Responsibilities

7.9.13 Planning applications for developments located within the defended and undefended Flood Zone 3a and Flood Zone 3b are likely to be required to be supported by a site-

[28] Environment Agency flood warning service

specific flood evacuation plan or flood response plan. The nature of this plan should be commensurate with the vulnerability and size of the proposed development. For example, for a single dwelling in Flood Zone 3a it may be appropriate to demonstrate that a safe haven has been provided at an appropriate level above the predicted floor level. However, for a larger development comprising of multiple dwellings, demonstration of safe evacuation routes within an appropriate timeframe is likely to be required.

7.9.14 It is also recommended that a site-specific flood evacuation plan or flood response plan is prepared for highly vulnerable development in Flood Zone 2, noting that this may also be required for sites within Flood Zone 1 if the site is at significant flood risk following reservoir failure or from other sources of flood risk.

7.9.15 Consultation with the Environment Agency should be undertaken for all developments in Flood Zone 3a and 3b, during which time their requirements for resilience measures should be established. Consultation should also be undertaken with the London Borough of Barking and Dagenham (in their capacity as the Lead Local Flood Authority) for all developments in Flood Zone 3a and 3b. This consultation should establish their requirements for a site-specific flood evacuation plan or flood response plan.

7.9.16 The Environment Agency advises that people and key infrastructure may be vulnerable at different stages of flooding:

- *before* – lack of preparedness – ensure people are aware (sign up to Flood Warnings Direct) infrastructure is protected or resilient;
- *during* – property and infrastructure is flood-resistant, escape and access is appropriate, refuge areas are provided;
- *after* – recovery is maximised - ensure emergency services can reach those most at risk/affected, no basement-only properties in areas if most flood risk, ensuring properties are properly flood-resilient.

7.9.17 For larger developments, vulnerable developments and/or developments in areas at high risk, the flood evacuation plan or flood response plan should include, but is not limited to, the following:

- Evacuation procedures or procedures for safe refuge;
- People responsible for evacuation and/or safe refuge;
- Evacuation and emergency refuge routes;
- Flood warning codes; and
- Local emergency services contact details.

7.10 Insurance

7.10.1 Many residents and business owners perceive insurance to be a final safeguard should damages be sustained as a result of a natural disaster such as flooding. Considerable media interest followed the widespread flooding of 2000 when it became clear that the insurance industry were rigorously reviewing their approach to providing insurance protection to homes and businesses situated within flood affected areas. Not

surprisingly, the widespread flooding of July 2007 and recent flooding of 2012 has further exacerbated the discussion surrounding the future of insurance for householders and business owners situated within flood affected areas.

7.10.2 The Flood Re scheme was agreed between the Government and the insurance industry in June 2013 and is now in operation as of 1st April 2016. The scheme is a not-for-profit flood reinsurance fund, owned and managed by the insurance industry, and established to ensure that those domestic properties in the UK at the highest risk of flooding can receive affordable cover for the flood element of their household insurance.

SECTION 8

CONCLUSIONS AND RECOMMENDATIONS

8 CONCLUSION AND RECOMMENDATIONS

8.1 Overview of SFRA Outcomes

8.1.1 This SFRA has been produced to inform the Barking and Dagenham Local Plan which will set out the future planning policy of the Borough. This report is an update to the Level 1 SFRA, published in 2008, and assesses the risk of flooding in the Borough from all sources, now and in the future, taking account of the impacts of climate change, and assesses the impact that land use changes and development in the area will have on flood risk.

8.1.2 This SFRA has been developed in accordance with National Planning Policy Framework (NPPF) and the supporting Planning Practice Guidance, and in consultation with both the Council and the Environment Agency. The Borough has been divided into areas of high, medium and low probability of flooding in accordance with NPPF and provides the basis for the application of the Sequential test.

8.1.3 This SFRA builds upon the information included in the 2008 SFRA to take into account the latest guidance and information available relating to flood risk. The most up to date flooding information has been gathered from the Council, the Environment Agency, Thames Water and other key stakeholders to inform the production of this SFRA and the associated flood maps. These flood maps along with the Environment Agency Flood Maps provide the detail and information required to assess the risk of flooding in Barking and Dagenham.

8.1.4 Fluvial and tidal flooding are the primary sources of flooding affecting Barking and Dagenham within the south of the Borough which is subjected to the highest risk. The River Thames is the source of tidal flooding in the Borough with the River Roding and Beam River the primary sources of fluvial flooding. Significant flood defences, including the Thames Tidal Defences and the fluvial defences on the River Roding and Beam River, are present in Barking and Dagenham and reduce the risk of flooding from these sources. It is important to note there is still a significant risk of flooding due to breach of these defences that could result in water flooding large areas of the Borough relatively quickly.

8.1.5 A number of areas in Barking and Dagenham are also at risk of flooding from surface water and groundwater. Whilst these sources of flood risk may have less influence over the suitability of land for development, it is essential that any new or developed sites take these risks into account and, where necessary, protect the development against flood risk and ensure no increased flood risk elsewhere as a result of development.

8.1.6 A Level 2 SFRA has been completed for the strategic development sites identified by the Council. The Level 2 SFRA provides a more detailed assessment of the flood risk at the strategic development sites where it is not possible to allocate all proposed development and infrastructure in accordance with the Sequential Test described in the NPPF. In these cases the Level 2 SFRA applies the Exception Test in accordance with the NPPF.

8.2 Development Control Guidance

8.2.1 The risk of flooding is most effectively addressed through avoidance, which in very simple terms equates to guiding future development (and regeneration) away from areas at risk. Development that is sustainable for future generations is essential and it is widely recognised that the risk of flooding cannot be considered in isolation.

8.2.2 NPPF endeavours to guide Local Planning Authorities and the Environment Agency in this decision making process and the Sequential and Exception tests underpin the method by which flood risk should be taken into consideration as part of the planning process.

8.2.3 As set out in the NPPF and as summarised within Environment Agency Standing Advice, local planning authorities should only consider development in flood risk areas where informed by a site-specific flood risk assessment. The developer will be required to demonstrate within the site-specific flood risk assessment that the Sequential Test has been applied and, where appropriate, that the risk of flooding has been adequately addressed in accordance with NPPF. Where development cannot be located in zones with a lower probability of flooding, developers will be required to demonstrate that the Exception Test has been passed.

8.2.4 The site-specific flood risk assessment should be commensurate with the risk of flooding to the proposed development. For example, where the risk of fluvial and/or tidal flooding to the site is negligible (e.g. Zone 1 Low Probability) and it is not indicated as being at risk of flooding from other sources or likely to impact on any known problem area off-site, there is little benefit to be gained in assessing the potential risk to life and/or property as a result of flooding. Rather, emphasis should be placed on ensuring that runoff from the site does not exacerbate flooding elsewhere in the catchment. The particular requirements for flood risk assessments within each delineated flood zone are outlined in Section 7.5.

8.2.5 Developers should be encouraged to demonstrate that their proposal will deliver a positive reduction in flood risk to the Borough, whether that be by reducing the frequency or severity of flooding (for example, through the introduction of SUDS), or by reducing the impact that flooding may have on the community (for example, through a reduction in the number of people within the site that may be at risk). This should not be seen as an onerous requirement, and if integrated into the design at the conceptual stage, will place no added demands upon the development and/or planning application process.

8.2.6 It is recommended that developers consult with the LLFA, namely the Council for Barking and Dagenham, at an early stage of the planning application process to discuss any known flood risk issues at this proposed development site, the need and scope of a site-specific flood risk assessment and opportunities to reduce the overall flood risk in the area, including the sustainable management of surface water runoff.

8.2.7 Developers should also consult the Environment Agency, a statutory consultee for many developments located within areas potentially at flood risk, at an early stage of the planning process. The Environment Agency is an excellent source information relating to (for example) up to date mapped outputs, historical flooding, hydraulic modelling and topography (LiDAR). It is emphasised that the information provided within the SFRA is the best available at the time of writing. More up to date information may be available and contact should always be made with the Environment Agency at an early stage to ensure that the detailed site based flood risk assessment is using the most current datasets.

8.2.8 For development within areas identified to be at risk of flooding, the developer will need to demonstrate that appropriate resistance and resilience measures have been incorporated to adequately protect the development from flooding.

8.3 Updating the SFRA

8.3.1 This SFRA has been developed using the latest guidance and information available in relation to flood risk assessment. The Environment Agency regularly update their flood mapping and these updates, other studies carried out in the area such as the Thames 2100 Project and observed flooding that may occur in the Borough will improve the current knowledge of flood risk in Barking and Dagenham and may alter the predicted flood extents in the Borough. A periodic review of this SFRA should be undertaken following the publication of any emerging policy directives, significant hydraulic modelling updates or flooding events to ensure the SFRA is still relevant and updates should be made as necessary.

APPENDIX A: MAP OF THE LONDON BOROUGH OF BARKING AND DAGENHAM

APPENDIX B: MAP OF THE MAIN RIVERS IN BARKING & DAGENHAM

APPENDIX C: DEFENCES, STRUCTURES AND FLOOD STORAGE AREAS

APPENDIX D: FLOOD ZONES IN BARKING & DAGENHAM

APPENDIX E: AREAS BENEFITTING FROM DEFENCES

APPENDIX F: SURFACE WATER FLOOD EXTENTS

APPENDIX G: FLOOD HAZARD AND RATE OF INUNDATION MAPS

APPENDIX H: THAMES WATER DG5 FLOODING INFORMATION

APPENDIX I: EXTRACTS FROM THE BARKING & DAGENHAM SWMP

APPENDIX J: HISTORIC FLOOD EVENTS

APPENDIX K: TOPOGRAPHIC MAP OF BARKING & DAGENHAM

APPENDIX L: BARKING AND DAGENHAM WARDS

APPENDIX M: CHARACTER AREAS AND FLOOD RISK

APPENDIX N: FLOOD WARNING AND ALERT AREAS (FLUVIAL & TIDAL)

APPENDIX O: EXISTING VULNERABLE LAND USES AND EMERGENCY SERVICES