AECOM **Final Report**

Submitted to
Royal Borough of Greenwich
Council

Submitted by
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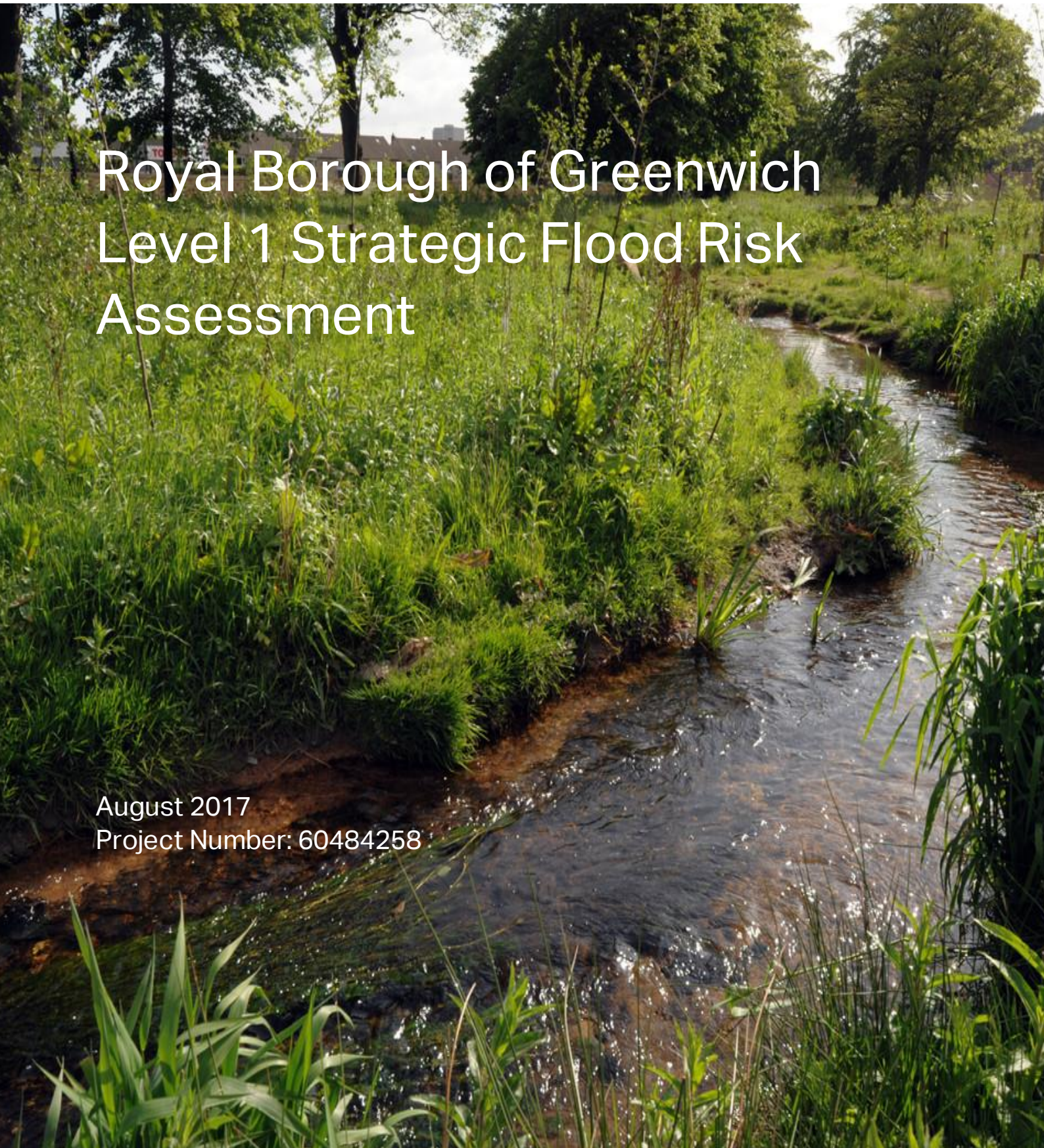

Royal Borough of Greenwich Level 1 Strategic Flood Risk Assessment

August 2017
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Rev No	Comments	Checked by	Approved by	Date
1	Draft for client and stakeholder comment	EC	JR	April 2017
2	Final	EC	SK	August 2017

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60484258

Date Created

August 2017

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Contents

List of Appendices

List of Tables

List of Figures

List of Acronyms

ABD	Areas Benefiting from Defences
AEP	Annual Exceedance Probability
AOD	Above Ordnance Datum
AIMS	Asset Information Management System
BGS	British Geological Survey
CDA	Critical Drainage Area
CFMP	Catchment Flood Management Plan
Defra	Department for Environment, Flood and Rural Affairs
DRN	Detailed River Network
FRA	Flood Risk Assessment
FRMP	Flood Risk Management Plan
FRR	Flood Risk Regulations
FWMA	Flood and Water Management Act 2010
LLFA	Lead Local Flood Authority
LPA	Local Planning Authority
LRF	Local Resilience Forum
NPPF	National Planning Policy Framework
RBD	River Basin District
RMA	Risk Management Authorities
PPG	Planning Policy Guidance
ROFSW	Risk of Flooding from Surface Water
SFRA	Strategic Flood Risk Assessment
SuDS	Sustainable Drainage Systems
SWMP	Surface Water Management Plan
TWUL	Thames Water Utilities Ltd

Glossary of Terms

Glossary	Definition
Annual exceedance probability (AEP)	Chance of occurrence in any one year, expressed as a percentage. For example, a 1% annual probability event has a 1 in 100 chance of occurring in any given year.
Areas Benefitting from Defences (ABD)	Hatched areas on the Environment Agency Flood Map for Planning (Rivers and Sea) behind flood defences, which, if the flood defences were not present, would flood, in the event of a river flood with a 1 per cent (1 in 100) chance of happening each year, or a flood from the sea with a 0.5 per cent (1 in 200) chance of happening each year.
Asset Information Management System (AIMS)	Environment Agency management system of assets associated with main rivers including defences, structures and channel types. Information regarding location, standard of service, dimensions and condition.
Aquifer	A source of groundwater comprising water bearing rock, sand or gravel capable of yielding significant quantities of water.
Catchment Flood Management Plan (CFMP)	A high-level planning strategy through which the Environment Agency works with their key decision makers within a river catchment to identify and agree policies to secure the long-term sustainable management of flood risk.
Civil Contingencies Act	This Act delivers a single framework for civil protection in the UK. As part of the Act, Local Resilience Forums must put into place emergency plans for a range of circumstances, including flooding.
Climate Change	Long term variations in global temperature and weather patterns caused by natural and human actions. Climate change allowances are based upon information within the NPPF and Planning Practice Guidance (PPG) and supporting guidance published by the Environment Agency.
Culvert	A channel or pipe that carries water below the level of the ground.
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.
Exception Test	A method set out in the NPPF to help ensure that flood risk to people and property will be managed satisfactorily, while allowing necessary development to go ahead in situations where suitable sites at lower risk of flooding are not available. The two parts to the Test require proposed development to show that it will provide wider sustainability benefits to the community that outweigh flood risk, and that it will be safe for its lifetime, without increasing flood risk elsewhere and where possible reduce flood risk overall.
Flood and Water Management Act (FWMA)	Part of the UK Government's response to Sir Michael Pitt's Report on the Summer 2007 Floods; the aim of which is to clarify the legislative framework for managing local flood risk (flooding from surface water, groundwater and ordinary watercourses) in England.
Flood Defence	Infrastructure used to protect an area against flooding such as floodwalls and embankments.
Flood Resilience measures	Measures designed to reduce the impact of water that enters property and businesses and to promote fast drying and easy cleaning; for example raising electrical appliances, installing tiled flooring.
Flood Resistance measures	Measures to prevent flood water entering a building or damaging its fabric, for example the use of flood guards. This has the same meaning as flood proofing.
Flood Risk	The level of flood risk is the product of the frequency or likelihood of the flood events and their consequences (such as loss, damage, harm, distress and disruption).
Flood Risk Regulations	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 Zone	Areas defined by the probability of river and sea flooding, ignoring the presence of defences. Flood Zones are shown on the Environment Agency's Flood Map for Planning (Rivers and Sea), available on the Environment Agency's web site.
Fluvial	Relating to the actions, processes and behaviour of a watercourse (river or stream).
Freeboard	The height of a flood defence crest level (or building level) above a particular design flood level.
Functional Floodplain	Land where water has to flow or be stored in times of flood. It is defined by LPAs within SFRAs. Functional floodplain (also referred to as Flood Zone 3b) is not separately distinguished from Zone 3a on the Environment Agency Flood Map for Planning.
Groundwater	Water that is in the ground, usually referring to water in the saturated zone below the water table.
Lead Local Flood Authority (LLFA)	As defined by the Flood and Water Management Act, in relation to an area in England, this means the unitary authority or where there is no unitary authority, the county council for the area. RB of Greenwich is the LLFA for their administrative area.
Local Planning Authority (LPA)	Body that is responsible for controlling planning and development through the planning system.

Glossary	Definition
Main river	Watercourse defined on a 'main river map' designated by Defra.
Mitigation measure	An element of development design which may be used to manage flood risk or avoid an increase in flood risk elsewhere.
National Planning Policy Framework (NPPF)	The National Planning Policy Framework was published on 27 March 2012. It is a framework which sets out the Government's planning policies for England and how these are expected to be applied.
Planning Practice Guidance	Supporting guidance to the National Planning Policy Framework, available at http://planningguidance.communities.gov.uk/
Ordinary watercourse	A watercourse that does not form part of a main river. This includes "all rivers and streams and all ditches, drains, cuts, culverts, dikes, sluices (other than public sewers within the meaning of the Water Industry Act 1991) and passages, through which water flows" according to the Land Drainage Act 1991.
Residual Flood Risk	The remaining flood risk after risk reduction measures have been taken into account.
Return Period	The average time period between rainfall or flood events with the same intensity and effect.
Risk	Risk is a factor of the probability or likelihood of an event occurring multiplied by consequence: Risk = Probability x Consequence. It is also referred to in this report in a more general sense.
Sequential Test	An approach to future site planning whereby new development is directed towards areas with the lowest probability of flooding before consideration of higher risk areas. The Sequential Test helps ensure that development can be safely and sustainably delivered and developers do not waste their time promoting proposals which are inappropriate on flood risk grounds.
Sewer Flooding	Flooding caused by a blockage or overflowing of a sewer or urban drainage system.
Surface Water	Rainwater (including snow and other precipitation) which is on the surface of the ground (whether or not it is moving), and has not entered a watercourse, drainage system or public sewer.
Surface Water Management Plan (SWMP)	A plan which 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.
Sustainable drainage systems (SuDS)	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques.
Topographic survey	A survey of ground levels.

Executive Summary

The Royal Greenwich Local Plan Core Strategy was adopted in July 2014, and sets the vision for future development for Royal Greenwich, as well as detailed policies to guide development. Royal Borough (RB) of Greenwich are now preparing a Site Allocations Local Plan to identify more specifically where in the Borough development will be delivered. RB of Greenwich faces the challenge of meeting the need for new development within some areas that have already been identified at risk of fluvial and surface water flooding, as well as large areas along the tidal River Thames floodplain, which are at residual risk of tidal flooding in the event of a breach or failure of the flood defence system.

The National Planning Policy Framework (NPPF) and associated Planning Practice Guidance (PPG) for Flood Risk and Coastal Change emphasise the active role Local Planning Authorities (LPAs) should take to ensure that flood risk is assessed, avoided, and managed effectively and sustainably throughout all stages of the planning process.

Assess Flood Risk

Section 4 of this Level 1 Strategic Flood Risk Assessment (SFRA) and the supporting mapping in Appendix A provide a strategic overview of flood risk across the Borough from all sources based on readily available datasets. A strategic assessment of the risk of flooding has been provided for the tidal Thames; fluvial watercourses including the River Ravensbourne, flooding from ordinary watercourses, surface water, groundwater, as well as reservoirs and the existing drainage infrastructure.

A database of potential development sites and strategic development areas that have been identified by RB of Greenwich has been created as part of the SFRA process. For each site, an assessment of the risk of flooding, based on the datasets presented in the Level 1 SFRA, has been undertaken and provided to RB of Greenwich to enable the direct comparison of sites in the application of the Sequential Test.

Avoid Flood Risk

The outputs of the Level 1 SFRA and the guidance presented in Section 5 should be used by RB of Greenwich to apply the Sequential Test to future site selection, so that development is, as far as reasonably possible, located where the risk of flooding from all sources is lowest, taking account of climate change, and the vulnerability of future users to flood risk.

Manage and Mitigate Flood Risk

Where alternative sites in areas at lower risk of flooding are not available, it may be necessary to locate development in areas at risk of flooding. In these cases, RB of Greenwich and developers must ensure that development is appropriately flood resilient and resistant, safe for its users for the lifetime of the development, and will not increase flood risk overall. RB of Greenwich and developers should seek flood risk management opportunities (e.g. safeguarding land), and to reduce the causes and impacts of flooding (e.g. through the use of sustainable drainage systems).

Level 2 Strategic Flood Risk Assessment

Due to the extensive area within the Borough that is located within the defended tidal floodplain of the River Thames, it is likely that, following completion of the Sequential Test, it may still be necessary to consider locating development in areas at risk of flooding. In such cases the Exception Test may need to be applied. Guidance on how an increased scope Level 2 SFRA should be prepared in the future is provided within this Level 1 SFRA.

Living Document

The Level 1 SFRA has been developed building heavily upon existing knowledge with respect to flood risk within the Borough. The Environment Agency may in the future revise the hydraulic modelling for the Marsh Dyke System, which will improve the current knowledge of flood risk, and may marginally alter predicted flood extents within parts of the study area in the future. Revised models will also need to take account of the revised climate change allowances published by the Environment Agency in February 2016.

New information may influence future development control decisions within these areas. Therefore it is important that the SFRA is adopted as a 'living' document and is reviewed regularly in light of emerging policy directives, flood risk datasets and an improving understanding of flood risk within the Borough.

1 Introduction and Background

1.1 Terms of Reference

AECOM Infrastructure and Environment UK Ltd ('AECOM') has been commissioned by Royal Borough (RB) of Greenwich to review and revise the Level 1 and Level 2 Strategic Flood Risk Assessment (SFRA) for its administrative area. This report comprises the Level 1 SFRA.

1.2 Project Background

The National Planning Policy Framework[1] (NPPF) and associated Planning Practice Guidance for Flood Risk and Coastal Change (PPG)[2] emphasise the active role Local Planning Authorities (LPAs) should take to ensure that flood risk is understood and managed effectively and sustainably throughout all stages of the planning process. The NPPF outlines that Local Plans should be supported by a Strategic Flood Risk Assessment (SFRA) and LPAs should use the findings to inform strategic land use planning.

The RB of Greenwich Strategic Flood Risk Assessment[3] (SFRA) was published in October 2011. Since the preparation of this report, there have been a number of further changes in legislation and guidance relating to planning and flood risk. The introduction of the Localism Act in 2011 was intended to create a planning system oriented round consideration of local planning issues. Planning Policy Statements (PPS), covering all aspects of national planning policy have since been replaced by the NPPF. The accompanying technical guidance document relating to flood risk, originally derived from the PPS documents has also been recently replaced by the PPG.

The Flood and Water Management Act (FWMA) attained royal assent in 2010, with the intention of enabling the provision of more effective flood management. As such, RB of Greenwich is designated a Lead Local Flood Authority (LLFA) and has significant duties and powers in relation to flooding from local sources, specifically surface water, groundwater and ordinary watercourses. The Environment Agency retains responsibility for leading and coordinating the management of flood risk associated with main rivers and the sea.

As well as legislative and planning policy changes, a number of new and revised datasets have been made available since the release of the previous SFRA in 2011. The Environment Agency has undertaken revised modelling of the River Ravensbourne catchment (2015) and is currently undertaking a combined fluvial and surface water modelling study of the Marsh Dykes system. As part of the Thames Tidal Breach Modelling study completed in March 2015, breach modelling at 13 locations along the River Thames frontage has been undertaken that is of importance to assessing the residual risk to RB of Greenwich. Additional Breach Modelling of the area upstream of the Thames Barrier was completed in May 2017 for breach locations from Teddington Weir to the Thames Barrier. The Environment Agency national surface water flood risk mapping, the Risk of Flooding from Surface Water Map (RoFSW), has been released by the Environment Agency for use by LPAs in SFRAs.

RB of Greenwich also have a number of new studies and strategy documents which have been used to inform the SFRA, including the outputs from a Groundwater Study undertaken by MHW and the findings of the Surface Water Management Plan (SWMP) (2011), Preliminary Flood Risk Assessment (PFRA) (2011) and Local Flood Risk Management Strategy (LFRMS) (2015).

The purpose of the revised Level 1 SFRA is to collate and analyse the most up to date readily available flood risk information for all sources of flooding, to provide an overview of flood risk issues across the study area. This will be used by RB of Greenwich to inform the application of the Sequential Test for future site allocations.

The NPPF sets stringent tests to protect people and property from flooding which all LPAs are expected to follow. Where these tests are not met, national policy is clear that new development should not be allowed. The main steps to be followed can be summarised as **Assess**, **Avoid** and **Manage and Mitigate** flood risk. These steps are set out below, and are designed to ensure that if there are better sites in terms of flood risk, or a proposed development cannot be made safe, it should not be permitted.

[1] Department for Communities and Local Government. 2012. *National Planning Policy Framework*. Available at: https://www.gov.uk/government/publications/national-planning-policy-framework--2
[2] Department for Communities and Local Government. 2014. *Planning Practice Guidance: Flood Risk and Coastal Change.* Available at: http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/
[3] JBA Consulting, October 2011, Royal Borough of Greenwich Strategic Flood Risk Assessment.

Assess Flood Risk	As the LPA, RB of Greenwich should undertake a **SFRA** to fully understand the flood risk in the area to inform Local Plan preparation. For sites in areas at risk of flooding, or with an area of 1 hectare or greater, developers must undertake a **site-specific Flood Risk Assessment** (FRA) to accompany planning applications (or prior approval for certain types of permitted development).
Avoid Flood Risk	RB of Greenwich should apply the **sequential approach** to site selection so that development is, as far as reasonably possible, located where the risk of flooding from all sources is lowest, taking account of climate change and the vulnerability of future users to flood risk. In **plan-making this involves applying the Sequential Test**, and where necessary the **Exception Test** to Local Plans, as described in Figure 1-1. In **decision-taking this involves applying the Sequential Test** and if necessary the **Exception Test** for specific development proposals.
Manage and Mitigate	Where alternative sites in areas at lower risk of flooding are not available, it may be necessary to locate development in areas at risk of flooding. In these cases, RB of Greenwich and developers must ensure that development is appropriately flood resilient and resistant, safe for its users for the lifetime of the development, and will not increase flood risk overall. RB of Greenwich and developers should seek flood risk management opportunities (e.g. safeguarding land), and to reduce the causes and impacts of flooding (e.g. through the use of sustainable drainage systems).

1.3 SFRA Deliverables

The Level 1 SFRA Report has been is structured as follows:

- Section 1: Description of Study Area and Partner Organisations
- Section 2: Legislative and Planning Policy Context
- Section 3: Level 1 SFRA Methodology
- Section 4: Level 1 **Assessment** of Flood Risk
- Section 5: **Avoiding** Flood Risk – Applying the Sequential Approach
- Section 6: Flood Risk Management Policy Considerations
- Section 7: Next Steps
- Appendix A: Figures
- Appendix B: Developer Guidance Document
- Appendix C: Residual Risk – Flood Hazard Mapping

Section 4 provides a strategic assessment of flood risk from all sources across the Borough. The figures included within Appendix A should be referred to when reading this Section.

Section 5 provides guidance on the application of the Sequential Test by RB of Greenwich when allocating future development sites as part of the plan-making process, as well as by developers promoting development on windfall sites. The strategic assessment of flood risk presented in Section 4 will inform the Sequential Test carried out by RB of Greenwich. The datasets presented in Section 4 have been used to prepare a site assessment database for RB of Greenwich, detailing the flood risk at each of their potential development sites to enable comparison of sites throughout the application of the Sequential Test.

Section 6 outlines a number of flood risk management objectives and policy recommendations for consideration by RB of Greenwich throughout the development of their strategic planning documents.

Section 7 presents the next steps for RB of Greenwich following completion of the Level 1 SFRA.

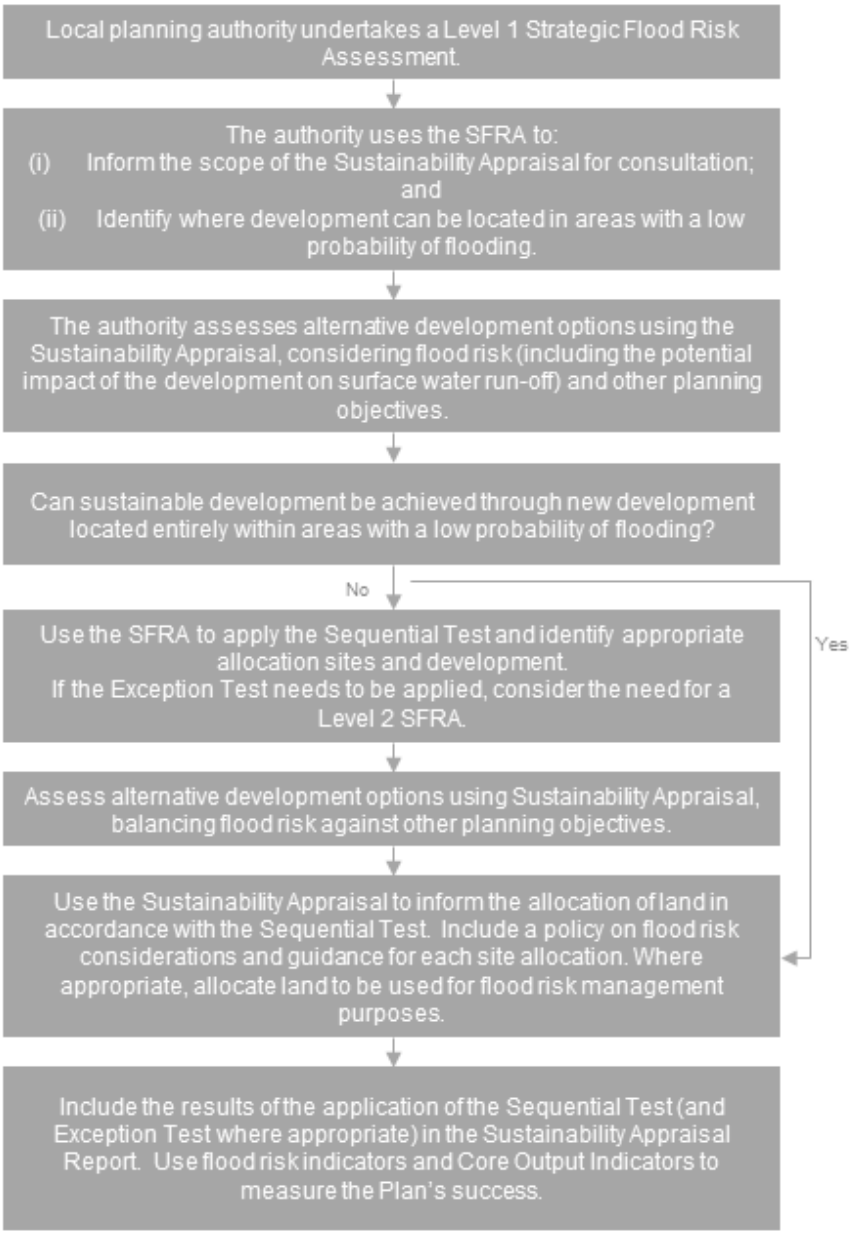


Figure 1-1 Taking flood risk into account in the preparation of a Local Plan (PPG, p6)

1.4 Partner Organisations

There are several risk management authorities (RMAs) involved in development and flood risk management across the study area. These are identified below.

Royal Borough of Greenwich is the LPA for the study area, responsible for long term strategic planning of future development through the preparation of Local Plans, as well as for determining planning applications within the Borough. In accordance with the FWMA and subsequent communication from Central Government, from 6th April 2015, RB of Greenwich is required to ensure that SuDS are implemented for all major developments where appropriate, and that through the use of planning conditions or planning obligations that there are clear arrangements in place for ongoing maintenance over the lifetime of the development.

As the designated LLFA under the FWMA, RB of Greenwich has a duty to lead and coordinate the management of local flood risk, which includes flood risk from surface water, groundwater and ordinary watercourses. RB of Greenwich is also a statutory consultee for surface water drainage in its capacity as the LLFA, and is required to assess applications for the provision of surface water drainage for all major development.

Environment Agency has a strategic overview role for all sources of flooding and coastal erosion which includes developing strategic plans, providing evidence and advice to inform Government policy and providing a framework to support local delivery.

Within Greenwich, the Environment Agency has operational responsibility for managing flood risk associated with main rivers and reservoirs and is a statutory consultee for any development, other than minor development, proposed within Flood Zone 2 or 3 or works in the bed of or within 20m of a Main River. The Environment Agency is continually improving and updating their flood map for main rivers and has permissive powers to carry out flood defence works, maintenance and operational activities for these main rivers. However, overall responsibility for maintenance lies with the riparian owner.

As part of taking a strategic overview for all sources of flooding the Environment Agency are involved in strategic flood risk mapping projects, such as the national mapping of surface water flood risk. The Environment Agency also has a key role in allocation of funding for flood and coastal erosion risk management projects.

Thames Water Utilities has a duty as a statutory body to provide clean and waste water services to the study area and is responsible for the management, maintenance and operation of flood control structures associated with their operational sources. Water Companies are defined as a Risk Management Authority (RMA) within the FWMA and are responsible for flood risk management functions in accordance with the Water Resources Act 1991 and the Land Drainage Act 1991. Thames Water Utilities Ltd (TWUL) is responsible for surface water drainage from development via adopted sewers and for maintaining trunk sewers into which many of the highway drainage in the study area connects.

Network Rail operates the railway lines and associated infrastructure (signalling, bridges, embankments and tunnels) across the study area. Network Rail is an important stakeholder with regards to flood risk management, through ensuring Network Rail assets are protected from flooding, and that the operation and maintenance of railway assets and infrastructure does not increase the flood risk to neighbouring areas. Network Rail embankments, cuttings and drainage infrastructure have a significant impact on surface water drainage and flood risk in the Borough.

Transport for London (TfL) has a responsibility under the Highways Act 1980 for the effectual drainage of surface water from adopted roads and along major roads (red routes) insofar as ensuring that drains, including kerbs, road gullies and ditches and the pipe network which connect to the sewers, are maintained.

1.5 Study Area

The study area, as shown in **Appendix A Figures 1 and 2**, is defined by the administrative boundary of RB of Greenwich, which is bordered to the west by London Borough of Lewisham, to the east by London Borough of Bexley and to the south by London Borough of Bromley. The River Thames forms the northern boundary of the Borough.

The Thames Barrier is a movable flood barrier in the River Thames located in the RB of Greenwich. Upstream of the Thames Barrier, high water levels are managed by the operation of the Thames Barrier to protect against tidal flooding. However, as the barrier is located half way along the Greenwich Thames riverside, not all of the RB of Greenwich is defended by the Thames Barrier.

RB of Greenwich is heavily developed. Population Density Mapping undertaken as part of the Local Plan Evidence Base identifies the areas of Woolwich, Thamesmead, Charlton, also the areas adjacent to the Deptford Creek and the area between Kidbrooke and Eltham as being densely populated, in which there are 100-199 people per hectare. Areas of open space are located in Greenwich Park, Shooters Hill, Avery Hill Park and Royal Blackheath Golf Club, Charlton Park, Eltham Common and Eltham Park South.

1.5.1 Topography

The topography of the Borough is presented in **Appendix A Figure 1**. The northern edge of the study area comprises low lying land adjacent to the River Thames. Land adjacent to the River Thames areas including Charlton, Thamesmead and Abbey Wood are located at approximately 2 mAOD. Ground levels increase gradually through the western part of the Borough towards the southern side of East Greenwich and Charlton reaching approximate levels of 40m AOD and 50 mAOD respectively. Ground levels increase more noticeably further east, reaching up to 60 mAOD at Bostall Woods. Between those two areas a valley is located at approximately 15 mAOD, where Butts Canal flows through.

The highest area in the Borough, reaching 125mAOD, lies south of Woolwich near Shooters Hill. From there the elevation drops gently westwards until it reaches Kidbrooke at elevation 20mAOD, associated with the floodplains of Kidbrook, Lower Kid Brook and River Quaggy.

1.5.2 Geology

The bedrock geology of the study area is presented in **Appendix A Figure 3** and consists of bands of Chalk and Sand in the north of the Borough, Sand, Silt, and Gravel in the north and south of the Borough, and Clay in the centre and very south of the Borough. The Borough is underlain by a large area of secondary aquifer, which coincides with the sand, silt and gravel bedrock, and a small area of principal chalk aquifer. **Appendix A Figure 4** identifies that the bedrock is overlain by Alluvium and Head Deposits in the north adjacent to the River Thames, and a band of Kempton Park Gravel Formation passes through Greenwich town centre in the north and west of the Borough, which are both classified as secondary aquifers.

1.5.3 Principal Watercourses

The northern part of the RB of Greenwich is characterised by the tidal River Thames. The following principal watercourses are also present within the Borough:

- The course of the fluvial sections of the River Ravensbourne does not flow through RB of Greenwich, however the Quaggy River is a tributary of the River Ravensbourne, draining the south western section of the Borough, and the floodplain of the Ravensbourne extends to impact areas within RB of Greenwich. As the River Ravensbourne nears its confluence with the River Thames it becomes tidally influenced and flows through the far north west of the Borough as the Deptford Creek.
- The Quaggy River is a tributary of the River Ravensbourne; it rises from Locksbottom in London Borough of Bromley, flows through Bromley and enters the southwestern side of RB of Greenwich at Sidcup Road. It flows north through Eltham and then west through Sutcliff Park and out of the RB of Greenwich to its confluence with River Ravensbourne near Lewisham station.
- The Kyd Brook is a tributary of the Quaggy; it rises in Kidbrooke and flows south west through Blackheath Park to Lee Road, where it flows south along the boundary of RB of Greenwich and joins the River Quaggy by Meadowcourt Road before flowing into the London Borough of Lewisham.
- The River Shuttle rises in Avery Hill Park in the south eastern part of RB of Greenwich and flows eastwards to join the River Cray just to the south of Hall Place and the A2 East Rochester Way in neighbouring London Borough of Bexley.
- The Wickham Valley Watercourse rises in Oxleas Wood and flows north before entering a culvert and flowing into the Butts Canal. The Butts Canal is culverted along much of its length from the playing fields adjacent to Woodbrook Road to its outfall into South Mere (outside of the Borough boundary) in the Thamesmead area. This forms part of the wider Marsh Dykes surface water management system which was put in place in the 1960s when a large area of land was reclaimed from the marshland for commercial and residential development.

2 Legislative and Planning Policy Context

2.1 Introduction

This Section provides an overview of the legislative and planning policy context specific to the updated Level 1 SFRA for RB of Greenwich. The information presented in the SFRA should be used by RB of Greenwich to establish robust policies in relation to flood risk as part of their emerging Local Plan and used to guide responses to applications for development within areas of flood risk.

2.2 Flood and Water Management Act 2010

In response to the severe flooding across large parts of England and Wales in summer 2007, the Government commissioned Sir Michael Pitt to undertake a review of flood risk management. The Pitt Review – Learning Lessons from the 2007 Floods, and subsequent progress reviews outlined the need for changes in the way the UK is adapting to the increased risk of flooding and the role different organisations have to deliver this function.

The FWMA enacted by Government in response to The Pitt Review, designated unitary authorities, including London Boroughs, such as RB of Greenwich, as LLFAs. As a LLFA, RB of Greenwich has responsibilities to lead and co-ordinate local flood risk management. Local flood risk is defined as the risk of flooding from surface water runoff, groundwater and ditches and watercourses (collectively known as ordinary watercourses).

The FWMA also formalises the flood risk management roles and responsibilities for other organisations including the Environment Agency, water companies and highways authorities establishing them as Risk Management Authorities (RMAs). The responsibility to lead and co-ordinate the management of tidal and fluvial flood risk remains that of the Environment Agency.

2.2.1 National Strategy for Flood and Coastal Erosion Risk Management

In accordance with the FWMA, the Environment Agency has developed a National Strategy for Flood and Coastal Erosion Risk Management (FCERM) in England. This Strategy provides a framework for the work of all flood and coastal erosion risk management authorities.

The National FCERM Strategy sets out the long-term objectives for managing flood and coastal erosion risks and the measures proposed to achieve them. It sets the context for, and informs the production of, local flood risk management strategies by LLFAs, which will in turn provide the framework to deliver local improvements needed to help communities manage local flood risk. It also aims to encourage more effective risk management by enabling people, communities, business and the public sector to work together to:

- ensure a clear understanding of the risks of flooding and coastal erosion, nationally and locally, so that investment in risk management can be prioritised more effectively;
- set out clear and consistent plans for risk management so that communities and businesses can make informed decisions about the management of the remaining risks;
- encourage innovative management of risks taking account of the needs of communities and the environment;
- ensure that emergency responses to flood incidents are effective and that communities are able to respond properly to flood warnings; and,
- ensure informed decisions are made on land use planning.

The Environment Agency's 'Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities'[4] guidance is a supporting note for the National FCERM Strategy. The 2016 version of the document reflects an assessment completed by the Environment Agency between 2013 and 2015 using the UK Climate Projections (UKCP09) data, to produce more representative climate change allowances for river flood flows and extreme rainfall for each of the river basin districts in England. It is essential that land use planning decisions consider the impact of a changing climate where appropriate both now and into the future. Further information is presented in Section 4.3.

[4] Environment Agency (2016) Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/516116/LIT_5707.pdf

2.2.2 Local Flood Risk Management Strategy

In June 2015 RB of Greenwich prepared a Local Flood Risk Management Strategy[5] (LFRMS) in line with the requirements of the FWMA. In the LFRMS, RB of Greenwich set out that the Council will work to deliver the following Flood Risk Management objectives:

- To reduce local flood risk;
- To reduce the impact of any flooding;
- To plan for flooding to enable quicker recovery after a flood; and,
- A combination of all the above.

The LFRMS is a document which sets out how the RB of Greenwich is responding to identified local flood risk across the Borough and specifies:

- the RMAs in RB of Greenwich;
- the flood and coastal erosion risk management functions that may be exercised by the RMAs in relation to RB of Greenwich;
- the objectives for managing local flood risk;
- the measures proposed to achieve those objectives;
- how and when the measures are expected to be implemented;
- the costs and benefits of those measures, and how they are to be paid for;
- the assessment of local flood risk for the purpose of the Local Strategy;
- how and when the LFRMS is to be reviewed; and,
- how the Local Strategy contributes to the achievement of wider environmental objectives.

RB of Greenwich is part of the South East London Flood Risk Management Partnership and will work within that partnership to manage local flood risk and fulfil the duties and responsibilities under both the Flood Risk Regulations (2009) (refer to Section 2.3 below) and FWMA.

To manage flood risk RB of Greenwich will:

- Work in partnership with other RMAs;
- Prepare a South East London sub-regional LFRMS;
- Prepare a LFRMS for RB of Greenwich; and,
- Prepare a six year Action Plan that will be reviewed annually.

2.2.3 Surface Water Management Plan

A Surface Water Management Plan (SWMP) was prepared for RB of Greenwich in October 2011[6] as part of the wider Drain London Project for all 33 Boroughs within Greater London. . In this context surface water flooding describes flooding from sewers, drains, groundwater, and runoff from land, small water courses and ditches that occurs as a result of heavy rainfall.

The objectives of the SWMP are to:

- Develop a robust understanding of surface water flood risk in and around the Borough of Greenwich, taking into account the challenges of climate change, population and demographic change and increasing urbanisation in London;
- Identify, define and prioritise Critical Drainage Areas (CDA), including further definition of existing local flood risk zones and mapping new areas of potential flood risk;
- Make holistic and multifunctional recommendations for surface water management which improve emergency and land use planning, and enable better flood risk and drainage infrastructure investments;
- Establish and consolidate partnerships between key drainage stakeholders to facilitate a collaborative culture of data, skills, resource and learning sharing and exchange, and closer coordination to utilise cross boundary working opportunities;

[5] https://consultations.royalgreenwich.gov.uk/uploadedfiles/Local%20Flood%20Risk%20Management%20Strategy%20report.pdf
[6] Halcrow(2011). Royal Borough of Greenwich Surface Water Management Plan

- Undertake engagement with stakeholders to raise awareness of surface water flooding, identify flood risks and assets, and agree mitigation measures and actions;
- Deliver outputs to enable a real change on the ground rather than just reports and models, whereby partners and stakeholders take ownership of their flood risk and commit to delivery and maintenance of the recommended measures and actions;
- Meet RB of Greenwich Council's specific objectives as recorded during the development of the SWMP (further details have been specified in the SWMP);
- Facilitate discussions and report implications relating to wider issues falling outside the remit of the work specified in the SWMP, but deemed important by partners and stakeholders for effectively fulfilling their responsibilities and delivering future aspects of flood risk management.

Where appropriate, the findings of the SWMP have been referred to within this Level 1 SFRA.

2.3 Flood Risk Regulations 2009

As well as the duties under the FWMA to prepare a LFRMS, LLFAs have legal obligations under the EU Floods Directive[7]**Error! Bookmark not defined.**, which was transposed into UK Law through the Flood Risk Regulations 2009[8] ('the Regulations').

2.3.1 Preliminary Flood Risk Assessment

Under the Regulations, all LLFAs were required to prepare a Preliminary Flood Risk Assessment (PFRA) report in 2011, which will be subsequently due for renewal on a 6-yearly cycle. The PFRA is a high level screening exercise to identify areas of significant risk as 'Indicative Flood Risk Areas' across England where 30,000 people or more are at risk from flooding for reporting to Europe. Defra identified the Greater London area to be an Indicative Flood Risk Area. All of the RB of Greenwich study area is within this Indicative Flood Risk Area.

A PFRA was prepared for RB of Greenwich in 2011 as part of the Drain London Project. The PFRA seeks to provide a high level overview of flood risk from local flood sources and includes flooding from surface water, groundwater, ordinary watercourses, and artificial sources, such as canals. It excludes flood risk from main rivers, the sea and reservoirs, as these are assessed nationally by the Environment Agency. The PFRA report looks at past flooding and where future flooding might occur across the area and the consequences it might have to people, properties and the environment. The report provides a useful baseline in the preparation of this revised Level 1 SFRA.

2.3.2 Thames River Basin District Flood Risk Management Plan 2015 – 2021

Under the Regulations, the Environment Agency is required to prepare FRMPs for all of England covering flooding from main rivers, the sea and reservoirs. As such, the Thames River Basin District FRMP[9] has been published by the Environment Agency and sets out the proposed measures to manage flood risk in the Thames River Basin District from 2015 to 2021 and beyond. This document draws on existing policies and actions within reports and plans which have been prepared in the past such as the Thames Catchment Flood Management Plan (CFMP) and the Thames Estuary 2100 Plan.

The Thames Catchment Flood Management Plan (CFMP) was published in 2008 and sets out policies for the sustainable management of flood risk across the whole catchment over the long-term (50 to 100 years) taking climate change into account. The Plan emphasises the role of the floodplain as an important asset for the management of flood risk, the crucial opportunities provided by new development and regeneration to manage risk, and the need to re-create river corridors so that rivers can flow and flood more naturally.

The Thames Estuary 2100 (TE2100) Plan[10], established by the Environment Agency in 2002, set out recommendations for flood risk management for London and the Thames estuary through to the end of century and beyond. The Plan primarily looks at tidal flooding, though other sources of flooding including high river flows as a result of heavy rainfall and surface water flooding are considered. The key driver for the project was to consider how tidal flood risk was likely to change in response to future changes in climate and people and property in the floodplain. Additional to this there was an understanding that many of the existing flood walls, embankments and barriers were getting older and would need to be raised or replaced to manage rising water levels. Along the Thames there are eight Action Zones, i.e. areas with similar characteristics that require a similar type and range of actions. TE2100 identifies that RB of Greenwich falls within two Action Zones; Action Zone 3 (Greenwich) and Action Zone 4 (Thamesmead).

[7] http://ec.europa.eu/environment/water/flood_risk/
[8] http://www.legislation.gov.uk/uksi/2009/3042/contents/made
[9] Environment Agency (March 2016) Thames River Basin District Flood Risk Management Plan https://www.gov.uk/government/publications/thames-river-basin-district-flood-risk-management-plan
[10] Environment Agency, November 2012. Thames Estuary 2100 Action Plan https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/322061/LIT7540_43858f.pdf

The measures set out within Appendix C of the Thames River Basin District FRMP that are of relevance to the RB of Greenwich administrative area are set out in Table 2-1.

Table 2-1 Thames River Basin District Measures (summarised by river catchments and TE2100 Action Zones) of relevance to the RB of Greenwich

River Ravensbourne Catchment
Short-term land use planning actions. The short to medium-term priority actions in line with National Planning Policy Framework (NPPF) to create safe and sustainable development that positively reduces flood risk in the Ravensbourne floodplain are: - Ensure the local council strategic flood risk assessments (SFRA) remain up to date. - Seek commitments in land use planning documents to retain the remaining floodplain for flood risk. - Encourage partners to develop policies, strategies and initiatives that seek to increase the resistance and resilience of existing development. - Encourage the local council to adopt and apply policies that ensure that all new properties built in the floodplain are resistant and resilient. - Seek greenfield runoff discharge rates, and a reduction in runoff volumes.
Long-term adaptation of the urban environment to be more flood resilient. The priority actions to achieve long-term adaptation of urban floodplain river corridors along the Ravensbourne, linked to the redevelopment of urban areas are: - Encourage refurbishment of existing buildings that increases resilience and resistance to flooding. - Identify opportunities to recreate river corridors and wetland habitats in urban areas. - Removing obstructions to flow and naturalising watercourses. - Increasing the available storage within the river corridor. - Encourage partners to assess the viability of future land swapping opportunities where there is a risk of flooding.
Surface water drainage. Consider the impact of other sources of flooding by supporting local councils and other risk management authorities in the production of local strategies and surface water management plans for those areas of the Ravensbourne that are most vulnerable to this source of flooding. These plans should investigate risk from local sources of flooding. This plan should consider increased risk to the drainage system from future development and climate change.
Optimising attenuation and conveyance within the catchment in the long-term. It is a priority to set out a clear vision for the future management of the flow of water in the catchment. This is necessary because: - Our current management relies heavily on conveyance and this is not sustainable. - We need to link the management of current assets to a more sustainable vision (action Ra5) The outcomes that we are seeking through this action are: - Conveyance maintained where we have to, but in a more natural state. - Greater attenuation in the catchment. - A re-established and enhanced river corridor. - Reduce future legacy costs by identification of redundant asset structures.
Short-term management of assets. Maintain the existing level of conveyance by keeping the existing channels clear and free from obstruction. Where regeneration is likely in the foreseeable future (including beyond the current plan period), manage those assets so that we avoid the need to replace the assets until the regeneration occurs and we have a better opportunity to replace them with something which supports our overall vision for the catchment (set out in RA2 and RA4). There is also a significant number/value of Third Party Owned assets in this policy unit. Attention should be given to the Environment Agency policy guidance on dealing with third party flood defence assets which describes actions of notification followed by enforcement for assets not being maintained to their target condition.
Flood warning, flood awareness and emergency planning. An important element of flood risk management is to prepare for and to address the consequences of flooding. The priority actions are: - Work with partners to identify critical infrastructure at risk of flooding and encourage appropriate action. - Work with partners, including the media, to ensure that effective communication plans are in place before, during and in the recovery phase of a flooding incident. - Increase public awareness. This is particularly important as we are going to be changing areas of flood warnings that are issued here.
Thamesmead and Marsh Dykes
Assessment of the operation of pumping stations and the impact on drainage within the area. Investigations required as to whether operation and carbon costs can be reduced.
TE2100 Action Zone 3 (includes Greenwich)
Recommendation 1: TE2100 Plan informs the development and revision of local authority strategic flood risk assessments (SFRAs) and flood plans.
Recommendation 2: To agree a programme of floodplain management including local flood protection, resilience and emergency plans for vulnerable key sites in action zone 3.
Recommendation 3: To agree partnership arrangements and principles to ensure that new development in the east London zone is safe, and that where possible the application of the national planning policy framework (NPPF) reduces the consequences of flood risk - particularly in the areas where large numbers of people congregate or there is aggregation of flood risk.
Recommendation 4: 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 our plan.
TE2100 Action Zone 3 - Recommendation 5: 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 plan.
TE2100 Action Zone 3 - Recommendation 6: To maintain, enhance, improve or replace the river defence walls and active structures through east London over the first 25 years of the plan from 2010 to 2034.
TE2100 Action Zone 3 - Recommendation 7: To maintain, enhance and improve or replace the defence walls and active structures through east London during the 15 year period of the Plan from 2035 to 2049.
TE2100 Action Zone 3 - Recommendation 8: To implement a programme of defence raising through east London from 2065 to 2070 (with defences upriver of the Thames Barrier being raised by 2065 and downriver in 2070).
TE2100 Action Zone 3 - Recommendation 9: To maintain, improve, enhance or replace the river defence walls and active structures through central London post 2070 and into the 22nd century.
TE2100 Action Zone 3 - Recommendation 10: To agree a programme of managing flooding from other sources in the defended tidal floodplain in the first 25 years of the TE2100 plan.
TE2100 Action Zone 4 (includes Thamesmead)
Recommendation 1: TE2100 plan informs the development and revision of local authority strategic flood risk assessments (SFRAs) and flood plans.
Recommendation 2: To agree a programme of floodplain management including localised flood protection, resilience and local emergency plans for vulnerable key sites in action zone 4.
Recommendation 3: To agree partnership arrangements and principles to ensure that new development in this zone is safe and that where possible the application of the national planning policy framework (NPPF) reduces the consequences of flood risk - particularly in the areas where large numbers of people congregate or there is aggregation of flood risk.
Recommendation 4: 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 our plan.
Recommendation 5: 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 plan.
Recommendation 6: To maintain, enhance and improve or replace the river defence walls and active structures through the east London downstream of the Thames Barrier zone over the first 25 years of the plan from 2010 to 2034.
Recommendation 7: To maintain, enhance and improve or replace the 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.
Recommendation 8: To implement our "end of the century" option between 2050 and 2070.
Recommendation 9: To maintain, improve and enhance or replace the river defence walls and active structures in east London downstream of the Thames Barrier zone post 2050 and into the 22nd century.
Recommendation 10: To agree a programme of managing flooding from other sources in the defended tidal floodplain in the first 25 years of the TE2100 plan.
Recommendation 12: To agree a programme for habitat enhancement and replacement and implement habitat improvement and replacement schemes up to 2050.

2.4 National Planning Policy Framework

The NPPF is a framework within which councils and local people can produce local and neighbourhood plans that reflect the needs and priorities of their communities. Paragraphs 100 -102 of the NPPF state:

'Local Plans should be supported by a SFRA and should develop policies to manage flood risk from all sources, taking account of advice from the Environment Agency and other relevant flood risk management bodies, such as lead local flood authorities and internal drainage boards. Local Plans should apply a sequential, risk-based approach to the location of development to avoid where possible flood risk to people and property and manage any residual risk, taking account of the impacts of climate change, by:

- applying the Sequential Test;
- if 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; and,
- where climate change is expected to increase flood risk so that some existing development may not be sustainable in the long-term, seeking opportunities to facilitate the relocation of development, including housing, to more sustainable locations'.

The aim of the Sequential Test is to steer new development to areas with the lowest probability of flooding. Development should not be allocated or permitted if there are reasonably available sites appropriate for the proposed development in areas with a lower probability of flooding. The SFRA will provide the basis for applying this test. A sequential approach should be used in areas known to be at risk from any form of flooding.

If, following application of the Sequential Test, it is not possible, consistent with wider sustainability objectives, 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.

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

Further detail regarding the Sequential and Exception Tests is included in Section 5 of this report.

2.4.1 NPPF Guidance SuDS Policy (April 2015)

Sustainable Drainage Systems (SuDS) are an approach to managing rainwater and surface water that replicates natural drainage, the key objectives being to manage flow rate and volume of runoff to reduce risk of flooding and water pollution. From 6th April 2015, LPAs such as RB of Greenwich are required to ensure that SuDS are implemented for all major developments where appropriate, and that through the use of planning conditions or planning obligations that there are clear arrangements in place for ongoing maintenance over the lifetime of the development.

As a LLFA, RB of Greenwich is also a statutory consultee for SuDS applications and will need to be consulted on the drainage elements of planning applications for major development to ensure they conform to necessary national and local SuDS standards.

2.5 Local Plan: Core Strategy with Detailed Policies

RB of Greenwich Core Strategy with Detailed Policies[11] is the most important spatial planning document that RB of Greenwich had produced since 2004. The document was adopted in 2014 and sets out the rules of how the Borough should be developed until 2028.

The key features of the Spatial Strategy summarised in the Local Plan are:

- High levels of growth with a minimum of 38,925 homes and an expected population increase which exceeds the London and national average;
- Enhancement of existing neighbourhoods in Royal Greenwich;
- Transformation of Woolwich into a vibrant, successful town centre with new retail, office, hotel, cultural and housing development that will claw back trade and warrant reclassification of the Town as a Metropolitan Centre towards the end of the plan period;
- Reinforce the role of Eltham Town Centre as the pre-eminent centre in the south of Royal Greenwich;
- Creation of a new mixed use urban quarter at Charlton Riverside incorporating around 3,000-5,000 new homes by 2031, which will involve substantial release of under-used industrial land and intensification of employment on remaining land;
- Creation of new mixed use urban quarter at Greenwich Peninsula West incorporating new residential units and employment use, which will involve release of industrial land;
- Regeneration of housing estates in Thamesmead, Charlton and the Woolwich area;
- Redevelopment at Kidbrooke incorporating 4,800 new homes, retail, leisure and community facilities into a new vibrant and mixed community;
- Re-modelling Thamesmead Town Centre, improving transport infrastructure and increasing services and facilities;
- Development will reflect the needs of an increasingly mixed and diverse community and will reduce existing inequalities across Royal Greenwich;
- Development of Crossrail with stations at Abbey Wood and Woolwich;
- A new District Centre at North Greenwich to serve the residents of around 14,000 new homes on Greenwich Peninsula;

[11] Royal Greenwich Local Plan Core Strategy with Detailed Policies, Adopted 30th July 2014.

- Protection and enhancement of Royal Greenwich's heritage assets and encouraging positive use of these assets as a catalyst for conservation-led regeneration;
- Protection and enhancement of Royal Greenwich's open spaces and the creation of new open spaces;
- Development throughout Royal Greenwich will mitigate and/or adapt to the impacts of climate change;
- The number of jobs in Royal Greenwich to grow up by up to 21,000 and will be focused in the waterfront area including the Peninsula and Woolwich;
- Infrastructure will be provided to support the proposed growth, including a package of new river crossings and the completion of the Thames Path;
- Development will reflect the needs of a growing and increasingly mixed population, taking advantage of enhanced digital technologies to improve social interactions and sense of community.

The Core Strategy with Detailed Policies contains two specific detailed policies which relate to flood risk.

Policy E2 Flood Risk

The Royal Borough's SFRA must be used to inform development and reduce flood risk in Royal Greenwich by:

i. Applying the sequential and exceptions tests as detailed in the NPPF and accompanying guidance;

ii. Demonstrating consideration of all forms of flood risk by preparing flood risk assessments, in line with advice from the Environment Agency. These must demonstrate:

1. *that the consequences and probability of flooding will be reduced, where possible, and that there will be no increased risk of flooding elsewhere;*
2. *how actual and residual risk to the development and flood risk to others from all sources will be managed over the lifetime of the development, taking into account climate change;*
3. *that development will be safe through layout, form and floor levels of the development and mitigation measures;*
4. *that development will be safe in terms of dry access, egress an refuge, and that emergency planning is considered;*
5. *that development will not constrain the natural function of the floodplain, either by impeding flood flows, reducing storage capacity or otherwise increasing flood risk elsewhere; and,*
6. *that development will safeguard existing tidal and fluvial flood defences.*

Policy E3 Residual Risk

In addition to the measures within policy E2, development within those areas protected by flood defences but with a high residual risk classification should implement risk reduction measured with the primary aim of reducing risk to life.

Applicants, as part of their flood risk assessment must provide details of indicative breach flood water levels, ground levels, ground, first, and second flood levels in metres AOD, and show the floor level for bedrooms and safe refuges, providing justification for the options chosen.

Applicants must also provide a flood plan, detailing evacuation and flood response procedures.

2.6 London Plan 2016

Under the legislation establishing the Greater London Authority (GLA), the Mayor has to produce a spatial development strategy (SDS) – which has become known as 'the London Plan'. The London Plan was published in 2016 and sets out the economic, environmental, transport and social framework for the development of London over the next 20–25 years.

The London Plan contains the following policies associated with flood risk:

Policy 5.12 Flood Risk Management

Development proposals must comply with the flood risk assessment and management requirements set out in the NPPF and the associated technical Guidance on flood risk over the lifetime of the development and have regard to measures proposed in Thames Estuary 2100 (TE2100 – see paragraph 5.55) and Catchment Flood Management Plans.

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

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

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

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

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

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

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

Policy 5.13 Sustainable Drainage

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

1 store rainwater for later use

2 use infiltration techniques, such as porous surfaces in non-clay areas

3 attenuate rainwater in ponds or open water features for gradual release

4 attenuate rainwater by storing in tanks or sealed water features for gradual release

5 discharge rainwater direct to a watercourse

6 discharge rainwater to a surface water sewer/drain

7 discharge rainwater to the combined sewer.

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

2.7 Summary

Figure 2-1 provides a summary of the documents that have been reviewed within this section. The figure demonstrates that the main driver for the SFRA is the NPPF, and that documents and plans prepared by both the Environment Agency and RB of Greenwich under the requirements of the FWMA and the FRRs, provide key inputs to inform the preparation of the revised SFRA and Local Plan.

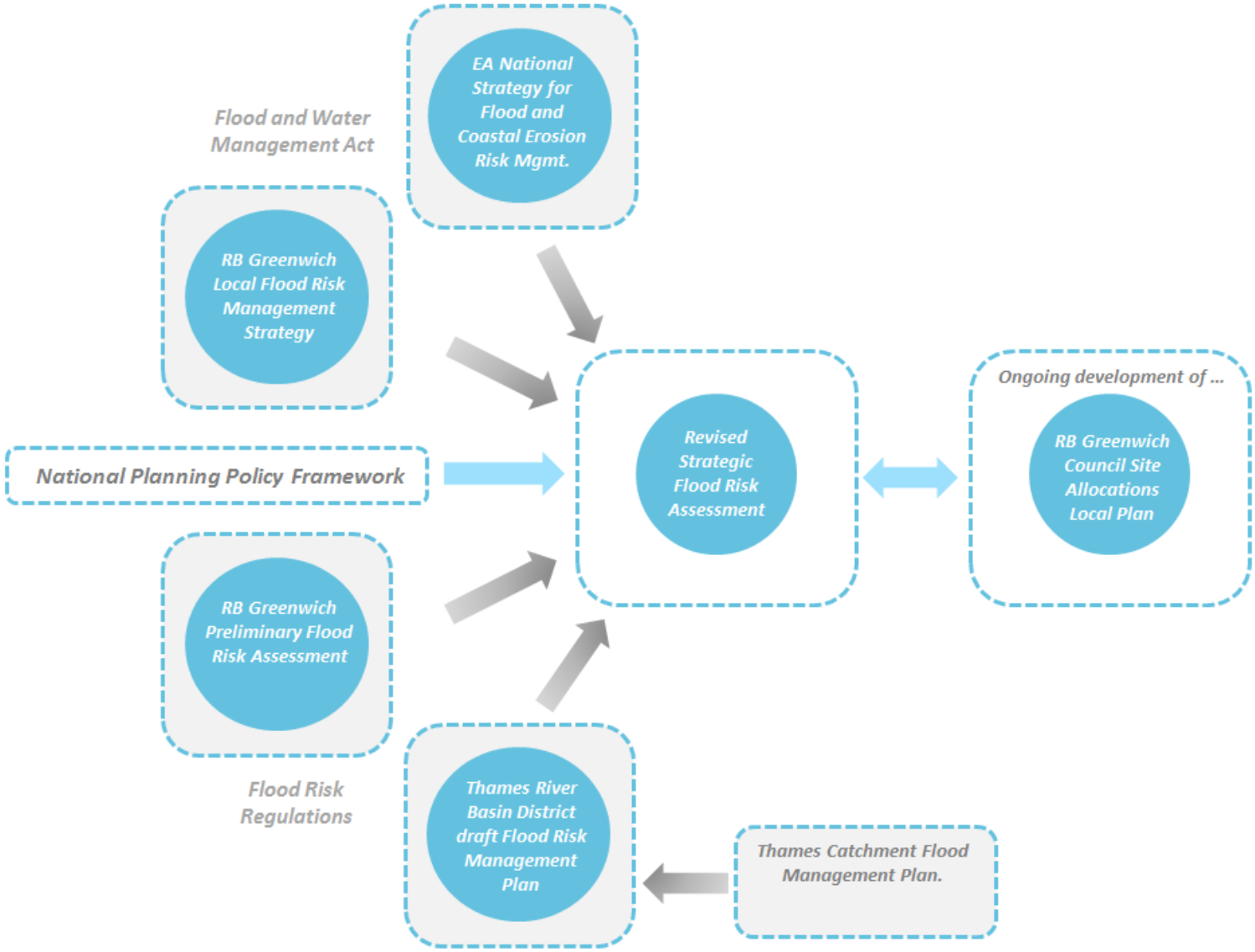


Figure 2-1 Summary of Legislative and Planning Context

3 Level 1 SFRA Methodology

The Level 1 SFRA is a desk-based study, using readily available existing information and datasets to enable the application of the Sequential Test and to identify where the Exception Test may be required. The main tasks in preparing the Level 1 SFRA are described below.

3.1.1 Establishing relationships and understand the planning context

An inception meeting was held to facilitate relationships between the project team, RB of Greenwich and the Environment Agency to aid collaborative working and enable the free exchange of available information and datasets. RB of Greenwich provided an overview of the current planning context with respect to the preparation of the new Local Plan and the main flood risk issues in the area were identified and discussed.

3.1.2 Gathering data and analysing it for suitability

Under Section 10 of NPPF, the risk of flooding from all sources must be considered as part of a Level 1 SFRA, including flooding from tidal sources, rivers (fluvial), land (overland flow and surface water), groundwater, sewers and artificial sources.

In order to provide this assessment of all sources of flooding in the study area, an extensive set of datasets was requested from a number of organisations, including RB of Greenwich, the Environment Agency and TWUL.

Datasets and information gathered as part of the preparation of the first iteration of the SFRA have been retained where appropriate. The datasets are described further in Section 4, including detail regarding appropriate uses and limitations, and how they have been used within the Level 1 SFRA.

3.1.3 Producing strategic flood risk maps, GIS deliverables and a technical report

A series of GIS maps have been produced using the data gathered during the study. The mapping deliverables are summarised in Table 3-1 and should be referred to when reading Section 4 'Level 1 Assessment of Flood Risk' which provides an overview of flood risk across the Borough.

Table 3-1 Strategic Flood Risk Assessment Maps

Figure No.	Figures Title and Content
Figure 1	Study Area Topography *(Administrative boundaries, LiDAR topography, catchments,)*
Figure 2	Watercourses and Catchments *(Administrative boundaries, catchments, watercourses, water bodies)*
Figure 3	Bedrock Geology
Figure 4	Superficial Geology
Figure 5A-5D	Flood Map (Rivers and Sea) *(Watercourses, surface waterbodies, infrastructure, Flood Zones, flood defences)*
Figure 6	Flood Zone 2 Data Sources and Historic Flood Map *(Flood Zone 2 showing data source, Environment Agency Historic Flood Map)*
Figure 7A-7C	River Ravensbourne Modelled Flood Extents *(Modelled flood extents from the Ravensbourne modelling study (2015))*
Figure 8A-8D	Risk of Flooding from Surface Water Map *(RoFSW, historic records of flooding)*
Figure 9	Potential Groundwater Flooding Zones *(Potential groundwater flooding zones (MHW Groundwater Study 2016), groundwater flood records)*
Figure 10	Sewer Flooding *(Historic records of sewer flooding)*
Figure 11	Flood Warning Areas *(Flood Warning Areas)*

3.1.4 Site Assessment Database

As a result of their site identification process for the Local Plan, RB of Greenwich has 6 strategic development locations and 84 site allocations. In addition, RB of Greenwich has subsequently identified 55 potential development sites as a result of a consultation exercise in early 2016. In order to facilitate the application of the Sequential Test to these sites, the Level 1 SFRA has included the preparation of a site assessment database containing flood risk information for each site to enable the comparison of sites. The database uses the GIS datasets to provide an assessment of the risk of flooding from sources, as well as an indication of historic records of flooding in the areas.

4 Level 1 Assessment of Flood Risk

4.1 Introduction

This Section provides the strategic assessment of flood risk across the RB of Greenwich from each of the sources of flooding outlined in the NPPF. For each source of flooding, the datasets used for the assessment are described, details of any historical incidents are provided, and where appropriate, the impact of climate change on the source of flooding is described. This section should be read in conjunction with the figures in Appendix A.

4.2 Tidal Flooding

4.2.1 Flood Zones

The River Thames forms the northern boundary of the RB of Greenwich. At this point along its course the water levels in the River Thames are tidally influenced. The Thames Barrier is located half way along the Greenwich Thames riverside at Charlton. Upstream of the Thames Barrier, high water levels from extreme tidal levels and/or storm surge events are managed by the operation of the Thames Barrier to protect against tidal flooding. The NPPF uses Flood Zones to identify the probability of tidal flooding, ignoring the presence of defences. The Flood Zones are shown on the Environment Agency's Flood Map for Planning (Rivers and Sea), available on the GOV.UK website[12]. The definitions for the Flood Zones with respect to tidal flooding are presented in Table 4-1.

Table 4-1 Tidal Flood Zone Definitions (extracted from the NPPG, 2014)

Flood Zone	Tidal Flood Zone Definition	Probability of Flooding
Flood Zone 1	Land having a less than 0.1% Annual Exceedance Probability (AEP) (1 in 1,000 chance each year) of tidal flooding. Shown as clear on the Flood Map – all land outside Flood Zones 2 and 3.	Low
Flood Zone 2	Land having between a 0.5% AEP (1 in 200 chance each year) and 0.1% AEP (1 in 1,000 chance each year) of tidal flooding. Shown as light blue on the Flood Map.	Medium
Flood Zone 3a	Land having a 0.5% AEP (1 in 200 chance each year) or greater of tidal flooding. Shown as dark blue on the Flood Map.	High
Flood Zone3b	Land where water has to flow or be stored in times of flood. Land within the River Thames channel that is riverward of the flood defence line has been defined by RB of Greenwich as Flood Zone 3b.	Very High

Appendix A Figures 5A – 5D presents the Environment Agency Flood Zones for the study area and identifies that a large area covering the area north of Greenwich Park, the sites north of the junctions between Woolwich Road and Horn Lane, the area of Charlton north of Woolwich Road and the areas north of Plumstead Road including Royal Arsenal East, Abbey Road and Thamesmead, are defined as Flood Zone 3 associated with the River Thames.

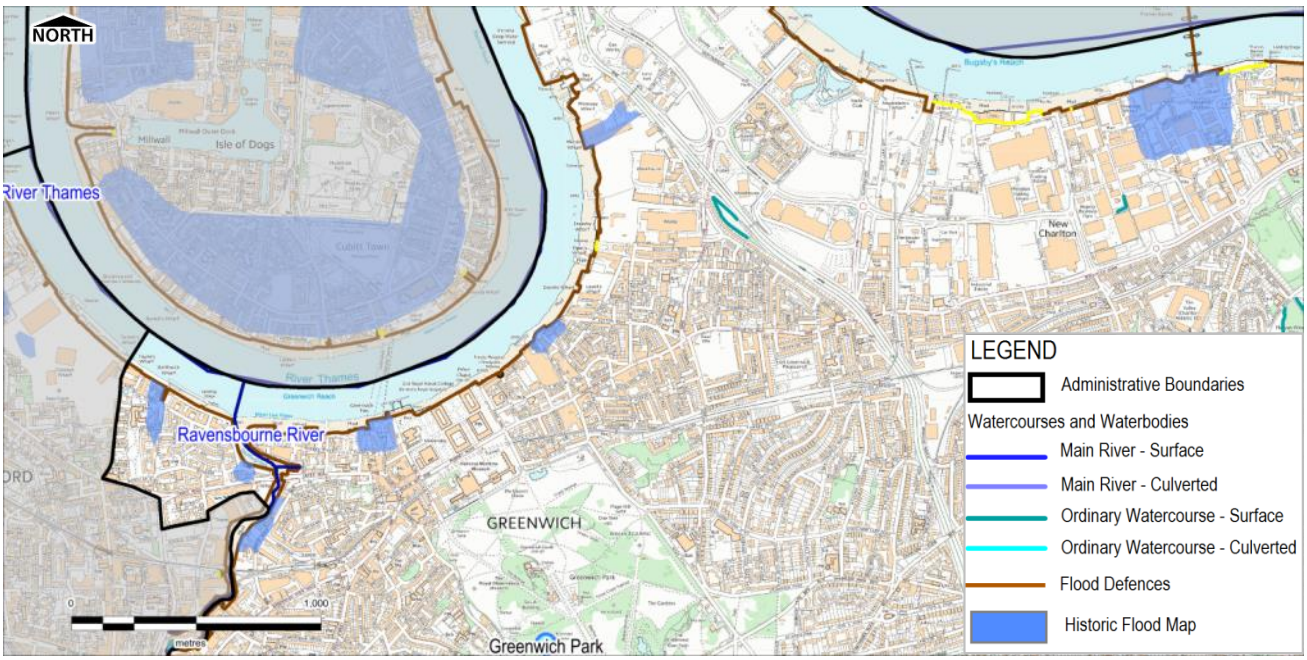
In RB of Greenwich, areas of Flood Zone 3 associated with the River Thames are also defined as 'Areas Benefitting from Defences' (ABD), i.e. they are shown to benefit from the presence of flood defences during a 0.5% AEP flood event. The Thames Tidal Defence (TTD) system includes both the raised flood defence walls along the River Thames frontage, as well as the Thames Barrier located at Woolwich.

The risk of tidal flooding to these northern parts of the study area is therefore a residual risk, in the event of a breach or overtopping of the local flood defences.

[12] https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?easting=538390&northing=177677

4.2.2 Historic Records

The Environment Agency Historic Flood Map is shown in **Appendix A Figure 6** and Figure 4-1**.** This dataset is based on a combination of tidal flooding events in RB of Greenwich in 1928 and 1953. In 1928 tidal flooding resulting in the overtopping of defences affected sites north of Greenwich Park, areas to the west of the junction between A102 and Blackwall Lane and sites east side of Charlton. In 1953, tidal flooding as a result of operational failure of defences resulted in the flooding of a large area north of Plumstead High Street covering Abbey Wood and Thamesmead.



Environment Agency Historic Flood Map (1928) Tidal Flood Risk
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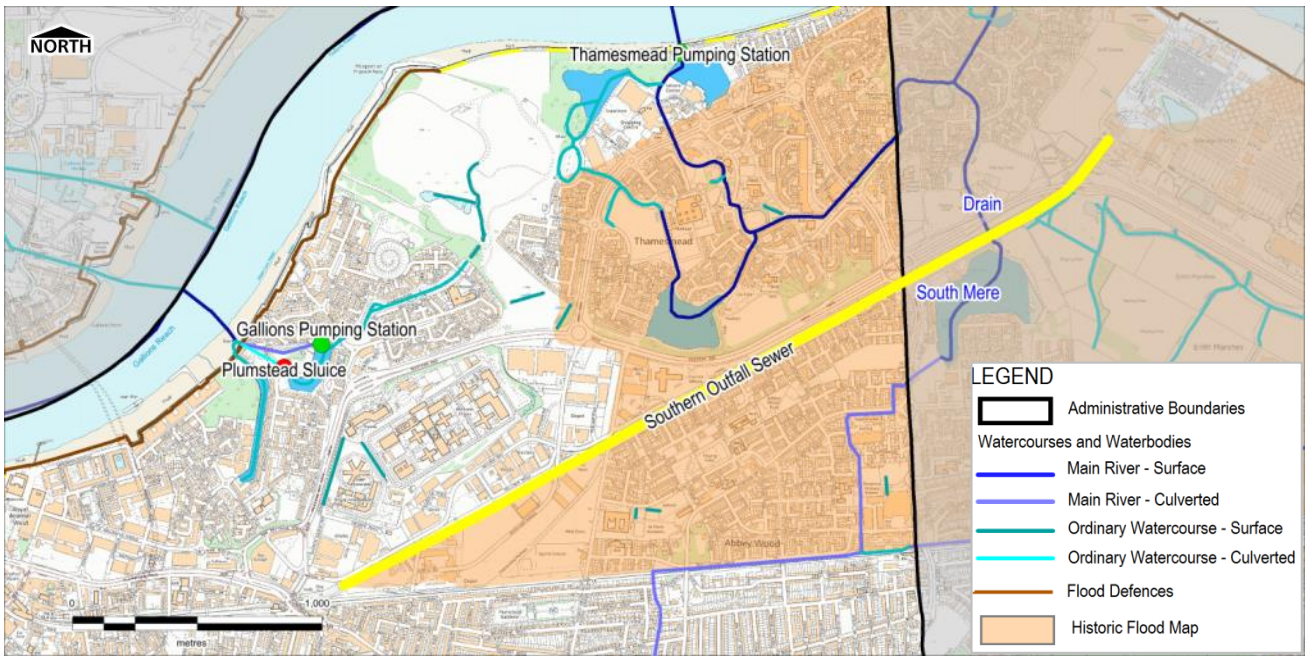

Environment Agency Historic Flood Map (1953) Tidal Flood Risk
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Figure 4-1 Historic Flood Map – Tidal Flood Events 1928 and 1953

Records of historic tidal flooding prior to 1928 have been recorded in the previous SFRA, dating back to 1236. The full list of historic tidal flooding events is presented in

Table 4-2.

Table 4-2 Historic tidal flood records in RB of Greenwich

Year	Location and Details (Source of information)
1236	Woolwich. (Source: Chronology of British Hydrological Events (CBHE)[13]).
November 1875	River Thames overflowed from Gravesend to its tidal limit (Source CBHE).
October 1882	Flooding of areas adjacent to the River Thames. (Source: Environment Agency).
1928	Flooding of areas adjacent to the River Thames. These include the areas north of Greenwich Park, areas to the west of the junction between A102 and Blackwall Lane and sites east side of Charlton as a result of overtopping of defences. (Source: Environment Agency).
1953	Area north of Plumstead High Street covering Abbey Wood and Thamesmead, flooding as a result of operational failure/breach of defence. (Source: Environment Agency).

4.2.3 Tidal Flood Defences

Extracts from the Environment Agency Asset Information Management System (AIMS) provided to inform the Level 1 SFRA show that the River Thames is defended predominantly by the presence of flood walls, as well as sections of embankments located at various sites along the Thames; a section from Angerstein's Wharf until east of Lombard Trading Estate, a section by the Thames Barrier Centre, another small section by Royal Arsenal West and finally, a section from Margaret or Tripcock Ness until the east boundary of the Borough. The AIMS dataset is shown in **Appendix A Figures 5A-5C.** The AIMS identifies the design standard of protection of the defences along the tidal River Thames for the 0.1% AEP flood event (1 in 1000 year return period).

The lower reach of the Ravensbourne River (the Deptford Creek) is tidally influenced, and is shown to be protected on both sides by a flood defence wall. Further upstream there is a flood wall on the western bank and high ground present on the eastern bank. These features are recorded to have a design standard of protection for the 0.1% AEP flood event (1 in 1000 year return period) in the AIMS.

4.2.4 Climate Change

A considerable amount of research is being carried out worldwide in an endeavour to quantify the impacts that climate change is likely to have on flooding in future years. Climate change may increase peak rainfall intensity, river flow, and tide levels which could result in more frequent and severe flood events. Climate change is perceived to represent an increasing risk to low lying areas of England, and it is anticipated that the frequency and severity of flooding will change measurably within our lifetime.

The TE2100 Plan[14], established by the Environment Agency in 2002, sets out recommendations for flood risk management for London and the Thames estuary through to the end of century and beyond. The recommendations from the Plan are presented in Table 2-1 and refer to the raising of flood defences upstream of the Thames Barrier by 2065, and downstream of the Barrier by 2070. There is also a recommendation to implement the 'end of the century option' by 2070, with respect to future protection for London from the tidal River Thames.

4.2.5 Residual Risk

In March 2015, the Thames Tidal Breach Modelling Study[15] was completed for the Environment Agency. The purpose of this Study was to simulate a series of breach scenarios along the Thames frontage, to quantify the residual risk of tidal flooding. In total, 113 breach locations were modelled as part of this study. The results from 8 of these breach locations are of relevance to the RB of Greenwich study area, as detailed in Table 4-3 and shown in **Appendix C Figure C0**. Breach locations Green04 – Thm07 are located downstream of the Thames Barrier.

In May 2017, the Thames Tidal Upriver Breach Inundation Assessment[16] was completed for the Environment Agency. The purpose of this Study was to simulate a series of breach scenarios along the Thames frontage, to quantify the residual risk of tidal flooding. In total, 5679 breach locations were modelled from upstream of the Thames Barrier to Teddington Weir as part of this study. The results from this study have been provided as a composite map, which shows the worst case scenario from all breach locations and does not show the impacts from individual breaches. The breach hazard results from this study are shown in **Appendix C Figure C1**.

[13] BHS Chronology of British Hydrological Events, http://www.dundee.ac.uk/geography/cbhe/
[14] Environment Agency, November 2012. Thames Estuary 2100 Action Plan https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/322061/LIT7540_43858f.pdf
[15] Atkins, May 2017, Thames Tidal Upriver Breach Inundation Assessment.
[16] Atkins, May 2017, Thames Tidal Upriver Breach Inundation Assessment.

Table 4-3 Thames Tidal Breach Modelling Parameters, Greenwich (Automated Breach Factsheet, CH2MHill 2015)

Breach Name	Breach Location	Defence Type	Breach Width (m)	Invert Level (m AOD)	Duration (hours)	Breach Coordinates	
Grn04	Thames Barrier (South bank terrace) - Earth Embankment	Embankment	50	3.65	35	541657.65	179314.60
Thm01	Royal Arsenal West, Woolwich	Wall	20	4.52	35	544198.49	179500.80
Thm02	Gallions Reach Pond, Thamesmead West	Wall	20	5.18	35	544622.80	179806.60
Thm03	Abbey Sluice, Thamesmead North	Wall	20	4.76	35	547525.13	181446.40
Thm04	Halfway Reach, Thamesmead East	Wall	20	2.44	35	549583.20	180758.50
Thm05	Jenningtree Point, Halfway Reach	Wall	20	1.58	35	550280.42	180632.10
Thm06	Belvedere Industrial Estate, Belvedere	Wall	20	4.92	35	550720.38	180113.20
Thm07	Erith Reach, Erith	Wall	20	2.13	35	550857.93	179587.00

Results from the modelling will be considered further as part of the Level 2 SFRA, however hazard mapping from the study has been provided at this stage to further inform the application of the Sequential Test by RB of Greenwich within those areas identified to be at residual risk of flooding from the River Thames (i.e. defended Flood Zone 3a).

Flood hazard categorises the danger to people for different combinations of flood water depth and velocity. The derivation of these categories set out in Table 4-4 is based on the methodology set out by Defra in Flood Risks to People FD2320[17] using the following equation:

*Flood Hazard Rating = ((v+0.5)*D) + DF*

Where v = velocity (m/s), D = depth (m), DF = debris factor

Table 4-4 Hazard categories based on FD2320, Defra & Environment Agency 2005

Flood Hazard		Description
Low	HR < 0.75	**Caution** – Flood zone with shallow flowing water or deep standing water
Moderate	0.75 ≥ HR ≤ 1.25	**Dangerous for some** (i.e. children) – Danger: flood zone with deep or fast flowing water
Significant	1.25 > HR ≤ 2.0	**Dangerous for most people** – Danger: flood zone with deep fast flowing water
Extreme	HR > 2.0	**Dangerous for all** – Extreme danger: flood zone with deep fast flowing water

For breach locations downstream of the Barrier (Green04 – Thm07), the following scenarios have been simulated:

- 0.5% AEP for present day (2014).
- 0.5% AEP under climate change conditions for the year 2065.
- 0.5% AEP under climate change conditions for the year 2100.
- 0.1% AEP for present day (2014).
- 0.1% AEP under climate change conditions for the year 2065.
- 0.1% AEP under climate change conditions for the year 2100.

[17] Defra and Environment Agency (2005) FD2320 Flood Risks to People.

Hazard mapping for the 0.5% AEP flood event for the year 2100 have been presented for breach locations Green04 – Thm07 in **Appendix C Figures C2-C8**.

For breach locations upstream of the Barrier , return periods cannot be applied to water levels in the same manner as they can downstream of the Barrier, as water levels are a function of the maximum tide level allowed through the Barrier, as defined by the barrier closure rule / matrix. As a result, a Maximum Likely Water Level (MLWL) is applied. The following scenarios have been simulated for breach locations upstream of the Barrier:

- Maximum Likely Water Level under present day (2014) conditions.
- Maximum Likely Water Level under climate change conditions for the year 2065.
- Maximum Likely Water Level under climate change conditions for the year 2100.

Hazard mapping for the MLWL for the year 2100 for breach locations upstream of the Barrier have been presented in **Appendix C Figures C1.** The results from this study have been provided as a composite map, which shows the worst case scenario from all breach locations and does not show the impacts from individual breaches.

4.3 Flooding from Main Rivers

4.3.1 Sources

Appendix A Figure 2 identifies the main river watercourses in the study area which form part of the catchments of the Ravensbourne in the west.

The course of the River Ravensbourne itself does not flow through RB of Greenwich, however the Quaggy River, the Kyd Brook and Lower Kyd Brook (designated from Kidbrook Park Road to its confluence with the River Quaggy) are tributaries of the River Quaggy, and the floodplain of the Ravensbourne does extend to impact areas within RB of Greenwich. As the River Ravensbourne nears its confluence with the River Thames it becomes the Deptford Creek and is influenced by tidal water levels. The Ravensbourne River is a designated main river.

The Quaggy River is a main river and tributary of the River Ravensbourne; it rises from Locksbottom in London Borough of Bromley, flows through Bromley and enters the southwestern side of RB of Greenwich at Sidcup Road. It flows north through Eltham and then west through Sutcliff Park and out of the RB of Greenwich to its confluence with River Ravensbourne near Lewisham station.

The Kyd Brook is a main river and tributary of the Quaggy; it rises in Kidbrooke and flows south west to Lee Road, where it joins the Quaggy at the borough boundary with Lewisham. A stretch of the Kyd Brook joins the River Quaggy at Blackheath Park. This is part of the Weigall Road flood storage area.

4.3.2 Historic Records

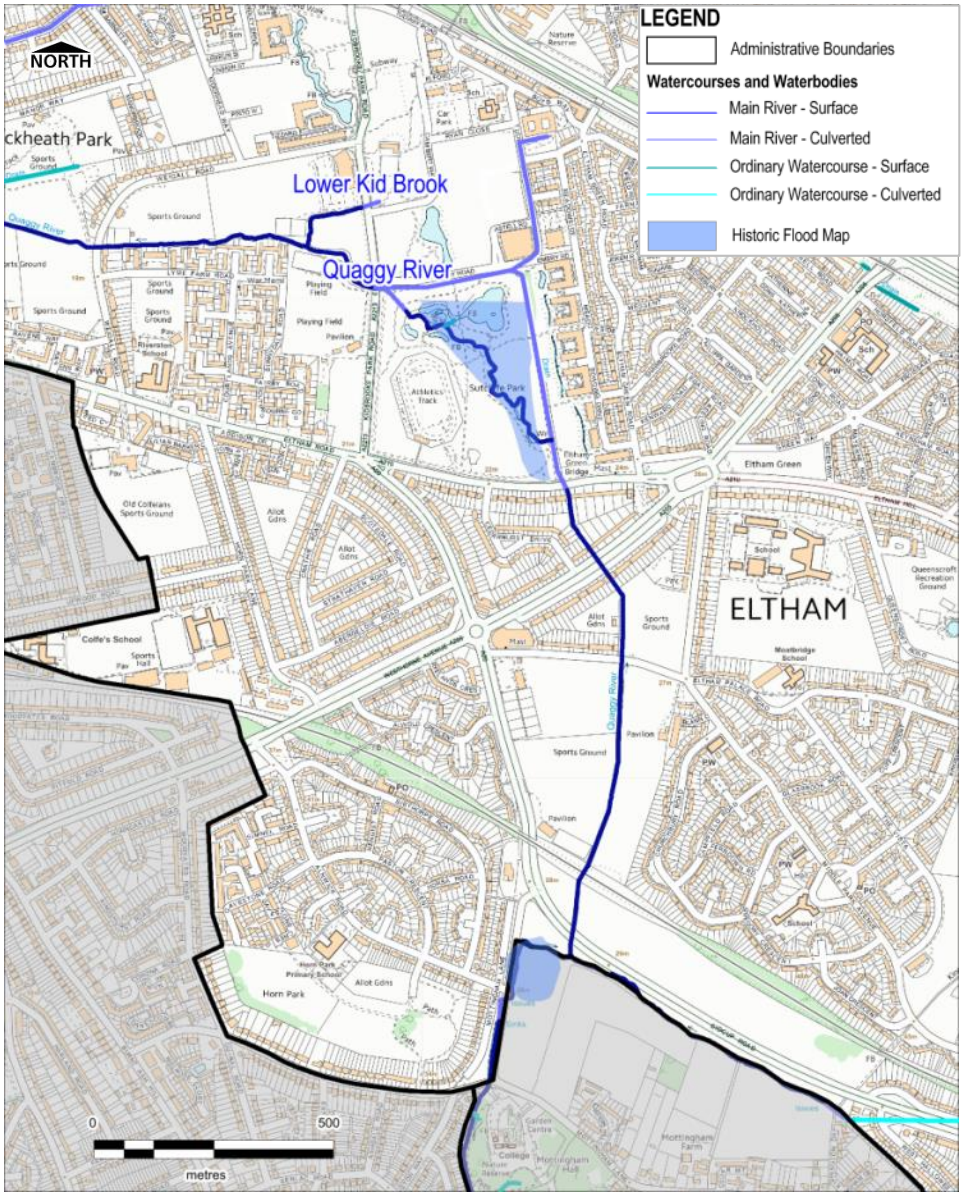
The Environment Agency Historic Flood Map which is shown in Figure 4-2 identifies historic flood outlines from flooding from main rivers in RB of Greenwich in 1965 and 1968.

In 1965 the channel capacity of the Quaggy River was exceeded resulting in flooding of the area west of the Eltham Green junction.

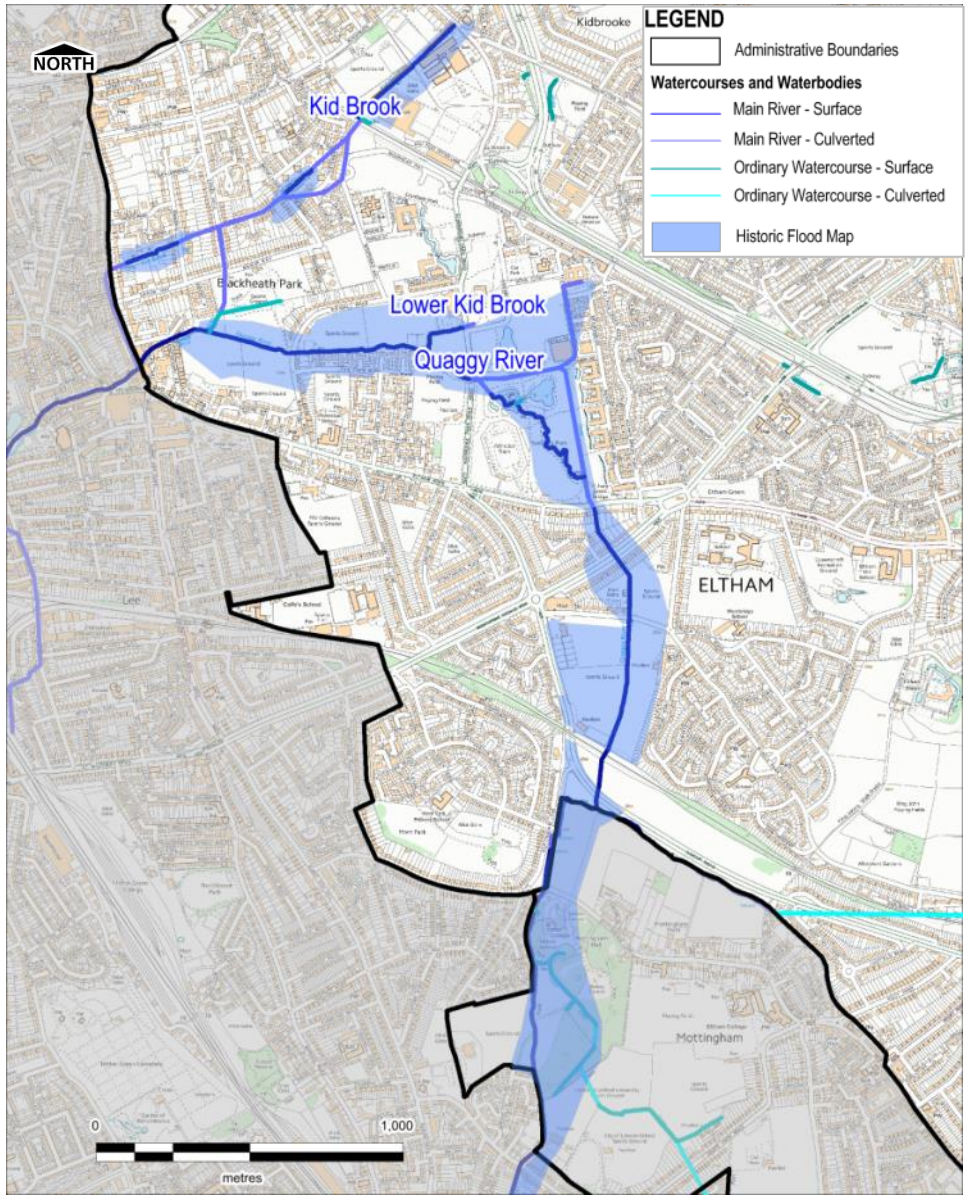
In September 1968, a number of areas across London flooded. In RB of Greenwich, heavy rainfall caused the Rivers Quaggy and Kyd Brook in the south west of the Borough to burst their banks causing flooding to the north and south of Blackheath Park and to the west of Eltham Green junction. The Ravensbourne, and in particular the Quaggy, have benefited from flood alleviation measures, such as the Sutcliffe Park flood storage area scheme, to reduce the risk to the community from fluvial flooding by removing the rivers from culverts and returning them to a more natural state.

RB of Greenwich and the Environment Agency also hold the following records of fluvial flooding that are recorded in the PFRA for the RB of Greenwich;.

- Flooding of properties and gardens in Meadowcourt Road as a result of combined surface water and fluvial flooding associated with the Quaggy River.



Environment Agency Historic Flood Map (1965) Fluvial Flood Risk



Environment Agency Historic Flood Map (1968) Fluvial Flood Risk

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Figure 4-2 Historic Flood Map – Fluvial Flood Events

4.3.3 Flood Zones

The risk of flooding is a function of the probability that a flood will occur and the consequence to the community or receptor as a direct result of flooding. The NPPF seeks to assess the probability of flooding from rivers by categorising areas within the fluvial floodplain into zones of low, medium and high probability, as defined in Table 4-5.

Table 4-5 Fluvial Flood Zone Definitions (extracted from the NPPG, 2014)

Flood Zone	Fluvial Flood Zone Definition	Probability of Flooding
Flood Zone 1	Land having a less than 0.1% Annual Exceedance Probability (AEP) (1 in 1,000 chance of flooding in any given year). Shown as clear on the Flood Map – all land outside Flood Zones 2 and 3.	Low
Flood Zone 2	Land having between a 1% AEP (1 in 100 chance of flooding in any given year) and 0.1% AEP (1 in 1,000 chance of flooding in any given year). ***In addition, Flood Zone 2 typically includes the extent of historic flood events that have been verified by the Environment Agency, and displayed on the Historic Flood Map dataset.***	Medium
Flood Zone 3a	Land having a 1% AEP or greater (1 in 100 chance of flooding in any given year).	High
Flood Zone 3b	Land where water has to flow or be stored in times of flood. LPAs should identify in their SFRAs areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. ***Flood Zone 3b is not separately distinguished from Flood Zone 3a on the Flood Map for Planning.***	Functional Floodplain

The 'Flood Map for Planning (Rivers and Sea)' provides information on the areas that would flood if there were no flood defences or buildings in the "natural" floodplain. The 'Flood Map for Planning (Rivers and Sea)' dataset is available on the Environment Agency website[18] and is the main reference for planning as it contains Flood Zones 1, 2 and 3a which are referred to in the NPPF and presented in Table 4-5. The 'Flood Map for Planning (Rivers and Sea)' was first developed in 2004 using national generalised modelling (JFLOW). It is routinely updated and revised using the results from the Environment Agency's programme of catchment studies, entailing topographic surveys, hydrological and/or hydraulic modelling as well as previous flood events.

The mapping shows the area to the south of Blackheath Road including Crosslet Vale, Franklin Close, Beck Close and Coldbath Street to be at risk of flooding during the 1% AEP flood event (ignoring the presence of defences) from the Ravensbourne. Further upstream, flooding from the Kyd Brook is shown to affect Casterbridge Road during the 0.1% AEP event and the warehouse and allotment gardens near Old Post Office Lane during the 1% AEP event.

Along the Quaggy River, the extent of flooding impacts Meadowcourt Road, the route of the A210 (Eltham Road), Weigall Road Sports Ground which forms a formal Flood Storage Area (FSA), properties along Lyme Farm Road and Weigall Road. Further upstream the flood extent continues to impact Eltham Road, and is stored in another FSA in Sutcliffe Park; properties along Cedarhurst Drive and Westhorne Avenue are also shown to be at risk extending to the south to include properties and allotment gardens, and the sports ground to the north and south of Eltham Palace Road respectively. Along the boundary of the Borough there is also shown to be some risk to Mottingham Lane and Sidcup Road.

It should be noted that a separate map is available on the Environment Agency website which is referred to as 'Risk of Flooding from Rivers and Sea'[19]. This map takes into account the presence of flood defences and so describes the actual probability of flooding, rather than the probability if there were no defences present. While flood defences reduce the level of risk they do not completely remove it as they can be overtopped or fail, for example, in extreme weather conditions or if they are in poor condition. As a result the maps may show areas behind defences to still have some risk of flooding. This mapping has been made available by the Environment Agency as the primary method of communicating flood risk to members of the public, however, for planning purposes the 'Flood Map for Planning (Rivers and the Sea)' and associated Flood Zones remains the primary source of information.

4.3.4 Functional Floodplain (Flood Zone 3b)

The Functional Floodplain is defined in the NPPF as 'land where water has to flow or be stored in times of flood'. The Functional Floodplain (also referred to as 'Flood Zone 3b'), is not separately distinguished from Flood Zone 3a on the

[18] Environment Agency Flood Map for Planning (Rivers and Sea) https://flood-map-for-planning.service.gov.uk/

[19] Environment Agency 'Risk of Flooding from Rivers and Sea' https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?easting=463722.696&northing=152577.6

Flood Map for Planning. The extent of the Functional Floodplain should be defined within the SFRA by RB of Greenwich as the LPA and LLFA in discussion with the Environment Agency

The NPPG states that the identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. However, land which would naturally flood during a 5% AEP or greater in any year, or is designed to flood (such as a flood attenuation scheme) in an extreme (0.1% AEP) flood, should provide a starting point for consideration and discussions to identify the functional floodplain. The NPPG does not provide any additional guidance on how to define the functional floodplain.

The PPG states that *'an area which would naturally flood, but which are prevented from doing so by existing defences and infrastructure or solid buildings, will not normally be defined as functional floodplain'.* There may be opportunities to reinstate areas which can operate as functional floodplain through the use of previously developed land adjacent to watercourses to provide space for flood water to reduce the risk to new and existing development.

The NPPG recognises the importance of pragmatic planning solutions that will not unnecessarily blight areas of existing urban development. It may not be practical to refuse all future development within existing urban areas falling within land which would flood during a 5% AEP event, therefore careful consideration must be given to future sustainability.

For the River Ravensbourne catchment, the flood extent for the 5% AEP (1 in 20 year) flood event has been used as a starting point to delineate the Functional Floodplain. **Appendix A Figures 7A-7C** show that floodwater largely remains in bank and within the Weigall Road Flood Storage Area and Sutcliffe Park Flood Detention Area. However there are also some developed areas shown to be at risk of flooding along Westorne Avenue, which have been reported to experience flooding (refer Section 4.3.1), and between the south circular and A210 Eltham Road.

At the time of publishing this Level 1 SFRA, the 5% AEP (1 in 20 year) scenario for the Wickham Valley Watercourse (Marsh Dykes) Flood Storage Area Study was not available. Therefore the extent of Flood Zone 3b Functional Floodplain for this catchment is not shown in Appendix A Figures 5B and 5C. The Environment Agency is in the process of developing a new model for the Marsh Dykes System. Developers should contact RB of Greenwich and the Environment Agency for the most up to date flood extent data for this catchment.

4.3.5 Flood Defences

Information from the Environment Agency Asset Information Management System (AIMS) relating to the Ravensbourne catchment is displayed on **Appendix A Figures 7A-7C**. It identifies the presence of high ground either side of the Quaggy River, Lower Kyd Brook and sections of the Kyd Brook. The standard of protection of these features ranges between 1 in 50 years and 1 in 100 years. The AIMS also identifies the presence of embankments surround the Sutcliffe Park Flood Detention Area, and a flood defence wall on the western downstream edge of the Weigall Road Flood Storage Area, which are both recorded to have a standard of protection of 1 in 70 years.

The results of the modelling study presented in **Appendix A Figures 7A-7C** also include the designation of areas which benefit from the presence of flood defences and therefore do not experience flooding during the 1% AEP flood event for the defended scenario. The maps show that these areas are quite sparse along the Ravensbourne and Quaggy floodplain, and include:

- A small area to the south of Blackheath Road and isolated areas along Coldbath Road;
- Warehouse site and allotment gardens adjacent to the Kyd Brook off Old Post Office Lane;
- Some properties along Meadowcourt Road adjacent to the River Quaggy;
- Some parts of the Civil Service Sports Ground.

4.3.6 Climate change

In February 2016 the Environment Agency published revised guidance on climate change allowances in an update to the document 'Adapting to Climate Change: Advice to Flood and Coastal Erosion Risk Management Authorities'[20]. This version of the document reflects an assessment completed by the Environment Agency between 2013 and 2015 using UKCP09 data, to produce more representative climate change allowances for river basin districts across England. The allowances for the Thames river basin district are of relevance to RB of Greenwich and are set out in Table 4-6.

[20] Environment Agency, February 2016, Adapting to Climate Change: Advice to Flood and Coastal Erosion Risk Management Authorities. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/516116/LIT_5707.pdf

Table 4-6 Peak river flow allowances for Thames river basin district (use 1961 to 1990 baseline)

River basin district	Allowance category	Total potential change anticipated for '2020s' (2015 to 2039)	Total potential change anticipated for '2050s' (2040 to 2069)	Total potential change anticipated for '2080s' (2070 to 2115)
Thames	Upper end (90th)	25%	35%	70%
	Higher central (70th)	15%	25%	35%
	Central (50th)	10%	15%	25%

The guidance states that in order to determine which range of allowance should be assessed for a proposed development or plan, the Flood Zone and vulnerability classification should be considered, as set out below.

In Flood Zone 2

- essential infrastructure – use the higher central and upper end to assess a range of allowances;
- highly vulnerable – use the higher central and upper end to assess a range of allowances;
- more vulnerable – use the central and higher central to assess a range of allowances;
- less vulnerable – use the central allowance; and,
- water compatible – use none of the allowances.

In Flood Zone 3a

- essential infrastructure – use the upper end allowance;
- highly vulnerable – development should not be permitted;
- more vulnerable – use the higher central and upper end to assess a range of allowances;
- less vulnerable – use the central and higher central to assess a range of allowances; and,
- water compatible – use the central allowance.

In Flood Zone 3b

- essential infrastructure – use the upper end allowance;
- highly vulnerable – development should not be permitted;
- more vulnerable – development should not be permitted;
- less vulnerable – development should not be permitted; and,
- water compatible – use the central allowance.

The hydraulic modelling study for the Ravensbourne catchment was updated in 2017 to incorporate the new climate change allowances for the Central and Higher Central scenarios for the 2080s epoch (as presented in Table 4-4). Simulations have been run for the 1% AEP event (1 in 100 year) including a 25% and 35% increase in river flow to account for the implications of climate change. The Upper end scenario with a 70% increase in river flow has not been included in this update. The climate change flood extents for the Central (the 1 in 100 year + 25%) and High Central (the 1 in 100 year + 35%) scenarios for the River Ravensbourne are shown in **Appendix A Figures 7A-7C**. This scenario includes the presence of flood defences along the Ravensbourne.

The climate change mapping for the River Ravensbourne catchment in **Appendix A Figures 7A-7C** shows a much greater extent of fluvial flood risk to the north through Greenwich town centre for these scenarios. Floodwater comes out of bank near Coldbath Street and flows northwards across Blackheath Road, Greenwich High Road and beneath the railway line towards Norman Road, Claremont Street, Thornham Street, and Tarves Way. It is noted that much of this area is also within Flood Zone 3a associated with River Thames and is also at residual risk of tidal flooding in the event of a local breach or failure of the tidal flood defence system.

At the time of publishing this Level 1 SFRA, the 1% AEP (1 in 100 year) plus climate change scenario for the Wickham Valley Watercourse (Marsh Dykes) Flood Storage Area Study was not available. The Environment Agency is in the process of developing a new model for the Marsh Dykes System, incorporating the updated climate change allowances. Developers should contact the Environment Agency for the most up to date flood extent data for this catchment.

4.4 Flooding from Ordinary Watercourses

4.4.1 Sources

An ordinary watercourse is a watercourse that does not form part of a main river and 'includes all rivers and streams and all ditches, drains, cuts, culverts, dikes, sluices (other than public sewers within the meaning of the Water Industry Act 1991) and passages, through which water flows' in accordance with Section 72(1) of the Land Drainage Act 1991. Main Rivers are the responsibility of the Environment Agency; all other watercourses are classified as Ordinary Watercourses and fall under the remit of RB of Greenwich as the LLFA.

Appendix A Figures 2, 5A-5D and 8A-8D identify the ordinary watercourses in the study area. This information is provided from the Environment Agency Detailed River Network (DRN) dataset as well as surveys of the watercourses completed in 2015[21] which captured information on the location, dimensions, condition and Water Framework Directive (WFD) status of each watercourse and associated asset or structure, for use by RB of Greenwich in their role as LLFA.

The following ordinary watercourses are present in the study area:

- A network of drains within the grounds of the Royal Blackheath Golf Course flow south into a culverted watercourse which passes west towards Mottingham and towards the course of the River Quaggy.
- The Little Quaggy rises near the Walden Road Recreation Ground by Chislehurst and flows west into the River Quaggy.
- The River Shuttle rises in Avery Hill Park in the south eastern part of RB of Greenwich as a network of drains and culverts, and flows eastwards to join the River Cray just to the south of Hall Place and the A2 East Rochester Way in neighbouring London Borough of Bexley.
- Further north, in the area extending from Eltham Common to Oxleas Wood, a network of culverts and open ordinary watercourses flows towards the eastern boundary of the Borough which includes the Shuttle, Falconwood Stream and Wickham Valley Watercourse.
- There are a series of ordinary watercourses in Shooters Hill, which flow in and out of culvert as they pass eastwards, and out of the Borough.
- A culverted ordinary watercourse passes through Bostall Woods.
- Ordinary watercourses are identified in Thamesmead. These form part of the wider surface water drainage network in this area, which is further described in Section 4.8.
- To the north of Charlton, a series of ordinary watercourses flow in open channel in Maryon Wilson Park and Repository Woods, before entering culvert. These are then assumed to then form part of the surface water sewer network.

4.4.2 Risk of Flooding from Surface

River modelling studies undertaken by the Environment Agency as part of their national programme of coastal and river modelling typically focus on flooding associated with main rivers, and therefore ordinary watercourses that form tributaries to the main rivers may not always be included in the models. In the absence of modelled flood extents for these watercourses, the Risk of Flooding from Surface Water Map (RoFSW) provides a useful indication of flood risk associated with these watercourses, particularly where they are flowing at surface level. The RoFSW mapping is provided in **Appendix A Figures 8A-8D**. Full details regarding the RoFSW dataset is provided in Section 4.5.

The RoFSW considers three design rainfall events. The most extreme of these (0.1% AEP) can be used to provide an indication of the impact of climate change on the extent of flooding associated with ordinary watercourses.

River Shuttle

The upstream extent of the River Shuttle is defined as ordinary watercourse and was not included in the Environment Agency modelling of the River Cray. There are therefore no modelled flood extents and corresponding flood zones available for this section of the watercourse. **Appendix A Figure 8D**, reproduced in Figure 4-3 provides an indication of the extent of the floodplain associated with the watercourse based on the RoFSW dataset.

[21] URS Infrastructure and Environment UK Ltd, JBA Consulting (April 2016), Royal Borough of Greenwich Ordinary Watercourse Database.

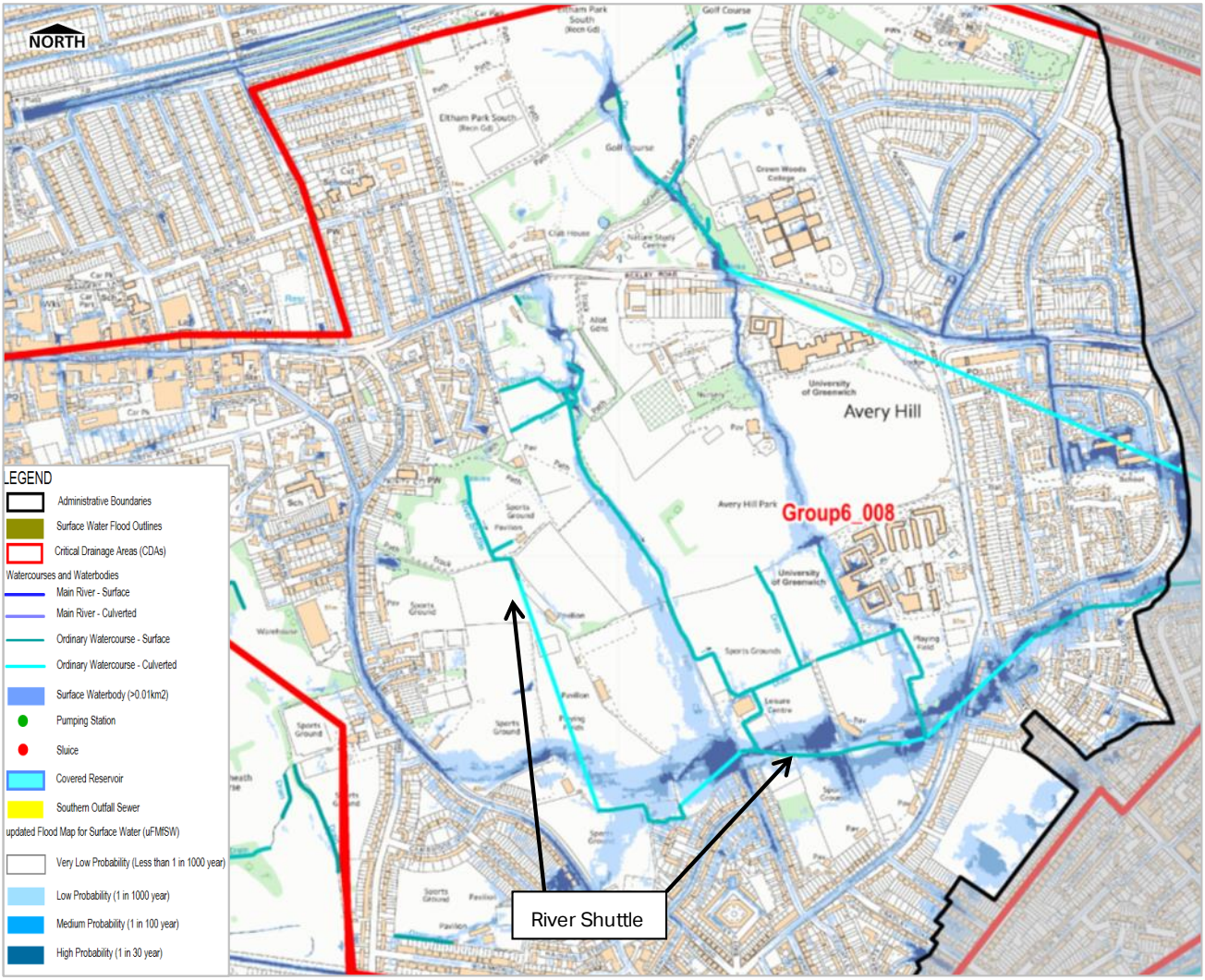

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Figure 4-3 River Shuttle floodplain as shown in the Risk of Flooding from Surface Water Map

4.5 Flooding from Surface Water

Overland flow and surface water flooding typically arise following periods of intense rainfall, often of short duration, that is unable to soak into the ground or enter drainage systems. It can run quickly off land and result in localised flooding. The NPPG states that an SFRA should identify areas at risk from surface water flooding and drainage issues, taking account of the surface water flood risk mapping published by the Environment Agency as well as other available information.

4.5.1 Historic Records

The SWMP for RB of Greenwich identifies that the main area with a frequent history of surface water flooding is the Eynsham Drive area, where approximately 40 residential properties are reported to have been affected. Other areas that have a notable record of flood incidents include Plumstead Common, Charlton, Kidbrooke, Cambert Way and New Eltham. These broad areas are referred to as 'Surface Water Flood Outlines' identified on **Appendix A Figures 8A – 8D**. The PFRA for RB of Greenwich also provides details of a number of surface water flooding records in the Borough, as described in Table 4-7.

Table 4-7 Summary of surface water flooding records, RB of Greenwich PFRA, 2011

Location	Source	Description	Consequence
Meadow Croft Road (Eltham Way)	Surface Water / Fluvial	Failure of drainage system in heavy rainfall causes flooding of gardens.	Flooding of properties (gardens).
Cambert Way	Surface Water	In the vicinity of EA Main River and TW surface water sewer.	This has now been addressed by SuDS.
Mottingham Road / Dunkery Road	Surface Water	Failure of drainage system in heavy rainfall causes flooding of highways.	This has been solved by installation of gullies in LB Bromley.
Thamesmead / Eynsham Drive	Surface Water / Fluvial	This is an inter-borough issue (with Bexley). The area has flooded three times since the 1990s. The culvert is usually full and there is no green space in which to overflow to. The system responds very quickly in high intensity rainfall and becomes inundated.	Flooding to highways and possible flooding to properties.
Waterdale Road	Surface Water/ Fluvial	Due to the high level of the Mere Lakes, this area responds very quickly during rainfall. Trash screens on culverts need to be maintained to allow free flow of water.	No property flooding yet but a possibility in the future.
Marmadon Road	Surface Water	In heavy rainfall the surface water sewer cannot cope with the increased flow.	Flooding to basement properties.
Abbey Grove	Surface Water	This area is very flat and so responds quickly to rainfall. However the problems have been resolved by increased gullies.	Flooding to properties – this has been solved.
The Slade, Plumstead Common	Surface Water	Not enough scope to resolve due to the topography of the area.	Flooding of highways.
Hart Road	Surface Water	(No description provided).	Flooding of highways.
Broadwalk	Surface Water	Mainly flooding at the junction.	Flooding of highways.
Tripcock Ness	Surface Water	Development planned for this area which is vulnerable to flooding.	Flood risk to 3000 planned dwellings.
Charleton Prospect Vale	Surface Water	There are a number of ground floor flats in an area of low lying land which are susceptible to flooding.	Properties at risk from flooding.
Thames Barrier	Surface Water	Water collects in this area during heavy rainfall. The receptors include the control centre for the Thames Barrier, however this does have protection.	Flooding of industrial park (Thames Barrier Centre).
Floyd Road	Surface Water	The drainage through the railway causes flooding to the subway (locally nicknamed 'Flood Passage').	Flooding of walkways.

4.5.1 RB of Greenwich Surface Water Management Plan

As part of the SWMP for the RB of Greenwich, direct rainfall modelling was undertaken and the results used to identify Local Flood Risk Zones (LFRZs) where surface water flooding poses risk to properties, businesses and infra structure. Subsequently, CDAs have been identified, which are defined within the SWMP as a discrete geographic area and usually a hydrological catchment, where multiple and interlinked sources of flood risk (surface water, groundwater, sewer, Main River and/or tidal) cause flooding in one or more Local Flood Risk Zones. It should be noted that CDAs identified within the SWMP are distinct from areas with critical drainage problems as notified by the Environment Agency, though such areas may intersect.

The Critical Drainage Areas (CDAs) and Local Flood Risk Zones (LFRZs) identified for the Borough are identified in Table 4-8. The CDAs are mapped in **Appendix A Figures 8A – 8D,** as well as the historic records of surface water flooding, (these are referred to in the figures as Surface Water Flood Outline' to be consistent with the SWMP mapping).

Table 4-8 Critical Drainage Areas and Local Flood Risk Zones (SWMP)

CDA	LFRZ	Site ID	Source of Flooding
Group6_001	6022	Thamesmead / Eynsham Drive	Surface Water / Fluvial
	6023	Wickham Lane	Surface Water / Fluvial
	6002	Marmadon Road, Abbey Grove	Surface Water
	6001a	Woolwich Town Centre	Surface Water
Group6_008	6009	Avery Hill	Surface Water
Group6_010	6019	Meadowcourt Road (Eltham Road)	Surface Water / Fluvial
Group6_011	6025	The Slade, Plumstead Common	Surface Water
Group6_012	6024	The Tarn	Surface Water
Group6_013	6026	Broadwalk and Charlton, Prospect Vale	Surface Water
	6032	Wendover Road	Surface Water
Group6_014	6027	Thames Barrier Industrial Estate	Surface Water
	6028	Ruston Road	Surface Water
	6029	Prentiss Court	Surface Water
	6030	Floyd Road/ Delafield Road	Surface Water
	6032	Bugsby Way	Surface Water
Group6_015	6035	A2 Rochester Relief Road/Eastbrook Rd	Surface Water
Group6_016	6033	Maritime Museum	Surface Water
		Cutty Sark	Surface Water
		Horseferry Place	Surface Water
Group6_017	6020	Cambert Way	Surface Water
Group6_018	6021	Mottingham Road / Dunkery Road	Surface Water

The SWMP identified potential high level options to manage and mitigate the flooding at each of the LFRZs as well as broader ranging actions for RB of Greenwich to meet the requirements of the FWMA in their role as the LLFA. Since the preparation of the SWMP in 2011, many of these broader actions have been progressed through the development of the LFRMS for the Borough, the completion of the ordinary watercourse surveys and mapping which informs the Asset Register for the Borough.

4.5.2 Risk of Flooding from Surface Water Map

The Environment Agency has undertaken modelling of surface water flood risk at a national scale and produced mapping identifying those areas at risk of surface water flooding during three annual probability events: 1 in 30 year (3.33% annual probability), 1 in 100 year (1% annual probability and 1 in 1000 year (0.1% annual probability). The latest version of mapping is referred to as the 'Risk of Flooding from Surface Water' (RoFSW) and the extents have been made available to RB of Greenwich as GIS layers. This dataset is also presented on the Environment Agency website.

The RoFSW provides all relevant stakeholders, such as the Environment Agency, RB of Greenwich and the public access to information on surface water flood risk which is consistent across England and Wales [22]. The modelling helps the Environment Agency take a strategic overview of flooding, and assists RB of Greenwich (as the LLFA) in their duties relating to management of surface water flood risk. For the purpose of this SFRA, the mapping allows an improved understanding of areas which may have a surface water flood risk.

The modelling represents an improvement on previous national scale mapping, namely the FMfSW (2010) and the Areas Susceptible to Surface Water Flooding (AStSWF) (2009), for example:

- Increased model resolution to 2m grid;
- Representation of buildings and flow routes along roads and manual editing of the model for structural features such as flyovers;
- Use of range of storm scenarios; and,

[22] Environment Agency, 2013. *'What is the updated Flood Map for Surface Water?'*

- Incorporation of appropriate local mapping, knowledge and flood incident records.

However, it should be noted that this national mapping has the following limitations:

- Use of a single drainage rate for all urban areas;
- It does not show the susceptibility of individual properties to surface water flood records; and,
- As with all models, the RoFSW is affected by a lack of, or inaccuracies in available data.

The datasets provide a picture of surface water flooding across the Borough and identify that areas of susceptibility to surface water flooding are widespread across most parts of the Borough. The following areas are shown to be at particular risk, although the list is by no means exhaustive:

- In the north of the Borough, surface water is shown to pond along Tunnel Avenue, West Parkside, Woolwich Road and Floyd Road in Charlton, within the Thames Barrier Industrial Park, and along Prospect Vale. Many of these areas have been recorded as experiencing surface water flooding by RB of Greenwich. Extensive ponding is also shown to occur adjacent to the Wickham Valley Watercourse, and to the south of the railway line in Abbey Wood.
- The mapped surface water flooding extents also correlate well with the presence of small ordinary watercourses, for example through Maryon Wilson Park and along Pound Park Road; through Repository Woods,
- In Kidbrooke, there are quite defined flowpaths of surface water which seem to form the upper catchment of the Lower Kyd Brook and Quaggy; surface water ponding affects Eastbrook Road, the A2, Langbrook Road, Sladebrook Road, Wendover Road, Purneys Road and Will Crooks Gardens. Similarly, surface water ponding is shown in Well Hall and adjacent Sports Ground, and along the South Circular Road towards the Quaggy River at Eltham Green.
- The natural floodplain of the Quaggy River and the River Shuttle are also picked up by the surface water mapping.

4.5.3 Climate Change

The RoFSW does not include a specific scenario to determine the impact of climate change on the risk of surface water flooding. However a range of three annual probability events have been undertaken, 3.3%, 1% and 0.1% and therefore it is considered appropriate to use the 0.1% AEP event as a substitute dataset to provide a worst case scenario and an indication of the implications of climate change.

4.6 Flooding from Groundwater

Groundwater flooding usually occurs in low lying areas underlain by permeable rock and aquifers that allow groundwater to rise to the surface through the permeable subsoil following long periods of wet weather. Low lying areas may be more susceptible to groundwater flooding because the water table is usually at a much shallower depth.

4.6.1 Sources

As shown in **Appendix A Figure 3**, a large proportion of the Borough, away from the River Thames, overlays London Clay and consequently the risk of groundwater flooding will typically be low. However there are also areas underlain by Claygate and Harwich formations, where there is greater potential for the presence of groundwater pathways. In addition, areas adjoining the River Thames and other river corridors are characterised by alluvium and 'river terrace deposits'. These are referred to as 'Thames Gravels' and there is evidence within RB of Greenwich and adjoining Boroughs of groundwater flooding occurring some distance from the river as a result of water finding a pathway through the gravels during high river levels. The Wickham Valley Watercourse, Lower Kyd Brook, River Shuttle and River Cray are groundwater fed watercourses.

4.6.2 Historic Records

The LFRMS for RB of Greenwich notes that the winter of 2013-14 was a significant event across southern England. The event was caused by prolonged and extreme rainfall during the wettest December to January period in the UK since records began. The prolonged heavy rainfall caused groundwater to rise to exceptionally high levels, which led to significant flooding in Surrey and a number of south London Boroughs. Groundwater level changes in the south east, as measured by borehole readings, resulted in an unprecedented situation that certain Boroughs found themselves dealing with. It became clear that groundwater flood impact is often delayed, as the water moves through the chalk towards the Thames. This was illustrated by London Boroughs of Bromley and Bexley continuing to experience emerging groundwater in March and April 2014.

During the 2014 groundwater flooding event, Croydon Council declared a Major Incident and, alongside other measures, established a local groundwater "Solution Cell" to monitor the situation in Croydon. As the groundwater moved north east towards the River Thames, the Solution Cell was expanded to a five Borough group (Croydon, Bexley, Bromley, Greenwich and Sutton).

Reported incidents of suspected groundwater flooding were collated as part of the Groundwater Flood Risk Study that is currently being undertaken by MWH Consulting. These records are included in Table 4-9 and **Appendix A Figure 9**.

Table 4-9 Groundwater Flooding Records (provided by MWH, 2016).

X	Y	Source	Comments	Date	Type	Mechanism
538907	177352	Other	Location of spring from the Harwich and Lambeth contact. Spring has been diverted to culvert to supply water to Naval College.		SPRING	Base of Harwich
540182	177644	EA	Flooded garden.	Jun 2008	GARDEN	Base of Harwich
542158	178954	RBG	There are a couple of soft spots on the tracks in this location could be GW.		OTHER	Base of Harwich
542641	178936	RBG	Water seeps through brick tunnel at the London-bound platform. Noticeable during high GW periods; believed to be superficial GW.		OTHER	Base of Harwich
545077	178359	EA	Flooding, possibly basement level.		BASEMENT	Crossrail underlying aquifer
545564	178859	CrossRail	Flooded cellar in Plumstead.	May 2012	BASEMENT	Crossrail underlying aquifer
545726	178899	CrossRail	Flooded property in Plumstead.	May 2012	BASEMENT	Crossrail underlying aquifer
545821	178879	CrossRail	Flooded cellar in Plumstead.	July 2012	BASEMENT	Crossrail underlying aquifer
545855	178871	RGB	Properties have had issues with rising GW believed to be a result of Crossrail de-watering.		BASEMENT	Crossrail underlying aquifer
546007	179013	RBG	Owner of sports field has complained pitches are unplayable due to GW - Issue seems to tie in with Crossrail and de-watering. Issue seems to have subsided since de-watering has ceased.		FLOODED AREA	Crossrail underlying aquifer
545740	178803	RBG	The western side of the park has suffered significant flooding recently this could be down to Crossrail and de-watering but could also be an old water supply leaking and/or loss of original land drainage over the years.		FLOODED AREA	Crossrail underlying aquifer
546919	179015	RBG	Colleagues have mentioned issues with GW in this area, though probably influenced recently by Crossrail works and de-watering. Also long history of flooding in this area due to the Wickham Valley watercourse culvert which runs along this line possible source.		OTHER	Crossrail underlying aquifer
546946	178899	EA	Flooding, possibly basement level.		BASEMENT	Crossrail underlying aquifer
544296	177340	RBG	Drain on park collects GW this is part of TW PSWS.		SPRING	Base of Claygate
543925	177355	EA	Continued/worsening flooding of rear garage this year.	Feb 2011	BASEMENT	Base of Claygate
543923	177335	EA	Waterlogged garden.	July 2007	GARDEN	Base of Claygate
543474	177210	RBG	GW captured in a drain and discharged to a gully (this site is near a watercourse, now culverted, on the 1920 Geological mapping).		ROAD WORKS	Base of Claygate
543408	177200	EA	Spring from Neighbours garden, Woolwich.	June 2001	GARDEN	Base of Claygate
543593	176920	EA	Water seep in Cellar, Shooters Hill.	June 2000	BASEMENT	Base of Claygate
542729	176491	RBG	Highways Engineers have dealt with issues of water at this location.		WORKS	Base of Claygate
542825	176685	RBG	Highways engineers have reported issues in the		WORKS	Base of Claygate

X	Y	Source	Comments	Date	Type	Mechanism
			past at this location (junction).			
542818	176532	RBG	GW rises in this location possible source of the ""Upper"" Kidbrooke		SPRING	Base of Claygate
542753	176374	RBG	GW rises here possible source for the ""Upper"" Kidbrook		SPRING	Base of Claygate
544080	176207	Obs	Spring Chamber Oxleas Wood		SPRING	Base of Claygate
543939	176080	Obs	Wet patch observed in field, continually seen in historic aerial photographs.		SPRING	Base of Claygate
543967	176136	RBG	Source of the Wickham Valley Watercourse is in Oxleas Wood.		SPRING	Base of Claygate
542917	176142	RBG	Water on the footway at back of path believed to be GW. A French drain has been constructed under the footway to collect the water and discharge to the nearest gully. Resident first notified RBG.		GARDEN	Base of Claygate
542752	176148	RBG	Reports of an issue in this location with GW (however, also reports in this location of blocked TWUL drains).		OTHER	Base of Claygate
541814	175577	EA	Water in basement	Feb 2004	BASEMENT	London Clay?
543832	174628	EA	Water in basement garage, Eltham	Jan 2004	BASEMENT	Base of Harwich
544693	174575	EA	Spring at bottom of Garden, Eltham	Apr 2001	GARDEN	Base of Harwich
540850	174050	EA	Spring in garden, approx. location	Jan 2001	GARDEN	
544833	173475	RBG	Summer of 2012 the GAA ""flattened"" the sports field. During winters of 2012, 2013 and 2014, internal flooding to properties on Halfway Street was averted due to positive intervention by residents to pump water and dig trenches in sports field.		OTHER	
542359	173483	Obs	Spring up track next to point 35.		SPRING	
542497	173361	Obs	Flooding at base of paddock, topographic low.		FLOODED AREA	
542356	173292	RBG	Highways engineers have reported issues with GW in this location (follows old path of a watercourse).		WORKS	
543340	173106	RBG	Reports from resident based in Green Lanes that there are issues with GW southern side of railway line (only conjecture no direct reports).		OTHER	
544123	173018	RBG	Network Rail have a pump located alongside the tracks at this location.		OTHER	
543563	172450	RBG	Water rising out of footway works to pipe water to nearest gully.		OTHER	
543556	171884	RBG	Resident had water appear in garden very consistent flow assumed to be GW.		GARDEN	
537565	176795	EA	Reported flooding in below-ground car park in December.	Dec 2014	BASEMENT	
538165	177034	EA	Flooding in Basement.	Jan 2009	BASEMENT	
538630	176728	RBG	Highways Engineers have been dealing with issues in this location assumed GW		WORKS	
542126	177927	OBS	Groundwater observed discharge from within Maryon William Park, from head of steep sided valley.	Feb 2016	SPRING	Base of Harwich
544137	176505	ANEC	Shooters Hill Golf Course - Stream rise location		SPRING	Base of Claygate
544359	176797	ANEC	Shooters Hill Golf Course - Stream rise location		SPRING	Base of Claygate
543413	176841	ANEC	Surface water pool seen on aerial photo		POND	Base of Claygate
543837	177328	ANEC	Wet patch continual observed on Mayplace lane		SPRING	Base of Claygate
543176	176591	ANEC	Christ College Spring		SPRING	Base of Claygate

4.6.3 MWH Groundwater Flooding Study

MWH Consulting has been commissioned by RB of Greenwich to undertake a study into groundwater flood risk across the Borough. To support the study, MWH collected a range of data to inform the groundwater flooding study, including the following:

- Rainfall data at two tipping bucket rainfall stations with the Borough;
- Gauged daily flow from the National River Flow Archive, and river level data;
- Monthly Hydrologically Effective Rainfall (HER) data obtained from the Met Office;
- Groundwater level records from the Environment Agency and Thames Water for 10 sites. Long-term water level monitoring data was obtained for the Chalk and Thanet Sands aquifer, though no records were available within the Harwich Formation or Claygate Member;
- BGS Borehole scans;
- Flooding Incidents;
- Groundwater abstraction details;
- Site visit to identify current locations of spring emergence and any current GW flooding, which informed the development of a hydrogeological conceptual model.

Conceptual models for groundwater emergence were developed using the above data. Schematic cross sections were developed in order to illustrate flooding mechanisms associated with Clearwater flooding within the Chalk and Thanet Sands and spring emergence at the contact between the Harwich Formation and Lambeth Group and the contact between the Claygate Formation and London Clay.

Four potential mechanisms for groundwater flooding were identified within the Borough:

1) *"Spring emergence from particular horizons around Shooter's Hill;*
2) *Flooding from the Chalk aquifer in the Thamesmead area where it is not overlain by low permeability units;*
3) *Spring emergence from the base of the Harwich Formation geological unit in the Eltham area;*
4) *Possible spring emergence where the Thanet Sand geological unit is present near ground surface in the Mottingham area."*

Mapped outputs have been supplied to inform the Level 1 SFRA and are presented in **Appendix A Figure 9**.

The mapping identifies potential groundwater flooding zones, as follows:

- Zone A – Limited potential for groundwater flooding to occur.
- Zone B – Potential for groundwater flooding of property situated below ground level.
- Zone C – Potential for groundwater flooding to occur at surface.

The mapping indicates a large area in the north of the Borough associated with areas of Chalk Formation and Thanet Sand as Zone A.

The mapping shows areas defined as Zone B in Charlton, extending to the west of the A102 Horn Lane, as well as parts of the Thames Barrier Industrial Park. There is also a large area of Zone B in Abbey Wood in the east of the Borough. In these areas of Zone B there may be potential for groundwater flooding of property situated below ground level.

Locations defined as Zone C are present in the east and central part of the Borough, notably in a concentric pattern around Shooters Hill which correlates with the presence of the underlying Claygate Member, comprising sand, silt and clay. In these areas of Zone C there may be potential for groundwater flooding to occur at the surface, and the historic records included in Table 4-9 and **Appendix A Figure 9** correlate well with this.

4.7 Flooding from Sewers

4.7.1 Source

The drainage system in RB of Greenwich is largely combined surface and foul water sewers, which drain to Crossness Sewerage Treatment works.

During heavy rainfall, flooding from the sewer system may occur if:

(1) The rainfall event exceeds the capacity of the sewer system drainage system:

Sewer systems are typically designed and constructed to accommodate rainfall events with a 3.3% AEP or less. Therefore rainfall events with a return period of frequency greater than 3.3% AEP would be expected to result in surcharging of some of the sewer system. While TWUL, as the sewerage undertaken for RB of Greenwich, is concerned about the frequency of extreme rainfall events, it is not economically viable to build sewers that could cope with every extreme rainfall event..

(2) The system becomes blocked by debris or sediment:

Over time there is potential that road gullies and drains become blocked from fallen leaves, build-up of sediment and debris (e.g. litter).

(3) The system surcharges due to high water levels in receiving water courses:

Within the study area there is potential for surface water outlets to become submerged due to high river levels. When this happens, water is unable to discharge. Once storage capacity within the sewer system itself is exceeded, the water will overflow into streets and potentially into houses. Where the local area is served by 'combined' sewers i.e. containing both foul and storm water, if rainfall entering the sewer system exceeds the capacity of the combined sewer and storm overflows are blocked by high water levels in receiving watercourses, surcharging and surface flooding may again occur but in this instance floodwaters will contain untreated sewage.

4.7.2 Historic Records

TWUL has provided an extract from their DG5 Flood Register for the study area. The DG5 is 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. Due to data protection requirements the data has not been provided at individual property level; rather, the register comprises the number of properties within 4 digit postcode areas that have experienced flooding either internally or externally within the last 10 years.

Appendix A Figure 10 shows that the areas of Abbey Wood, Plumstead Common and Kidbrooke have the highest total number of incidents of sewer flooding, with 7-10 records within the last 10 years.

It should be noted that records only appear on the DG5 register where they have been reported to TWUL, and as such they may not include all instances of sewer flooding. Furthermore given that TWUL target these areas for maintenance and improvements, areas that experienced flooding in the past may no longer be at greatest risk of flooding in the future.

4.7.3 Climate Change

Climate change is anticipated to increase the potential risk from sewer flooding as summer storms become more intense and winter storms more prolonged. This combination is likely to increase the pressure on the existing efficiency of sewer systems, thereby reducing their design standard and leading to more frequent localised flooding incidents.

TWUL will monitor the risk of sewer flooding and put plans in place to manage this, as required, based on their business plan and priorities. RB of Greenwich will work with TWUL to identify flooding hotspots and locations of known sewer capacity issues where risk could be exacerbated.

TWUL will prioritise investment for potential flood alleviation schemes depending on the severity and frequency of flooding, but this can only be identified where affected property owners report the incident to the water company.

4.8 Flooding from Reservoirs, Canals and Other Artificial Sources

4.8.1 Sources

The main source of flooding from artificial sources in the RB of Greenwich is from the surface water management system in the north east of the Borough, referred to as Marsh Dykes System including Butts Canal. In addition, there are two Flood Storage Areas (FSAs) along the course of the Quaggy River in the south of the Borough, which are identified as reservoirs on the Environment Agency Risk from Reservoir mapping. Five covered reservoirs are located within the London Borough of Greenwich. Two are located at Woolwich Common and three are located in Greenwich Park, Castlewood and Oxleas Wood. Further information about these systems is provided in the following sections.

4.8.2 Marsh Dykes System and Butts Canal

The Marsh Dykes are an area of commercial and residential development, reclaimed from marshland in the 1960s and managed as 5 sub catchments; Crayford Marsh, Erith, Green Level, Great Breach and Thamesmead. The Thamesmead sub catchment falls within the RB of Greenwich. In this area surface water is managed through a system of five lakes and a canal network (including the Butts Canal).

The original surface water drainage scheme for the Thamesmead section of the Marsh Dykes system involved surface runoff from the surrounding hills discharging onto the site by culverts under passing existing development and then flowing under gravity to three sluices via ditches and dykes. The sluices are named Plumstead Sluice, Abbey Sluice and Great Breach Sluice. This surface water drainage system was replaced by five lakes and a canal network (including the Butts Canal) and has a water surface area of approximately 250 hectares. The canals drain into the River Thames under gravity but in times of tide lock flow can be pumped at Great Breach, Tripcock and Gallions pumping stations. The new system was designed to have a capacity exceeding everyday requirement, thus allowing for storm water. The total storage volume is 189,069m^3. A study conducted by the Environment Agency states 184,870 m^3 of storage volume is required to absorb a 1% AEP (1 in 100 year flood event)[23]. It is reported that this network can therefore technically accommodate this, although in practice the capacity has been reduced by reed growth.

Butts Canal rises near Woolwich Cemetery in East Wickham and is culverted along much of its length from the playing fields adjacent to Woodbrook Road to its outfall into South Mere (to the east of the Borough boundary) in the Thamesmead area. This upper portion of the Butts Canal is informally known as the Wickham Valley Watercourse.

The culverted part of the Butts Canal poses an increased flood risk as a result of blockage and siltation. The two silt traps along this section of the Butts Canal have to be regularly cleared. Riparian owners are responsible for clearing silt traps and reed growth; the Environment Agency do have permissive powers which allow them to enter land and carry out these works, but they do not have a duty or responsibility to do so. Two areas have been highlighted as at risk of blockage, the Bracondale Road silt trap and the Woodbrook Road trash screens.

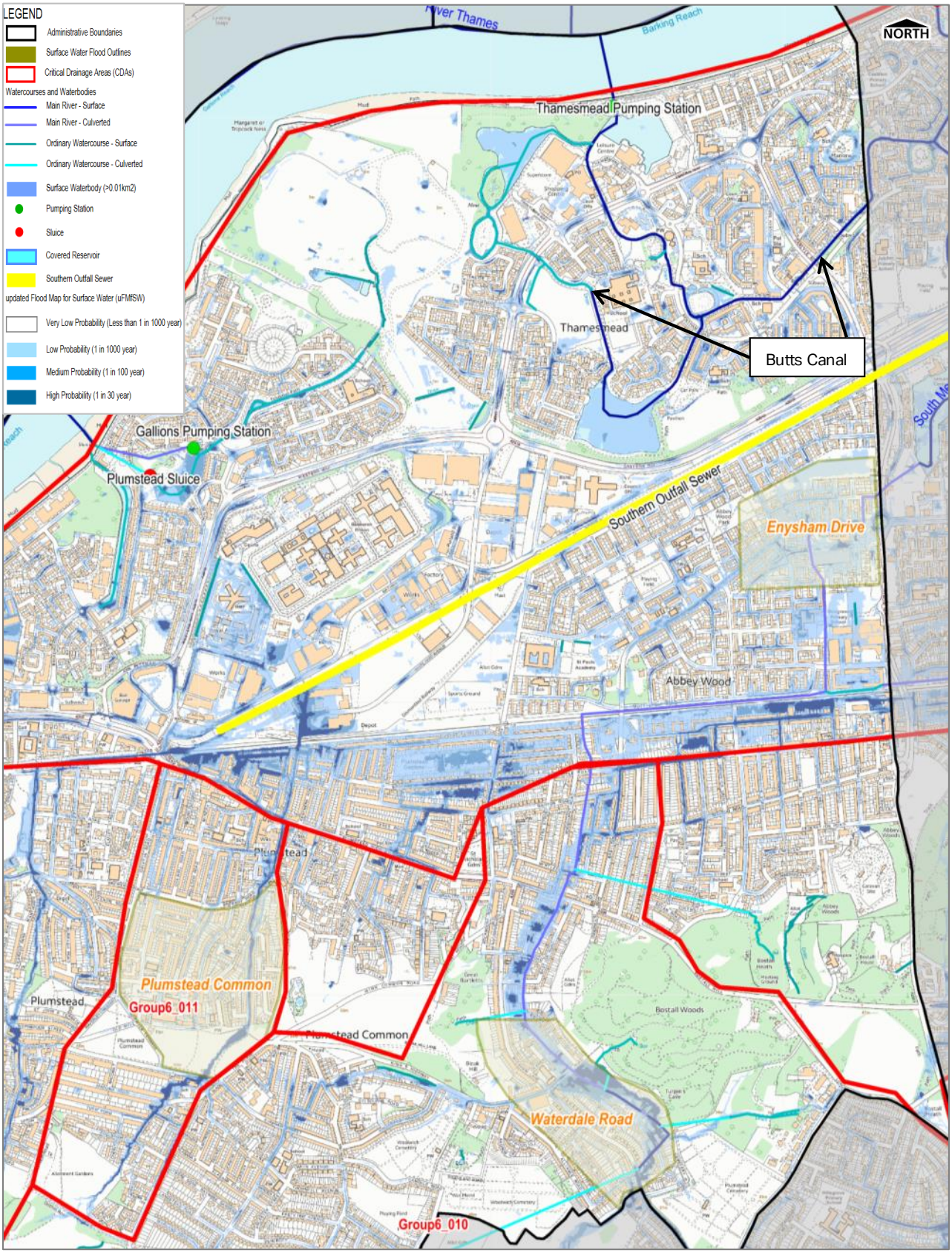
The surface water flooding experienced in Abbey Wood in 2005 and 2007 were a direct consequence of water not being able to discharge to the culvert fast enough.

Figure 4-4 (and **Appendix A Figure 8B**) shows the indicative drainage path and flood extent of the Butts Canal from Woolwich Cemetery up to Abbey Wood, where the Butts Canal leaves the Borough. The RoFSW mapping does not account for the capacity of the culvert, and therefore the flood extents should be considered as indicative of flooding in the event of a total blockage of the culvert.

The other section of the Butts Canal in the Borough is at Thamesmead, where the watercourse flows through a series of open drainage channels until it joins the River Thames. There is no fluvial Flood Zone covering the Butts Canal, the area is only covered by a tidal Flood Zone. However, the surface water flooding map presented in Figure 4-4 (and A**ppendix A Figure 8B**) provides an indication of the extent of flooding that could be experienced adjacent to the Butts Canal.

At the time of publishing this Level 1 SFRA, the Environment Agency is in the process of developing a new model for the Marsh Dykes System. Developers should contact RB of Greenwich and the Environment Agency for the most up to date flood extent data for this catchment.

[23] JBA Consulting, October 2011, Royal Borough of Greenwich Strategic Flood Risk Assessment.



(Contains Ordnance Survey data © Crown copyright and database right 2017. Contains Environment Agency data © Environment Agency and database right 2017). Not to scale

Figure 4-4 Marsh Dykes and Butts Canal as shown in the Risk of Flooding from Surface Water Map

4.8.3 Risk of Flooding from Reservoirs Mapping

The failure of a reservoir has the potential to cause catastrophic damage due to the sudden release of large volumes of water. The NPPG encourages LPAs to identify any impounded reservoirs and evaluate how they might modify the existing flood risk in the event of a flood in the catchment it is located within, and / or whether emergency draw-down of the reservoir will add to the extent of flooding.

Reservoir flooding is extremely unlikely to happen; there has been no loss of life from reservoir flooding in the UK since 1925. All large reservoirs are regularly inspected and supervised by reservoir engineers under the enforcement authority for the Reservoirs Act 1975 in England. If a reservoir were to breach, a large volume of water would cascadedown the surrounding valleys with very little warning. People living and working in these areas would be at great danger; therefore it is necessary to plan in advance an emergency strategy should such event occur. The reservoirs located within the London Borough of Greenwich are shown in

Table 4-10 Details of Reservoirs

Reservoir	Details	Administrator	Covered by Reservoir Act
Woolwich Common	Planning permission granted November 2006 for infill of existing reservoir and temporary use of site as a construction compound.8	Unknown	No
Woolwich Common b	Unknown	Unknown	Unknown
Greenwich Park	Constructed 1841-44, covered over in 1871. Currently not operational.	Thames Water	No
Castlewood	Two 7 mega litre compartments. Footprint 81m x 35.5m, Floor level 97.9m AOD, Max depth 5.5m. 450 and 600m diameter Inlet and outlet pipelines underground from reservoir to existing pipework.	Unknown	No Compartments can hold 7,000 m^3 each
Oxleas wood	Approximately 18 million gallon capacity9 (81,829 m^3)	Unknown	Yes

The Environment Agency 'Flooding from Reservoirs' mapping[24] available online shows that the reservoirs that could result in flooding in the Borough are the Weigall Road Flood Storage Area and Sutcliffe Park Detention Area. The area shown to be at risk is a small extent of the floodplain of the Quaggy River and Ravensbourne River downstream of these storage features.

4.9 Emergency Planning

4.9.1 Flood Warning Areas

The Environment Agency provides a free Flood Warning Service[25] for many areas at risk of flooding from rivers and the sea. The Environment Agency has provided a GIS layer of Flood Warning Areas in the study area which are presented in **Appendix A Figure 11.** The Environment Agency Flood Warning Areas in the RB of Greenwich are identified in Table 4-11.

[24] Environment Agency (2016) Risk of Flooding from Reservoirs Mapping available online https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?easting=463722.696&northing=152577.6

[25] Environment Agency Flood Warning Service https://www.fws.environment-agency.gov.uk/app/olr/register;jsessionid=NLTLZL6MJbnNQYsn8DHpMzFp93qnpL5mXvbh1wJFP1nHlxzQQbTx!1734060942

Table 4-11 Flood Warning Areas in Greenwich (Environment Agency 2015)

Flood Warning Area	Watercourse / Estuary
River Quaggy at Kidbrooke, Lee and Hither Green	River Quaggy
Tidal Thames from Woolwich Arsenal to Deptford Creek	Thames
Tidal Thames from Erith High Street East to Woolwich Arsenal	Thames
Ravensbourne at Deptford	River Ravensbourne
Beck at Beckenham	Beck
Pool River at Bell Green and New Beckenham	Pool River
Ravensbourne at Bromley	River Ravensbourne
Ravensbourne from Bellingham to Catford	Rver Ravensbourne
River Quaggy at Chinbrook, Mottingham and Eltham	River Quaggy
Ravensbourne at Lewisham	River Ravensbourne
Kyd Brook at Sundridge Park	Kyd Brook
River Cray in St Marys Cray, Sidcup, Bexley and Crayford	Cray
River Shuttle in Blackfen, Sidcup, Old Bexley and Crayford	Shuttle
Tidal Thames from Deptford Creek to Wandsworth Bridge	Thames

5 Avoiding Flood Risk – Applying the Sequential Test

5.1 Sequential Approach

This Section guides the application of the Sequential Test and Exception Test in the Plan-making and planning application processes. Not all development will be required to undergo these tests, as described below, but may still be required to undertake a site specific FRA. Guidance is included in Appendix B Developer Guidance.

The sequential approach is a simple decision-making tool designed to ensure that sites at little or no risk of flooding are developed in preference to sites at higher risk. This will help avoid the development of sites that are inappropriate on flood risk grounds and to minimise the extent of development in areas at risk of flooding. The subsequent application of the Exception Test, where required, will ensure that new developments in areas of particular flood risk will only occur where flood risk is clearly outweighed by other sustainability drivers and where development can be made safe from flooding and will not increase the risk of flooding elsewhere.

All opportunities to locate new developments (except Water Compatible) in reasonably available areas of little or no flood risk should be explored, prior to any decision to locate them in areas of higher risk.

5.2 Applying the Sequential Test – Plan-Making

As the LPA, RB of Greenwich must demonstrate that, throughout the site allocation process and related Sustainability Appraisal process, a range of possible sites have been considered in conjunction with the flood risk and vulnerability information set out in the SFRA, and that the Sequential Test, and where necessary the Exception Test, has been applied.

The Sequential Test, as set out in the NPPF, is principally based on the definition of Flood Zones associated with tidal and fluvial flood risk, and the PPG provides guidance on the application of the Sequential Test with reference to tidal and fluvial flood risk. However, the NPPF acknowledges that some areas will be at risk of flooding from sources other than tidal or fluvial. All sources of flood risk must be considered when planning for new development including: flooding from land or surface water runoff; groundwater; sewers; and artificial sources. If a location is recorded as having experienced repeated flooding from the same source this should be acknowledged within the Sequential Test.

In order to ensure that the Sequential Test takes account of flood risk from all sources, Table 5-1 provides a suggested flood risk classification based on available datasets in the SFRA that could be employed by RB of Greenwich to apply the Sequential Test.

Table 5-1 Flood Risk Classifications for Sequential Test

Risk	Source of Flooding				
	Fluvial/Tidal	Surface Water	Groundwater	Sewer	Reservoir
Low	Flood Zone 1	RoFSW Very Low	Not within a Potential Groundwater Flooding Zone OR Within Zone A – Limited potential for groundwater flooding to occur	TWUL to assess the sewer network for each site.	Use EA Flooding from Reservoirs map
Medium	Flood Zone 2	RoFSW Low to Medium	Potential Groundwater Flooding Zone B – Potential for groundwater flooding of property situated below ground level.		N/A
High	Flood Zone 3a	RoFSW High OR Within Critical Drainage Area	Potential Groundwater Flooding Zone C – Potential for groundwater flooding at surface. – and/or Historic records of groundwater flooding.		N/A
Very High	Flood Zone 3b	N/A	N/A		N/A

As well as an understanding of flood risk across the study area, the Sequential Test requires an understanding of the vulnerability classification of the proposed developments. Flood risk vulnerability classifications, as defined in the NPPG are presented in Table 5-2.

Table 5-2 Flood Risk Vulnerability Classification (PPG, 2014)

Essential Infrastructure	• Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk. • Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including electricity generating power stations and grid and primary substations; and water treatment works that need to remain operational in times of flood. • Wind turbines.
Highly Vulnerable	• Police stations, ambulance stations and fire stations and command centres and telecommunications installations required to be operational during flooding. • Emergency dispersal points. • Basement dwellings. • Caravans, mobile homes and park homes intended for permanent residential use. • Installations requiring hazardous substances consent. (Where there is a demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or such installations with energy infrastructure or carbon capture and storage installations, that require coastal or water-side locations, or need to be located in other high flood risk areas, in these instances the facilities should be classified as "essential infrastructure").
More Vulnerable	• Hospitals. • Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels. • Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels. • Non–residential uses for health services, nurseries and educational establishments. • Landfill and sites used for waste management facilities for hazardous waste. • Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.
Less Vulnerable	• Police, ambulance and fire stations which are not required to be operational during flooding. • Buildings used for shops, financial, professional and other services, restaurants and cafes, hot food takeaways, offices, general industry, storage and distribution, non–residential institutions not included in "more vulnerable", and assembly and leisure. • Land and buildings used for agriculture and forestry. • Waste treatment (except landfill and hazardous waste facilities). • Minerals working and processing (except for sand and gravel working). • Water treatment works which do not need to remain operational during times of flood. • Sewage treatment works (if adequate measures to control pollution and manage sewage during flooding events are in place).
Water Compatible Development	• Flood control infrastructure. • Water transmission infrastructure and pumping stations. • Sewage transmission infrastructure and pumping stations. • Sand and gravel working. • Docks, marinas and wharves. • Navigation facilities. • MOD defence installations. • Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location. • Water-based recreation (excluding sleeping accommodation). • Lifeguard and coastguard stations. • Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms. • Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan.

Table 5-3 is reproduced from the NPPF PPG and indicates the compatibility of different development types with each of the Flood Zones.

Table 5-3 Flood Risk Vulnerability and Flood Zone 'Compatibility' (PPG, 2014)

Flood Risk Vulnerability Classification		Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone	1	✓	✓	✓	✓	✓
	2	✓	✓	Exception Test Required	✓	✓
	3a	Exception Test Required	✓	×	Exception Test Required	✓
	3b	Exception Test Required	✓	×	×	×

✓ - Development is appropriate × - Development should not be permitted

Figure 5-1 and Figure 5-2 illustrate suggested approaches for applying the Sequential Test that RB of Greenwich could adopt in the allocation of sites as part of the preparation of their Local Plan. Figure 5-1 relates to sites at risk of fluvial flooding. Figure 5-2 relates to those sites within defended Flood Zone 3a associated with the tidal River Thames, and therefore at residual risk of flooding. The approach is also described in the steps below. The Sequential Test should be undertaken by RB of Greenwich and accurately documented to ensure decision processes are consistent and transparent.

5.2.1 Stages for LPA application of the Sequential Test in Plan-Making

The information required to address many of these steps is provided in the accompanying maps in **Appendix A** and site assessment database held by RB Greenwich.

a. Assign potential developments with a vulnerability classification (Table 5-2). Where development is mixed, the development should be assigned the highest vulnerability class of the developments proposed.

b. The location and identification of potential development should be recorded.

c. The Flood Zone classification of potential development sites should be determined based on a review of the Flood Map for Planning (Rivers and Sea)[26]. Where these span more than one Flood Zone, all zones should be noted.

d. The risk of flooding from other sources should also be identified, based on readily available datasets and local information as set out in Section 4 of this Report and the figures in **Appendix A**.

e. Identify existing flood defences serving the potential development sites. (However, it should be noted that for the purposes of the Sequential Test, Flood Zones ignoring defences should be used).

f. The design life of the development should be considered with respect to climate change:

- 100 years – up to 2115 for residential developments; and
- Design life for commercial / industrial developments will be variable, however a 75 year design life may be assumed for such development, unless demonstrated otherwise.

g. Highly Vulnerable developments to be accommodated within the LPA area should be located in those sites identified as being within Flood Zone 1 and at low risk of flooding from other sources. If these cannot be located in areas of low flood risk, because the identified sites are unsuitable or there are insufficient sites in areas of low risk, sites in Flood Zone 2 can then be considered. Highly Vulnerable developments in Flood Zone 2 will require application of the Exception Test. If sites in Flood Zone 2 are inadequate then the LPA may have to identify additional sites in Flood Zones 1 or 2 to accommodate development or seek opportunities to locate the development outside their administrative area. Within each Flood Zone Highly Vulnerable development should be directed, where possible, to the areas at lowest risk from all sources of flooding. It should be noted that Highly Vulnerable development is not appropriate in Flood Zones 3a and 3b.

h. Once all Highly Vulnerable developments have been allocated to a development site, the LPA can consider those development types defined as More Vulnerable. In the first instance, More Vulnerable development should be located in any unallocated sites in Flood Zone 1 and at low risk of flooding from other sources. Where these sites are unsuitable or there are insufficient sites remaining, sites in Flood Zone 2 can be considered. If there are insufficient sites in Flood Zone 1 or 2 to accommodate More Vulnerable development, sites in Flood Zone 3a can

[26] And the modelled flood extents for the River Ravensbourne, prior to their incorporation into the Flood Map for Planning (Rivers and Sea) by the Environment Agency.

be considered. More Vulnerable developments in Flood Zone 3a will require application of the Exception Test. As with Highly Vulnerable development, within each Flood Zone, More Vulnerable development should be directed to areas at lowest risk from all sources of flooding. It should be noted that More Vulnerable development is not appropriate in Flood Zone 3b.

i. Once all More Vulnerable developments have been allocated to a development site, the LPA can consider those development types defined as Less Vulnerable. In the first instance Less Vulnerable development should be located in any remaining unallocated sites in Flood Zone 1 and at low risk of flooding from other sources, continuing sequentially with Flood Zone 2, then Flood Zone 3a. Less Vulnerable development types are not appropriate in Flood Zone 3b – Functional Floodplain.

j. Essential Infrastructure should be preferentially located in the lowest flood risk zones, however this type of development may be located in Flood Zones 3a and 3b, provided the Exception Test is satisfied.

k. Water Compatible development has the least constraints with respect to flood risk and it is considered appropriate to allocate these sites last. The sequential approach should still be followed in the selection of sites; however it is appreciated that Water Compatible development by its nature often relies on access and proximity to water bodies.

l. Where the development type is Highly Vulnerable, More Vulnerable, Less Vulnerable or Essential Infrastructure and a site is found to be impacted by a recurrent flood source (other than tidal or fluvial), the site and flood sources should be investigated further regardless of any requirement for the Exception Test.

5.2.2 Stages for LPA application of the Sequential Test in Plan-Making – Tidal Defended Sites

For sites that are within the tidal floodplain of the River Thames (Flood Zone 3a), but are protected by the presence of tidal defences (i.e. within the 'Areas Benefitting from Defences'), RB of Greenwich may wish to use additional flood risk information to consider the variation in flood risk within the Flood Zone when applying the Sequential Test. In this case, the flood hazard mapping described in Section 4.2.5 could be used to apply the Sequential Test to ensure that development is directed towards areas of Low hazard prior to the consideration of areas at Moderate, Significant and Extreme hazard.

5.2.3 Windfall Sites

Windfall sites are those which have not been specifically identified as available in the Local Plan process. They comprise previously-developed sites that have unexpectedly become available. In cases where development cannot be fully met through the provision of site allocations, LPAs are expected to make a realistic allowance for windfall development, based on past trends and expected future trends. It is recommended that the acceptability of windfall applications in flood risk areas should be considered at the strategic level through a policy setting out broad locations and quantities of windfall development that would be acceptable or not in Sequential Test terms.

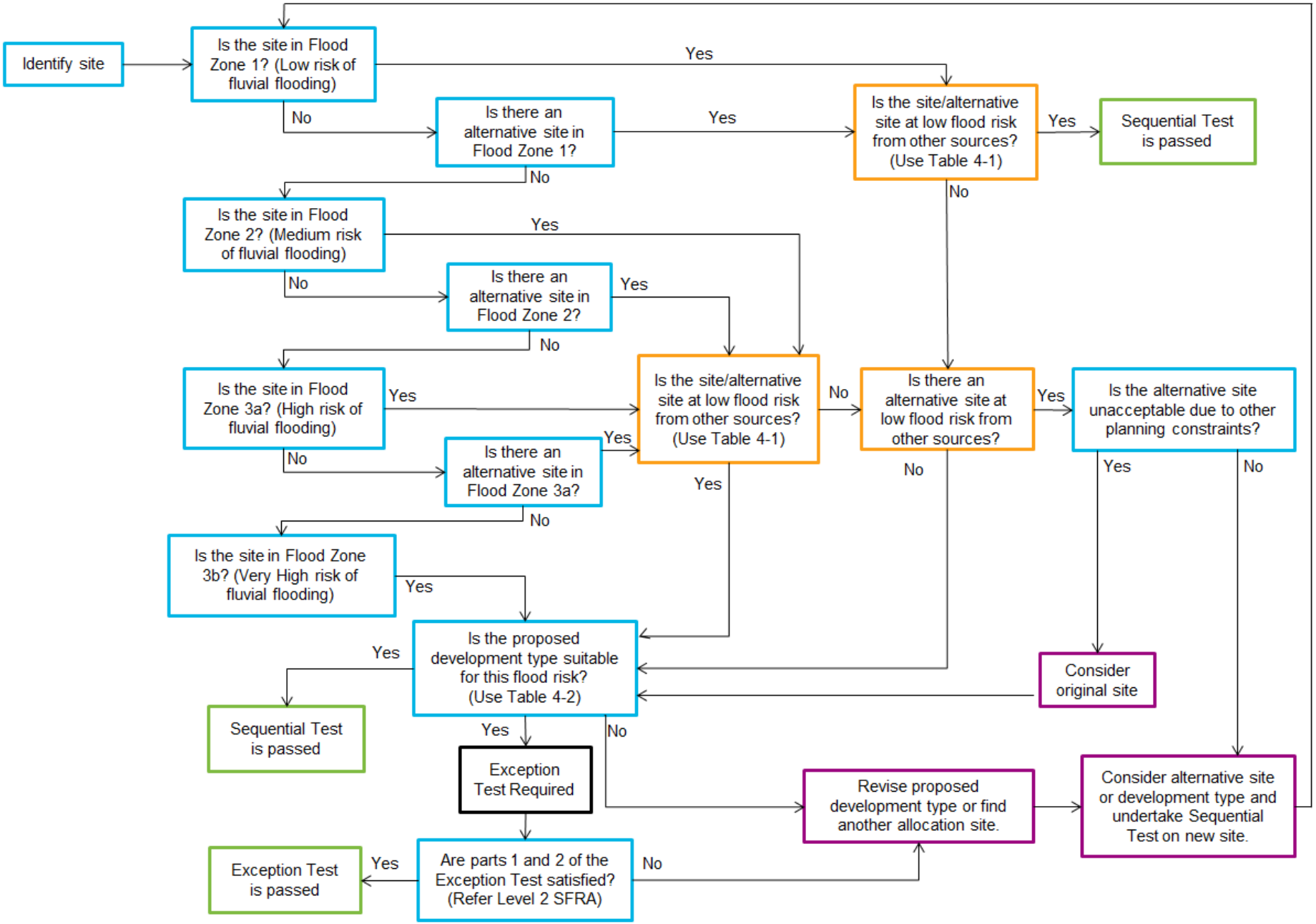


Figure 5-1 Suggested Sequential Test Approach – Sites at Risk of Fluvial Flooding

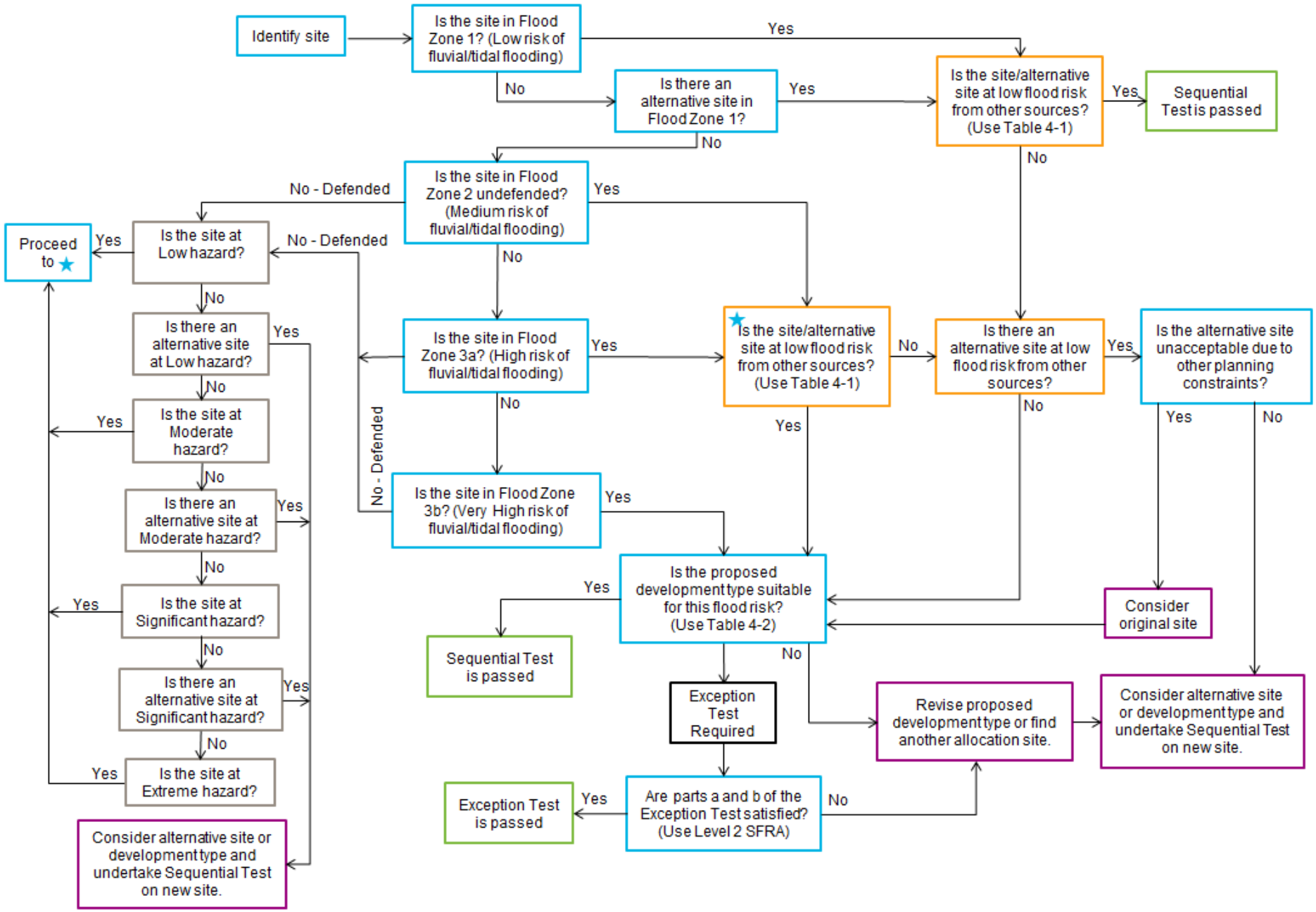


Figure 5-2 Suggested Sequential Test Approach – Sites Defended from Tidal Flooding

5.3 Applying the Sequential Test – Individual Applications

If development is proposed in Flood Zone 2 or 3, and the Sequential Test has not already been carried out for the site for the same development type at the Local Plan level, then it is necessary to undertake a Sequential Test for the site. The Environment Agency publication 'Demonstrating the Flood Risk Sequential Test for Planning Applications'[27] sets out the procedure as follows:

- Identify the geographical area of search over which the test is to be applied; this could be the Borough area, or a specific catchment if this is appropriate and justification is provided (e.g. school catchment area or the need for affordable housing within a specific area identified for regeneration in Local Plan policies).
- Identify the source of 'reasonably available' alternative sites; usually drawn from evidence base / background documents produced to inform the Local Plan.
- State the method used for comparing flood risk between sites; for example the Environment Agency Flood Map for Planning, the SFRA mapping, site-specific FRAs if appropriate, other mapping of flood sources.
- Apply the Sequential Test; systematically consider each of the available sites, indicate whether the flood risk is higher or lower than the application site, state whether the alternative option being considered is allocated in the Local Plan, identify the capacity of each alternative site, and detail any constraints to the delivery of the alternative site(s).
- Conclude whether there are any reasonably available sites in areas with a lower probability of flooding that would be appropriate to the type of development or land use proposed.
- Where necessary, as indicated by Table 5-3, apply the Exception Test.
- Apply the Sequential approach to locating development within the site.

It should be noted that it is for LPAs, taking advice from the Environment Agency as appropriate, to consider the extent to which Sequential Test considerations have been satisfied, taking into account the particular circumstances in any given case. The developer should justify with evidence to the LPA what area of search has been used when making the application. Ultimately RB of Greenwich needs to be satisfied in all cases that the proposed development would be safe and not lead to increased flood risk elsewhere.

5.3.1 Sequential Test Exemptions

It should be noted that the Sequential Test does not need to be applied in the following circumstances:

- Individual developments proposed on sites which have been allocated in development plans through the Sequential Test.
- Minor development, which is defined in the NPPF as:
  - minor non-residential extensions: industrial / commercial / leisure etc. extensions with a footprint <250m^2;
  - alterations: development that does not increase the size of buildings e.g. alterations to external appearance;
  - householder development: for example; sheds, garages, games rooms etc. within the curtilage of the existing dwelling , in addition to physical extensions to the existing dwelling itself. This definition excludes any proposed development that would create a separate dwelling within the curtilage of the existing dwelling e.g. subdivision of houses into flats;
- Change of Use applications, unless it is for a change of use of land to a caravan, camping or chalet site, or to a mobile home site or park home site;
- Development proposals in Flood Zone 1 (land with a low probability of flooding from rivers or the sea) unless the SFRA, or other more recent information, indicates there may be flooding issues now or in the future (for example, through the impact of climate change);

5.4 Exception Test

The purpose of the Exception Test is to ensure that, where it may be necessary to locate development in areas at risk of flooding, new development is only permitted in Flood Zone 2 and Flood Zone 3 where the flood risk is clearly outweighed by other sustainability factors and where the development will be safe during its lifetime, considering climate change.

[27] Environment Agency, April 2012, 'Demonstrating the flood risk Sequential Test for Planning Applications', Version 3.1

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

- Part 1 - *"It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by the SFRA where one has been prepared"*; and
- Part 2 – "*A site-specific Flood Risk Assessment must demonstrate that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall."*

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

In order to determine Part 1) of the Exception Test, applicants should assess their scheme against the objectives set out in the Sustainability Appraisal as set out in the Sustainability Appraisal on Core Strategy: (Proposed Submission Version) and reproduced in Table 5-4. In order to demonstrate satisfaction of Part 2) of the Exception Test, relevant flood risk management and mitigation measures should be applied and demonstrated within a site-specific FRA as detailed in Appendix B Developer Guidance.

With respect to the ongoing preparation of the Site Allocations Local Plan by RB of Greenwich, the next step will be to prepare a Level 2 SFRA for potential site allocations, to provide further flood risk information to facilitate an assessment of the likelihood of being able to satisfy the requirements of the Exception Test, and therefore support the allocation of the site.

Table 5-4 RB of Greenwich Sustainability Appraisal Objectives[28]

	Sustainability Objectives
1	Improve conditions and services that engender good health and reduce health inequalities.
2	Reduce and prevent crime and fear of crime.
3	Preserve and enhance areas and buildings designated for their historic and/or archaeological interest and protect their settings.
4	Create places, spaces and buildings that are well designed, integrate effectively with one another, respect identified views and vistas, and enhance the diversity and distinctiveness of the local character.
5	To provide everyone with the opportunity for rewarding and satisfying employment
6	To improve opportunities for prosperity and economic growth in the Borough
7	Increase participation and improve access to education, skills based training, knowledge and information, and lifelong learning
8	Ensure everyone has access to decent, appropriate and affordable housing
9	To enhance the area as a business and tourist destination.
10	Ensure community services and facilities are accessible to everyone.
11	To encourage a sense of place, community identity and belonging
12	Minimise waste, maximise reuse and recycling of waste, and increase landfill diversion.
13	Reduce the need to travel by delivering more sustainable patterns of urban development that integrate with accessible and sustainable methods of transportation
14	Address climate change by reducing greenhouse gas emissions, and improving the Boroughs ability to adapt to climate change.
15	Protect, restore and enhance biodiversity, landscapes and the open space network while improving appropriate access to these areas
16	Manage efficiently air quality and natural resources such as soil, land, ecosystems and water.
17	To reduce and manage flood risk.

[28] RB of Greenwich, Sustainability Appraisal on Core Strategy: (Proposed Submission Version)

6 Flood Risk Management Policy Recommendations

6.1 Overview

In order to encourage a holistic approach to flood risk management and ensure that flooding is taken into account at all stages of the planning process, this section builds on the findings of the Level 1 SFRA to set out key recommendations for consideration by RB of Greenwich in relation to flood risk planning policy and with respect to development management decisions on a day-to-day basis.

6.2 Policy Considerations

In order to help the development of Local Plan policy related to flood risk, a series of recommendations for how flood risk can be managed or minimised through the plan making process and through the development control process has been provided. These recommendations also seek to provide general improvement to the water environment as well as flood risk management, and should be taken into account by RB of Greenwich during the policy making process. Guidance on how these objectives can be met throughout the development control process for individual development sites will be set out in Appendix D.

6.2.1 Seeking Flood Risk Reduction through Spatial Planning and Site Design

- The Sequential approach within development sites should be used to inform site layout by locating the most vulnerable elements of a development in the lowest risk areas. For example, the use of low-lying ground in waterside areas for recreation, amenity and environmental purposes can provide an effective means of flood risk management as well as providing connected green spaces with consequent social and environmental benefits.
- Avoid development immediately downstream of flood storage reservoirs which will be at high hazard areas in the event of failure.
- Seek opportunities for new development to achieve reductions to wider flood risk issues where possible, e.g. larger developments may be able to make provisions for flow balancing within new attenuation SuDS features.
- Identify long-term opportunities to remove development from the floodplain through land swapping, whereby existing development is removed from the floodplain and the site returned to provide its original flood storage function.
- Build resilience into a site's design (e.g. flood resistant or resilient design, raised floor levels).
- Ensure development is 'safe'. For residential developments to be classed as 'safe', dry pedestrian egress out of the floodplain and emergency vehicular access should be possible. Dry pedestrian access/egress should be possible for the 1 in 100 year return period event including an allowance for climate change for fluvial flooding, or the 1 in 1000 year return period associated with tidal flooding.

6.2.2 Reducing Surface Water Runoff from New Developments

- All sites require the following:
  - Use of SuDS (where possible use of strategic SuDS should be made).
  - Discharge rates should be restricted to Greenfield runoff rates.
  - 1 in 100 year attenuation of surface water, taking including an allowance for climate change.
- Space should be specifically set aside for SuDS and used to inform the overall layout of development sites.
- Surface water drainage proposals should have a clear plan for the long term maintenance and adoption of the systems, prior to approval of any planning permission in line with national planning policy.
- Large potential development areas should be planned with a holistic approach to the provision of SuDS. This will need to be on an integrated and strategic scale and where necessary will require the collaboration of all developers involved in implementing a specific expansion area or site.
- Careful assessment of the potential impact of surface water drainage from new developments will be necessary in areas with constrained drainage networks, particularly those networks that are dependent upon sewers, culverted watercourses and pumping stations with limited or a finite capacity.

6.2.3 Enhancing and Restoring the River Corridor

- Those proposing development in proximity to watercourses should look for opportunities to undertake river restoration and enhancement as part of a development to make space for water. Enhancement opportunities should be sought when renewing assets (e.g. de-culverting, the use of bio-engineered river walls, raising bridge soffits to take into account climate change).
- Further culverting and building over culverts should be avoided. Where practical, all new developments with culverts running through their site should seek to de-culvert rivers for flood risk management and conservation benefit. Any culverting or works requires the prior written consent of either the Environment Agency for main rivers, or RB of Greenwich for ordinary watercourses affecting the flow of that watercourse, under the terms of the Environmental Permitting Regulations 2010 and the Flood and Water Management Act 2010. These regulatory bodies seek to avoid culverting, and their consent for such works will not normally be granted except as a means of access.
- Set development back from rivers, seeking an 8 metre wide undeveloped buffer strip for development by all watercourses including those where the Flood Zone does not exist.

6.2.4 Protecting and Promoting Areas for Future Flood Alleviation Schemes

- Protect Greenfield functional floodplain from future development (our greatest flood risk management asset) and where possible reinstate areas of functional floodplain which have been developed (e.g. reduce building footprints or relocate to lower flood risk zones).
- Identify sites where developer contributions could be used to fund future flood risk management schemes or can reduce risk for surrounding areas.
- Seek opportunities to make space for water to accommodate climate change.

6.2.5 Improving Flood Resilience and Emergency Planning

Where flooding affects only a limited number of properties, it is unlikely that measures to improve flood defences will attract priority funding. Instead it may be necessary to place greater reliance on making properties that are at risk more resilient to flooding. Similarly, steps should be made to improve the resilience of properties and infrastructure that is at risk of surface water flooding, through:

- Seeking to improve the emergency planning process using the outputs from the SFRA.
- For areas at risk of fluvial and tidal flooding, encouraging all those within existing Flood Zone 3a and 3b (residential and commercial occupiers) to sign up to Flood Warning Service operated by the Environment Agency.
- Ensuring robust emergency (evacuation) plans are implemented for new developments.
- Considering locations where flood resistant and resilient measures, (to be presented in Appendix B Developer Guidance) can be retrofitted to properties at risk of surface water or fluvial flooding.

7 Next Steps

7.1 Overview

This Level 1 SFRA provides a strategic overview of the flood risk in RB of Greenwich from all sources of flooding based on readily available datasets, local knowledge and historic information supplied by the stakeholders. The mapping and information in Section 4 has been used to assess the 6 strategic development locations, 84 site allocations and additional 55 potential development sites across the Borough, to enable a robust consideration of flood risk throughout the drafting of the Site Allocations Local Plan for the Borough.

7.2 Sequential Test

The information, mapping and site assessment database included in this report should be used by RB of Greenwich to apply the Sequential Test and identify any sites where the Exception Test may be required. The guidance presented in Section 5 should be used to facilitate the application of the Sequential Test and the process should be carefully documented by RB of Greenwich.

7.3 Level 2 Strategic Flood Risk Assessment

Following the application of the Sequential Test, it is likely that RB of Greenwich may identify development sites where future development is required in areas of flood risk. Where More Vulnerable development is proposed in areas of Flood Zone 3, or Highly Vulnerable development in Flood Zone 2, a Level 2 SFRA is required to help determine whether the NPPF Exception Test can be passed. The Level 2 SFRA will provide further detail regarding the flood risk at each of the potential development sites, including consideration of the residual risk of tidal flooding in the event of a breach in the tidal River Thames flood defences.

7.4 Living Document

The Level 1 SFRA has been developed building heavily upon existing knowledge with respect to flood risk within the Borough. The Environment Agency are in the process of updating the Wickham Valley watercourse modelling study, which in time will be incorporated into the Flood Map for Planning (Rivers and Sea), which will result in some alterations to the flood zones in the study area.

New information may influence future development control decisions within these areas. Therefore it is important that the SFRA is adopted as a 'living' document and is reviewed regularly in light of emerging policy directives, flood risk datasets and an improving understanding of flood risk within the Borough.

Appendix A. Figures

Appendix B. Developer Guidance

Appendix C. Residual Risk – Flood Hazard Mapping

About AECOM

AECOM (NYSE: ACM) is a global provider of professional technical and management support services to a broad range of markets, including transportation, facilities, environmental, energy, water and government. With approximately 100,000 employees around the world, AECOM is a leader in all of the key markets that it serves. AECOM provides a blend of global reach, local knowledge, innovation, and collaborative technical excellence in delivering solutions that enhance and sustain the world's built, natural, and social environments. A Fortune 500 company, AECOM serves clients in more than 100 countries and has annual revenue in excess of $6 billion.

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