

North London

Strategic Flood Risk
Assessment

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Produced for
North London Waste Plan

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Glossary

The following are the main abbreviations and terms used throughout this report. Other terms and abbreviations have a local meaning and are defined where they occur.

AOD	Above Ordnance Datum
CIRIA	Construction Industry Research and Information Association
DEFRA	Department of the Environment, Food and Rural Affairs
DEM	Digital Elevation Model
EA	Environment Agency
FEH	Flood Estimation Handbook
Fluvial	Pertaining to a river
FRA	Flood Risk Assessment
GARDIT	General Aquifer Research, Development and Investigation Team
GIS	Geographical Information System
ISIS	Hydrodynamic software produced by Wallingford Software
JFLOW	Two-dimensional dynamic flood model, produced by JBA Consulting
JW DPD	Joint Waste Development Plan Document
LDF	Local Development Framework
LFB	London Fire Brigade
LPA	Local Planning Authority
NFCDD	National Flood and Coastal Defence Database
NLWP	North London Waste Plan
OFWAT	The economic regulator for the water and sewerage industry in England and Wales
OLF	Olympic and Legacy Facilities
Pluvial	Pertaining to precipitation
PPS1	Planning Policy Statement 1: Delivering Sustainable Development
PPS3	Planning Policy Statement 3: Housing Objectives

PPS6	Planning Policy Statement 6: Planning for Town Centres and Retail
PPS 25	Planning Policy Statement 25: Development and Flood Risk
PPG 25	Planning Policy Guidance note 25: Development and Flood Risk
Response Times	The time a catchment takes to respond to rainfall and for the flow to enter a point of discharge. Factors such as catchment slope and soil characteristics will affect this time.
RFRA	Regional Flood Risk Appraisal
RSS	Regional Spatial Strategy
SFRA	Strategic Flood Risk Assessment
SPG	Supplementary Planning Guidance
SUDS	Sustainable Urban Drainage Systems
TFL	Transport for London
Tidal	Pertaining to the movement of coastal waters
TUFLOW	A finite-difference 2D and 1D flood and tide simulation by WBM Pty Ltd and The University of Queensland
UKCIP	UK Climate Impacts Program

Executive Summary

The North London Boroughs of Barnet, Camden, Enfield, Hackney, Haringey, Islington and Waltham Forest are in the process of compiling their Local Development Framework (LDF) to guide future development needs of the Boroughs. The seven Boroughs have a history of co-operating on waste matters, having combined to prepare a Joint Waste Development Plan Document (JWDPD) also known as the North London Waste Plan (NLWP). Due to an already active collaboration between the seven Boroughs the NLWP was identified as the most appropriate means for the Strategic Flood Risk Assessment (SFRA) to be procured. Mouchel was commissioned in July 2007 to undertake a SFRA in order to ensure that flood risk is considered as part of the spatial planning process.

The objectives of the SFRA were predominantly informed by the requirements of Planning Policy Statement 25, which requires decision makers involved in the planning process to consider regional and local flood risk issues when planning development.

The Primary aims of the SFRA were:

- Identify the areas within North London that are at risk of flooding for all Flood Zones identified in table D1 in PPS 25, and within Flood Zone 3, the variations in the actual flood risk including the effect of any formal or informal flood defences.
- Identify the risk of flooding due to surface water either in the form of flash flooding due to surface water run-off, rising groundwater, inadequate drain/sewer capacity or inadequate drain/sewer maintenance
- Identify the likely effects of climate change on flood risk
- Identify catchment areas and the potential for development to affect flood risk in areas beyond the individual Borough boundaries
- Provide the basis for allocating sites in the Local Development Framework (LDF) including, if necessary, applying the sequential test approach to site allocation within the indicative flood plain.
- Provide a clear rationale for assessing the merits of potential development allocations based on a sequential flood risk assessment, taking into account the flood risk vulnerability of proposed uses (table D2, PPS25)
- Recommend policy options for dealing with the range of flood risks and provide guidance for developers

- Recommend appropriate monitoring and review methods

All forms of flooding were investigated, primarily by compiling and reviewing relevant information provided by a wide variety of sources, but primarily the Environment Agency, the North London Boroughs, London Fire Brigade and Thames Water.

In general only limited data pertaining to sewer flooding has been obtained from Thames Water. While Thames Water has provided extracts from their flooding database, the sensitivity of the data restricts them from identifying individual flooding problems. Other data requested from Thames Water, such as GIS extracts of the main sewer lines and modelling data or results of Drainage Area studies, has not been made available for the study. The data obtained so far is insufficient to enable a thorough investigation of sewer flooding within the study area and the time constraints of the project. Without this data no verification or quantification of surface water flood risks could be undertaken.

A source pathway receptor model was used to assess those flood sources which had the greatest consequences for each of the borough as shown in Table 18. The primary source of flood risk was determined to be the posed by the watercourses both fluvial and tidal in each of the concerned boroughs. The risk of flooding from secondary sources was in general found to be low, also the information required to make detailed assessments of the secondary sources was less available such as the sewer and canal information.

The findings of the study were used to assess the flood risk across the study area and recommendations for further work were provided. Guidance on applying the sequential test to developments in the North London Boroughs has also been provided.

The findings of the SFRA were used to advise on local planning policy issues and provide guidance to developers on the management of residual flood risk and surface water drainage through the use of Sustainable Urban Drainage Systems. These findings included recommendations for potential work which may be required for further stages of the SFRA and the maintenance of the 'live' SFRA document.

1 Introduction

1.1 Background

Planning Policy Statement 25: Development and Flood Risk (PPS25) issued in December 2006 by the Department for Communities and Local Government; sets out the national policy for land use planning and flood risk management in England. The policy highlights the requirement for each Local Planning Authority (LPA) to consider flood risk and flood risk management within local development documents and ensure that informed decisions on the flood risk attributed to new developments are made by those involved in the planning process. Key to this risk based approach is the production of a Strategic Flood Risk Assessment (SFRA) report to consider catchment wide flood risk issues. SFRAs are required to be produced by individual or groups of LPAs in conjunction with their Local Development Framework (LDF).

Mouchel were commissioned in July 2007 to undertake a SFRA for the seven North London Boroughs, Barnet, Camden, Enfield, Hackney, Haringey, Islington and Waltham Forest. The seven Boroughs have a history of co-operating on waste matters, having combined to prepare a Joint Waste Development Plan Document (JWDPD). The proposed JWDPD is also known as the North London Waste Plan (NLWP) and is the preferred approach to implementing the principles of sustainable waste management for all controlled waste streams. As an already active collaboration between the seven Boroughs the NLWP was identified as the most appropriate vehicle through which the SFRA could be procured. The report is intended to provide each individual Borough with the evidence base required to develop their LDFs. As such, the focus of the report is not entirely on the activities of the North London Waste Plan, but on the overall development within each Borough in the context of flood risk.

At the time of Mouchel's appointment Enfield and Islington had already produced their own separate SFRAs, and Waltham Forest had commissioned a SFRA covering a small area within their Borough. It is intended that this report comprises one over arching SFRA covering all seven of the North London Boroughs and in order to achieve this aim it was agreed that the Enfield and Islington SFRAs would be reviewed as part of this study and where appropriate data will be incorporated into this report. Where necessary the data in the Enfield and Islington SFRAs will be updated to include more recent information and any deficiencies in the assessment will be improved to ensure a consistent level of detail across all seven Boroughs. While this approach may lead to some duplication of data from the Islington and Enfield SFRAs, it is important for this to take place to ensure that those using the North London SFRA for cross Borough planning purposes, such as the North London Waste Plan, have a single document containing all base line data related to

flooding. The status of the Waltham Forest SFRA is currently unknown and no review of this document has taken place.

1.2 Project Objectives

The objectives of this SFRA are based on the brief agreed with the North London Waste Plan which has predominantly been informed by the requirements of PPS25. The primary objective of any SFRA is to provide decision makers involved in the planning process with a better understanding of local flood risk issues thus enabling flood risk to be considered at the earliest stages of the planning process. The SFRA is aimed at identifying areas most suitable for sustainable development through the application of the sequential test as set out in PPS25. A summary of the objectives of this study are summarised below:

- Identify the areas within North London that are at risk of flooding for all Flood Zones identified in table D1 in PPS 25, and within Flood Zone 3, the variations in the actual flood risk including the effect of any formal or informal flood defences.
- Identify the risk of flooding due to surface water either in the form of flash flooding due to surface water run-off, rising groundwater, inadequate drain/sewer capacity or inadequate drain/sewer maintenance
- Identify the likely effects of climate change on flood risk
- Identify catchment areas and the potential for development to affect flood risk in areas beyond the individual Borough boundaries
- Provide the basis for allocating sites in the Local Development Framework (LDF) including, if necessary, applying the sequential test approach to site allocation within the indicative flood plain.
- Provide a clear rationale for assessing the merits of potential development allocations based on a sequential flood risk assessment, taking into account the flood risk vulnerability of proposed uses (table D2, PPS25)
- Recommend policy options for dealing with the range of flood risks and provide guidance for developers
- Recommend appropriate monitoring and review methods

In addition to informing the LDF the aims of the SFRA are to provide advice on flood risk management policies, inform the local sustainability appraisal and provide advice on the requirements for local development flood risk assessments. Although the objectives of an SFRA are defined in PPS25, where appropriate the scope of this assessment has been tailored to suit the unique requirements of each Borough,

ensuring that all sources of flood risk are addressed at a level consistent with the scale of consequences and the risk which they pose to development and infrastructure within the North London sub-region.

The majority of the North London Borough area is located outside of the fluvial floodplain, and it was determined early on in the project that a high level assessment of flood risk would be appropriate for the majority of the study area. However, where fluvial flood zones exist the scope of the assessment has been widened to provide sufficient level of detail to enable the application of the exception test within flood risk zones by determining the residual risk within Flood Zones 2 and 3.

1.3 SFRA Scope

This is a Level 1 SFRA. Any further work will be conducted at a later date. The scope and objectives of a SFRA are often described through a three tiered process (levels 1, 2 and 3). Level 1 assessments should cover an entire Borough and provide an LPA with the flood risk information required to undertake the spatial planning process implemented through their LDF. Where significant development is identified at the Regional Spatial Strategy stage, such as the Olympics or Thames Gateway, further assessment constituting a level 2 and 3 assessment may be undertaken, with coverage of the planned development areas only.

A level 1 SFRA is a coarse assessment using information already available to identify areas of flood risk. From this initial review of existing data it can be determined whether a level 2 assessment is required, generally a level 2 assessment is required where development allocation will require the application of the exception test or where there is either high uncertainty about flood risk data. Where flood risk data with high uncertainty, or missing data is identified, further work such as hydraulic modelling may be required. The need to infill or improve data will partly depend on the spatial relationship between the areas of potential flooding and planned development zones. Any further work will be identified but not undertaken as part of this study. A level 3 assessment is when a detailed study is to be undertaken if the Level 2 SFRA concludes that further quantitative analysis is required to assess flood risk issues.

1.4 Methodology

For simplicity the study has been broken down into three stages, the first is a data collection and validation exercise which assesses the suitability of all data and identifies any missing or incomplete data. The second stage involves a review of all flood risk sources identified through a thorough review of data collected during stage one. In order to ensure that the study adequately addresses each area of flood risk to the required level of detail, a source pathway receptor model is created which identifies the scale of consequence of each flood source. This model is then used to identify the critical sources of flood risk. Stage three addresses these critical risks in

greater detail and provides further break down of the flood risk such as undertaking breach or overtopping assessments and identifying areas benefiting from formal or informal flood defences.

While the report aims to address catchment wide flood risk, in some instances a flood source may not impact on all Boroughs. In these cases some Boroughs have been omitted from selected maps to ensure that the report and mapping remains as concise as possible.

1.5 Setting the Scene

The North London study area is home to approximately 1,676,000¹ people from a range of different social backgrounds. This population maintains local business activities that are supported by appropriate infrastructure and services. The area has undergone development and regenerations over the last 20 years that has seen improvements in social conditions and prosperity. The North London region consists of 7 Boroughs, Barnet, Camden, Enfield, Hackney, Haringey, Islington and Waltham Forest. Each borough is predominately urbanised with the density of urbanisation tending to reduce further from the centre of London. Figure 1 shows the North London study area and the borough boundaries. More detailed maps can be found in Appendix A in Maps No.1 to 6).



¹ London Fire Brigade (May 2005) Borough Profiles, http://www.london-fire.gov.uk/about_us/borough_profiles0506.asp

Figure 1 - North London Study Area

The North London sub-region is drained by a series of watercourses which all form part of the overall Thames Catchment. The main rivers generally drain in a southerly direction towards the Thames. However, most of the watercourses in the study area have been influenced by urbanisation to some degree, with sections of culverted or canalised watercourses commonplace. Some of the rivers such as the Hackney Brook have been urbanised to such an extent that they are now incorporated into the London sewer system. In these built up areas, much of the surface water goes into the surface water drains before being discharged into watercourses.

1.5.1 *London Borough of Barnet*

Barnet is an affluent suburb of London with significant Greenbelt and Metropolitan Open Land areas. Barnet has a total area of 86.7km² and a population of approximately 330,000². Barnet is the 4th largest London borough in area and the 2nd largest in population. Within Barnet Mill Hill East, Colindale and Brent Cross / Cricklewood are identified as opportunity or intensification areas in the London Plan and form a significant part of the growth targets for housing and employment in the sub-region.

The Dollis Brook and Silk Stream are the two dominant watercourses within the borough, draining the majority of Barnet towards the south where the River Brent begins at their confluence. Mutton Brook, Deans Brook and Folly Brook are significant tributaries to these watercourses. The Environment Agency is currently developing a £1.8million scheme to protect 133 homes and businesses from flooding attributed to the Edgwarebury Brook in the Silk Stream catchment. East Barnet is drained by the Victoria Watercourse, Bounds Green Brook and to a lesser extent the Monkenmead Brook, all of which are tributaries of the Pymmes Brook which is part of the River Lee catchment.

The south west boundary of Barnet is marked by the River Brent and the Silk Stream confluence at the Brent Reservoir (Welsh Harp). The 598,000 m² Brent Reservoir is owned and maintained by British Waterways and is main supply reservoir for the Grand Union Canal.

² London Fire Brigade (May 2005) Barnet Borough Profile, http://www.london-fire.gov.uk/about_us/borough_profiles0506.asp

1.5.2 *London Borough of Camden*

Camden is a diverse Borough with a varied mix of land-uses including a number of entertainment and tourist attractions such as theatres and Camden Market. The total size of Camden is 21.8km² with a population of approximately 226,000 people³. It stretches north as far as Hampstead Heath and to the south incorporates the central London areas of Euston, Kings Cross and Holborn. The Further Alterations to the London Plan includes Camden within the Central London sub-region and identifies Kings Cross, Euston and Tottenham Court Road as opportunity areas.

Regents Canal runs from west to east and bisects Camden borough. The River Fleet, which is formed from two springs on Hampstead Heath is the largest of London's subterranean rivers and historically drained the Camden area. The Fleet has long since been incorporated into the London sewer network although the traditional route of the Fleet and the large sewer in its place can still be traced in the south of the Borough as it passes into the City of London. Highgate and Hampstead Ponds were constructed to increase London's water supply. They are fed by the Fleet and are now used by the public for leisure activities. Camden suffered widespread surface water flooding in August 2002 due to a high intensity rainfall event.

1.5.3 *London Borough of Enfield*

Enfield is London's most northerly borough and one of the largest by land area. The total area of Enfield is 82.2km² containing an approximate population of 280,000⁴. Forty-nine percent of Enfield is designated as green belt or open space. There are 17 industrial estates in Enfield with further areas identified as preferred industrial locations in the London Plan, all located within the Upper Lee Valley, in the east of the Borough.

Enfield has the longest length of watercourses among the London boroughs in the study area. Pymmes Brook, Salmons Brook and Turkey Brook are the principle tributaries for the River Lee that's flows south to the River Thames. The River Lee Diversion Channel forms the Eastern borough boundary. The borough also contains several large reservoirs that help manage water supply. The New River is an artificial watercourse that supplies water to the centre of London and flows north to south through the centre of Enfield.

³ London Fire Brigade (May 2005) Camden Borough Profile, http://www.london-fire.gov.uk/about_us/borough_profiles0506.asp

⁴ London Fire Brigade (May 2005) Enfield Borough Profile, http://www.london-fire.gov.uk/about_us/borough_profiles0506.asp

1.5.4 *London Borough of Hackney*

Hackney has one of the most ethnically diverse populations in the country and covers a total area of 19km² with an approximate population of 208,000⁵. Hackney is a borough of regeneration, with many developments having taken place over the last 20 years. Nearly one third of the Olympic Park will be located within Hackney and will be accompanied by associated infrastructure improvements and long term regeneration.

Regent's Canal passes across the southern section of Hackney borough between Shoreditch and Dalston. The man made New River flows through the north west of the borough to the Stoke Newington Reservoirs. The River Lee travels south towards the Hackney marshes where it splits into the old River Lee and the Hackney Cut. The culverted Hackney Brook travels diagonally through the centre of the borough, although the Brook is now lost and incorporated into the sewer network. Clissold Park's eastern lake is one of two which marks the original course of the Hackney brook.

1.5.5 *London Borough of Haringey*

Haringey is another particularly diverse borough, with over 160 different languages spoken. Haringey has a total area of 29.6km², supporting a population of approximately 225,000 people⁶. The Borough has a high level of deprivation, particularly in the east of the borough, where unemployment levels are high. The London plan identifies the areas of Tottenham Hale and the Upper Lee Valley as areas of opportunity and the Haringey heartlands as areas suitable for intensification.

The Moselle Brook (River Moselle) flows predominately through Tottenham. It was originally a natural tributary of the River Lee but has since been mostly culverted and in now artificially flows into Pymmes Brook. The New River flows south through the middle of the borough along the eastern boundary of Alexandra Park and into Finsbury Park. The River Lee forms the eastern Haringey boundary with Waltham Forest.

⁵ London Fire Brigade (May 2005) Hackney Borough Profile, http://www.london-fire.gov.uk/about_us/borough_profiles0506.asp

⁶ London Fire Brigade (May 2005) Haringey Borough Profile, http://www.london-fire.gov.uk/about_us/borough_profiles0506.asp

1.5.6 *London Borough of Islington*

Islington is situated on higher ground in the central district of London. Islington has an area of 14.9km² and a total population of approximately 183,000⁷. It is one of the smallest London Boroughs by land mass. The dense population with a high proportion of multiple occupation of most buildings as 60% of households are in flats. The borough used to supply the city of London with water. Historical Islington contained sprigs and marshes that were import in the development of London as a city. However, as the city developed the demand for water increased and the New River aqueduct was constructed. The New River is no longer in use within Islington, instead it ends at Stoke Newington and is piped to the Coppermills Water Treatment Works where it contributes to the north London water supply. Currently, Islington still has over 35 recorded boreholes.

The Regent's Canal was constructed in the early 1800's and flows through Islington, largely contained within the 886m long Islington tunnel, which runs from Colebrook Row to the King's Cross area where the canal emerges.

It is important to note the critical role that the borough plays in London's transport network. Due to the high degree of connectivity in the borough, an incident will have a wider impact than in other boroughs in a short amount of time.

1.5.7 *London Borough of Waltham Forest*

Waltham Forest is another particularly diverse borough and has the fifth largest Muslim population in England and the third largest in London (coming after its neighbouring boroughs, Newham and Tower Hamlets). Waltham Forest is 38.8km² and has an approximate population of 224,000⁸. Waltham Forest is one of five host boroughs in East London for the 2012 London Olympics.

The River Lee and the River Ching are the principal rivers in Waltham Forest. The Lee in Waltham Forest is a largely artificial route and is tidal as far as Low Hall Playing Fields with the Lee Bridge Road marking the mean high water limit. The Lee Flood Relief Channel was completed in 1976 to prevent a repeat of the flooding that took place in 1947 and is a wide concrete culvert that rejoins the River Lee at Hackney Marshes. The River Lee forms the eastern borough boundary with Hackney at Hackney Marshes.

⁷ London Fire Brigade (May 2005) Islington Borough Profile, http://www.london-fire.gov.uk/about_us/borough_profiles0506.asp

⁸ London Fire Brigade (May 2005) Waltham Forest Borough Profile, http://www.london-fire.gov.uk/about_us/borough_profiles0506.asp

The Lee Valley also contains the Chingford and Walthamstow Reservoirs which together represent one of the largest expanses of open water in London. Many other smaller ponds are also found within the Epping Forest.

2 Planning Policy and Flood Risk

The enactment of the Planning and Compulsory Purchase Act 2004 instigated major alterations to national, regional and local planning policies. Regional Spatial Strategies (RSSs) replaced Regional Planning Guidance, with the London Plan being published in February 2004. Following on from the RSSs, Local Planning Authorities are required to replace existing Unitary Development Plans with a suite of documents known as Local Development Frameworks (LDFs), which provide guidance on the use and development of land. LDFs must conform to the overarching RSS.

The North London SFRA is a freestanding document that will be part of each Boroughs overall LDF. The assessment is undertaken in the context of Planning Policy Statement 25: Development and Flood Risk (PPS 25) published in December 2006. This statement replaces Planning Policy Guidance note 25: Development and Flood Risk (PPG 25), published in 2001, and is part of the Government's ongoing strategy of replacing Planning Policy Guidance with Planning Policy Statements that provide "statements of government policy on nationally important land use and other planning matters, supported where appropriate by locational framework"⁹

2.1 National Planning Policy and Guidance

2.1.1 *Planning and Compulsory Purchase Act 2004*

The Planning and Compulsory Purchase Act 2004 received Royal Assent in May 2004. The Act influences the planning process at both regional and local levels, with the requirement for development of RSSs and LDFs. The Act is designed to accelerate the planning process, make planning decisions more predictable and provide a more sustainable approach to planning.

Regional planning bodies and LPAs will now have a statutory duty to ensure that development documents promote sustainable development and Sustainability Appraisals must be carried out as part of the LDF process. Annual reports on the achievement of locally set policies and targets are required from LPAs, ensuring they promote and implement good quality development rather than just facilitating the planning process.

⁹ Department of Communities and Local Government Planning Policy Guidance 1: General Policy and Principles, 1997

2.1.2 *Planning Policy Statement 1*

The overarching planning policies and guidance from which the other PPSs will follow is set out in Planning Policy Statement 1: Delivering Sustainable Development, published in 2005. PPS1 clearly identifies the requirement for future development to take account of sustainability and flood risk. The following extracts taken from PPS1 identify the need for regional and local plans to take account of flood risk and flood management.

“Regional planning bodies and local planning authorities should ensure that development plans contribute to global sustainability by addressing the causes and potential impacts of climate change.”

“Development plan policies should take account of environmental issues such as: the potential impact of the environment on proposed developments by avoiding new development in areas at risk of flooding and sea-level rise, and as far as possible, by accommodating natural hazards and the impact of climate change.”

“Key objectives should include ensuring that developments are sustainable, durable and adaptable (including taking account of natural hazards such as flooding)...”

The introduction of PPS1 and subsequently PPS25 (see chapter 2.1.4) is a clear Government led policy change towards the management of flood risk through the planning process. Those involved in the planning process must be provided with clear guidance in order to effectively action this policy change.

2.1.3 *Planning Policy Statement: Planning and Climate Change: Supplement to PPS1*

In December 2007 the Government published a supplement to PPS1 entitled “Planning and Climate Change”. This policy set key planning objectives relating to the delivery of spatial strategies which aim to “*secure new development and shape places that minimise vulnerability, and provide resilience, to climate change.*”

The supplementary policy sets out key principles which planning authorities should apply during decision making about spatial strategies;

“new development should be planned to minimise future vulnerability in a changing climate;” and *“climate change considerations should be integrated into all spatial planning concerns;”*

The supplementary policy also highlights the importance of Sustainability Appraisals and Strategic Environmental Assessment when developing planning strategies.

The policy does not deal directly with flooding issues except for the requirement for considering flood risk when selecting land for development. Planning Policy Statement 25 remains the key planning policy development and flood risk.

2.1.4 *Planning Policy Statement 25*

The introduction of PPS 25 in December 2006 outlined the responsibility of Regional Planning Bodies and Local Planning Authorities to prepare and implement planning strategies which help to deliver sustainable development by ensuring that flood risk is understood and managed effectively as an integral part of planning process. This is primarily achieved through preparation of Strategic Flood Risk Assessments (SRFAs) or Regional Flood Risk Appraisals (RFRAs) as appropriate. These look at catchment wide flooding issues with the aim to appraise, manage and reduce risk by:

- *“Identifying land at risk and the degree of risk of flooding from river, sea and other sources in their areas”*
- *“Only permit development in areas of flood risk when there are no reasonably available sites in areas of lower flood risk and benefits of the development outweigh the risks from flooding”*
- *“Reduce flood risk to and from new development through location, layout and design, incorporating sustainable drainage systems (SUDS)”*

SFRAs must be prepared by Local Planning Authorities in consultation with the Environment Agency, emergency response teams and the local drainage authority. The SFRA should build upon existing flood maps by taking into account other sources of flooding in order that it can provide a basis from which to apply the Sequential Test and Exception Test in development allocation.

2.2 **The Sequential Test and Exception Test**

2.2.1 *The Sequential Test*

To determine the suitability of land for development in areas at risk of flooding, a sequential risk based approach should be applied at the outset of the planning process. The aim of the Sequential Test is to guide new developments to areas with the lowest probability of flooding.

Flood zones are the basis of the sequential approach. Zones 2 and 3 are shown on Environment Agency Indicative Floodplain Maps with Flood Zone 1 being all land falling outside Zones 2 and 3.

In areas at risk of sea or river flooding, preference should be given to locating development in Flood Zone 1. If there is no reasonably available site in Flood Zone 1, the flood vulnerability of the proposed development should be taken into account

in locating the development in Flood Zone 2 and then Flood Zone 3. The vulnerability classification of proposed development is provided in Table 2 which is extracted from PPS25.

New development should be located at sites with the lowest probability of flooding from all sources within each Flood Zone, as indicated by the SFRA.

Table 1 below defines each Flood Zone referring to the probability of sea and river flooding only, ignoring the presence of all existing flood defences; Table 3 defines the vulnerability classification of proposed developments against flood zone locations.

Table 1 - Definition of Flood Zones

Flood Zone	Definition	Appropriate Uses
Zone 1 Low Probability	< 1 in 1000 annual probability of river or sea flooding in any year (<0.1%)	All uses of land are appropriate in this zone.
Zone 2 Medium Probability	1 in 100 to 1 in 1000 annual probability of river flooding (1% - 0.1%) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% - 0.1%) in any year.	<p>“Water-compatible”, “less vulnerable” and “more vulnerable” uses of land and essential infrastructure are appropriate in this zone.</p> <p>Subject to the Sequential Test being applied, the “highly vulnerable” uses of land are only appropriate in this zone if the Exception Test is passed.</p>
Zone 3a High Probability	1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.	<p>“Water-compatible” and “less vulnerable” uses of land are appropriate in this zone.</p> <p>“Highly vulnerable” development should not be permitted in this zone.</p> <p>“More vulnerable” uses of land and “essential infrastructure” should only be permitted in this zone if the Exception Test is passed.</p> <p>Essential infrastructure permitted in this zone should be designed and constructed to remain operational and safe for users in times of flood.</p>
Zone 3b The Functional Floodplain	<p>Land where water has to flow or be stored in times of flood.</p> <p>SFRAs should identify this Flood Zone (land which would flood either an annual probability of 1 in 20 (5%) or greater in any year or is designed to flood in an extreme (0.1%) flood, or at another probability to be agreed between the LPA and the Environment Agency, including water conveyance routes).</p>	<p>Only the water-compatible uses and the essential infrastructure that has to be there should be permitted in this zone. It should be designed and constructed to:</p> <ul style="list-style-type: none"> • remain operational and safe for users in times of flood; • result in no net loss of floodplain storage; • not impede water flows: and • not increase flood risk elsewhere <p>Essential infrastructure in this zone should pass the Exception Test.</p>

Explanation of Flood Risk Probability

Flood events and flood risk zones are commonly referred to in terms of the probability that a particular flood event will occur. A flood event with a probability of 1% is defined as an event that has a 1 in 100-year or greater chance of occurring in any one year.

Table 2 - Flood Risk Vulnerability Classification

Essential Infrastructure	<ul style="list-style-type: none"> • Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk, strategic utility infrastructure, including electricity generating power stations and grid and primary substations.
Highly Vulnerable	<ul style="list-style-type: none"> • 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
More Vulnerable	<ul style="list-style-type: none"> • Hospitals • Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels • Buildings used for : dwellings 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	<ul style="list-style-type: none"> • Buildings used for: shops, financial, professional and other service, restaurants and cafes; hot food takeaways, offices, general industry, storage and distribution, non-residential institutions not included in 'more vulnerable' and assembly and leisure. • Land and buildings used for agriculture and forestry. • Waste treatment (except landfill and hazardous waste facilities). • Minerals working and processing (except for sand and gravel working). • Water Treatment Plants • Sewage Treatment Plants (if adequate pollution control measures are in place).

2.2.2 The Exception Test

The Exception Test should be applied by decision-makers once the Sequential Test has been applied and unable to deliver acceptable sites located in zones of lower probability of flooding. The Exception Test can be applied, as shown in PPS25 Table D.1, as a method of managing flood risk while still allowing necessary development to occur. However, the exception test should not be used to justify highly vulnerable development in the high risk flood zones.

The Exception Test should be applied when “more vulnerable” development and “essential infrastructure” cannot be located in Zones 1 or 2 and “highly vulnerable” development cannot be located in Zone 1. The circumstances where the exception test may be applied are shown in Table 3.

Table 3 - Flood Risk Vulnerability and Flood Zone Compatibility

Flood Risk Vulnerability classification	Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	✓	Exception Test required	✓	✓
Zone 3a	Exception Test required	✓	✗	Exception Test required	✓
Zone 3b	Exception Test required	✓	✗	✗	✗

Source Annex D PPS 25

Further guidance on the exception test is provided in section 7.3.1.

2.3 Planning Responsibilities

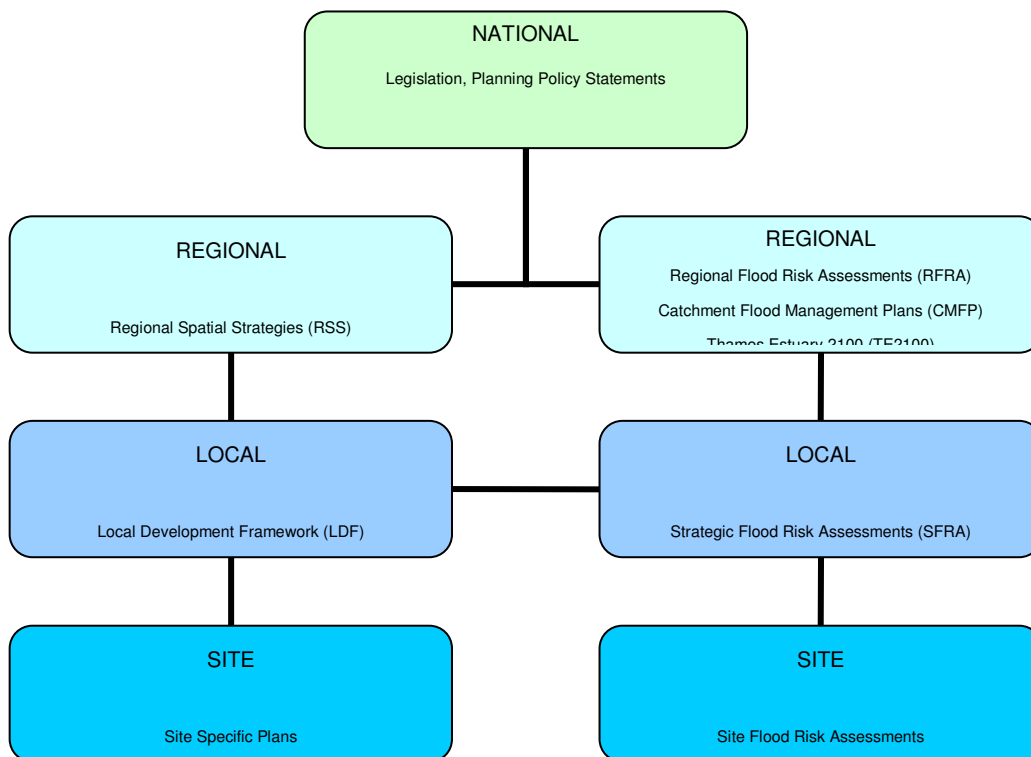
DEFRA has overall policy responsibility for flood risk in the England and the Environment Agency has statutory responsibility for flood management and defence.

The Regional Planning body should prepare a Regional Flood Risk Assessment (RFRA) in consultation with the Environment Agency to inform their Regional Spatial Strategy.

The Local Planning Authority is responsible for the planning system which aims to direct development away from areas at highest flood risk. They are required under PPS 25 to produce a SFRA in consultation with the Environment Agency, to inform their sustainability appraisals, land allocations and development control policies and the to undertake the application of the sequential test for new development.

At a site level developers should consult the Environment Agency, sewerage undertakers, highways authorities and any other relevant bodies to supply information for a Flood Risk Assessment of the site. This is to provide information to the Local Planning Authority from which they can reach a decision on the development application. PPS25 requires that planning applications for development proposals of 1 hectare or greater in Flood Zone 1 and all proposals for new development located in Flood Zones 2 and 3 should be accompanied by a FRA.

Figure 2 - Planning Hierarchy and Flood Risk



2.4 Other Planning Statements and Policies

PPS3 and PPS6 sets out the Government's national policy framework for delivering Housing Objectives and national policy on Planning for Town Centres and Retail Developments. Although not directly related to the SFRA they should be read together with other relevant statements of national planning policy including PPS 25.

PPS3 states that physical restrictions such as flood risk should be taken into account when identifying locations for development but emphasis is placed upon the priority for *"development to be located on previously developed land, in particular vacant and derelict sites and buildings."* The national annual target is that at least 60 percent of new housing should be provided on previously developed land.

PPS6 requires that a sequential approach be applied to retail developments in identifying suitable locations with growth largely encouraged in existing centres. While this has obvious benefits, it may also direct future development towards areas of high residual flood risk.

These two planning documents highlight that in exceptional circumstances, with sufficient justification, development within areas of higher residual flood risk may be permitted.

The North London River Restoration Strategy produced by the Environment Agency highlights the benefits of river restoration in North London and promotes the use of river restoration in the management of flood risk.

2.5 The Thames Catchment Flood Management Plan (CFMP)

The Thames CFMP was published for consultation in December 2007 by the EA. The plan covers the fluvial Thames catchment and its tributaries and reviews the present and future flood risk. The Thames CFMP identifies the most sustainable direction for managing fluvial flood risk within the Thames catchment for the next 50 to 100 years. There are specific messages, objectives and actions for each of the rivers within this SFRA (Brent, Lower Lee and all its tributaries). These have been recommended after consideration of the opportunities and constraints in the catchment and should be considered when forming flood risk policy.

There are four main messages that apply to the whole of the Thames CFMP area:

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

In addition, the plan emphasises the importance of land use planning, the role of the natural floodplain, use of sustainable approaches in urban areas, flood defences and increasing the resilience of the properties while reducing the consequences of flooding. These policies are inline with the development approach defined in PPS25.

2.6 Making Space for Water

Recent flooding incidents such as those experienced in 1998 and 2000 highlighted the need for the Government to develop an integrated strategy for managing future flood risks in England. In response to this, DEFRA carried out a consultation exercise known as “Making Space for Water” with stakeholders in 2004 to debate the future direction of UK flooding strategy.

Policies outlined in Making Space for Water follow the governments’ ideal of sustainable development with an overall strategy aim of managing risks from flooding whilst working to deliver the greatest environmental, social and economic benefit.

The Making Space for Water strategy highlighted the importance of a holistic approach when dealing with all forms of flooding. This is especially significant in urban areas where complex interaction of drainage systems can exist leading to difficulty in identifying responsibility for dealing with floods. The government propose that different authorities responsible for different parts of the drainage system work together to manage flood risk and take a long term strategic approach.

The Governments commitment to the use of Sustainable Urban Drainage Systems (SUDS) is outlined in the strategy through the support of the National SUDS Working Group working to address key issues such as ensuring adoption, ownership and operation responsibility is clearly defined.

It is highlighted that approximately 10 per cent of England is located within mapped areas of flood risk with a significant proportion of previously developed land sighted for redevelopment also being within areas of higher flood risk. The report advises planning authorities to ensure that the minimum standard of protection be provided for the lifetime of the development in line with PPS25 when considering developments located within flood plains. Measures to reduce flood risk through land use planning are dealt with in Section 7 of this report.

Making Space for Water also refers to the need for Regional Spatial Strategies and Local Development Frameworks to take full account of current and future flood risks and incorporate the sequential approach in PPS25 and integrated approach with catchment flood management plans.

2.7 The Pitt Review – Final Report

The Pitt Review was undertaken in the 10 months after the 2007 Summer Floods that led to 13 deaths, 55,000 properties being flooded and the largest loss of essential services since World War 2.

The report reviewed many different aspects of flood risk management, regulations, the water industry, roles and responsibilities in association with flood risk, the technical methods of risk assessment and further issues connected with them. The Pitt Review made 92 recommendations that are summarised in the Foreword to the Secretary of State (see extract below). Some of these recommendations will be highlighted in the report.

Extract from the Foreword of the Pitt Review Final Report (Page vii)

- *We believe that there must be a step change in the quality of flood warnings. This can be achieved through closer cooperation between the Environment Agency and Met Office and improved modelling of all forms of flooding. The public and emergency responders must be able to rely on this information with greater certainty than last year.*
- *We recommend a wider brief for the Environment Agency and ask councils to strengthen their technical capability in order to take the lead on local flood risk management. More can be done to protect communities through robust building and planning controls.*
- *During the emergency itself, there were excellent examples of emergency services and other organisations working well together, saving lives and protecting property. However, this was not always the case; some decision making was hampered by insufficient preparation and a lack of information. Better planning and higher levels of protection for critical infrastructure are needed to avoid the loss of essential services such as water and power. There must be greater involvement of private sector companies in planning to keep people safe in the event of a dam or reservoir failure. Generally, we must be more open about risk.*
- *We can learn from good experience abroad. People would benefit from better advice on how to protect their families and homes. We believe that levels of awareness should be raised through education and publicity programmes. We make recommendations on how people can stay healthy and on speeding up the whole process of recovery, giving people the earliest possible chance to get their lives back to normal.*

2.8 Flood Risk Management Key Stakeholders

2.8.1 Environment Agency

The Town and County Planning Order was amended in 2005 to make the Environment Agency a statutory consultee for development where flood risk is an issue under any of the following criteria:

- Development within 20m of the bank top of a Main River
- Any culverting operation or development which controls the flow of any river or stream
- Development other than minor development in Flood Zones 2 & 3
- Development in Flood Zone 1 where there are critical drainage problems
- Any development exceeding one hectare in extent

Major development is defined as residential development with 10 or more dwellings or site area of 0.5 hectare or more, or a non-residential development of 1000 square metres or more.

The EA are a statutory consultee and have to be consulted in the town and country planning process. The EA's representations to local planning authorities relate to the environmental matters that the EA are responsible for reviewing, including flooding. The EA only comment on planning policies or applications – the EA do not decide them. The EA aims to protect flood plains from inappropriate development. The EA local offices can provide advice on development issues. Further details of government policy on development and flood risk, are found in Planning Policy Statement 25, published by the Department for Communities and Local Government in England.

Where a LPA is minded to approve a major development against the objection of the EA, the LPA must notify the Secretary of State¹⁰ who will review the application against the requirements of PPS25 and call in the application for determination if necessary. If this is the case and the development proceeds against EA advice the Association of British Insurers have made it clear that it is highly unlikely that insurance against flood risk will be available for such developments.

¹⁰ Circular 04/06 (Communities and Local Government): The Town and Country Planning (Flooding) (England) Direction 2007

Under the Water Resources Act 1991, the EA have powers to maintain and improve main rivers, in order to ensure the efficient passage of flood flow and to manage water levels. These powers allow the EA to do work but they do not oblige the EA to carry out either maintenance or construction of new works on main rivers. Further explanation of the EA's responsibilities are available are outlined in the 'Living on the Edge' publication. For further information, please contact the EA at their Area Office in Hatfield at the following address.

Environment Agency
North East Area Office,
Apollo Court,
2 Bishops Square Business Park,
St Albans Road West,
Hatfield,
Hertfordshire,
AL10 9EX

2.8.2 Thames Water and Three Valleys Water

Thames Water as the Sewerage Undertaker in North London are responsible for surface and foul drainage discharge from developments where disposal is to the adopted sewer network. SFRAs are required to take account of any specific capacity problems associated with these artificial drainage networks. Developers are responsible for consulting sewerage undertakers directly for surface and foul water disposal issues.

Thames Water is responsible for the day to day maintenance of the network and looking after its interest in any associated planning issues.

Thames Water is also the main supplier of potable water within the North London area and is responsible for the day to day maintenance and operation of the clean water distribution network.

The North of Barnet is supplied by Three Valleys Water. Three Valleys Water are responsible for the water supply, but not the surface and foul water discharge. Areas supplied include Arkley, Barnet, Colindale, Edgware, Finchley, Hadley Wood, New Barnet, North Finchley, Mill Hill and Totteridge.

2.8.3 British Waterways

British Waterways is a public corporation that manages more than 2,200 miles (3,540 km) of canals and rivers in England, Scotland and Wales. It is the responsibility of British Waterways to ensure no flooding occurs from the canal networks.

Within the London Borough of Barnet, British Waterways manages the Brent Reservoir. The Brent Reservoir, also known as the Welsh Harp, supplies water to the

Grand Union Canal. The Regents canal is the primary canal for the study area, connecting the Grand Union Canal with the Thames. Further information can be found in section 5.6.2.

British Waterways are under no obligation to receive discharge from the surface water networks into the canals but this may prove to be a suitable option during extreme rainfall events.

2.9 Flood Risk Responsibility

Organisations that are responsible for providing flood defence are known as operating authorities. They have different powers and responsibilities as follows:

- The **EA** is responsible for works on all main rivers.
- **Local Authorities** look after ordinary watercourses (different tiers of Local Authorities; Counties, Metropolitan, Unitary and Districts have differing flood defence responsibilities).

The powers given to the operating authorities to carry out works are all permissive, which means they can choose either to carry out works, or not at their discretion.

2.9.1 Main Rivers

Main rivers are usually large streams and rivers, but also include smaller watercourses of strategic drainage importance. The designation of every watercourse is held on an official document known as the main river map, held by the EA and can include any structure or appliance for controlling or regulating the flow of water in, into or out of a main river. The decision as to what is designated 'main river' is made by DEFRA. The EA have powers to maintain and improve main rivers as well as carrying out *flood defence* works. However, responsibility for maintenance of main rivers remains with riparian owners as discussed in section 2.9.3. The EA has a duty to exercise general supervision over flood defence works.

2.9.2 Ordinary Watercourse

All other watercourses are defined as 'ordinary watercourses' and the local Borough Council is responsible for making sure that the districts land drainage system performs satisfactorily. An ordinary watercourse is every river, stream, ditch, drain, dyke, cut, sewer (other than public sewer) and passage through which water flows and which does not form part of a main river¹¹. The Land Drainage Act 1991 gives

¹¹ EA Publication, *Living on the Edge: A Guide to the Rights and Responsibilities of Riverside Occupation*, available on the EA website.

local authorities powers to deal with obstructions in ordinary watercourses. If the obstruction impedes the flow, the council may serve notice on the riparian owner to remove the obstruction.

2.9.3 Riparian Owners

The owner of land or property adjacent to a watercourse is known in legal terms as the "riparian owner" of the watercourse. Riparian owners have certain rights and responsibilities which are primarily established through Common Law. Where the watercourse forms the boundary between two properties, owners usually possess the land up to the centre of the watercourse unless the property deeds indicate otherwise.

Riparian owners are required to maintain a watercourse in such a condition that the free flow of water is not impeded, including maintaining banks and clearing natural and man-made debris regardless of its origin. The riparian owner has the responsibility to accept the flood flows through their land, even if caused by inadequate capacity downstream. Riparian owners have no duty to improve the drainage capacity of a watercourse. Where structures such as trash screens or culverts are present, riparian owners have a duty to clear debris. Failure to uphold responsibilities can result in legal action in some circumstances.

Riparian owners can refer to the EA's "Living on the Edge" booklet for further details on their rights and responsibilities.

3 Review of Development Framework

3.1 Regional Planning Policy – The London Plan

The London Plan is the Regional Spatial Strategy for London produced by the Mayor. The plan covers a wide range of issues from employment and resources to housing and transport.

Chapter 2 of The London Plan outlines the key components of the spatial development strategy. Policy 2A.5 highlights “Opportunity Areas” where as part of producing the Sub-Regional Development Frameworks a sustainable development programme will be created for each Opportunity Area. The London Plan highlights Cricklewood Brent Cross, Colindale, King’s Cross, Stratford, Tottenham Hale and the Lee Valley as opportunity areas, capable of accommodating substantial new jobs or homes. These areas generally include major brownfield sites with capacity for new development and increases in density.

Policy 2A.6 highlights area for “intensification” where development should exploit public transport and accessibility and potential for increases in residential, employment and other uses through higher densities and more mixed and intensive use. Arsenal/Holloway, Farringdon/Smithfield, Haringey Heartlands/Wood Green and Mill Hill East have been highlighted as intensification areas.

Chapter 4C of The London Plan concentrates on the river and water network and the inter-relationships of all of London’s waterways, referred to as the “Blue Ribbon Network”. It highlights the importance that development and use of water and waterside land should respect natural forces in order to ensure that future development and uses are sustainable and safe.

The London Plan outlines 34 policies referring to the Blue Ribbon Network, a number of which refer directly to flooding and flood plains.

Policy 4A.12 Flooding states that *“in reviewing their DPDs, boroughs should carry out strategic flood risk assessments to identify locations suitable for development and those required for flood risk management. Within areas at risk from flooding (flood zones) the assessment of flood risk for development proposals should be carried out in line with PPS25”*.

Policy 4A.13 Flood risk management *“Where development in areas at risk from flooding is permitted, (taking into account the provisions of PPS25), the Mayor will, and boroughs and other agencies should, manage the existing risk of flooding, and the future increased risk and consequences of flooding as a result of climate change, by:*

- *protecting the integrity of existing flood defences*
- *setting permanent built development back from existing flood defences to allow for the management, maintenance and upgrading of those defences to be undertaken in a sustainable and cost effective way*
- *incorporating flood resilient design*
- *establishing flood warning and emergency procedures*

Opportunities should also be taken to identify and utilise the areas for flood risk management, including the creation of new floodplain or the restoration of all or part of the natural floodplain to its original function, as well as using open space in the flood plain for attenuation of flood water.

The Mayor will, and boroughs and other agencies should, take fully into account the emerging findings of the Thames Estuary 2100 Study, the Regional Flood Risk Appraisal and the Thames Catchment Flood Management Plan.”

Policy 4A.14 Sustainable drainage *“The Mayor will, and boroughs should, seek to ensure that surface water run-off is managed as close to its source as possible in line with the following drainage hierarchy:*

- *store rainwater for later use*
- *use infiltration techniques, such as porous surfaces in non-clay areas*
- *attenuate rainwater in ponds or open water features for gradual release to a watercourse*
- *attenuate rainwater by storing in tanks or sealed water features for gradual release to a watercourse*
- *discharge rainwater direct to a watercourse*
- *discharge rainwater to a surface water drain*
- *discharge rainwater to the combined sewer*

The use of sustainable urban drainage systems should be promoted for developments unless there are practical reasons for not doing so. Such reasons may include the local ground conditions or density of development. In such cases the developer should seek to manage as much runoff as possible on site and explore sustainable methods of managing the remainder as close as possible to the site.

The Mayor will encourage multi agency collaboration (GLA Group, Environment Agency, Thames Water) to identify sustainable solutions to strategic surface water and combined sewer drainage flooding/overflows.

Developers should aim to achieve greenfield run off from their site through incorporating rainwater harvesting and sustainable drainage. Boroughs should encourage the retention of soft landscaping in front gardens and other means of reducing, or at least not increasing the amount of hard standing associated with existing homes.”

Policy 4A.15 Rising groundwater In considering major planning applications *in areas where rising groundwater is a existing or potential problem, the Mayor will and boroughs should, expect reasonable steps to be taken to abstract and use that groundwater. The water may be used for cooling or watering purposes or may be suitable for use within the developments or by a water supply company”.*

The London Plan promotes the use of SUDS and highlights the importance that developers and local planning authorities to work together with water supply and sewerage companies to enable the inspection, repair or replacement of water supply and sewerage infrastructure.

Supplementary Planning Guidance (SPG) has been produced to provide additional information to support the implementation of the London Plan.¹²

The SPG outlines the Mayors “essential” and “preferred standards” to include the importance of the use of SUDS wherever practical and the need to “achieve 50% attenuation of the undeveloped site’s surface water runoff at peak times” as an essential standard and “achieve 100% attenuation of the undeveloped sites surface water runoff as peak times” as a preferred standard.

¹² Supplementary planning guidance, Sustainable design and construction Mayor of London, May 2006

Section 4.9 identifies Opportunity Areas or Areas for Intensification, some of which includes or adjoins parts of London’s Blue Ribbon Network. The areas included in, or influencing this study are listed in

Table 4.

Table 4 - London Plan Opportunity Areas that adjoin the Blue Ribbon Network

Opportunity Areas	Relevant water spaces
Cricklewood/Brent Cross	River Brent
Colindale	River Brent
King’s Cross	Regents Canal
Lower Lee Valley	Bow Back Rivers, River Lee
Stratford	Bow Back Rivers, River Lee
Tottenham Hale	River Lee, Pymmes Brook
Haringey Heartlands/Wood Green	Moselle Brook

3.2 Lower Lee Valley Opportunity Area Planning Framework

The Lower Lee Valley Opportunity Area Planning Framework sets out in more detail the Mayor of London’s plans for the area extending through the Lee Valley from the Thames in the south, to Leyton in the north. The regeneration area extends into the south of both the Boroughs of Hackney and Waltham Forest and any policies and proposals outlined therein must also be taken forward by those Boroughs.

The Framework rightly identifies flood risk as a key issue and a potential threat to creating sustainable development in the Lee Valley regeneration area. The salient points of interest are as follows.

A significant proportion of the regeneration area is included within flood zone 3, although protected by defences to a varying standard of protection. The areas of Leyton and Hackney Wick are considered to be at “actual flood risk”, defined as having a greater than 1% probability of flooding.

The framework sets out a number of policies relating to flood risk, the aim of which is to ensure that future developments do not “put people and property at unacceptable risk” and to ensure that the flood risk to 3rd parties is not increased by any future development.

The framework also identifies that those areas that are at actual risk of flooding will require site specific or strategically planned defences of some form or another in order that development classed as “more vulnerable” in PPS25 might be accepted.

Such development must also first pass the sequential and exception tests as set out in PPS25.

3.3 Water Matters, Draft Water Strategy

The Mayor of London's draft water strategy was issued for consultation in March 2007 and sets out to provide a London wide strategy for managing water resources and flooding, particularly aiming to prepare London for the stresses that population growth and climate change will have on the existing water management infrastructure. The strategy is designed to compliment and develop further the policies set out in the London Plan. To ensure a consistent policy approach any policies set out by individual Boroughs in their LDDs should be developed to compliment those of both the London Plan and draft water strategy. As such, those preparing planning policies relating to flood risk should ensure that they are fully conversant with the final water strategy document when it is released by the Greater London Authority.

3.4 Local Planning Policy – The UDP and LDF Core Strategies

The Unitary Development Plan (UDP) is a "land use" plan produced by each London Borough and forms the development plans used for the purpose of Section 54A of the Town and Country Planning Act 1990. The UDP's set out each Boroughs policies regarding planning and transportation.

The Local Development Framework (LDF) is the spatial planning strategy introduced in England and Wales by the Planning and Compulsory Purchase Act 2004. The LDF is to be made up of a series of planning documents that together will set out the overall planning vision, looking forward 10 to 15 years, in general conformity with the London Plan. The LDF will replace the existing UDP in each borough. All boroughs have published a Local Development Strategy (LDS) which sets out the councils 3 year plan explaining how the LDF will be produced. In the interim period the UDPs still steer planning policy in the Boroughs and in order to identify potential development locations and existing flood risk management policies, each Boroughs' UDP has been reviewed. Table 5 offers a brief summary of the policy coverage from each UDP. In general the policies set out in the Boroughs UDPs are outdated and will require modification to bring them into line with PPS25.

Table 5 - Summary of UDPs and Policies

UPD Authority / Policy	Flood Risk & Development	Brownfield Development	SUDS	Environmental Conservation	Groundwater	Watercourse Enhancement	Opportunity /Development Areas	Comments
Barnet	✓ ENV9	✓	✓ ENV 10	✓		✓ O12/O13	Cricklewood, Brent Cross, West Hendon, Colindale, Mill Hill East	
Camden	✓	✓	✓	✓ N6		✓ RC1	Kings Cross Railway Lands	
Enfield	✓ GD12		✓ GD13	✓ ENV1		✓ O6/O7/O8/O9		
Hackney	✓ EQ9	✓	✓ HO20/E18	✓ ST13/ST42		✓ ST12/EQ26		Promotes Flood Mitigation
Haringey	✓ ENV1R	✓	✓ ENV 2	✓			Tottenham Hale, Haringey Heartlands, Wood Green	
Islington	✓ D35	✓	✓	✓ ENV8/ENV21/ENV23	✓	✓ ENV25		
Waltham Forest	✓ WPM 18	✓	✓ WPM 19	✓ WPM 15	✓ WPM 15	✓ WPM 15	Leyton, Blackhorse Road	

The delivery schedule of the Local Development Framework Development Plan Documents for each of the boroughs is indicated in the Borough's Local Development Scheme reports. Local Development Schemes set out the timetable for delivery of LDF documents and are therefore subject to change. Borough websites will provide the most recent version of the Local Development Scheme. In addition a few of the Development Plan Documents have already been produced and adopted by the Borough Councils. A summary of the Borough's delivery dates for each of the documents is given in Table 6. The dates for the Area Action Plans show the start date of the first one and the adoption date of the final Area Action Plan for each borough.

Table 6 - Summary of Boroughs Development Plan Documents Timescales taken from the Local Development Scheme Reports

Document Title	Barnet	Camden	Enfield	Hackney	Haringey	Islington	Waltham Forest
Core Strategy	Start: ? Adopt: Aug 10	Start: Mar 07 Adopt: Sep 10	Start: Jan 07 Adopt: Jul 09	Start: Apr 04 Adopt: Oct 07	Start: ? Adopt: Dec 09	Start: Jul 07 Adopt: Dec 10	Start: Jan 06 Adopt: Jan 08
Core / Development Policies	Start: Sep 07 Examination: Oct 10	Start: Mar 07 Adopt: Sep 10		Start: May 04 Adopt: Dec 10		Start: Oct 07 Adopt: May 11	Start: Apr 06 Examination: Oct 08
Joint Waste Management Plan	Start: Jun 07 Adopt: Dec 10	Start: Jun 07 Adopt: Dec 10	Start: Jun 07 Adopt: Dec 10	Start: Jun 07 Adopt: Dec 10	Start: Jun 07 Adopt: Dec 10	Start: Jun 07 Adopt: Dec 10	Start: Jun 07 Adopt: Dec 10
Area Action Plans	Start: ? Adopt: Mar 10	Adopted Jun 06	Start: Jan 07 Adopt: Jun 10	Start: May 05 Adopt: Dec 10	Adopted: Feb 08	Start: Apr 05 Adopt: May 11	Start: Jun 06 Examination: Dec 08
Statement of Community Involvement	Start: ? Adopt: Jun 07	Adopted Jun 06	Adopted Jun 06	Start: Jun 04 Adopt: Sept 06	Adopted: Dec 07	Adopted Jul 06	Adopted Jun 07
Site Allocations /Schedule	Adopted Aug 05	Start: Sep 08 Adopt: Feb 11	Start: Nov 07 Adopt: Jul 10	Start: May 04 Adopt: Dec 10		Start: Oct 07 Adopt: May 11	Start: Apr 06 Examination: Oct 08
Proposals Map	Continuous Production	Adopted Jun 06	Start: Jan 07 Adopt: Jul 09	Start: Apr 04 Adopt: Dec 10		Adopted Dec 07	Start: Apr 06 Examination: Oct 08

4 Data Collection and Validation

A large amount of data has been made available from a variety of sources for this SFRA study. All incoming data has been scrutinised to determine its authenticity and validated where appropriate to determine its accuracy and suitability for use. Not all data was deemed suitable for inclusion in the study. Appendix B - Data Summary, presented at the end of this chapter lists all data and reports acquired for the study including the source, its relevance to the scheme and any individual licensing restrictions.

The majority of the data for this study has been provided by the Environment Agency and participating London Boroughs. A brief explanation and summary of the key data sources is summarised in the following chapters.

4.1 Mapping and Topographic Data

Mapping data for this study has been provided by each of the London Boroughs and is licensed for use in this study only. The preferred mapping source for this study is Ordnance Survey's MasterMap topography layer, which can be viewed at up to 1:1250 scale. Ordnance Survey Landline mapping is also used to represent the wider catchment area as MasterMap data is only provided to cover the study boundary. However, to date, not all Boroughs have been able to provide MasterMap data and alternative sources have been used.

A Digital Terrain Model (DTM) has been provided by the EA for use in the study. The DTM is supplied in an Arcview compatible format and consists of LiDAR data provided in 500m x 500m files at a 0.5m grid cell. The DTM is a bare earth terrain model with building and vegetation removed by filtering the original Digital Surface Model using the supervised classification technique. The data has been briefly reviewed to ensure that buildings or vegetation have been correctly identified and filtered. LiDAR data coverage is unavailable for significant areas of the North London sub-region. Supplementary topographic data to fill missing gaps is not available from the EA but has been requested from the individual Boroughs. The Nextmap DTM data has been made available to supplement the missing areas. The areas with no LiDAR coverage are generally the regions where no main rivers are present, which predominantly covers Camden, Islington, Hackney and Haringey.

The EA has also provided GIS layers to identify the location of watercourses, canals, flood zones, green belt and public open space areas within the seven boroughs. The location of green belt and metropolitan land has also been obtained for Barnet separately.

4.2 Flood Defences

The Environment Agency has extracted information about flood defences in the study area. The location, standard of protection and condition grade of the flood defences and structures have been provided from the National Flood and Coastal Defence Database (NFCDD) in GIS format.

4.3 Thames Water Data

Thames Water maintains records of flooding arising from surcharging of adopted drains and sewers within its responsibility. Thames Water has provided an extract from this register, known as the DG5 register. The data is provided with a reference by truncated post code only so the exact location or source of flooding is not identified. It does however enable some comparison with other sources of flooding data such as that received from the London fire Brigade.

In general only limited data pertaining to sewer flooding has been obtained by the study team. The data obtained so far is insufficient to enable a thorough investigation of sewer flooding within the study area and the time constraints of the project. No GIS extracts of the main sewer lines, modelling data or results of Drainage Area studies have been obtained. Some additional information about the main sewer lines in Haringey were made available in paper format.

Other data requested from Thames Water has not been made available for the study and without this data no verification or quantification of surface water flood risks could be undertaken. Further discussion on the missing data and the subsequent limitations of the study are included later in the report.

4.4 Clean Water Supply Data

Neither Thames Water nor Three Valleys Water were contacted for details of potential clean water supply flood risks due to the unpredictable nature of such risks and the sensitivity of reproducing the information in a publicly available document. The flood risks associated with clean water supply pipework predominantly occurs from bursts, which compared with other sources of flood risk are generally small in nature and extremely difficult if not impossible to predict. As such this information is unlikely to be beneficial to the planning process and has not been pursued further as part of this study.

4.5 River Lee and Brent Data

4.5.1 *Historic Flood Records*

The Environment Agency maintains records of past flood events which are used in conjunction with river modelling in the preparation of the flood risk maps made available to the public via the internet. The EA have some historic flood data for North London which has been made available in GIS format. Haringey and Enfield councils were also able to provide additional historic flood records.

4.5.2 *Flood Modelling Results*

The EA have commissioned numerous flood studies for the main rivers in the study area. Most of the designated main rivers have been mapped and modelled under section 105 of the Water Resources Act 1991.

The River Lee catchment has been well studied over the years with the most recent being the 'Hydrology and Mapping Study' (2007) undertaken by Halcrow Group Limited using ISIS hydraulic modelling software. The Holyhill Brook and the upstream end of Turkey Brook, Salmons Brook above the Hounsden Gutter confluence are also modelled in JFLOW.

The final version of the River Brent Mapping study report was completed by Jacobs in 2007. Flood levels have been determined using an ISIS hydraulic model divided into two models for manageability. The Upper Brent hydraulic model includes the Dollis Brook, Mutton Brook, Folly Brook and the River Brent to the Brent Reservoir inlet. The Silk Stream was modelled separately a couple of years earlier due to the pressing need to develop a flood alleviation scheme. The flood zones produced have been incorporated into the mapping.

4.6 **Regional Flood Risk Appraisal**

The draft Regional Flood Risk Assessment was issued for consultation in June 2007, with a view to finalising the document in late 2007. The report has been produced by the Greater London Authority and gives a "broad consideration of flood risk" for the whole of London, identifying the types and the spatial implications of flood risk for the region. The report is considered to be a live document and will continue to be updated to reflect changes in legislation, policy and developments into climate change investigations.

The RFRA identifies that 40% of the areas of opportunity and 30% of the areas identified for intensification are located within flood risk zones, much of it in the Lee Valley. Applying the sequential test at a regional level would appear to show that alternative sites are not available without encroaching onto green belt or other protected areas. This further highlights the importance of addressing flood risk within the Lee Valley such that development of these sites can be carefully planned to ensure that the sequential and exception tests can be applied at a local level. It also identifies the requirement for strategic review of flood defence protection in the Lower Lee Valley.

For the North London sub-region, fluvial flood risk is identified as the prime flood risk source especially with regard to the Lee Valley, where the River Lee Flood Relief Channel is identified as having a standard of protection below the current required standard. The additional development in the upstream catchment is believed to have reduced the level of protection that Flood Relief Channel provides.

The River Brent is identified as being sufficiently protected from flood risk, although the upstream tributaries in Barnet have suffered localised flooding in the past.

The RFRA surmises that Canals poses a low flood risk but the River Lee Navigation may convey flood waters from other watercourse and so needs to be considered within SFRAs and FRAs. The RFRA does not address reservoir flood risk as this is dealt with under different legislation.

The impacts of flood risk on the area are considered with particular interest on the critical infrastructure. Several tube lines, utilities and important facilities are within the flood plain, these are detailed in Table 7 and Table 8. This information is important for use in emergency planning and is included in the RFRA to help stimulate co-operation between emergency and spatial planners. Most of the locations have been plotted on Map 24.

Table 7 - Transportation / Facilities at Risk of Flooding

Transportation / Facilities at Risk of Flooding	Watercourse Presenting Risk
Colindale Hospital	Partially within Silk Stream Floodplain
Edgware Hospital	Wholly within Silk Stream Floodplain
Burnt Oak Tube Station – Northern Line	Silk Stream floodplain
Tottenham Hale Tube Station - Victoria Line	River Lee floodplain

Source: Regional Flood Risk Appraisal

Table 8 - Utility Infrastructure within Flood Risk Zones

Borough	Location Within Borough	Infrastructure in Floodplain
Enfield	Leeside Road N18	Gas
Enfield	Albany Road N18	Gas
Enfield	Bolton Road N18	Unknown
Enfield	Balham Road N9	Unknown
Enfield	Lee Park Way N18	Waste North London Waste to Energy
Enfield	Picketts Lock Lane N9	Deephams Sewage Treatment Works
Enfield	Woodhall Road EN3	Gas
Enfield	Edison Road EN3	Electricity
Enfield	Brancroft Way EN3	Electricity Brimsdown Power Station
Enfield	Lee Valley Reservoirs EN3	Water Reservoirs including pumping stations
Enfield	Brancroft Way EN3	Electricity Sub Station
Enfield	Hadley Road EN2	Drainage Pumping Station
Enfield	Station Road N11	Gas
Enfield	Dendridge Close EN3	Unknown
Hackney	Millfields Road E5	Electricity
Hackney	Millfields Road E5	Waste
Haringey	Leeside Road N17	Electricity
Haringey	Marsh Lane N17	Drainage Pumping Station
Haringey	Reform Row N17	Unknown
Waltham Forest	Westdown Road E15	Unknown
Waltham Forest	Osier Way E10	Sewage
Waltham Forest	Clementina Road E10	Gas
Waltham Forest	South Access Road E17	Council Depot
Waltham Forest	Coppermill Lane E17	Water Coppermills Waterworks
Waltham Forest	South of Lockwood Reservoir E17	Water Pumping Station
Waltham Forest	west of Chingford Road E4	Electricity
Waltham Forest	May Road E4	Unknown
Waltham Forest	Harbert Road E4	Water Pumping Station
Waltham Forest	Lee Valley Reservoirs E4	Water Reservoirs

Source: Regional Flood Risk Appraisal

4.7 Lower Lee Flood Risk Management Strategy

The Lower Lee Flood Risk Management Strategy is an Environment Agency produced document which aims to identify a strategy for managing flood risk over the next 100 years.

Downstream from Ware it is identified that the flood defences (including the flood relief channel) provide protection against storms with a greater than 5% probability of occurrence (or 1 in 20 year return period flood). Further upstream the level of protection is reduced even further to a 20% probability (or 1 in 5 year return period flood). Development in the upstream catchment and climate change is likely to further erode this level of protection in future. The standard of protection provided by the Lower Lee Valley defences is a significant threat to the opportunity areas identified in the London Plan.

The principle fluvial flood risk areas are identified in the Lower Lee Flood Risk Management Strategy are detailed in Table 9.

Table 9 - Lower Lee Flood Risk Areas

Flood Risk Area	Watercourse
Enfield Lock to Stewardstone	Lower Lee
Waltham Forest	Lower Lee
Lee Valley Trading Estate	Lower Lee
Walthamstow Area	Lower Lee
Grange Park	Salmons Brook
Chingford	Ching
Upper Edmonton	Pymmes

4.8 Other Drainage Studies

In recent years, the need for integrated has increased and so the number of multi authority organisations has grown. With flooding and drainage has become more of a cross boundary issue various wide area studies, forums and working groups that focus on different issues have been established. Below are these known to cover the London area that includes the North London Boroughs in this study.

4.8.1 The Drain London Project

The Drain London Project is to look into issue of surface water management in the London area. The project aims to:

- Map the layout, ownership and capacity of surface water drains
- Assess the location, frequency, severity and cause of surface water flooding in London, and the impact of surface water flows on the tributary river network
- Assess the capacity of the surface water drainage network and urban river networks to manage future increases in rainfall
- Identify current and future flood hot spots and their causes
- Identify and prioritise solutions and determine responsibility to deliver actions

4.8.2 *Central London Forward*

Central London Forward (CLF) is a local authority-led partnership for Central London set up in 2007 that comprises of six boroughs in the Central Activities Zone (as defined in the London Plan). The boroughs are: City of London, City of Westminster, Kensington & Chelsea, Camden, Islington, and Southwark. Further more the private sector and third sector feed into CLF through Advisory Panels and Local Strategic Partnerships.

Alongside East London, Central London will be amongst the main growth areas in London. So in light of the huge growth predicted in this part of London over the next 10 years, Central London Forward's purposes are:

- To influence policy on major issues affecting Central London, including making the case for additional resources.
- To promote the strategic importance and needs of Central London with a focus on sustainable economic development and the improvement of the quality of life of workers, residents and visitors.
- To identify and co-operate on areas of mutual interest to partners, including tourism, the Olympics and its legacy

4.8.3 *North London Strategic Alliance*

The North London Strategic Alliance (NLSA) was established in 1999 as the sub-regional strategic partnership for North London, bring together public, private and voluntary organisations. The NLSA currently works across Barnet, Enfield, Haringey and Waltham Forest. However this is a transitional period and the new sub regional arrangements being progressed by the Greater London Authority means NLSA will

also be looking to develop relationship across Camden, Hackney, Islington and Westminster.

The NLSA provides a forum for different interest groups within the Lee Valley to discuss and plan development activities across borough boundaries. The NLSA website can be found at www.nlsa.org.uk

4.9 Strategic Flood Risk Assessments

A number of Strategic Flood Risk Assessments have been produced or are in production which may influence the North London SFRA. These also include the Enfield and Islington SFRA's which are to be reviewed as part of this report and the relevant flood risk data and mapping incorporated where appropriate.

The following sections offer a brief review of each SFRA including identifying the key interfaces with the North London SFRA.

4.9.1 *East London SFRA*

The East London SFRA was commissioned by the Thames Gateway London Partnership to cover the boroughs of Barking and Dagenham, Bexley, Greenwich, Havering, Lewisham, Newham, Redbridge and Tower Hamlets. The project was completed in 2005 and the scope of the study was designed to meet with the requirements for PPG25. Since then PPS25 has been published and contains a stronger emphasis on flood risk management through the planning process. The East London SFRA does not contain all of the information required by Boroughs to spatially plan development within the requirements of PPS25.

The East London SFRA has one key point of interaction with the North London SFRA which is the River Lee valley. The East London SFRA assesses the downstream end of the River Lee in Newham and Tower Hamlets before it joins the River Thames. The SFRA reviews the delineation of flood risk zones around the Lower Lee Valley and covers the southern portions of Waltham Forest, Hackney and to a lesser extent, Haringey.

The hydraulic models derived for this study could be used for any further assessment required for the 3 Boroughs listed above, although further definition of the flood plains may be required to improve accuracy in areas which were actually outside of the East London SFRA study area.

4.9.2 *Lower Lee SFRA*

The London Development Agency has commissioned a SFRA covering the Lower Lee Valley. The Lower Lee SFRA is intended to support the regeneration of the Lower Lee Valley and in particular development associated with the 2012 Olympic Games and its associated infrastructure. There are likely to be significant overlaps

between the Lower Lee and North London SFRA. To facilitate the SFRA the LDA has commissioned a model to look at fluvial flood risk and breach hazards. This model could provide the majority of data on residual flood risk for the Waltham Forest and Hackney Boroughs. The requirement for this data and the recommendations for further work, including flood risk is discussed in section 11.1.

The Thames Estuary 2100 is an EA initiative that aims to determine the appropriate level of flood protection needed for the Thames Estuary for the next 100 years. *Thames Estuary 2100* is the first step of the process and will help shape the way in which future flood defence schemes are designed and managed. Taking action now will allow time for research, design and the physical construction of the defences.

4.9.3 *Enfield SFRA*

The London Borough of Enfield has completed a comprehensive level 1 SFRA in line with PPS25. The assessment provided a background to the main sources of flooding and includes sufficient detailing of the flood risk zones to enable application of the sequential test at a Borough level. The report recommends further assessment of the flood zones around four Area Action Plans, such that the exception test may be applied during the spatial planning of these future developments.

Where appropriate the flood risk information produced in the Enfield SFRA will be incorporated into the overall North London SFRA maps to provide consistency. In some instances, such as assessment of surface water and sewer flooding, additional information has been obtained for this study which has not been included in the Enfield SFRA. This information is discussed further in section 4.12. Again for consistency this data will be utilised in the same way for all Boroughs. This may develop the assessment of certain flood sources to a greater extent than the Enfield SFRA, however, it is not anticipated that the results will contradict the Enfield SFRA findings.

In Enfield, the bench mark for fluvial flooding was the 1947 flood on the River Lee and its tributaries. Since then many alleviation schemes have been undertaken to reduce fluvial flooding including the River Lee Flood Relief Channel. Even now more sustainable flood risk management schemes are being developed. The assessment of groundwater and surface water flooding would appear to suggest that Enfield does not have a significant problem associated with these flood risks, other than a small number of localised problems that could be expected in any urban environment.

The London Borough of Enfield are intending to extend the scope of their SFRA to include a level 2 assessment, covering only allocated sites.

4.9.4 *Islington SFRA*

The Islington SFRA has been completed; however, it is not comprehensive enough to fulfil the brief of an SFRA as described in PPS25. The SFRA does consider some aspects of flood risk in the borough of Islington but there are some sources of flooding that are either not addressed in sufficient detail, or not reviewed at all. The SFRA identifies different sources of flooding yet only fluvial flooding has been investigated in any detail.

The map of Islington and its watercourses only shows open channels. The Canal that flows through the borough has not been discussed. The sewage and main water systems as sources of flooding have only been mentioned in regards to who is responsible for their maintenance. In addition, surface water and ground water flooding has not been considered or investigated other than a brief statement from the EA.

A review of various policies that effect or manage water and flood water were included. However, no developer or planner guidance is available on the application and use of PPS25 in regards to Flood Risk Assessments and sustainable development. In addition, no SUDS guidance is provided in the main assessment. Appendix 5 does discuss SUDS but there is no discussion on what SUDS are and which SUDS techniques might be appropriate for use in the London Borough of Islington (LBI).

The short comings of this document will be addressed and further investigation into other sources of flooding undertaken as part of this study, such that the LBI have a comprehensive assessment of flood risk consistent with their neighbouring North London Boroughs.

4.9.5 *Olympic FRA*

The Olympic FRA was published by the Olympic Delivery Authority in May 2007 and the study boundary includes part of the Lower Lee Valley in the Boroughs of Hackney and Waltham Forest. The FRA supports the planning application of the Olympic and Legacy facilities. The FRA uses the Lower Lee Valley Regeneration Strategy computational model (licensed from the London Development Agency) and updates it to create the Olympic and Legacy Facilities (OLF) baseline model. The model is a linked 1D - 2D fully hydrodynamic TUFLOW model with input hydrographs provided by a routing model. An allowance for climate change is included in the flow and tidal components in line with PPS25. The tidal influence on the River Lee is taken into account by assuming a 1 in 20 annual probability tidal level with a level hydrograph extracted from the River Thames ISIS model. The modelling work undertaken for this study could form the basis of any level 2 assessment required for the Boroughs of Waltham Forest and Hackney if such an assessment is identified as being necessary.

4.10 Community Risk Registers

The Civil Contingencies Act 2004 places a legal duty on Category 1 responders to produce a Community Risk Register. The Resilience forums that cover several authorities in an area produce a Community Risk Register. The study area contains two Resilience Forums each of which have their own Community Risk Register; the North Central London Resilience Forum and the North East London Resilience Forum. The North Central London Community Risk Register covers Barnet, Camden, Enfield, Hackney, Haringey and Islington while the North East London Community Risk Register includes Waltham Forest. Both the registers identify flooding from two main sources: surface water, coastal and fluvial as hazards.

4.11 Groundwater Data

Borehole data has been received from the Environment Agency stating details of the boreholes and groundwater levels dating back to January 2004. The information about the boreholes is not filtered and shows ALL the boreholes both active and disused known to the EA in the study area. Boreholes are predominately located towards the south of the region towards the Thames, and within the Lee catchment area. The boreholes are sparsely located within the Brent catchment area. Borehole records dating back further than 2004 have also been requested. It should be noted that 217 of the 509 borehole are of an unknown status or type, 71 of the 509 are disused and 105 of the 509 are for observational information. The EA were also able to provide the depth Groundwater contours. It is hoped that these records will allow assessment of the long term trend in groundwater levels.

4.12 Flood Records

Flood records have been collected and collated from a range of sources to produce the most complete flood history of North London as possible. Records have been obtained from the borough councils, Transport for London, London Fire Brigade and the EA. Other organisations were asked for information but were unable to share their records.

4.12.1 Individual Boroughs

All the boroughs were asked for their flood records. Camden and Enfield were able to provided GIS mapping of recent flood events that occurred within their borough. Haringey were able to provide an Inception Report for Haringey Flood Management Strategy. The Enfield SFRA also contains locations of flood records. Barnet provided a range of flood records, most of which related to isolated highway flooding incidents.

4.12.2 Transport for London

Transport for London is responsible for the management of the 580km of main road within the M25. They maintain a list of flood events related to these road assets. A

list of flooding incidents has been obtained, dating only from May 2006 to August 2007.

4.12.3 *London Underground*

Several requests have been made for information on flooding incidents at underground stations within the seven London Boroughs but no response has been received.

4.12.4 *The London Fire Brigade*

The London Fire Brigade (LFB) have provided an extract of calls received about flooding in the seven London boroughs from April 1999 to August 2007. The 15,500 calls handled by the LFB were concerned with different types of flooding that include fluvial, surface water and burst pipes. The data has been filtered down to exclude calls where no location has been recorded and calls that appear unrelated to flooding. The records were then reduced further by using data from grouped flood events that were defined by receiving 12 or more calls in 48 hours. These were then cross referenced with rain gauge data from the EA to try and determine whether events could be attributed to pluvial flooding or whether events may be attributed to other factors.

4.13 **Public Reservoirs**

A public list of reservoirs as defined by the 1975 Reservoirs Act in the North London SFRA study area has been received from the Environment Agency as part of their GIS mapping layers. This data list specifies the locations, capacities, age, type and the operators of each reservoir. A request has been made for further details regarding the condition and maintenance of the reservoirs but no information has been received.

The EA are responsible for the enforcement of the Reservoirs Act which defines reservoirs as having 25,000m² of storage above the natural ground level. The EA are responsible for the management of EA owned reservoirs. The list provided by the EA provides details of any reservoirs within the study boundary which come under this category. There are other reservoirs which are smaller or not raised above ground which are not included as part of this assessment. Reservoirs set below the natural ground level have a much lower flood risk and smaller reservoirs, particularly those associated with clean water supply have reduced flooding consequences due to their size.

4.14 **British Waterways**

A request has been made for information on the canals in the North London region. However, no information has been received from British Waterways.

4.15 Low Confidence Data

4.15.1 EA Asset Data

The standard of protection data extracted from the EA's National Flood and Coastal Defence Database (NFCDD) has been reviewed. For nearly all of the flood defences and structures in the study area a standard of protection of up to a 1 in 5 years is listed. In areas where known flood alleviation schemes have been constructed such as the Silk Stream where a large amount of work is complete there is no acknowledgement of these formal defences on the database extract. These defences also provide a higher standard of protection. The EA have commented that 5 is the default value they use for unknown standards of protection. However, with this many unknowns, there is low confidence in the NFCDD standard of protection data set.

4.15.2 Barnet Flooding Records

The data provided by Barnet on their flooding hotspots covered a two year period. However no dates were associated to the flood events data making it difficult to analyse flood patterns by comparing records with rainfall data.

4.16 Data Gaps

Data required to enable assessment of the primary source of flooding has been made available for the study, predominantly by the EA. However, the information required to undertake a thorough assessment of secondary sources of flood risk such as sewer flooding and infrastructure failure is not widely available. Without the requisite background information on these flood risk sources a comprehensive assessment has not been possible.

4.16.1 Thames Water

Information pertaining to sewer flooding is particularly limited, which has resulted in a low confidence on the potential risks and impacts of such flooding included in the study. While Thames Water have provided extracts from their flooding database, the sensitivity of the data restricts them from identifying individual flooding problems. The flood records are identified by truncated postcode only. No hydraulic models or results of hydraulic studies of the sewer network were made available, which prevented a thorough assessment of the potential limitations of the network.

Thames Water's response to these requests is quoted as follows:

"Due to the complexities of the sewage and surface water networks and the infinite number of development opportunities at this point of the planning process, it is not possible to accurately assess areas which will be affected by flooding as a result of future development. To ensure all future development is sustainable detailed computer modelling of development sites needs to be carried out. To do this the exact location and scale of development needs to be known. The LPA will work

closely with the water company to ensure that development will not be allowed to precede the delivery of essential infrastructure by rejecting un-sustainable developments or attaching 'Grampian' style planning conditions on sites where essential infrastructure is required."

4.16.2 *London Underground Flood Records*

Several attempts were made to get information and data regarding historic flooding of the tube stations but no response or information was provided.

5 Sources of Flooding

5.1 Introduction

The following section provides details of the specific flood sources which pose a risk to the North London Boroughs. The sources have been identified through the review of the data supplied in the initial phase of the study. This initial assessment is used to inform the source pathway receptor model presented at the end of this chapter, which in turn focuses the needs of this study into further areas of investigation.

Assessment of flood risk is generally approached by considering the probability of occurrence of a particular flood event along with the consequences. The probability of flooding is usually determined through computational modelling and reviewing historic flood events. In extreme cases the consequences may be loss of life; however, less severe consequences would normally include economic loss, inconvenience and disruption to public services.

Flood Risk in the North London study area has been assessed principally through the review of existing data sources. The assessment focuses on fluvial flooding as the primary source of flood risk and on secondary sources, including reservoirs, artificial drainage, groundwater, surface water, sewer flooding and the tidal influence on the Lee. A brief assessment of infrastructure failure is also included. The accuracy and thoroughness of any assessment into secondary sources is unfortunately limited by the data available. In most cases the opportunity to fill in such data gaps is outside of the scope of this study.

The main sources of information used for the assessment have been provided by the EA and the participating North London Borough Councils through the provision of historic flood records.

5.2 Key Watercourses

The key watercourses affecting the study area are listed in Table 10 along with significant details regarding each. The key water features in the study area are represented on map 9 and the individual catchment areas are shown on map 11. The following sections provide a brief description of the key watercourses including details of any hydraulic studies which may inform this study.

Table 10 - Rivers List

Watercourse Name	River Status	Boroughs Affected	Length (km)	Catchment Area (ha)	Hydraulic Studies
Barnet Ditches	Main River	Barnet	3.1	2,918	JFLOW
Mimmshall Brook	Main River	Barnet	12.5		JFLOW
River Brent	Main River	Barnet	25.1	10,150	JFLOW
Broomsfields Ditch	Main River	Barnet	0.79		JFLOW
Deans Brook	Main River	Barnet	5		JFLOW
Deers Hill Road	Main River	Barnet	0.3		JFLOW
Dollis Brook	Main River	Barnet	13.7		JFLOW
Edwarebury Brook	Main River	Barnet	1.8		JFLOW
Edgware Brook	Main River	Barnet	9		JFLOW
Hendon Cemetery Drain	Main River	Barnet	1.4		JFLOW
Mutton Brook	Main River	Barnet	5		JFLOW
Oakhampton Road Drain	Main River	Barnet	0.2		JFLOW
Springwood Crescent Drain	Main River	Barnet	1.0		JFLOW
Silk Stream	Main River	Barnet	8		JFLOW
Tramway Ditch Colindale	Main River	Barnet	0.5		JFLOW
Watling Ditch	Main River	Barnet	1.8		JFLOW
Folly Brook	Main River	Barnet	1.1		JFLOW
Victoria Water Course	Main River	Barnet	0.4		JFLOW
Cuffley Brook	Main River	Enfield	9.2		JFLOW
Enfield Ditch	Main River	Enfield	1.7		ISIS
Boundary Ditch	Main River	Enfield			TUFLOW
Glenbrook South Drain	Main River	Enfield	0.8		ISIS
Holyhill Brook	Main River	Enfield	1.6		JFLOW
Hounsden Gutter	Main River	Enfield	4.0		JFLOW
Leeging Beech Brook	Main River	Enfield	1.2		JFLOW
Small Lee	Main River	Enfield	9.0		ISIS
Merryl Hills Brook	Main River	Enfield	2.7		JFLOW
Monken Mead Brook	Main River	Enfield	4.0		ISIS
Salmons Brook	Main River	Enfield	14.4	4,149	ISIS
Sadlers Mill Stream	Main River	Enfield	6.6		TUFLOW
Turkey Brook	Main River	Enfield	13.7	4,158	ISIS
Bounds Green Brook	Main River	Enfield, Barnet	3.7		ISIS
Pymmes Brook	Main River	Enfield, Barnet	15.5	4,427	TUFLOW
River Lee	Main River	Hackney, Waltham Forest, Enfield, Haringey	33	141,234	ISIS
Lee Navigation (Lower)	Main River	Hackney, Waltham Forest	22.9		ISIS
Lee New Cut	Main River	Haringey	9.5		ISIS
Moselle Brook	Main River	Haringey	8.5		TUFLOW
Stonebridge Brook	Main River	Haringey	1.7	726	ISIS

Intercepting Drain	Main River	Haringey, Enfield	5.4		ISIS
The Ching	Main River	Waltham Forest	6.8	1,747	ISIS
Dagenham Brook	Main River	Waltham Forest	5.3		ISIS
Eastern Flood Channel	Main River	Waltham Forest	9.1		ISIS

5.2.1 Lower River Lee (Lee)

The River Lee is one of the largest Thames tributaries which drains a large rural catchment to the north of London. The total catchment is about 1415 km² and extends as far north as Luton, encompassing a large part of Hertfordshire and parts of west Essex.

The Lee catchment within the study area can be characterised as developed flood plain with built flood defences, with tributaries which rise in the green belt with undeveloped natural flood plains. The Lee Valley forms the eastern borders of Enfield, Haringey and Hackney and borders Waltham Forest to the West. The River Lee flows into the River Thames through the Borough of Newham. The downstream side of Lee Bridge Road marks the tidal extent on the River Lee which is within the Boroughs of Waltham Forest and Hackney.

The River Lee experienced severe flooding in 1947 and since then the Lee has been heavily altered and defended. The development of several man-made channels has provided flood relief in the area by increasing conveyance capacity through the catchment. The River Lee Flood Relief Channel was designed to protect against the 1947 event which was believed to be approximately a 1 in 70 year flood. This is below the level of protection that might be considered acceptable for new development. Furthermore the level of protection is known to have been reduced further by the extensive development in the upper catchment.

The EA provides a flood warning service to properties in flood zones 2 and 3 along the River Lee. The EA will aim to provide a lead time of 2 hours wherever possible. Many of the tributaries of the Lee have fast response times due to their small urban catchments and impermeable London Clay associated with North London.

In recent years, the River Lee has been studied quite intensively due to its importance in the London 2012 Olympics. The most recent was the '*Lee Flood Risk Mapping Study*' (March 2007) undertaken by Halcrow for the EA which used TUFLOW and ISIS to model the watercourses. The May 2007 Olympic FRA and the Lower Lee Valley SFRA models are more detailed for the area downstream of Lee Bridge Sluices than the Lee Hydrology and Mapping Study. Further information about the Olympics can be found in section 4.9.5.

The EA is concerned that there is insufficient space available for much needed flood alleviation schemes. They are pursuing a long term approach that could consider ideas like land swaps to remove more vulnerable development from the floodplain and release land for flood storage. The Thames CFMP provides further more localised guidance on the approaches most applicable to the sub-catchments as further discussed in the following sections.

The hydrology of North London is influenced primarily by the high urbanisation and impermeable geology of the London Clay which is typical of the area. The Upper Lee catchment is founded on the chalk uplands and is predominantly rural. The soils are slowly permeable in nature which gives the Upper Lee an increased response time.

The Lee and its tributaries in North London have little supply from groundwater sources and rise quickly during rainfall. Rainfall in clay areas cannot penetrate into the ground and instead runs off quickly into the rivers. The rivers flow over the London Clay which overlies the chalk aquifer and generally prevents interaction of surface water with the groundwater.

5.2.2 *River Lee Tributaries*

The River Lee has many tributaries that enter the watercourse mostly from the west. These watercourses form a dense drainage network across the western side of the Lower Lee catchment.

The catchment includes several large tributaries which are prone to localised flooding; these include Salmons Brook, Turkey Brook and Pymmes Brook. Many of the Lee tributaries have extensively developed catchments which experience a rapid response to rainfall. The EA provides a flood warning service to properties in flood zones 2 and 3 along the Lee Tributaries.

The Ching Brook, located in the northern part of the Waltham Forest, arises at Connaught Water and flows south then west to enter the River Lee to the north of Banbury Reservoir. The total catchment area for the Ching Brook is 1747 hectares.

Turkey Brook drains a more rural catchment with an urban extent of just 4%, the total area is 4,158 hectares. The source of Turkey Brook lies just outside the northern boundary of Enfield. Its main tributary is the Cuffley Brook which rises 5 kilometres to the north of Enfield and flows through predominately agricultural land to meet with Turkey Brook. Turkey Brook then flows eastwards to the confluence with the Small River Lee, before entering the River Lee to the north of the King George V reservoir. The other main tributary of the Turkey Brook is the Holyhill Brook.

The Salmons Brook catchment covers a total area of 4149 hectares. The rivers tributaries include Merryll Hills Brook, Leeging Beech Brook, Gelnbrook South Drain, Saddlers Mill Stream and Houndsden Gutter. The Salmons Brook rises in the east of Barnet and runs through fairly flat agricultural land for approximately 6km, picking up

a number of small tributaries from the south. The underlying geology of the catchment is predominantly London Clay with sporadic gravel beds. As it enters the urban areas of Enfield the watercourse is culverted in a number of locations. The Salmons Brook joins the Pymmes Brook to the south of the North Circular Road.

The Pymmes Brook catchment covers a total area of 4,427 hectares with an urban extent of 44%. The heavily engineered watercourse passes through over 4 kilometres of concrete lined channels and almost 2 kilometres of culvert. The river rises in Barnet and flows through Hadley Wood, flowing eastward through Enfield towards the River Lee, picking up Bounds Green Brook along the way.

The Thames CFMP suggests that whilst these urban watercourses experience rapid runoff, floodplain encroachment and modified channels, they still have sufficient river corridors that to support more sustainable approaches. The implementation of sustainable approaches would be most appropriate during the development or redevelopment of sites along with maintaining existing open space.

5.2.3 *River Brent and Tributaries Upstream of the Brent Reservoir*

A small reach of the River Brent connects Dollis Brook to the Brent reservoir. For completeness this reach will be included within the Brent tributaries. The River Brent tributaries within the study area are Folly Brook, Dollis Brook, Springwood Crescent Drain, Watling Ditch, Silk Stream, Hendon Cemetery Drain, Tramway Ditch Colindale, Oakhampton Road Drain, Edgware Brook, Mutton Brook flow into the Brent Reservoir.

Some of the tributaries have been recently taken on as main rivers by the EA due the level of fluvial flood risk. These are the Broomfields Ditch, Deer Hill Road Brook, Edwarebury Brook, Deans Brook, Hendon Cemetery Drain, Watling Ditch, Tramway Ditch Colindale, Springwood Crescent Drain and Oakhampton Road Drain.

The Dollis Brook becomes the Brent once it confluences with Mutton Brook in the South of Barnet. The Dollis Brooks tributaries include Folly Brook, Hendon Cemetery Drain, Deers Hill Road and Oakhampton. The Brent confluences with the Silk Stream at the Brent Reservoir.

The Silk Streams main tributary is Deans Brook which flows south, meeting Springwood Crescent Drain, Broomfields Ditch and Edwarebury Brook before forming the Silk Stream at the confluence with Edgware Brook. Watling Ditch and Tramway Ditch both enter the Silk Stream before it reaches the Brent Reservoir.

The CFMP suggested that flood risk along these watercourses should be accepted in the short term but the long term flood risk should be prevented from rising beyond the existing level. It is suggested that the as opportunities arise through re-development the urban layout can be changed to ensure greater flood resilience and sustainability.

All these watercourses are defended in places and a low standard of protection is offered to properties in the floodplain. In recent years, a flood alleviation scheme has raised the standard of protection to properties along the silk stream. The EA provides a flood warning service to properties in flood zones 2 and 3 along the Brent Tributaries. The Silk Stream is noted for being flashier than the neighbouring watercourses.

5.2.4 *Subterranean and Culverted Rivers*

Historically a number of watercourses in London have been integrated into the urban environment through canalisation and culverting. In some cases these watercourses have been entirely incorporated into the sewer network and are often referred to as London's "Lost Rivers".

The River Fleet is one such subterranean river. The River Fleet historically originates from springs on Hampstead Heath and drains to the Thames approximately via Kentish Town, Camden Town and Holborn. Through Camden and the City of London the Fleet is entirely incorporated within the sewer network, owned and maintained by Thames Water. For the purposes of this study it is considered as a sewer. The catchment of what was the River Fleet is shown on map 11, the catchment is extracted from Flood Estimation Handbook (FEH) and has not been verified for accuracy. The Fleet would have been the main drainage body for the Camden area and any future development activities in Camden could have significant impacts on flood risk within the City of London if they are not adequately managed.

The Hackney Brook is also a subterranean river located in the Borough of Hackney, which is also now incorporated into the sewer network. Before 1860 the Hackney Brook had been heavily culverted and in was increasing being used as a sewer. In 1860, the Hackney Brook was incorporated into the Northern High Level Sewer. Map No. 11 in Appendix A, shows the catchment as extracted from the FEH. Again the catchment has not been verified for accuracy and is intended as a guide only.

The Moselle Brook in the Borough of Haringey has been mostly culverted with a small reach of the river above ground in Tottenham Cemetery. Culverting of key sections of the Moselle started in 1836 and further culverting of the watercourse took place in 1906. The original culverting is believed to have taken place in order to reduce flood risk. However, this often has the opposite effect.

5.3 **Fluvial Flooding**

Fluvial flooding occurs when the capacity of a watercourse is exceeded and flood plains become inundated. In urban environments, man made structures within the watercourse or flood plain can also cause inundation of areas outside of the natural floodplains. Fluvial flooding also occurs when flood defences are overtopped or breached. Overtopping usually results in a gradual inundation of the defended areas and is usually easier to predict through flood warnings. Breaching can be much more difficult to predict and can result in rapid inundation with little warning.

5.3.1 *Historic Fluvial Flood Events*

Historic flood records have been supplied from a variety of sources. The key flood events are summarised below and referenced on map 10 included in Appendix A.

5.3.1.1 **March 1947 floods**

The floods of 1947 were the largest since records began over 100 years previous to this event. A large rainfall event and thawing of snow in the Thames catchment combined with a storm surge in the North Sea, causing flooding in the River Thames and its associated tributaries.

The 1947 floods also affected some of the Lee tributaries including the Cuffley Brook, Turkey Brook, Salmons Brook (predominately between Leeing Beech Brook and Hounsdon Gutter, and the Ching.

The areas immediately around the Warwick Reservoirs were flooded which include the Walthamstow Marshes and Nature Reserve downstream, Leyton Industrial Village, the Cromwell Estate, Riding School, Roxwell Trading Park, Forest Business Park, Fairways Business Park, filter beds south of the Lee Bridge at Hackney Marsh. Since 1947 areas that were inundated by flood waters have been developed. This is most noticeable between the Stonebridge Brook junction with the Lee Navigation (Lower) and where the Pymmes Brook meets the Salmons Brook.

The flooding in 1947 led to the construction of the River Lee Flood Relief Channel, which became operational in 1976. There has been no major flooding in this region since then, although the flood relief channel almost reached full capacity in 1987, 1993 and 2000.

5.3.1.2 **December 2000 Floods**

In October 2000, flooding occurred at the confluence between Salmons Brook and Sadlers Mill Stream, and along a reach of the Eastern Flood Channel at Douglas Eyre playing fields and in Walthamstow Marshes nature reserve. The most severe flood event occurred when the Montagu Road culvert became overloaded. All of the flood locations are within flood risk zone 3.

5.3.1.3 **Silk Stream Floods**

The Silk Stream flooded twice in the 1990's, once in 1992 and once in 1999. The trigger to these flood events is not known, however, the lead time of the watercourses would indicate that they are susceptible to flooding caused by short, intense rainfall events typical of summer storms.

5.3.1.4 **Other Localised Fluvial Flooding**

Other smaller more localised flood events have occurred since 1947. Most of these flood events took place in the summer as a result of intense rainfall events. All of the historic flooding is located within flood risk zones and in some instances (where no

hydraulic study has been undertaken) it is evident that the flood risk zones have been derived from the historic flood events.

5.3.1.5 **Haringey Council Flood Management Strategy Report Review**

The Borough of Haringey commissioned a report to consider flood risk from a spectrum of sources in their borough and produce appropriate strategies for the management of flood risk. The report identifies the council as the riparian owner on much of the Moselle Brook meaning that they have a greater responsibility than realised prior to this report.

A number of flooding incidents were reported, the most significant of which was flooding occurring in July 1965. The area around White Hart Lane appeared to be most affected including the White Hart Lane Station and properties on The Roundway. Montagu Road flooded during this event and is also reported to have flooded in 1956. White Hart Lane is also reported to have flooded in 1993 with the Wedges Yard Trash Screen a particular flood hazard.

An outline analysis of the affects of flooding on transportation suggested that rail and tube lines are unlikely to be flooded but may be affected if the embankments are eroded or washed away.

It was concluded that Haringey was at risk from fluvial, sewer and pluvial flooding but not groundwater or tidal flooding. Several strategies were put forward that included the improvement of flood risk mapping, emergency planning and development planning.

The Haringey flood locations are represented on maps 10, 13 and 20 in appendix A.

5.3.2 *Tidal Flooding*

Tidal flooding can also occur as a result of overtopping or breaching of flood defences, wave action or where tide-locking causes ponding of fluvial or surface water flows.

Parts of the south of Waltham Forest and Hackney are located within the tidal reach of the River Thames, which extends up the Lower Lee Valley to the Lee Bridge sluices. The flood levels in the River Lee can therefore be affected by tidal processes as very extreme tidal events in the Thames could result in flooding of these areas. The areas are defended against such flooding with local flood defences and crucially, the Thames Barrier, which currently provides tidal flooding protection in excess of 0.1% annual probability flood event. The Thames Barrier combined with local flood defences means that any extreme tide level would have to be accompanied by a breach in flood defence to result in severe flooding. Localised flooding could still occur where surface water outfalls become tide-locked, causing short term ponding behind defences.

5.3.3 *Flood Risk Modelling and Mapping*

5.3.3.1 **Flood Mapping Overview**

Section 105 of the Water Resources Act, 1991 required the Environment Agency to produce a series of maps showing the extent of areas at risk of flooding from tidal or fluvial sources. These maps have subsequently been modified and released under various guises. The latest incarnation of these maps is the flood zone mapping which have been provided to Local Planning Authorities in electronic format for use as a spatial planning tool.

The zones defined by the flood risk maps are those areas considered to be at risk from annual fluvial or tidal flooding with a probability of 0.1% or more. The flood risk maps generally provide a broad high level assessment of flooding. The level of accuracy does vary from catchment to catchment. The Brent and Lee outlines are of good quality from detailed studies. It is important to note that there are a small number of models in the flood maps do not account for structures within the flood plains such as bridges and culverts. In addition, most of the models do not take climate change into account but often a separate climate change outline is available.

Flood Zones show the undefended flood extents but the EA do have defended outlines available. Both the River Brent and River Lee studies have mapped the Areas Benefiting from Defences. The flood risk maps only provide an indication of flood risk from fluvial or tidal sources. The zones are consistent with the approach to flood risk assessment set out in PPS25. These maps form the basis of the initial flood risk assessment, however for the purposes of applying the sequential test and exception test additional assessment may be required in some catchments. This is discussed further in Section 6.

5.3.3.2 **Review of Modelling Techniques**

The flood zones in North London are generally produced using either ISIS or JFLOW hydraulic models. The ISIS models were constructed to update the existing simplified steady state models. The models were improved using a 1D hydrodynamic approach that is supplemented by 2D TUFLOW modelling. The JFLOW modelling technique uses a 2D wave equation to determine flood levels over short discreet sections of watercourse, using automated hydrology calculations. The model is based on a national Digital Elevation Model (DEM) with a 0.5m – 1m accuracy. JFLOW modelling provides a fairly quick an invaluable method of determining flood maps where more accurate hydraulic modelling is not available. While the JFLOW modelling may predict flood plains and allow some degree of spatial planning to take place the accuracy is insufficient for assessing site specific flood risk. The accuracy of flood risk mapping from the JFLOW modelling can be significantly lower than that produced from ISIS modelling and a review of the flood risk zones produced using this method is discussed in section 6.

5.3.3.3 River Lee Modelling and Mapping

The River Lee Modelling and Mapping Study was undertaken to improve the accuracy of flood zone 2 and 3 outlines for the EA's flood map while identifying the areas that benefit from existing flood defences. The modelled area extends north and south out of the study area along the Lower River Lee providing a complete picture of flood risk in the Lower Lee Valley.

The Lower River Lee and tributaries flood outlines were modelled using ISIS and TUFLOW by Halcrow for the 1 in 5, 20, 100, 100 + 20% and 1000 year return periods. The return periods of 1 in 2, 10, 25, 50 and 200 year events were modelled but the outlines were not mapped.

The recent '*Lee Flood Risk Mapping Study*' by Halcrow remodelled the Cobbins Brook, Nazeing Brook and Boundary Ditch in ISIS and TUFLOW produced 'notable improvements' to the flood risk mapping.

The ISIS modelling of the River Lee catchment predominantly covers the urban areas. However there are two reaches of watercourses in the urban area that have not been modelled in ISIS which are the upper reaches of the Hounsdon Gutter and the upper reach of Pymmes Brook. The flood risk zones for these stretches of watercourse are defined using JFLOW modelling.

5.3.3.4 River Brent Modelling and Mapping

The River Brent and its associated watercourses have recently been modelled and mapped using a new ISIS study. This revised mapping has been incorporated into this SFRA. This study covers Dollis Brook, Folly Brook, Mutton Brook and Deans Brook. The Silk Stream was modelled and mapped in a separate study.

5.3.4 Flood Zone 3b - Functional Floodplain

The Flood Zone 3b shows the 1 in 20 year flood extent known as the Functional Floodplain. This area as stated by PPS25 is suitable for water-compatible uses and essential infrastructure as described in table 2. The Flood Zone 3b has been obtained from the Environment Agency as a GIS layer from the more recent modelling studies in the River Lee and River Brent Valleys as shown on map 8.

5.3.4.1 Lower Lee Valley Functional Floodplain

In the Lower Lee Valley, the 1 in 20 year extent is present mostly in open spaces. However there are some developed areas within flood zone 3b (see Table 11 below). The River Lee Flood Relief Channel was built to provide a standard of protection up to a 1 in 70 year flood event, which means that most of the man made channels contain the 1 in 20 year event. There are two areas; one area to the north of the River Ching confluence with the River Lee and one area to the west of Enfield Island, that are indicated to be within the 1 in 20 year floodplain.

Table 11 - Approximate Number of Properties in Flood Zone 3b in Lee Valley

Watercourse	Number of Properties
Salmons Brook	4
Pymmes Brook	74
River Ching	130
River Lee	78
Bow Back River	84

A large number of existing properties and their associated land appear within the 1 in 20 year flood plain on the tributaries of the River Ching, Pymmes Brook and Bow Back River. The remaining area of flood zone 3b along these watercourses is mostly in the undeveloped floodplain of the river corridor.

5.3.4.2 Upper Brent Valley Functional Floodplain

The Silk Stream mapping for Flood Zone 3b shows the flood outline post scheme for a 1 in 25 year event from the 2006 Halcrow study. On the upper reaches, flood alleviation work has taken place to protect properties to a minimum standard of 1 in 20 years.

On the Dollis Brook, Mutton Brook and the River Brent a more substantial 1 in 20 year flood envelop is present mostly in the narrow undeveloped river corridor. Approximately 40 properties are already present within flood zone 3b.

The functional floodplain also includes areas which are designed to flood. The Silk Stream FAS are located within the Upper Brent catchment. This is discussed further in section 5.3.5.1.

5.3.5 Flood Defences and Inline Structures

The majority of the flood defences in North London are located along the Lower Lee and are characterised by heavily engineered channels and hard engineered defences. This section describes the significant flood defences and culverts within the catchment including a discussion on the standard of protection they offer and their general condition. Flood defences along the main rivers in the study area are inspected on an annual basis by the EA. The condition of these defences is graded between Poor (5) and excellent (1). Maps 14, 15, 16, 17, 18 and 19 show the location and condition grade of the defences across the study area along with the type of defence.

The River Lee has been altered within the Lower Lee Valley in order to manage flood risk and prevent a reoccurrence of the 1947 floods, whilst encouraging development in the area. The Lee New Cut and Eastern Flood Channel are both artificial channels designed to take flood waters away from the main river. The main river itself forms the Lee Navigation that since the River Lee Act 1766 has been operated like a canal that runs from Hertford to the Thames. The Act authorised improvement works, the construction of locks and new channel sections which include the Limehouse Cut, a connecting canal at the southern end of the watercourse.

River Lee flood relief channel and associated structures were designed to have a standard of protection of approximately 1 in 70 return period. However, urbanisation of the upstream catchment has significantly reduced this standard of protection in some locations. Overall the standard of protection of the defences is generally above 2% (1 in 50) annual probability, but is as low as 5% (1 in 20) in some areas. In some locations the standard of protection is greater than 1% (1 in 100) annual probability. It is intended to produce a map highlighting the areas with defences which have a low standard of protection, however, identifying the exact standard of protection of each defence, and therefore the areas of highest risk has not been entirely possible due to the limited data in the NFCDD. Further information on flood defence levels will be required to enable these areas to be mapped with any degree of accuracy. Where possible the standard of protection by locality is described below. Although there is a lack of standard of protection information for the catchment, the Lee and Brent mapping studies produced defended outlines which would give an idea of risk.

The flood defences on the fluvial reach of the Lower Lee through Hackney affords a high standard of protection (greater than 1 in 100 years (1%), with the exception of properties along Mandeville, Oswald and Pedro Streets. Other open spaces in this area also have a lower standard of protection.

Properties along the Lower Lee through Waltham Forest appear to be protected to a standard lower than 1 in 100 years (1%), in particular properties near the confluence with the Ching Brook, from Uplands Business Park to Douglas Eyre Playing Fields including Eward Road, the area between Coppermill Lane and Salop Road and from St James Park down to Roxwell Trading Centre, including Cromwell Estates and residential properties near Lee Bridge Road. Other areas with low standards of protection include Walthamstow Marshes and the railway sidings opposite Hackney marsh.

The defences along the River Lee are estimated to have a residual life of 50 to 60 years. While most of these assets are assessed as being in good to fair condition, several reaches of the Lee tributaries are in a wider variety of conditions with some sections being in poor condition. These are listed in Table 12 below.

The Housden Gutter, Pymmes Brook, Moselle Brook, Interceptor Drain, Saddlers Stream, The Ching and Bounds Green Brook all have associated flood defences.

These defences are a mixture of culverts, embankments, piling and channel reinforcement. The standard of protection data provided by the EA from NFCDD shows that 1.7% of recorded flood defences have a known level of protection.

In the Olympics area of the River Lee further work is being conducted to improve the watercourses. Some of the proposed watercourse structures are having additional work undertaken on them. This includes the setting back of flood defences on Waterworks River, the in-filling of Pudding Mill River, the culverting and extending of Hennikers Ditch and inlet improvements.

Currently British Waterways (BW) is building structures on the Prescott Channel and Three Mills Channel that will prevent tidal ingress up these channels (currently the River Lee is tidal up to Lea Bridge Sluices at Lea Bridge Road). The intention will be to prevent tidal ingress and maintain a roughly constant water level (approx 2.3mAOD) upstream of the structures which will enable 24hr navigation of the Prescott, Three Mills and Waterwork rivers, and allow for boat movements between these channel and the rest of the navigation channels (Old River Lea, City Mill River, Lee Navigation, Limehouse Cut). River flows coming down the Lee catchment will discharge through the structures when tide levels permit (by lowering of gates at Prescott Channel).

When tide levels are high there will be no fluvial discharge through the structures and water levels will build up until the tide falls. The design and operation of the structures will be such that there should be no increase in flood risk as a result of the structures, either through the impounded section or on tributaries that discharge into the impounded section. all structures should be complete and fully automated by October 2008.

Table 12 – River Lee Tributaries Flood Defence Grades 4 and 5

Asset Reference	Grade	Watercourse
0625353BO0101R02	4	Bounds Green Brook
0625353CH0101R03	5	River Ching
0625353CH0101R04	4	River Ching
0625353CH0101R10	5	River Ching
0625353CH0102R03	5	River Ching
0625353DA0101R02	5	Dagenham Brook
0625353DA0103R05	4	Dagenham Brook
0625353MB0103R02	4	Moselle Brook
0625353PY0103R02	5	Pymmes Brook
0625353PY0202L03	4	Pymmes Brook
0625353PY0202R03	5	Pymmes Brook
0625353PY0304R05	4	Pymmes Brook

0625353SA0103R02	5	Salmons Brook
0625353TU0202R02	4	Turkey Brook
0625353BO0102L02	5	Bounds Green Brook
0625353CH0103R06	4	River Ching
0625353TU0101L05	4	Turkey Brook

The River Brent tributaries are less heavily defended. The defences in the Upper River Brent catchment are estimated to have a residual life of 11 to 20 years. The Silk Stream has a greater number of defences that vary between fair and poor condition while the defences on the Dollis Brook range from good to poor. Table 13 shows the defences in poor condition. The proposed Silk Stream flood alleviation scheme should improve flood defences in this region to between 1 in 20 and 1 in 25 standard of protection.

Table 13 - River Brent Tributaries Flood Defence Grades 4 and 5

Asset Reference	Grade	Watercourse
0623838MU0102R02	4	Mutton Brook
0623838WD0101R03	4	Watling Ditch
0623838DE0104R02	4	Deans Brook
0623838SC0101R02	4	Springwood Crescent Drain
0623838HD0101R05	4	Hendon Cemetery Drain
0623838HD0101R03	4	Hendon Cemetery Drain
0623838BF0101R03	4	Broomfield Ditch
0623838BF0101R05	4	Broomfield Ditch
0623838BF0101R07	4	Broomfield Ditch
0623838HD0101R07	4	Hendon Cemetery Drain
0623838EB0101R02	4	Edwarebury Brook
0623838EB0101R04	4	Edwarebury Brook
0623838EB0101R06	4	Edwarebury Brook
0623838ED0101R03	4	Edgeware Brook
0623838ED0101L03	4	Edgeware Brook

Informal flood defences are structures or man made objects which unintentionally act as flood defences. Examples of these would include railway embankments across a flood plain, buildings that block the flow path of the water and changes in ground profiles which may provide flood storage.

5.3.5.1 Silk Stream Flood Alleviation Scheme

Along the Silk Stream in Barnet the EA is currently constructing a £1.8 Million Flood alleviation Scheme to protect 746 properties.

The project began in 1992 after 293 properties were flooded in Edgware. Once the scheme is finished, it will comprise of a series of 6 storage reservoirs that will provide a standard of protection of between 1 in 20 to 1 in 25 years. A higher standard of protection has not been provided because a higher protection scheme did not meet the required DEFRA cost benefit criteria. The primary barrier to an improved scheme is the difficulty in finding larger sites for flood storage.

The four flood storage areas that are constructed are at Prince Edward Playing Fields, RAF Stanmore, Summerhouse Lakes and Bentley Heath. While the Edwarebury Park and Bury Farm storage areas are currently in construction.

5.3.5.2 Salmons Brook Flood Alleviation Scheme

In October 2000, 192 properties were flooded when the complex culvert arrangement at the confluence of Sadlers Mill Stream and Salmons Brook reached full capacity due to heavy rainfall. The arrangement at the Montagu Road culvert prevented Sadlers Mill Stream from flowing into the Salmons Brook. The 2000 floods lead to the development of the proposed Salmons Brook Flood Alleviation Scheme.

The scheme is designed to protect 1700 properties against a minimum 1 in 75 year flood event. Amended designs will go to public consultation in late 2007 with construction planned for 2009-10, subject to funding and land agreements.

The scheme consists of improvement works at four locations in Enfield. These are the creation of new food storage areas at Hog Hill and Enfield Golf Course upstream of the previously affected properties. The works at Montagu Road Area consist of a bypass channel from Salmons Brook to Pymmes Brook, the raising of banks, culvert improvement works and environmental enhancement. While in the Eleys Industrial Estate in Edmonton the river banks will be raised.

5.3.6 Overtopping

Overtopping of flood defences occurs when water levels exceed the protection level of raised flood defences. The worst case occurs when the fluvial or tidal levels exceed the defence level as this can lead to prolonged flooding. Less severe overtopping can occur when flood levels are below defence levels, but wave action causes cyclic overtopping, with intermittent discharge over the crest level of the defence. Flood defences are commonly designed with a freeboard to provide protection against overtopping from waves.

The risk from overtopping due to exceedance of the flood defence level is much more significant than the risk posed by wave overtopping. Exceedance of the flood

defence level can lead to prolonged and rapid flooding with properties immediately behind the defences at highest risk.

5.3.7 *Breach*

Breaching of flood defences can cause rapid inundation of areas behind flood defences as flow in the river channel discharges through the breach. A breach can occur with little or no warning, although they are much more likely to concur with extreme river levels or tides when the stresses on flood defences are highest. Flood water flowing through a breach will normally discharge at a high velocity, rapidly filling up the areas behind the defences, resulting in significant damage to buildings and a high risk of loss of life.

Breaches are most likely to occur in soft defences such as earth embankments although poorly maintained hard defences can also be a potential source of breach. The condition grading of the North London flood defences has been obtained from the National Fluvial and Coastal Defence Database (NFCDD) which is maintained by the EA.

5.4 **Groundwater Flooding**

It is estimated that groundwater flooding affects a few hundred thousand properties in the UK¹³. Groundwater flooding most commonly occurs in low lying areas which are underlain by permeable rocks or aquifers. Flooding occurs when the groundwater table rises up from the permeable rocks to the ground surface, flooding low lying areas or occurring as intermittent springs. Flooding is most likely to occur after prolonged periods of rainfall when a greater volume of rain will percolate into the ground, causing the groundwater table to rise above its usual level. Low lying areas are generally more prone to groundwater flooding because the water table is usually at a much shallower depth and groundwater flow paths tend to travel in a direction from high to low ground. Areas prone to groundwater flooding also often experience surface water flooding problems.

Groundwater flooding occurs much more slowly than other forms of flooding and the risks to people are generally low, however, the slow onset of groundwater flooding is mirrored by the time that flood water can take to dissipate back into the ground unless there is an alternative flow path for the flood water.

Localised groundwater flooding can also occur around specific geological features, such as areas of permeable soils overlying impermeable strata. Such features where they occur in North London are discussed in section 5.4.1.

¹³ UK Groundwater Forum, <http://groundwateruk.org/html/faq3.htm>

5.4.1 *Geology*

North London is almost entirely underlain by the London Clay formation which overlays a significant chalk aquifer. The London Clay layer varies in thickness from less than 10m near the Lee Valley to over 100m in the areas of higher ground in Camden and Barnet. The clay layer is almost entirely impermeable which has a considerable impact on lead times of fluvial flows in many of the watercourses, especially when combined with intense urban development. The upstream catchment in the River Lee comprises a predominantly chalk soil, which results in increased permeability and slower response times in the watercourse.

In places the London Clay layer is overlain by deposits of gravels and silts. This is most prominent in the Lee Valley and East of Hackney where alluvium deposits from the River Lee are in evidence. There are also notable outcrops of gravels and silts further to the west in Enfield, Stanmore gravels in Barnet and gravel outcrops on Hampstead Heath. These gravel and silt deposits are much more permeable than the underlying clay layer and flooding can occur at the edges of these deposits and outcrops when the groundwater percolating through the permeable layer meets the impermeable clay layer, causing the water to flow out at surface level, appearing as small springs. The locations of the most prominent of these geological features are discussed below.

The Lee Valley consists of a layer of gravels and silts deposited by the river within its natural flood plain that covers a layer of London Clay. Silts and gravels are also found in smaller quantities along the flood plains of other main rivers in the area, which include the River Brent, Dollis Brook, Silk Stream, Salmons Brook, Pymmes Brook and the River Ching. The Lee Valley is the lowest lying area within North London and is therefore susceptible to groundwater flooding. Groundwater levels in shallow deposits in the Lee Valley are hydraulically linked to the watercourses through the alluvium deposits and may be responsive to rainfall events and the corresponding increases in fluvial flows. However for the major aquifer, the chalk, this is not always true. During prolonged rainfall events the groundwater table may experience a relatively short term rise which could cause localised flooding incidents.

Further to the west of the Lee Valley, within Enfield there are a number of drift deposits of silts and sands. A small number of groundwater flooding incidents are known to have occurred in the vicinity of these deposits. Groundwater flooding history is discussed further in the following section.

Hampstead Heath lies on a silty sand layer on top of the London clay. During rainfall events water drains through the sands before reaching the impermeable layer beneath, causing the formation of springs which feed the Highgate Ponds and form the source of the River Fleet.

In the Finchley and Hendon area to the north of Hampstead, a Till, chalky sandy clay and gravel outcrop lies on the surface that may lead to a localised groundwater flooding, although there is no history of groundwater flooding in this location.

5.4.2 Groundwater Flooding

Very few groundwater flooding records have been provided by the EA and all of those that are recorded lie within the London Borough of Enfield. The locations of the flooding incidents are shown on map 20.

Almost all of the recorded incidents occur within the upland areas of the Borough in the vicinity of the drift deposits which overlay the impermeable London Clay. A small cluster of flood events also occur further west within the Borough. These three events are located on the down slope from an outcrop of Stanmore Gravels, which may account for these localised flooding incidents.

A small number of flooding incidents are located in the Lee Valley to the north of the Borough. These flooding incidents are most likely to be attributed to the low lying areas where the groundwater table is relatively close to the surface.

Identifying the cause of each of these flood incidents is outside the scope of this report, however, it does identify a number of flooding trends which should be considered at a site specific stage.

5.4.3 Borehole Data and Groundwater Contour Data

The EA has supplied a series of borehole records which provide a snapshot of the groundwater levels across the study area on recorded date of February 2007. The borehole data matches the groundwater levels provided, validating in places the contours provided. The boreholes are sparsely located across the study area, especially in the larger boroughs of Barnet and Enfield. The majority of the borehole data is situated at the lower end of the Lee catchment in Waltham Forest, Hackney and further south of the study area. Boreholes in the Brent catchment are very limited.

The groundwater contours representing depth below ground are shown on map 12. These groundwater levels are for the chalk aquifer underlying the confining clay, which are not necessarily the level of the groundwater beneath any particular location and relate to the peizometric pressure of the groundwater at that point. This means, the water level in the borehole would rise up to the stated value due to the pressure under the confining clay, it does not mean that the water in the ground is at that level. Therefore, flooding from the chalk aquifer is not that likely in areas where the chalk is confined by the clay even though groundwater levels may read that groundwater is only a few meters below ground level.

The groundwater profile through London shows relatively little change in elevation, however, the topography of the North London sub-region shows significant variation,

with a general fall in an easterly direction from the higher ground in Barnet to the Lee Valley, where much of the areas is only a few metres above sea level. As expected, groundwater levels are closest to the surface around watercourses, particularly in the low lying Lee Valley. The groundwater levels in the Lee catchment are significantly closer by approximately 30m to the surface than within the Brent catchment. A region of higher ground between river catchments stretches from central Camden and up through central Barnet to the north west of the overall assessment region. Throughout this region the groundwater levels are at a depth of 80-90m below the surface.

The borehole data provided records the depth of the groundwater table in the chalk aquifer. It does not record the intermittent groundwater levels which occur where the gravel and silt deposits overlay the London Clay layer.

5.4.4 GARDIT

During the 19th and 20th centuries significant volumes of groundwater were abstracted from the deep aquifer below London to support the industries prevalent at the time. This intensive abstraction of groundwater had a dramatic impact on the groundwater levels. As these industries began to decline the volume of water extracted correspondingly reduced and groundwater levels began to rise back to their natural levels. The decline in abstraction began in the 1940's and from around the 1970's onwards groundwater levels began to rise dramatically, at more than 1m / year¹⁴ in many areas. Building foundations and infrastructure which had previously been designed with little regard for groundwater began to be at risk as the water table began returning to its natural level. It is estimated that during the period of heavy abstraction groundwater levels may have lowered by as much as 90m¹⁵, and a corresponding rise could cause a substantial flood risk to critical infrastructure and basements, while also causing instability to building foundations.

In 1992 GARDIT (General Aquifer Research, Development and Investigation Team), an umbrella organisation consisting of Thames Water, London Underground and the EA, was formed to address the issue of rising groundwater. The GARDIT group established a five stage solution to maintain groundwater levels at an acceptably agreed level on an area by area basis. The solution involved reusing existing boreholes and creating a series of new boreholes which would extract a total of 70MI/day across London. The project was due to be fully implemented by 2005 and as such groundwater levels are expected to stabilise to a manageable level.

¹⁴ CIRIA Special Publication 69 (1989) *The Engineering Implications of rising groundwater levels in the deep aquifer beneath London*

¹⁵ Thames Water *Central London Rising Groundwater*

The GARDIT report states that “as a result of the GARDIT strategy and the controls imposed on central London, the whole of the London Basin Chalk aquifer is becoming a highly managed entity”. Also included is that the ground water contours “have barely changed compared to last year, so the groundwater level can now be considered static.”

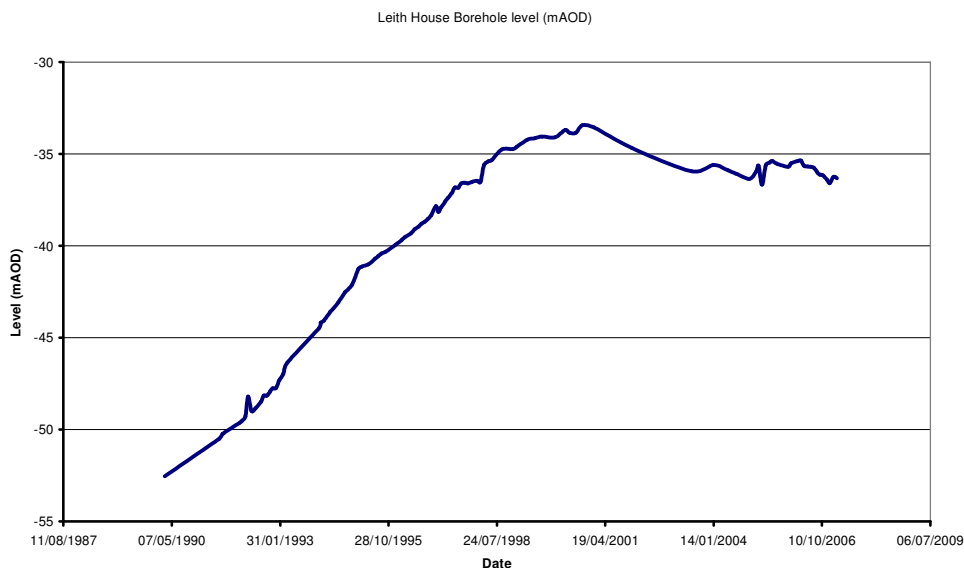
The monitored area consists of observation boreholes stretching from Hatfield in the north to Epsom in the south, with Dagenham and Dartford on the eastern boundary and Staines and Uxbridge to the west.

The continued increase in use of abstraction licences is demonstrated within the report. It is intended that “substantial further increase in abstraction will control groundwater levels at significantly lower levels than previously seen.”

5.4.5 Groundwater trends

The EA’s groundwater monitoring team have provided historic levels of a borehole located within the City of London Boundary (other more relevant borehole data has also been requested but not received) at Leith House, Gresham Street. A graph of the boreholes recorded levels from 1990 to 2006 are presented in Figure 3. A plan showing the location of the borehole is included in Appendix A, (Map No. 12).

Figure 3 - Leith House Borehole Level



The borehole record shows the trend of rising in groundwater during the 1990’s with an approximate rise of 2m/year occurring from 1990 to 1998. Since then levels have stabilised below -35m AOD (Above Ordnance Datum) as a result of abstraction of groundwater across London.

The actions of the GARDIT team will significantly reduce the future risk of groundwater flooding in London providing the current abstraction rates are maintained indefinitely. However, a residual risk of groundwater flooding could still remain to some new developments or below ground infrastructure.

The impacts of the groundwater levels within the chalk aquifer on proposed development and the planning process are not considered further in this report as the overall risk of groundwater flooding is considered to be low given the current stability in groundwater levels. However, groundwater flooding is still a potential issue within some of the permeable soils which overlay the London Clay including the River Lee Valley. Further discussion on this groundwater flooding problem is discussed in Section 6.

5.5 Sewer and Surface Water Flooding

5.5.1 Sewer Flooding

Sewer and surface water flooding generally results in localised short term flooding caused by intense rainfall events which overload the capacity of sewers or run off adjacent land as sheet flow. Flooding can also occur as a result of blockage, poor maintenance or structural failure. Sewer systems in London are often very old, particularly within the Boroughs of Camden, Islington and Hackney. These older sewers were sometimes designed to convey storms of relatively low return periods such as a 1 in 10 year rainfall event. Even new surface water systems are designed to a minimum standard of 1 in 30 years, much less than the 1 in 100 year standard of protection expected from fluvial flooding. As a result sewer flooding events where they occur can often be frequent, although the scale of consequence is generally smaller than those associated with fluvial flooding. Some of the London sewer network is a combined system with storm and foul drainage served by a single sewer. This makes flash flood events particularly inconvenient and unpleasant as floodwaters will often be contaminated with sewage.

The annual rainfall for the North London area is 640mm, somewhat less than the national annual average of 897mm. Rainfall in London also experiences less seasonal variation than other areas of the country, with the winter months experiencing only marginally higher rainfall than summer months, however, the rainfall in summer months will often occur in a smaller number of rainfall events leading to intense rainfall peaks which can lead to flash flooding and overloading of sewer systems. Climate change predictions indicate that these intense summer storms will become more frequent. Over time the standard of protection of existing sewers will reduce leading to an increase in localised flooding incidents.

Sewer flooding does not always respect the topography of a catchment and flooding can just as easily occur at the head of a network as it can near to the outfall. However, flood events occurring at the downstream end of a drainage system are likely to be more severe due to the sheer volumes of flow involved. London's sewer network is generally protected from such large scale flooding by storm overflows

which discharge high storm flows from the sewer system into watercourses, thus preventing flooding from the sewer network. In the event that an extreme fluvial event coincided with heavy rainfall within the catchment, storm water would be unable to discharge via storm overflows and would therefore surcharge within the sewer network. This could result in significant sewer flooding problems. Without access to hydraulic sewer models it is not possible to determine the extent of this risk or the areas most likely to be affected. Naturally low lying areas such as the river valleys and the areas immediately behind the locally raised flood defences could be potential receptors of such a flood event.

The Pitt Review looked at sewer flooding and considered the current regulations that allow the automatic right to connect surface water to sewers. The report recommends that this right should be removed (Recommendation 10) to encourage greater consideration of SUDS in the management of storm water runoff.

It is essential that any new development takes account of known sewer flooding problems to ensure that the development is not put at risk and that the development does not worsen an existing problem. Future development if not adequately planned can increase the flood risk from sewer flooding and in some cases cause new flood problems to occur. Potential increases in surface water or sewage discharge from new development must be adequately managed and mitigation measures introduced.

5.5.2 *Thames Water Flood Database*

Thames Water have provided an extract of their flood register for use in this study, however, the data is referenced by truncated postcode only and therefore cannot specifically identify a particular flooding problem. This is not a unique situation as Water Authorities have in general been reluctant to release flooding data for use in other SFRAs due to the sensitive nature of the information. The results of the Thames Water data is referenced on map 13 in appendix A. Table 14 below shows the number of flood records by Borough.

Table 14 - Thames Water Flooding Records by Borough

Borough	No. of Properties on Thames Water Flooding Database
Barnet	42
Camden	90
Enfield	5
Hackney	47
Haringey	12
Islington	1
Waltham Forest	55

Water Authorities are only required to maintain records of flood events which occurred more frequently than once in ten years. This is primarily down to targets set by OFWAT, the regulating body of the water industry. This inconsistent approach in recording sewer flooding compared with the EA's recording of fluvial flooding can make it difficult to assess the risks and consequences of sewer flooding. It is possible that a less frequent but substantial flood risk from sewers exists in the North London, but without the requisite information these potential risks cannot always be addressed by a pro-active approach, such as mitigation at the planning stage of a new development. Instead such risks often have to be addressed through a reactionary approach once a flood event had occurred.

It should be noted that the flood records provided by Thames Water may not be a complete and accurate record of flood events in the boroughs over the last 10 years. Some minor flooding incidents may go unreported, particularly if no property is affected by such flooding.

The Thames Water records shows a reasonable correlation with other historic flood records, including those of the Camden floods discussed later in this chapter. A substantial number of the postcode zones include a small number of isolated flooding incidents with no correlation to the adjacent postcode zones, however, there are five locations which should be highlighted, either because they contain a higher number of flooding incidents or there is a cluster of postcodes all containing flood events. These locations are listed in Table 15 and account for approximately half of the events on the Thames list.

Table 15 - Thames Water Flooding Records, Highlighted Areas

Location	North London Borough(s) Affected	Other London Borough(s) Affected	Comments
Edgware and Cannon Hill	Barnet	Harrow	Flooding occurs around the upper tributaries of the Silk Stream
West Hampstead, Cricklewood, South Hampstead and west to Church End	Barnet / Camden	Brent	
Stamford Hill	Hackney		Flooding incidents located south of Seven Sisters Road.
Leyton, Leytonstone	Waltham Forest		
South Tottenham	Haringey		Flooding occurs around the Stonebridge Brook Area

The scale and exact cause of the individual flooding problems is unknown and further investigation of each incident is clearly outside of the both the timescale and economic constraints of this study. However, the data has been combined with other flood history data discussed below and used to identify those areas which may be susceptible to surface water, this approach discussed in more detail in chapter 6.

5.5.3 *Impermeable Surfaces and Urban Creep*

Over the past couple of decades, there has been a growing trend of paving front gardens in urban areas to provide additional car parking. This practise has lead to urban creep that increases the impermeable area and the associated run off.

The Communities and Local Government website provides an Impact Assessment of Permeable Surfaces (January 2008) which considers the problem of paving front gardens further. This document provides evidence about the problem and reviews the permitted development rights for permeable surfacing.

The Pitt Review also considers the growth of paving front gardens and made a recommendation (Recommendation 9) that householders should no longer be able to lay impermeable surfaces as a right on front gardens and that the government should consult on whether to extend this to back gardens and business premises.

5.5.4 *Basement Flooding*

Flooding of basements of buildings is flooding of space below ground level. In the mildest case this may involve seepage of small volumes through walls, temporary loss of services. In more extreme cases larger volumes may lead to the catastrophic loss of stored items and failure of structural integrity.

5.5.5 *Other surface water flooding records*

5.5.5.1 *Barnet Flood Hot Spots*

The London borough of Barnet has provided a list of flood locations within Barnet over the last 2 years. The flood locations also include the associated reasons for flooding. A substantial number of the flood events were attributed to maintenance of gullies and this data has been removed from the data set.

The remaining recorded flood events are generally in close proximity to a major watercourse. The large majority are in the west of the borough along stretches of the Silk Stream and Edgware Brook, predominately along the western banks of the watercourses. These incidents generally correlate with the Thames Water flood records. The Edgware area appears particularly prone to surface water flooding problems. Other significant flooding problems are identified in the Colindale area and around the Silk Bridge in West Hendon.

5.5.5.2 *Review Transport For London flood records*

Transport for London is the authority that manage and maintain public transportation within the M25. On request they have made their flooding records available for use in

this study. The records comprise an extract of 288 records covering the Greater London area in regard to flood incidents from July 2006 to August 2007. These were reduced to relevant 16 records that fall within the study area. Of these, 6 incidents occurred in the summer and 3 are attributed to the same flood event.

The TFL data is a list of reported flood incidents on transport routes within the M25. There are numerous events in south Barnet and south Hackney. Islington and Camden have very few or no recorded TFL flood events.

Hackneys flood events are concentrated around Wick Road which appears to be in a depression and accounts for 6 of the incidents. Those in Enfield are located on the watercourses of Pymmes Brook, Bounds Green Ditch and Salmons Brook, either within or very close to the flood plain. These events are likely to be attributed to the interaction between the watercourse and highway or surface water drainage.

Waltham Forest has flood events along the A406 North Circular with the majority of these being a reasonable distance from the River Lee and the Ching. They are unrelated to any other flood records reviewed as part of this study. It may be attributed to inadequacies with the local highway drainage.

The TFL flooding in Barnet was linked to watercourses in the east of the borough, the Dollis Brook and the Mutton Brook.

5.5.5.3 Floods in Camden – Report of the Floods Scrutiny Panel

The report investigates the serious floods that occurred in some parts of the Borough on the 7th August 2002. The flooding inflicted considerable damage on some Camden residents and their homes, public services and facilities, and private businesses.

High rainfalls levels and flood events are a recurring feature in Camden due to the nature of summer thunderstorms and the topography of Hampstead. The report suggests that the similarities between floods in 1975 and 2002 conclude that these flood events have not been recently created by changes in the global climate.

The flood event on the 7th August 2002 was caused by excessive rainfall causing the main sewer system to become completely inundated. The surcharge pressure forced the water to back onto the streets through manholes and gully gratings and into residents' homes at basement and ground floor level. It was stated that "Any blocked or otherwise deficient Camden Council highway gullies could not have caused flooding on this scale" as the flood water could not drain to the trunk sewer.

This was supported by Thames Water's evidence confirmed that the flooding was caused by its sewer system reaching maximum capacity very quickly so that surface water could not be drained at the rate as the rain fell.

Following the flood event Thames Water is to make further funding cases to OFWAT to relieve more properties from flooding and they indicated that flooding issues in Camden will be picked up as part of their prioritisation programme.

The report suggests numerous recommendations to ensure the councils and key agencies responses are improved including task groups, regular maintenance of gullies and pipe networks and emergency response systems.

Map 22 shows the roads affected by flooding during the August 2002 floods. The map shows a reasonable correlation between the Thames Water records although the Camden floods would appear to be more widespread than is identified on Thames records. This can be attributed to the fact that some of the properties flooded in 2002 will not be included on the Thames Water database unless they flood twice in ten years.

5.5.5.4 London Fire Brigade Flood Calls

The London Fire Brigade record all incoming calls including those about flooding. Across the seven boroughs since April 1999 to August 2007, the London Fire Brigade received 15,515 calls regarding flooding, all of which have been made available for this study. Of those calls 247 calls were immediately discounted as they had no locational information. The remaining calls were divided into two categories, 'Water provision or removal, including flooding' and 'Flood calls'. The differentiation between the two categories is related to how the Fire Brigade manage their service. When a series of calls are received in a short period of time an immediate response can not be sent to each incident. 'Batch Mobilisation' takes place when the appliances deal with one call and go straight to the next call. This is likely to happen if an intensive down pour occurred and localised flooding took place. The batch mobilisation calls are denoted as 'flood call'.

Due to the large number of incidents it was necessary to look at groups of incidents rather than individual calls. The calls were sorted into date order and groups of 12 or more events occurring within a 48 hour period were selected. 52 of these "flood groups" were noted and the distribution of the calls across the seven boroughs was examined. Rainfall data from the nearest rain gauge has then been reviewed in order to determine whether the flooding incidents can be related to sewer flooding or surface run-off. This assessment is discussed further in section 6.4.

5.6 Artificial Drainage Bodies

5.6.1 Reservoirs

Reservoirs as defined by the Reservoirs Act 1975 are bodies of water above natural ground level that hold at least 25,000 cubic metres of water. Within the study area there are 17 reservoirs that managed and maintained in accordance with the Reservoir Act 1975. These are listed in Table 16 and shown on map 9. The enforcement of this legislation is conducted by the Environment Agency, who maintain the Public Reservoirs List.

The Pitt Review considered Reservoirs and Dams in a separate chapter that reviewed the existing situation and legislation. Recommendation 57 highlights the need for inundation mapping and emergency management plans to be created for both large and small reservoirs. Currently, the Reservoir Act would not cover all the reservoirs present in the North London boroughs, yet these smaller reservoirs in a densely populated area would still present a risk.

The largest of the reservoirs are in the Lower Lee Valley and most of these reservoirs are owned and operated by Thames Water. The King George V and the William Girling reservoirs have a combined capacity of nearly 30,000,000 m³. Both these reservoirs are within the 1:1000 year floodplain. They are both non-impounding reservoirs with raised embankments around them. The inflows to these two reservoirs are pumped from the Eastern Flood Channel.

There are also two Flood Storage Reservoirs under construction by the EA, one on Salmons Brook and the other at Stoney Wood in Barnet. These are also included in the above list.

The New River (discussed further in section 5.6.3), whilst not included on the reservoir list may also be considered in the same context as reservoir flooding. Sections of the New River are elevated above ground level and a failure of the embankment at these locations would result in a significant discharge of flow.

Table 16 - Reservoirs List

Reservoir	Location	Undertaker (Owner)	Category	Capacity (m ³)
Banbury	Near Chingford	Thames Water Ltd	Non-impounding	2846000
Brent	Near Willesden	British Waterways	Impounding	1632330
East Warwick	Near Walthamstow	Thames Water Ltd	Non-impounding	905000
Grovelands Park Lake	Near Southgate	London Borough of Enfield	Impounding	40000
Highgate Pond No.2	Near Camden	Corporation of London	Impounding	36000
Highgate Pond No.3	Near Camden	Corporation of London	Impounding	46000
High Maynard	Near Walthamstow	Thames Water Ltd	Non-impounding	462000
Hornsey	Near Hornsey	Thames Water Ltd	Non-impounding	102000
King George V	Near Chingford	Thames Water Ltd	Non-impounding	13970000
Lockwood	Near Walthamstow	Thames Water Ltd	Non-impounding	1787000
Salmons Brook FAS	Near Edmonton	Environment Agency	Impounding	Not Listed
Stoke Newington (East)	Near Stoke Newington	Thames Water Ltd	Non-impounding	182000
Stoke Newington (West)	Near Stoke Newington	London Borough of Hackney	Non-impounding	227000
Stoney Wood FSA	Barnet	Environment Agency	Impounding	56000
Trent Park Lake	Near Enfield	London Borough of Enfield	Impounding	25000
Walthamstow No.4	Near Walthamstow	Thames Water Ltd	Non-impounding	591000
Walthamstow No.5	Near Walthamstow	Thames Water Ltd	Non-impounding	713000
West Warwick	Near Walthamstow	Thames Water Ltd	Non-impounding	805000
William Girling	Near Chingford	Thames Water Ltd	Non-impounding	16500000

There are two types of reservoirs, impounding and non-impounding. Impounding reservoirs are defined as those constructed by damming a watercourse to intercept flows. Impounding reservoirs often pose the greatest flood risk as inflows to the reservoir are generally uncontrolled and dams are usually elevated above the downstream valley. An uncontrolled release of water from an impounding reservoir can result in catastrophic flooding leading to loss of life. The most serious cause of flooding would be attributed to a dam breach.

The responsibility for managing flood risk from reservoirs lies with the owners of each reservoir, while the EA have a duty to ensure that this responsibility is enforced. Through this enforced process of regular inspection and maintenance the potential risk of catastrophic reservoir failure is managed such that the probability of occurrence is low.

The Water Act 2003 requires that Reservoir Flood Plans be produced for certain reservoirs. Defra is in the process of producing a 'Guide to Emergency Planning for UK Reservoirs', which will go out to consultation in Summer 2008. They are expected to become a legal requirement in Spring 2009 when the Secretary of State in England will direct undertakers to produce flood plans for reservoirs where failure could have a major impact. It is not yet clear what criteria will be used to determine which reservoirs require Flood Plans but this information would be provided in future versions of this SFRA.

Other reservoirs, not covered by the Reservoirs Act are also present within the North London study area. Many of these will be clean water supply reservoirs, which are covered. This study does not address the risk associated with these reservoirs, predominantly due to the relatively small size, combined with the low risk associated with the type of failure that would be required to cause a flooding incident. The location of these reservoirs is also considered sensitive and it would not be appropriate to map the locations of such assets.

5.6.2 *Canals*

Regents Canal was constructed in 1820 to form the London arm of the Grand Union Canal. The Grand Union Canal came into being in January 1929 from an amalgamation of several different canals and was later extended in 1932. It was formed from the amalgamation of 11 different canals connecting London to Birmingham, stretching 135 miles and has 160 locks.

The Regents Canal stretches from Limehouse basin in Docklands to Paddington passing through Mile End, Hackney, Islington, King's Cross, Camden, Regents Park and Little Venice. Within this reach of the Regents Canal there are three tunnels; Islington Tunnel (886 meters) and Maida Hill Tunnel (251 meters) and the smaller Eyre's tunnel (48 meters).

Currently, the Camden lock system apparently holds a head of water of some 25 miles. The risks associated with the canal were sufficient that in the WWII war barriers were closed across the canal during air raids. These barriers are now unserviceable. In the past, British Waterway have commented that damage to canal walls from developer is quite common.

5.6.3 *New River*

The New River is a water supply aqueduct, constructed in 1613 to supply drinking water to London from Ware in Hertfordshire. The New River is the owned and operated by Thames Water. It is located to the west of the Lee Valley, and runs north to south, parallel to the path of the River Lee. The original route and size of the aqueduct has been altered to increase carrying capacity as demand increased. The New River's carrying capacity is now up to 220 megalitres (48 million gallons) per day. The length however has been shortened to 38km (24 miles), ending at storage reservoirs in Stoke Newington, northwest Hackney.

The New River water level is regulated by sluice gates, designed to allow flow to meet the requirements of the pumping stations and reservoirs. The Artificial Recharge Scheme consists of a series of boreholes which enable surplus treated water to be stored in the chalk aquifer and then pumped into the New River as required.

The New River contains many sections which are raised above the existing ground level. These include the crossing over the M25 close to junction 25 and several sections within residential areas (see map 9 for its route). Should any of these raised sections fail they could pose a significant flood risk to adjacent properties. The inspection and maintenance of these raised sections of the New River is therefore critical.

5.7 **Infrastructure Failure**

Infrastructure Failure can be generally be associated with the following sources, Reservoir, Canals, Burst Water Mains, Blocked sewers or failed pumping stations. In extreme cases infrastructure failure has the potential to release large volumes of water at high velocities with little warning time. This makes flooding from infrastructure very different from other types of flooding. Review of Infrastructure failure at a strategic level is generally hampered by limited or sensitive information, which cannot be made available.

Infrastructure failure causing flooding can be linked to the following three categories of infrastructure.

5.7.1 *Water Infrastructure*

Water artificially contained in large water bodies such as reservoirs and canals contain a significant risk. CIRIA C542 Risk Management for UK Reservoirs provides guidance on the application of risk assessment and risk management procedures to

UK reservoir practice. The main reservoirs and water bodies are primarily located in the Lower Lee Valley as shown in Map 9.

Canals are at risk of overtopping and breach in a similar manner to watercourses. Canals can breach at any point making risk assessments a difficult proposition. The Grand Union Canal and New River are the two main artificial watercourses within the study area. Others include the Intercepting Drain and Eastern Flood Channel, all located within the Lower Lee Valley.

5.7.2 *Flood Defence Infrastructure*

Flood defence infrastructure includes flood defences, flap valves, pumping stations, culverts and any other structure which may help to alleviate flooding. To be able to perform a risk assessment it is necessary to understand the reasons for the defence, its conditions and any potential failure mechanisms, as well as the consequences of any infrastructure failure.

5.7.3 *Bridge and Culvert Blockage*

Blockages of this nature can cause, be caused by and magnify flooding. Unprotected culverts may become blocked whilst debris and security screens obscured with debris restrict flow. This is often made amplified during floods due to the increased amount of debris carried in the flow. The large quantity of culverts in such an urbanised area increases the likelihood of blockages but it cannot be predicted.

5.7.4 *Overview*

Risks of this infrastructure failure need to be assessed in a site specific flood risk assessment and assessments into the condition of the infrastructure may be required.

5.8 **Source Pathway Receptor Model**

The seven North London boroughs form a large area with each borough affected by a different range of flood sources. The strategic level at which this report is targeted permits only a broad level of assessment of flood risk and the timescales required by the North London Boroughs do not allow a detailed assessment of all flood risks. In order to focus the SFRA it is necessary to identify sources of flooding with the largest potential consequences. To this end a source pathway receptor model has been created in Table 17. The model identifies sources of flooding while approximately assessing the potential scale of consequences of such flooding. The consequences of each flood source are described on a Borough by Borough basis.

Table 17 - Source Pathway Receptor Model

Source	Pathway	Receptor	Potential Scale of Consequence							Assessment in SFRA	Comment
			Barnet	Camden	Enfield	Hackney	Haringey	Islington	Waltham Forest		
Fluvial Flooding from the River Lee and Tributaries	Inundation of floodplains / overtopping of flood defences / breaching of flood defences	Properties and infrastructure within the defined flood plain and in locality of Pathway	Medium	N / A	Large	Medium	Large	N / A	Large	Assessment of fluvial flood levels, flood risk zoning and defence conditions.	Potentially large consequence and risk of loss of life
Fluvial Flooding from the River Brent Tributaries	Inundation of floodplains / overtopping of flood defences / breaching of flood defences	Properties and infrastructure within the defined flood plain and in locality of Pathway	Large	N / A	N / A	N / A	N / A	N / A	N / A	Assessment of fluvial flood levels, flood risk zoning and defence conditions.	Potentially large consequence and risk of loss of life
Tidal Flooding from the River Lee	Overtopping of flood defences / breaching of flood defences / wave Action / ponding of surface water behind defences	Properties and infrastructure within the defined flood plain and in locality of Pathway	N / A	N / A	N / A	Medium	N / A	N / A	Medium	Low risk due to presence of local defences and Thames Barrier. Review of condition of flood defences to be undertaken.	Potentially large consequences and risk of loss of life. Low probability of occurrence due to flood defences including the Thames Barrier.
Surface Water / Combined Sewer Flooding / Overland Flow	Exceedance of sewer capacity	Properties and infrastructure in the locality of Pathway	Small	Medium	Very Small	Small	Very Small	Very Small	Small	Moderate flooding possible some further assessment of flood risk required. Study is limited by the information provided	Thames water have provided limited information on flood history. London Fire Brigade and Borough Council information on flood history
	Blockage of Pipework										
Groundwater Flooding	Tidelocking of outfalls	Development in low lying areas or developments with basements	Very Small	Very Small	Very Small	Very Small	Very Small	Very Small	Very Small	Groundwater levels obtained from EA. Comparison with ground levels and research into future trends in groundwater levels	Limited information on which to base assessment. Potential for flood risk to infrastructure.
	Rising Groundwater										
Infrastructure Failure from Reservoirs / Canals (including the New River) / blocked Sewers / burst water mains	Overtopping of reservoir embankments	Watercourse, property and infrastructure downstream of infrastructure	Medium	Medium	Large	Large	Large	Medium	Large	Limited information available but low likelihood for flooding to occur due to enforced management of risks. Reservoir flood inundation plans are in the process of being produced as required by changes in legislation.	Limited information available on which to base assessment
	Breach of reservoir or canal embankments										
	Outlet failure										

5.8.1 Scale of Consequences

The scale of consequences used in the source pathway receptor model are presented in Table 15. The assessment of the consequences are approximate only and intended to guide the study towards the pertinent flooding issues and allow further assessment of the critical flood sources affecting planning decisions. They make no consideration of the likelihood of flooding.

Table 18 - Scale of Consequences

Scale	Consequence
Very Large	> 2000 Buildings
Large	500 – 2000 Buildings
Medium	90 – 500 Buildings
Small	40 – 90 Buildings
Very Small	0 – 40 Buildings

The consequences outlined in the above table provide a very simplified approach based solely on the number of properties affected, however, within the Source Pathway Receptor model other factors are considered. For instance the number of properties affected by infrastructure failure is largely unknown at this stage of the study, however, it is clear that such failure could have severe consequences based on other factors such as the velocity and rate of onset of such flooding.

5.9 Community Risk Registers

The Civil Contingencies Act 2004 places a legal duty on Category 1 responders to produce a Community Risk Register. The Resilience forums that cover several authorities in an area produce a Community Risk Register. The study area contains two Resilience Forums each of which have their own Community Risk Register; the North Central London Resilience Forum and the North East London Resilience Forum. The North Central London Community Risk Register covers Barnet, Camden, Enfield, Hackney, Haringey and Islington while the North East London Community Risk Register includes Waltham Forest.

Both the registers identify flooding from two main sources: surface water, coastal and fluvial as hazards. The level of risk varies between areas. It should be noted that the hazard sub-category titles are not particularly clear and are difficult to align with existing system of defining flooding throughout England and Wales. In future reviews of the Community Risk Register, it would be ease communications between planners

and emergency planners, if the hazard sub-categories titles were brought into alignment with the existing system.

Table 19 Summary of flooding risks as described in Community Risk Register (May 2008)

Area	Hazard	Magnitude (Risk Ref)	Likelihood	Impact	Risk
North Central	Coastal Flooding	Major (H19)	Unlikely	Significant	Very High
		Major Local (HL16)	Rare	Significant	High
		Localised (HL17)	Possible	Moderate	High
	Fluvial Flooding	Major (H20)	Rare	Catastrophic	High
		Major (H21)	Unlikely	Catastrophic	Very High
		Major Local (HL18)	Unlikely	Catastrophic	Very High
		Significant Local (HL19)	Possible	Significant	Very High
		Localised (HL20)	Possible	Moderate	High
	Structural	Reservoir Failure (H44)	Negligible	Catastrophic	Medium
	North East	Coastal Flooding	Major (H19)	Rare	Catastrophic
Major Local (HL16)			Rare	Moderate	Medium
Localised (HL17)			Rare	Moderate	Medium
Fluvial Flooding		Major (H20)	Rare	Catastrophic	High
		Major (H21)	Probable	Moderate	High
		Major Local (HL18)	Unlikely	Significant	Very High
		Significant Local (HL19)	Possible	Moderate	High
		Localised (HL20)	Unlikely	Significant	High
Structural		Reservoir Failure (H44)	Negligible	Catastrophic	Medium

6 Strategic Flood Risk Assessment

The following chapter aims to further assess the flood risk from with the key flood sources identified in the source pathway receptor model. Where available data permits the assessment is intended to provide planners who will use this document with the appropriate information required to make informed and sustainable planning decisions and also provide developers with baseline data from which site specific flood risk assessments can be developed. The degree of assessment attributed to sources has been dictated by the approximate risk posed by each source partly assessed through the source pathway receptor model approach, the accuracy of flood risk data already available and also the limitations on data that would be required for further assessment.

6.1 Sustainability and Climate Change

There is now a common consensus that climate change will continue to have a detrimental impact on flood risk on a global scale. Around the United Kingdom, sea levels are predicted to rise and changes in weather patterns are likely to lead to longer winter storms and increasingly intensified summer storms. Such changes in sea levels and weather patterns will lead to an increase in the frequency and scale of flooding, with predicted rises in fluvial flows, rising groundwater and increases to peak rainfall run-off and volumes all contributing to an increase in flood risk. Future development must take climate change into account when considering sustainable development and PPS 25 explicitly states that future development must take into account climate change when considering flood risk.

A number of climate change studies exist which use global climate predictions to model potential impacts on sea level rise and rainfall. Despite these various studies there is still uncertainty about the extent of global warming and therefore the potential impact on flood risk. The UK Climate Impacts Program (UKCIP)¹⁶ has published a series of scenarios based on varying global emission levels which form the basis for the London's Warming Technical Report¹⁷. The scenarios presented in UKCIP02 use 4 different scales of emissions to model the potential impact on rainfall and sea levels. The output of the models provides a range of results which could be applied to this strategic flood risk assessment through sensitivity testing of the computational hydraulic models used to determine flood risk zones. However, the EA studies which provide predicted flood zones and levels for this report generally use

¹⁶ UK Climate Impact Partnership (2002) *Climate Change Scenarios for the United Kingdom: The UKCIP02 Scientific Report*

¹⁷ London Climate Change Partnership (2002) *London's Warming: A Climate Change Impacts in London Evaluation Study*

the precautionary allowances stated in PPS25 as the basis for climate change consideration. PPS25 recommends an increase in fluvial flows of up to 20% and an increase in peak rainfall intensity of up to 30% by 2115. The main climate change tables from PPS25 (B.1 and B.2) are reproduced below in Table 20 and Table 21.

To review all of the hydraulic studies in relation to the UKCIP02 scenarios is considered too onerous and unnecessary for a study of this nature. The precautionary allowances in PPS25 are considered appropriate for both the SFRA and site specific FRA process since a more complex approach will not guarantee greater certainty.

The EA flood zones which form the basis of the zoning for this report do not include an allowance for climate change, however, the Lower Lee Valley study applied an adjustment of 20% to fluvial flows to determine the increase in zoning. Climate change forecasts are likely to be periodically revised in years to come. UKCIP are expected to release further climate change models in 2008. Site based flood risk assessments for future development would be expected to make use of the most up to date guidance on climate change allowances where appropriate.

Table 20 Recommended national precautionary sensitivity ranges

Parameter	1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115
Peak rainfall intensity	+5%	+10%	+20%	+30%
Peak river flow	+10%	+20%		
Offshore wind speed	+5%		+10%	
Extreme wave height	+5%		+10%	

Table 21 Recommended contingency allowances for net sea level rise

Administrative Area	Net Sea Level Rise (mm/yr) relative to 1990			
	1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115
East of England, East Midlands, London, South East England (south of Flamborough Head)	4.0	8.5	12.0	15.0
South West	3.5	8.0	11.5	14.5
NW England, NE England (north of Flamb'g Head)	2.5	7.0	10.0	13.0

6.2 Fluvial Flooding

Unsurprisingly, the source pathway receptor model identifies fluvial flooding as the most significant flood risk to North London. The number of properties at risk from fluvial flooding combined with the low standard of protection of some flood defences give rise to significant flood risk issues. The Lee Valley poses a considerable flood risk, affecting 4 of the 7 Boroughs, Enfield, Hackney, Haringey and Waltham Forest. The Lower Lee Valley is defined as an opportunity area in the London Plan despite having considerable deficiencies in the standard of flood protection within much of the area. Any development which passes the sequential test within the Lower Lee Valley will still require careful consideration of the residual flood risks in order to ensure that a safe and sustainable development can be achieved.

The Silk Stream, Dollis Brook and their tributaries also pose inherent flood risk, albeit to a lesser scale than the Lee Valley. The Silk Stream Flood Alleviation Scheme will go some way to mitigating the flood risks in this area although the standard of protection offered by the scheme is only approximately 1 in 25 years.

As discussed in section 5.3.3, the flood risk zones provided by the EA have been derived using two separate methods. Map 21 shows the usage of these two methods, showing the differing extents of JFLOW and alternative modelling studies.

6.2.1 Lower Lee Flood Risk Zone

The Lee Valley has been extensively modelled in recent years and the flood extents are entirely derived from these studies. The majority of the Lee Valley tributaries have also been included in these studies. Only the upper reaches of Holyhill Brook, Salmons Brook, Hounsdon Gutter, Monken Mead Brook and Bounds Green Brook are modelled using the JFLOW modelling process. The upper reaches of these watercourses generally extend into Green Belt or Metropolitan Open Land and therefore the low certainty regarding the flood risk zones will not affect the application of the sequential test during the allocation of development sites. As such no refinement of these flood risk zones through a level 2 SFRA is deemed necessary.

The exception to this is the Hounsdon Gutter that passes through a highly urban area but is using an older and less detailed JFLOW model and to a lesser extent Bounds Green Brook, where the JFLOW modelling extends into both urban and rural areas, see Map 9 and 21. Some consideration must be given to whether these watercourses lie within proposed development areas as the JFLOW derived flood risk zones contain a high degree of uncertainty. Where development is proposed near to these flood risk zones a buffer strip of 20m could be added to flood risk zones to allow for any such inaccuracies. In Annex E of PPS25, (Para. E6) state that “where decision-makers have been unable to allocate all proposed development and infrastructure in accordance with the sequential test, taken account of the flood vulnerability category of the intended use, it will be necessary to increase the scope

of the SFRA to provide the information necessary for application of the exception test.”

6.2.2 *Silk Stream and Dollis Brook Flood Zones*

The Silk Stream and Dollis Brook Flood Zones included in this SFRA have recently been remodelled by Jacobs for the EA using ISIS. The new flood risk zones have been included in the flood zone mapping. These are considered suitable for use in sequential testing for allocation of development sites.

6.2.3 *Actual Flood Risk*

The flood risk zones shown on map 8 and discussed above do not take into account flood defences, either formal or informal. As such the flood risk zones do not always represent the actual risk of flood inundation. Where areas of high flood risk are identified, such as the Lee Valley it is appropriate to assess the actual flood risk, both to defended and undefended areas, taking into account overtopping and breach risks to determine the flood hazards. Such an assessment is essential where development is planned in areas behind defences, particularly in the Lee Valley (identified as an opportunity area) where the standard of protection is often less than the 1% annual probability. Such an assessment falls within the remit of a level 2 SFRA and is therefore outside of the scope of this report. Further discussion on the requirement, extent and recommendations for a level 2 SFRA is included in section 6.2.4.

6.2.4 *Recommendations for Further Work*

The improved level of assessment which comes from a Level 2 SFRA is generally required where high uncertainty exists over the existing data or where areas of high risks are identified. A level 2 SFRA is not required to cover the whole LPA area in the way that a level 1 SFRA must.

The principal purpose of a Level 2 SFRA is to facilitate application of the Sequential and Exception Tests. These studies should focus only on proposed development areas where there is data with high uncertainty or high flood risk. Within the North London Boroughs there does not appear to be a requirement for a level 2 SFRA.

6.2.4.1 *River Lee Catchment*

The Lower Lee Valley and its tributaries are extensively modelled and the flood risk zones provided by the EA have a high confidence level associated with them. As such no further delineation of these flood zones are required, although allocation of sites around the upper reaches of the Hounsdon Gutter and Bounds Green Brook should allow for a 20m buffer strip to account for inaccuracies in the flood risk zones. The information contained in the flood risk zones is sufficient for allocation of sites using the sequential test.

The Lower Lee Valley has extensive flood plains and a number of interacting flood defences, including the Lee Flood Relief Channel. The raised flood defences provide

varying standards of protection and actual flood risk will vary considerably from the undefended flood risk zone map. There is limited scope for large scale development elsewhere in many of the Boroughs and the sequential test is likely to place a number of development sites within flood zone 3 in the Lower Lee Valley. The sequential test requires that where more than one potential site exists within the same flood zone, development is prioritised into the areas of lowest probability of flooding. In order to demonstrate this, Boroughs will need to understand the actual flood risk while also having information on flood hazards including those from overtopping and breach analysis. Data on depth of flooding, flood velocities and the rate of onset of flooding will be required to delineate sites within flood zone 3, such that the sequential test can be fully demonstrated.

Waltham Forest and Hackney may already be sufficiently covered in the London Development Agency commissioned Lower Lee Valley SFRA and it is recommended that this be reviewed before they undertake any further work. If the LDA are not able to make the Lower Lee SFRA available for use by the Boroughs it may be possible to obtain the Lower Lee model under license from the LDA and undertake their own study. This approach would inevitably involve some duplication of work already undertaken in the Lower Lee SFRA and is not the preferred option.

6.3 Groundwater Flooding

Groundwater flooding records have been combined with geological and topographic plans (where available) to identify a series of groundwater flood risk locations. The risk map (map 23) identifies areas close to the outcrops and deposits of gravels and silts and also the low lying areas within the Lee Valley where the groundwater table is close to the ground surface and in hydraulic connectivity with the watercourses. The Silk Stream and Dollis Brook valleys are also identified due to the presence of the alluvium deposits overlying the impermeable clay layer.

The groundwater flood risk zones within the river valleys clearly overlap with the fluvial flood risk zones which will take precedent when undertaking the sequential test. The groundwater flood risk zones in the upper catchment slopes should not be taken into account when allocating the sites using the sequential test as the groundwater flood risk is relatively low compared with other sources of flooding and can be adequately mitigated at a site flood risk assessment level. Other factors away from flooding are likely to have a greater bearing on the allocation of site.

The information should be used by developers when considering flood risk at a site specific level. As well as assessing flood risk to their own development, developers should also consider the impact that their site could have on groundwater flows elsewhere in the catchment. Large basements or strip foundations can impede groundwater flow causing springs to arise on adjacent sites. Care should be taken in the groundwater flood risk zones to ensure that this is adequately addressed. The provision of basements or conversion of basements into flats in areas of

groundwater flood risk must be carefully considered by both developers and planners.

6.4 Assessment of Surface Water and Sewer Flooding

A number of flood records relating to surface water and sewer flooding have been obtained as part of the study and were reviewed in detail in section 5.5. This section attempts to combine these flood records and use them in conjunction with topographic maps to identify potential overland flow paths. It would be beneficial to review the maps against sewer record plans to identify areas at risk. However, in the absence of such data this exercise could not be completed for this version of the SFRA.

6.4.1 Pluvial Flood Records

The largest data set relating to flooding was received from the London Fire Brigade. Over 15000 individual incidents were provided and these records have been grouped together into flood groups and correlated with high rainfall events taken from gauge data received from the EA. The correlation attempts to try and determine whether events could be attributed to pluvial flooding or whether events may be attributed to other factors such as infrastructure failure.

In total 55 grouped flood events were identified and of these 23 events were successfully cross referenced with the EA rain gauge data. Rainfall data for the other events was not available from the EA and it has not been possible to determine if these events were as a result of pluvial flooding.

The 23 events are displayed on map 20 through the marking of points where a flood incident was recorded. The points have been divided by the sources of information as not all the events were associated with dates. The points show an even split of events across the summer and winter seasons. Most of the calls were recorded in the southern part of the study area within the heavily urbanised areas.

The densest cluster of flood calls occurs in central and southern Islington and Hackney. These flood events do not appear to correlate with Thames Water flood records or other sources of flood risk. The incidents are generally spread across the Boroughs and as such they do not highlight any significant areas of flood risk. Once topographic information is available for these Boroughs, a further review of the flooding incidents will be considered against the topography to determine if there are any particularly vulnerable locations within these Boroughs.

A small number of flood events were recorded in the Edgware area of Barnet, which correlates with both the Barnet and Thames Water records.

A small number of events were also recorded in Camden and the locations of these events also correlate with the flood records of the 2002 floods in Camden. It is

noticeable that the Camden floods of 2002 do not significantly appear in the flood data sets derived. This may be attributed to a lack of available rainfall data.

A number of flood events are recorded on the Hackney / Haringey border in the Stamford Hill area. These flood events correlate with the Thames Water flood records where a significant flood risk area is identified.

The number of events recorded in Waltham Forest and Enfield are relatively low and do highlight any significant surface water or sewer flood risk areas other than those previously identified from inspection of the other sources of flood records.

6.4.2 Surface Water Flood Risk

For the purpose of the SFRA, there is a need to better understand the risk from surface water flooding and the performance of the urban drainage system during flood events.

Unlike fluvial flood mapping which is well recorded and has plenty of information available for future developments. This is not the case for overland flooding, which may be attributable mainly to large impermeable areas and incapacity in the surface water drainage systems. Therefore consideration must be made to upstream and downstream conditions, soil conditions, age of drainage systems, topography and any local evidence of surface water during the planning process.

Map 23 shows the likely drainage paths of the surface water run off based on the topography and the drainage catchments of the study area. However, the urban nature of the study area will have a large influence the surface water flow paths and pooling locations.

Five surface water flood risk areas are listed below and are marked on Map 23. These have been identified from reviewing all available flood records relating to surface water and sewer flooding. Further assessment of these flood zones has not been possible without information on the local sewer networks. Thames Water was unable to make this information available to inform the study.

Table 22 – Locations of Surface Water Flood Risk Zones

Location	North London Borough(s) Affected	Suggested Planning Considerations	Comments
Edgware and Cannon Hill	Barnet	Site specific flood risk assessments or surface water drainage strategy to be encouraged for all developments if not required under PPS25	Flooding occurs around the upper tributaries of the Silk Stream. Culverted sections may be responsible for such flooding
West Hampstead, Cricklewood, South Hampstead and west to Church End	Barnet / Camden	Site specific flood risk assessments or surface water drainage strategy to be encouraged for all developments if not required under PPS25. Development of basement flats to be restricted	
Stamford Hill	Hackney / Haringey	Site specific flood risk assessments or surface water drainage strategy to be encouraged for all developments if not required under PPS25	Flooding incidents located south of Seven Sisters Road.
Leyton, Leytonstone	Waltham Forest	Site specific flood risk assessments or surface water drainage strategy to be encouraged for all developments if not required under PPS25	
South Tottenham	Haringey	Site specific flood risk assessments or surface water drainage strategy to be encouraged for all developments if not required under PPS25	Flooding occurs around the Stonebridge Brook Area

**Other Flood Risk Zones may be added to this list once topography plans are obtained for Camden, Islington and Hackney.*

The Edgware and Cannon Hill areas of Barnet (and Harrow) are located at the head of the Silk Stream and Edgware Brook where a number of smaller tributaries

combine. A number of the watercourses are culverted and the capacity of these culverts may be responsible for the flooding problem which exists in this area. Future development should take account of this potential flooding problem. Aiming to restrict the run-off from future development and considering the potential for on-site flooding. The area may benefit from a combined flood analysis, reviewing both the fluvial and sewer flooding in one combined assessment.

The areas of West Hampstead, Cricklewood and South Hampstead would appear to be the areas at most risk from pluvial flooding within the North London areas. This flood risk extends to a lesser extent to Church End in the Barnet and also into the east of Camden, which experienced flooding during the 2002 Camden Floods. The extent of the 2002 Camden floods is shown on Map 22. The cause of these floods was attributed to surcharged sewers which could not cope with the volume of run-off. Without access to sewer records this cannot be verified. As such the flood risk zones are identified to highlight the potential for flood risk in these areas.

A number of surface water and sewer flood risk areas have been identified and development within these areas should consider measures to reduce flood risk and ensure that new development considers the residual risk. Some types of developments such as basement flat conversions may be considered inappropriate within these areas without a thorough flood risk assessment. However, in the majority of the North London area, surface water flood risk is limited and is considered a minor influence to the sequential test when allocating development sites. In addition, the Pitt Review supported the introduction of Surface Water Management Plans in Recommendation 18.

6.4.3 *Basement Flooding*

In the Central London boroughs of Camden and Islington, there are a large number of basements that are used for commercial and residential purposes. This number reduces slightly as you move north to the suburban boroughs of Barnet, Hackney, Haringey, Enfield and Waltham Forest.

Islington report 12,800 basement properties in their borough. While there is low fluvial flood risk to the borough the greater likelihood of surface water flooding poses a threat to these properties and other like them in Camden. In other boroughs, basement properties face flooding from a variety of different sources of flooding such as fluvial, tidal, surface water, sewer or groundwater depending upon their location. Basement flooding is a new area of consideration for planner. At present the best example of Basement Flooding Guidance for development is a note prepared by the EA to assist planners in Hammersmith and Fulham. This can be found in Appendix C.

6.4.4 *Recommendations for Further Work*

Further assessment of the surface water risk is recommended to better define the surface water flood risk zones. However, this cannot take place without the co-

operation or collaboration of Thames Water who have set out their stance regarding the SFRA process. Engagement of Thames Water is recommended to determine whether any flood relief schemes are in place to alleviate any of the flooding within these zones.

As further information is made available about the location of basements and the results of surface water modelling for the boroughs would allow identification of basement properties with the highest risk of flooding. Boroughs should use the EA Guidance Note on the flood risk for basement development issued to Planners Hammersmith and Fulham to assist them in planning decisions while policy is being formed.

6.4.5 *Reservoirs*

In the North London boroughs there are a large number of reservoirs (large one on the reservoir register and smaller ones that are not). These reservoirs are either for commercial or recreation purposes with the most noticeable reservoirs present in the Lee Valley. While there is low risk of the reservoirs failing in the North London boroughs, the consequences of such an event are severe to down stream areas. Reservoirs that are too small to be on the register, pose more risk of failing due to the lack of regulation governing their maintenance and management. In Spring 2009, all reservoirs under the 1975 Reservoir Act, will require the development of a Flood Plan and associated inundation mapping.

6.4.6 *Recommendations for Further Work*

Due to the densely populated nature of North London, it is recommended that each of the boroughs takes the time to locate the smaller reservoirs and assimilate information about them on a par with the reservoirs on the register. It is also suggested that the emergency planners liaise with the reservoir operators and work with them on the development of the reservoirs flood plans and inundation mapping. The reservoir operators are encouraged to work with and share information with the Borough Councils so to reduce the risk to development in the future from the reservoirs.

6.5 Emergency Planning Measures for Flooding

6.5.1 *London Boroughs*

All seven boroughs have Emergency Planning Units that handle incidents of flooding. The boroughs all participate in the North East Local Resilience Forum for Waltham Forest and the North Central Local Resilience Forum for the other six boroughs. The Community Risk Registers for both these forums are available on the London Fire Brigade Website.

The individual boroughs have different types of flooding to deal with and plan for accordingly. At present the London Boroughs have not specified whether they currently have flood incident plan. The only details of the Local Authorities response are outlined in their Emergency Plan. The London Borough of Enfield has stated that

they are currently looking at writing a specific plan in order to enhance their response to a flood event.

6.5.2 *Environment Agency*

Under the Civil Contingencies Act 2004, the Environment Agency is a Category 1 or Core Responder to incidents including the management of fluvial and coastal flood events. The Environment Agency operates a flood incident management system that includes flood warning, incident management, river and river structure management and awareness raising on flood preparation, safety, mitigation and cleaning up after a flood. The Environment Agency fully participates in the North East Local Resilience Forum for Waltham Forest and the North Central Local Resilience Forum for the other six boroughs.

The Environment Agency has developed a multimedia Flood Warning System. There are four levels of warnings which are Flood Watch, Flood Warning, Severe Flood Warning and All Clear. The warnings are aimed at communities in flood zones two and three and delivers messages direct to the public, businesses, emergency services and the media via phone, fax, sms (text messaging), email and pager. People are able to register for the service if they call the Floodline service on 0845 988 1188. This warning system will be further developed to allow online registration for the service.

The Environment Agency has one Flood Warden who has provided a service to properties within Hemming Road and Bransgrove Road that are at risk of fluvial flooding from Edgeware Brook and close to Silk Stream and Deans Brook for over two years. There three further Flood Wardens in the North London area. The EA is continuously trying to establish further Flood Warden Schemes but frequently find that people do not consider volunteering as a flood warden while they do not feel the threat of flooding. Local Authorities are encouraged to promote new and existing flood warden schemes.

To support all the activities, the EA in association with other drainage authorities are undertaking a targeted flood awareness programme throughout the population with interests in the flood zones 2 and 3. This programme includes the use of local advertising campaigns, open meetings, awareness raising road shows and mail shots.

6.5.3 *Civil Contingencies Act*

The Civil Contingencies Act states that Category 1 presents those organisations at the core of the response to most emergencies (e.g. emergency services, local authorities, NHS bodies). Category 2 responders are less likely to be involved in the heart of the planning work but will be heavily involved in incidents that affect their sector. Examples include Health and Safety Executive, transport and utility companies). Category 2 responders have a lesser set of duties - co-operating and

sharing relevant information with other Category 1 and 2 responders. The Resilience Forums that cover several authorities in an area produce a Community Risk Register.

6.5.4 *The Pitt Review*

The final provided many recommendations relating to emergency planning and business continuity management. This section highlights a few of the key issues, however, it is suggested that planners and emergency planners read the Pitt Review as this report will have repercussions on improving the UK's resilience to flooding in the future.

Recommendation 13 should be noted by Local Authorities that there will be more requirements in the future to promote business continuity and property flood resistance and resilience by businesses as part of there already agreed duties under the Civil Contingencies Act 2004.

Other recommendations promoted in the Pitt Review suggest Local Authorities take more of a lead on local flood risk management (Recommendation 14 and 15), while improving their in-house technical capabilities in Flood Risk Management (Recommendation 19). In addition, the final report recommends that the Local Authority takes on responsibility to collate and map main food risk management and drainage assets including the ownership and the condition of these assets (Recommendation 16).

7 Application of Sequential Flood Risk Test

PPS25 encourages LPAs to undertake the sequential flood risk test to help gain an understanding of the potential flood risk associated with future development. The key aspect of the sequential flood risk test is the assessment of the flood risk zones in accordance with PPS25. This is done by delineation of the flood risk zones using topographic data and flood modelling results. Following the application of the sequential test, further separation of development sites can be assessed using the exception test. This requires consideration of individual development risks such as the risk to vulnerable users and also further appraisal of area in Flood Zone 3 by determining the risk from overtopping and breach.

The sequential and exception tests are risk based assessment tools intended to ensure that preference is given to development of sites of little or no risk of flooding over areas of higher risk. The approach uses flood risk zones as defined in section 2.2.

7.1 Flood Risk Zone Categories

The following Flood Zone risk categories are highlighted on the flood zone map, which should be employed when applying the sequential test to development proposals.

Table 23 - Flood Risk Zones and Development Restrictions

Flood Zone	Description and Development Restrictions
Zone 1	All Development types acceptable
Zone 2	Exception Test Required for Highly Vulnerable Development
Zone 3a	More Vulnerable development and essential infrastructure requires Exception Test, Highly Vulnerable Development not permitted.
Zone 3b	Land where water has to flow or be stored in times of flood. Only water-compatible uses and essential infrastructure that has to be there should be permitted. Exception test required for essential infrastructure.

For vulnerability of development classes refer to section 2.2.

7.2 Application of Sequential Test

The objective of the Sequential Test is to steer development to areas at the lowest probability of flooding from various sources. The test logically guides Local Planning Authorities through site selection by identifying whether a suitable site is available in the low probability zone (Flood Zone 1). If no site is available in Flood Zone 1 then Flood Zone 2 can be considered depending on the vulnerability of the development, as outlined in Table D.2 in PPS25. This vulnerability classification will then allow further consideration of appropriate locations of the proposed development. Table D.1 in PPS25 defines the suitability of different flood zones for the proposed development's vulnerability classification. Site selection must review the sites with the lowest risk of flooding first before considering sites in higher risk areas.

7.3 Assessment of Risk within Zones 2 and 3

7.3.1 Application of the Exception Test

The Exception Test is only applied after the Sequential Test and is intended to ensure that vulnerable type of property are not developed in areas of high flood risk. Three conditions must be met in order to pass the exception test:

Criteria for Passing the Exception Test

- a) *The Development must provide wider sustainability benefits to the community that outweigh the flood risk. Where appropriate the benefits should contribute to the Core Strategy's Sustainability Appraisal*
- b) *The development site must be on developable previously developed land or if it is not on previously developed land there should be no reasonable alternative sites on developable previously developed land*
- c) *A site specific flood risk assessment must demonstrate the development will be safe without increasing flood risk elsewhere and also demonstrate the reduction of flood risk*

The exception test is applied only after the sequential test has been applied as is only applicable when "more vulnerable" development and "essential infrastructure" cannot be located in flood zones 1 or 2 and "highly vulnerable" development cannot be located in flood zone 1. It should not be used to justify "highly vulnerable" development in flood zones 3a, or "less vulnerable", "more vulnerable" and "highly vulnerable" development in flood zone 3b. LPAs are required to undertake parts A and B of the test with developers usually undertaking parts C.

The Environment Agency provide clear guidance on LPA responsibilities for undertaking the sequential and exception tests when allocating development sites. The following website provides step by step guidance on assessing development proposals under the sequential test.

<http://www.pipernetworking.com/floodrisk/sequential.html>

However it should be noted that flood risk standing advice will soon no longer be available from piper networking it will soon be available from the EA website.

7.4 **Brownfield Development**

PPS3 encourages LPAs to give preference to previously developed site and disused properties prior to allocating greenfield sites for development. These brownfield sites characterise a substantial amount of the potential development land within the North London study area.

Brownfield Development Advice

If there are two sites with the same probability of flooding, the brownfield site should be developed in preference to the greenfield site.

If the brownfield site has a higher probability of flooding than the greenfield site, then a trade-off must be made between benefits and disadvantages of the two sites. Should the LPA consider that developing on the brownfield site is beneficial then appropriate mitigation measures need to be included in the design and guidance provided in PPS25 regarding elderly and vulnerable occupants still applies.

A site located within a flood risk zone that has been previously developed does not automatically warrant planning approval for a replacement development. The flood risk assessment and management of the new application should be dealt with in the same manner as a greenfield site.

In practice some of the PPS25 flood zonings are difficult to apply to London since development already lies within Zones 2 and 3 which would not now pass the sequential test. However, when considering re-development of these areas the sequential test must be considered in full and development should not be allocated within flood zone 3b.

8 Local Policy Guidance

8.1 Introduction

The evolution from Unitary Development Plans to Local Development Frameworks provides an opportunity for the North London Boroughs to introduce planning policies which are consistent with both national and regional policy.

The findings of the North London SFRA have been used to produce a series of draft policy recommendations outlined in this section. The policy recommendations are split into the following three themes: Policy, Development Control and Technical. The Boroughs may choose to adapt and adopt some of these policies where applicable at a local level. These policy recommendations are written to reflect the national and regional policies outlined in the London Plan. The wording and approach of these recommended policies would need to be reviewed in the context of other local policies. It should be noted that these do not in any way reflect actual policies of the boroughs and they are provided only as a starting point from which the Boroughs can develop their own appropriate flood risk policies in consultation with the Environment Agency.

For the Boroughs to assess the current and future policy recommendations, consultation of and information from the latest versions of the Planning Policy Statement on Development and Flood Risk, Sewers for Adoption and Flood Estimation Handbook would be suggested. Sewers for Adoption provides sewer network design guidance that is used by the water companies. The document has specific sections on flood capacity design. While the Flood Estimation Handbook provides information and guidance on both flood estimation and flow design.

8.2 Policy Recommendations

8.2.1 Policy

01: Incorporation of SFRA findings into the Core Strategies and other Development Framework Documents

In order to ensure a robust approach to flood risk appraisal, management and reduction, the findings of the SFRA need to be incorporated into each of the Boroughs' Development Framework Documents and support documents. This will ensure a holistic and robust approach to flood risk management, ensuring that the matter is taken into account at all stages of the planning process. The findings of the SFRA demonstrate the level of flood risk within the boroughs. Key issues identified by the SFRA will be a priority for future spatial planning in the seven North London.

Future policy should seek to address how defences will be maintained and address how development can be accommodated. These issues are considered in greater detail in subsequent policy recommendations. The Boroughs should endeavour to

ensure that the findings of the SFRA feed into policy preparation and is incorporated within planning policy.

02: The Core Strategy should include a clear policy statement on flood risk in urban areas

In accordance with PPS12, the Core Strategy should set out the key spatial elements of the planning framework for the area and include core policies. All other development plan documents must be in conformity with the Core Strategy. In setting out a spatial vision for the boroughs, a clear borough-wide policy statement on flood risk should be included to set a clear policy hierarchy on planning for flood risk. This should reflect the approach of pro-active management of flood risk through the reduction of causes of flooding to existing and future development. It is recommended that a specific policy on flood risk is included within the Core Strategy. This should focus on ensuring that, where possible:

- Development is located in the lowest risk area
- New development is flood-proofed to a satisfactory degree and does not increase flood risk elsewhere
- Surface water is managed effectively on site
- The Borough applies the sequential approach when determining planning applications
- Flood storage and SUDS used where practicable

Site specific and other detail should then be included in subsequent development plan documents as they are prepared.

03: Linkages with other Flood Risk Management Strategies

The Boroughs should ensure that in developing and taking forward the findings of the SFRA they have regard to other developing strategies that consider flood risk management in the area to ensure that wider concerns are reflected where appropriate. The Thames Catchment Flood Management Plan (CFMP) has been produced and is considered within the SFRA. The CFMP will also be updated like the SFRA. Other SFRA reports such as the Lower Lee, the Upper Lee, the Brent and the Olympics development and the Blue Ribbon Strategy are included and updates will be required as changes are applied. Also the outputs from these studies especially the CFMP should be considered for taking forward in policy recommendations.

04: Flood Risk Guidance should be included in the Area Action Plans

Action plans should comply with Core Strategies, and recommendations for Action plans should be included for Core Strategies. The Area Action Plans are currently being produced and should include a planned approach to flood risk within the document that is based on the recommendations of the SFRA. This will include reviewing any associated documents to ensure compliance with the SFRA recommendations. The precise scope of the flood risk policy to be included is not within the scope of this report. However, the findings have identified the following recommendations for inclusion:

- Highly vulnerable development should be avoided in the high and medium flood zones
- More vulnerable development should not be located on the ground floor
- Flood proofing and flood resilience should be incorporated in the overall design of any development
- Access/egress points and specified refuge points that meets EA Guidance layout in Appendix C.
- Any proposals will need to demonstrate that emergency planning measures have been taken into account and, where appropriate, secured in perpetuity through legal agreements
- Any particular requirements relating to flood risk and specific designations

It is recognised that the Strategic Development Areas (SDAs) within the Area Action Plans (AAPs) have specific design and development issues that are subject to Supplementary Planning Documents (SPDs) providing detailed design guidance. Further design policy in relation to flood risk, as relevant and sympathetic to each SDA should be included within the SPDs. However, the Boroughs should be cautious of the approach of adopting the SPDs in order that they may be used in advance of the formal adoption of the Area Action Plans.

8.2.2 Development Control

05: Development adjacent to flood defences, reservoirs and canals

Development adjacent to flood defences should be set back from defences, reservoirs and canals to allow for the replacement/repair of the structures. Any future raising of the standards of protection provided by these structures should be done in a sustainable and cost effective way. Boroughs should ensure that development does not breach or undermine flood defence, reservoir or canal structures in any way. All new development should be set back 16 metres from tidal rivers, eight

metres from main rivers and five metres from canals. For reservoirs, it is recommended that discussions with the Operator and their Inspecting Engineer of the Reservoir in question.

06: Appropriate development of urban centres

The SFRA identifies some areas of North London being at a high risk of flooding. Particular care should be given to policy development for the urban centres, which act as a social, economic and regeneration hub. In line with other recommendations and the approach adopted in the guidance, the Boroughs should develop policies which comment on the appropriateness of vulnerable uses in the urban centres. Particular issues for consideration include:

- Guidance on the suitability of land uses on the ground floor of more vulnerable development
- The incorporation flood proofing and flood resilience measures in the overall development design
- The use of Sustainable Urban Drainage Systems (SUDS) (See Chapter 9 for more information)
- Demonstration that emergency planning measures have been designed into the proposed development
- The location and appropriateness of uses

07: Flood risk and housing market renewal

Areas where housing market renewal are located in mixed Flood Zones ranging from Zone 1 to Zone 3 would involve the simple application of the Sequential Approach. However due to the specific role of housing market renewal in terms of regenerating housing demand in various areas care should be given to their development.

The boroughs should ensure that flood risk is considered as part of the spatial planning and regeneration of the housing market renewal. These areas should take account of the flood risk and adopt any measures necessary to ensure minimal risk to future communities in the immediate area and wider areas. Regeneration should aim to prioritise brownfield sites over greenfield sites in accordance with wider sustainability policies and development should seek to reduce run-off rates.

These developments will seek to incorporate flood proofing and resilience through design, take advantage of greenspace water storage where possible and any other measures possible. The emerging Area Action Plans should include a policy on flood risk reflecting the recommendations of the SFRA to ensure that a planned approach to flood risk is embedded within the document.

The Pitt Review Recommendation 11 suggests that building regulations should be revised to ensure that all new or refurbished buildings in high flood risk areas are flood resistance or resilient. While in Recommendation 12 the reviewers believe that the Local Authority should include flood resistance and resilience activities should be included under the home improvement grants for properties at high flood risk.

08: The Functional Floodplain should be protected from development

PPS25 defines the Functional Floodplain as Flood Zone 3b where the water will flow or will store water during times of flood. The guidance states that only Water Compatible Development and/or Essential Infrastructure should be permitted within this zone. The Functional Floodplain has an essential role to play in the effective long term flood risk management of North London. The Functional Floodplain should be reviewed each time the SFRA is updated to ensure that latest information is available and in use. This is support by Recommendation 7 in the Pitt Review.

09: Develop Flood Risk and Design Policy

Flood risk management in the highest risk zones is likely to affect the design of new development. This could use non-invasive techniques such as site layout or landscaped swales to address flood risk management issues. Alternatively, this could involve invasive design solutions to ensure that developments are flood resilient through the use of particular materials or flood exclusion measures such as barriers to doorways.

The Boroughs should develop policy to address flood risk management and design from the non-invasive measures to the specific design issues relating to design sensitive areas like Listed Buildings and disabled access in relation to raised floor levels. On small sites there are difficulties in providing the required length of ramp to meet Disability Discrimination Act requirements.

10: Develop policy for basement dwellings in flood zones 3 and 2

PPS25 states that while flooding can not be prevented, its impacts can be avoided and reduced through good planning and management. The risk to people residing in basement dwellings could be a real time threat in a flood event. The Boroughs should seek to prevent self-contained basement dwellings within Flood Zone 3 and 2 to minimise the flood risk to occupants. Any basement development should ensure that no sleeping accommodation is provided at basement level and internal access to higher floors should be maintained. All development in Flood Zones 3 and 2 should adopt flood proofing measures to minimise risk to people and property in a flood event.

11: Consideration of Sustainable Urban Drainage Systems (SUDS) for surface water runoff

A key mitigation measure the Boroughs should consider is the potential increase of use of surface water storage. Development should seek to ensure that surface water run-off is managed as close to its source as possible through the use of surface water storage options in public open spaces, car parks and green-roofs. The use of SUDS should be promoted for developments unless there are practical reasons for not doing so. The developer should restrict peak run-off from the site to the undeveloped greenfield run-off rate for both developments on greenfield and brownfield sites. SUDS can then be used to attenuate the surface flood water and relieving pressure on the drainage network. Measures which could be adopted include:

- Compensatory storage and floodplain compensation
- Sustainable Urban Drainage Systems (more information available in Chapter 9)
- No increase in the development footprint
- Surface water run-off must be restricted to existing levels with a reduction if possible

However, where surface water management options are proposed consideration needs to be given to their adoption and maintenance. However, it is realised changes at the national level are required to ensure the adoption issue do not hinder the uptake of sustainable urban drainage systems. Recommendation 20 of the Pitt Review Final Report urges the government to resolve the ownership issue of SUDS.

12: Flood proofing for all new development

The Boroughs should develop a flood proofing policy for their area in consultation with key partners such as the Environment Agency, the insurance industry and developers. Flood proofing measures incorporated would reflect on the level of risk and the vulnerability of the development use, as defined on the Flood Risk Maps and PPS25. In developing the flood proofing policy, the borough should consider all sources of flood risk and should therefore address the surface water drainage management of sites, sustainable drainage systems and specific design measures including:

- Electrical circuits lowered from the ceiling, raised sockets
- Flood gates to doors
- Air brick covers

- Horizontal plaster boards
- Damp proof membranes

Any such guidance or standards should be the subject of continual review and updating to ensure it reflects the latest techniques and guidance. Further information is contained in 'Improving the Flood Performance of New Buildings – Flood Resilient Construction', Department of Communities and Local Government, May 2007 and www.ciria.org. This policy suggestion is supported by Recommendation 11 of the Pitt Review.

13: Windfall sites

Windfall sites are sites which are not the subject of an allocation in an adopted development plan. These sites should also be considered against flood risk management policy, as outlined above. Such sites, dependant on their location within the identified flood zone maps and the use, may need to be subject to the Sequential and Exception Tests, as relevant, and are likely to require site-specific flood risk assessments.

14: Guidance on the application of the Sequential and Exception Tests

The SFRA has identified areas that have a relatively high risk of flooding. In accordance with PPS25, the Sequential Test and Exception Test shall be applied in allocating sites and reviewing applications for permission. Evidence will need to be provided to demonstrate that there are no reasonably available alternatives sites in areas with a lower probability of flooding that would be appropriate for the type of development.

Chapter 7 in the SFRA provides guidance on the process of applying the Sequential and Exception Tests, based on the approach identified in PPS25. It is recommended that a policy statement on the application of the Sequential and Exception Tests is included in the each of the Boroughs' Development Framework and explicitly requires developers to approach the Borough and other key organisations to discuss flooding issues.

15: Location of Development Types

The SFRA shows that some urban areas are within Flood Zone 3 and 2. The historic development pattern North London has led to concentrations of particular types of land use for example, the River Lee corridor frontage historically host industrial and commercial land uses. However, several of these locations are adjacent to rivers and are at the high to medium risk of flooding. Applications for development in Zones 2 and 3 must be accompanied by a local flood risk assessment. Developers should

ensure that flood risk is managed through a process of sequential design, mitigation and implementation of flood resilience measures where appropriate.

Boroughs should ensure that development is located in areas of lowest probability of flooding when taking into account all relevant flood sources, while ensuring that development achieves an overall reduction in flood risk. Given the likely competition for land between more/highly vulnerable developments within North London, less vulnerable uses should be directed to higher risk sites or should at least be required at ground floor level in the high risk locations. This approach would lower risk to the vulnerable uses and would help to safeguard land at lower risks of flooding for more vulnerable development such as housing, hospitals and residential institutions.

However, flood risk should not stifle regeneration and the loss of land that currently hosts less vulnerable uses to development of a more vulnerable classification, such as ground floor residential should be avoided where possible. The Boroughs should work with its development partners to address the implications of flood risk.

16: Emergency Planning and Evacuation Routes

The London Resilience Forum is currently undertaking a strategic flood plan which will address emergency planning issues in North London. The Boroughs should incorporate the findings of the SFRA within their Emergency Plans, in consultation with its key stakeholders. This should specifically identify strategic evacuation routes ('red routes') to enable emergency services to continue work during a flood event. The flood risk of key command centres and emergency facilities, and the adequacy of the level of protection which they are afforded, should be assessed using this SFRA.

The Emergency Plan should identify key strategic locations for protection in flooding emergencies and the locations of refuge areas which are capable of remaining operational during flood events. Based on the findings of this SFRA, there may be some works required to enable the implementation of the Emergency Plan. Legal agreements should be sought where necessary to ensure that any maintenance requirements are carried forward in perpetuity. See Appendix C for EA Guidance on 'Safe Access'

8.2.3 Technical

17: Development of Surface Water Management Plan (SWMP)

The SFRA incorporates flood risk from surface water flooding. This should be developed to more accurately identify areas that are at risk from surface water flooding, and be reflected in the policy approach for those areas. A SWMP (or similar) should be developed to work towards solutions to urban flooding, developed in partnership with other North London Boroughs and other key partners, including

Thames Water and the Environment Agency to ensure integrated working. This is supported by Recommendation 18 of the Pitt Review.

18: Working in Partnership

The SFRA process has involved the Boroughs working in partnership with the Environment Agency. While Thames Water and British Waterways were consulted their participation in the SFRA Process was limited. In future revisions of this SFRA this partnership and working involvement needs to improve. The sharing of knowledge and information on a continual basis also needs to improve, to ensure the SFRA and any subsequent flood risk management policy is based on the latest and best information available, with mutual agreement with partners in its implementation.

The London Resilience Team requested the SFRA to consider the implications of flood risk on existing utilities. To date the utilities information required to undertake this exercise has not been made available by the utility companies. It is understood that the data has been supplied to the London Resilience Team and many of the utilities companies were unwilling to supply the data for a second time. This demonstrates a wider reluctance of many organisations other than the Environment Agency to engage in the SFRA process. This is supported by Recommendation 17 of the Pitt Review.

19: SFRA Review

The SFRA is a living document and should be subject to rolling review, to ensure that new guidance and data is incorporated within the study. Issues that could trigger a review include the availability of new modelling data, occurrence of a major flood event, revised DCLG advice issued, change to the preferred River Lee, River Brent and River Thames Flood Risk Management Strategy and any significant planning issues arising. Data and mapping should be reviewed regularly to identify any updates or additional data available. A review should be undertaken at least every one to two years or to tie in with the development and review of the Core Strategy, or as required by key stakeholders responsible for flood risk management.

9 Guidance for Developers

9.1 Development and the management of residual flood risk

The following section is provided as a guide to developers on the management of flood risk and provision of flood risk assessments for future development. The guidance is based on recommendations arising from the findings of the SFRA while also following the requirements of PPS25.

At a site level, developers should consult the Environment Agency, sewerage undertakers, highways authorities and any other relevant bodies to supply information for a Flood Risk Assessment (FRA) of the site. This will provide information to the Local Planning Authority from which they can reach a decision on the development application.

Developers are recommended to consult with the LPA over all developments in Flood Zones 2 and 3 at the earliest opportunity to ensure that the Sequential Test has been satisfied. This should be done before a FRA is undertaken as it may be the case that the proposal is refused on Sequential Test grounds.

Planning applications for development proposals of 1 hectare or greater in Flood Zone 1 and all proposals for new development located in Flood Zones 2 and 3 should be accompanied by a local FRA. For developments in Flood Zones 2 and 3, the FRA should identify opportunities to reduce the probability and consequence of flooding.

With reference to PPS25, the objectives of an FRA are to establish:

- Whether a proposed development is likely to be affected by current or future flooding from any source.
- Whether it will increase flood risk elsewhere
- Whether the measures proposed to deal with these effects and risks are appropriate
- Whether the developer will be able to demonstrate that the site will be safe, without increasing flood risk elsewhere and where possible will reduce flood risk overall (part c of the exception test).

The scope of each FRA should be agreed with the LPA, EA and any other relevant consultees but it may include some or all of the following outputs:

- Development description and location

- Definition and assessment of all potential sources of flooding including: fluvial, coastal and tidal, estuarial, groundwater, artificial drainage systems, infrastructure failure.
- Assessment of the probability of flooding (existing and post development)
- Assessment of the sequence of flooding across the site, rate of rise of water level, flow velocities, depths and the duration of flood (existing and post development and including consideration of climate change)
- Detailed development proposals including estimation of the volume of runoff likely to be generated by the development and assessment of the hydraulic performance of the artificial drainage system for both storm and foul whether existing or proposed.
- Flood risk management measures and assessment of long term sustainability
- Assessment of the change in flood risk to the surrounding area caused by the development site both upstream and downstream including volumes of displaced water and flood levels
- Residual risks to both the development site and the surrounding area after inclusion of any mitigation measures. Where new or modified structural measures are provided, an assessment of their behaviour in extreme events should be provided.

Developments within medium or high risk flood zones should be further classified to ensure that flood resilience measures are considered to manage the residual risk of flooding. These measures include:

- The location of most vulnerable elements of a development within the areas of lowest risk.
- Maintenance of access/egress routes
- Location of critical infrastructure.
- The use of flood resilient and securely fastened infrastructure, seats etc
- Planning of escape routes. In areas of high and medium risk it may not be possible to ensure dry egress routes in time of flood. In these cases consideration should be given to the likely occupancy during flooding, the availability of safe refuge, potential for provision of key services and the expected duration of inundation.

Reference should be made to the following sources:

- C624 Development and flood risk - guidance for the construction industry CIRIA 2004” for details of best practice.
- National Flood Forum at www.floodforum.org.uk
- Damage Limitation Guide and Flood Product Advice Guides by the EA
- Preparing for Floods by DCLG.
- Flood Resistance and Resilience solutions: an R& D scoping Study Joint DEFRA and EA.
- Further information and guidance about the production of flood risk assessments can also be found at www.pipenetworking.com/floodrisk
- EA developer guidance can also be found at www.environment-agency.gov.uk/developers

9.2 Drainage Assessments

All developments which increase the overall impermeable area of a site or result in an increase in foul water discharge should require a surface and foul water management strategy, which must comply with the policies outlined in the LDF.

All drainage design should comply with the latest national and regional design guidance. At present these are Sewers for Adoption 6th Edition and, Document H – Drainage and Waste Disposal of the Building Regulations (BR part H). The integrity of the existing drainage should be maintained in compliance with the Building Regulations Part C.

Responsibility for drainage is fragmented which makes management more complex. Sewerage undertakers are responsible for the public sewerage system that serves most urban areas. Within the North London study area, Thames Water is the responsible sewerage undertaker. Thames Water is responsible for the drainage of flow arising from the boundaries of developments. Property owners are responsible for drainage within the boundary of their development.

Where new developments are proposed the planners role is to ensure that the development can be effectively drained from above and below ground without any detrimental effects downstream.

Guidance from Sewers for Adoption 6th Edition and PPS25 is as follows:

- PPS25 states that *“In general terms, sewers should be designed to ensure that no flooding occurs above ground level for events with a return period in*

the range of 30 to 50 years, depending on the development type". Sewers for Adoption 6th edition states that "all systems should be designed not to flood any part of the site in a 1 in 30 year return period design storm"

- *"any underground storage to be constructed to attenuate the 1 in 30 year event should be sited within the system being offered for adoption. Storage over and above the 1 in 30 year event should not be sited within the adoptable system"* (Sewers for Adoption 6th Edition)
- Sewers for Adoption 6th Edition states that *"During extremely wet weather, the capacity of the surface water sewers may be inadequate. Under such conditions surface water may escape from the system. Checks should be made to ensure that an adequate level of protection against flooding of properties is achieved"*. Following PPS25 guidance, for return periods greater than 1 in 30 years, surface flooding of open spaces such as car parks or landscaping is acceptable for short periods of time.
- *"In designing the site sewage and layout, developers should demonstrate flow paths and potential effects of flooding resulting from storm events exceeding the design criteria."* Design of the drainage system should ensure that water is routed away from any vulnerable property and no flooding of property should occur as a result of a 1 in 100 year event including allowance for climate change.
- *PPS25 states that "The development rate of runoff into a watercourse or other receiving water body should be no greater than the existing rate of runoff for the same event."* This should also be applied to discharges to sewer system as per the majority of the North London.

Developers should be encouraged to reduce runoff rates from previously developed sites as far as possible and supplementary planning guidance of the London Plan outlines the Mayors "essential" and "preferred standards" to include the importance of the use of SUDS wherever practical and the need to achieve:

- "at least 50% attenuation of the undeveloped site's surface water runoff at peak times" (essential standard)
- "100% attenuation of the undeveloped sites surface water runoff as peak times" (preferred standard).

Areas located within the critical drainage areas should apply the preferred standard.

All drainage design should be undertaken in close liaison with Thames Water and where the scale of development permits, in liaison with the Environment Agency.

Further guidance is provided in Designing for exceedance in urban drainage, good practice (CIRIA C 635) 2006.

9.3 Sustainable Urban Drainage Systems

Surface water drainage systems developed in line with the concept of sustainable development are referred to as Sustainable Urban Drainage Systems (SUDS). SUDS are made up of one or more structures used to manage environmental risks arising from urban runoff and to provide environmental enhancement wherever possible.

Both PPS1 and PPS25 require that Regional Planning Bodies and LPAs should promote SUDS. To comply with PPS25 Regional Spatial Strategies should include specific policies to encourage the use of SUDS. In response to this The London Plan highlights the importance of using SUDS in new developments wherever possible:

Policy 4C.8

“Boroughs should seek to ensure that surface water run-off is managed as close to its source as possible. The use of SUDS should be promoted for developments unless there are practical reasons for not doing so. Such reasons may include the local ground conditions or density of development. In such cases the developer should seek to manage as much runoff as possible on site and explore sustainable methods of managing the remainder as close as possible to the site.”

SUDS should be designed to mimic natural catchment processes as closely as possible. In order to do this, surface water drainage needs to be considered throughout the design process.

9.3.1 *The SUDS management train*

The SUDS Manual describes how design can be split into four stages often referred to as a “management train”. These four stages are outlined below:

1. Prevention – the use of good site design and maintenance to prevent runoff and pollution e.g. rainwater reuse/harvesting;
2. Source control – control of runoff at or near to its source e.g. soakaways, green roofs, permeable pavements;
3. Site control – management of water in a defined area e.g. routing water from roofs to a detention basin;
4. Regional control – management of runoff from a number of sites, typically in a large balancing pond or wetland.

The SUDS management train highlights prevention as the first step. This may just involve good site design and maintenance or features such as rainwater harvesting.

Figure 4 – Illustration of an office building with a rainwater harvesting pond at base



(Source: Design-build network website)

Rainwater from roofs and hard surfaces such as car parks can be stored and used in and around properties. The collected water can be used for a range of purposes such as flushing toilets and irrigation. While the system is in place for rainwater harvesting, where attenuation is required extra storage volume can be provided within the storage tanks to attenuate storm water flows.

The second stage of the management train is source control. New development or re-development should ensure that surface water run-off is managed as close to its source as possible.

There are many different SUDS techniques that can be used within a development site, however, not all techniques will be suitable for all locations. Therefore, it is important that site constraints are identified in order that appropriate SUDS technique can be used.

Despite the relatively high density of development in the North London Boroughs, a number of suitable SUDS techniques exist which can be incorporated into new developments to help manage flood risk.

9.3.2 *SUDS Selection*

The method for assessing the suitability of SUDS techniques based on site characteristics has been adapted from (CIRIA Sustainable Drainage Systems, Hydraulic, structural and water quality advice 2004” (C609)).

The seven boroughs have been split into two groups that share similar characteristics such as local ground conditions or density of development.

The selection of SUDS techniques is divided into five sections based on the following criteria:

- Hydrological performance
- Land use characteristics
- Physical and site features
- Community and environment
- Economic and maintenance

A weighting score is given to each criteria, scored from 1 to 3, with 1 having least weighting. The SUDS are scored out of 5 with 5 being good. The score is then multiplied by the weighting to give the score for that element of the SUDS technique.

For the purpose of this SFRA, the suitability of SUDS has been based purely on hydrological performance, land use characteristics and physical site features.

The community and environment, economic and maintenance criteria should be considered by developers in choosing appropriate SUDS in accordance with specific site objectives. The matrix provides a guide as to which SUDS features might be most useful, however, developers are ultimately responsible for assessing the most suitable techniques as part of their overall drainage strategy.

The total scores have been shaded as follows to highlight the most appropriate SUDS techniques:

Red = <60 Unlikely to be suitable for use

Orange = 60-70 May be possible to design into schemes

Green = >70 A good SUDS option

The results are shown in Table 15 and Table 16 below.

Table 24 - SUDS Score within Haringey, Waltham Forest, Barnet and Enfield

Criteria	Assessment	Weighting	Pervious Pavements				Filtration techniques			Infiltration devices		Extended detention ponds		Storm water wetlands		On-/off-line storage
			Pervious Pavements	Green roofs	Bio-retention	Filtration techniques	Grassed filter strips	Swales	Infiltration devices	Filter drains	Infiltration basin	Wet ponds	Storm water wetlands			
Hydrological	Is pollutant removal a priority?	3	15	15	15	12	6	12	9	9	12	9	12	15	3	
	Is water quantity control a priority?	3	15	12	9	6	6	9	10	9	15	12	15	9	15	
	Is flow rate control a priority?	3	12	12	6	9	6	12	12	6	12	12	12	12	12	
	Is groundwater recharge required?	1	3	3	3	1	3	3	1	1	1	2	2	2	3	
Land use	Suitability to type of development	2	10	10	10	8	4	8	6	6	8	6	8	8	8	
	Catchment Area	1	5	5	1	4	1	1	3	3	3	3	3	3	4	
Physical site features	Site slope	1	5	5	5	5	5	5	5	5	5	5	5	5	5	
	Space required	1	5	5	3	5	2	2	5	3	1	1	1	1	5	
	Soil infiltration rate	1	5	5	5	5	5	4	3	3	1	5	4	3	5	
	Water table depth	1	5	5	5	5	5	5	4	5	5	5	5	4	5	
Total Score			80	77	62	60	43	61	60	50	63	60	67	62	65	

Table 25 - SUDS Score Technique within Camden, Islington and Hackney

Criteria	Assessment	Assessment													
		Weighting	Pervious Pavements	Green roofs	Bio-retention	Filtration techniques	Grassed filter strips	Swales	Infiltration devices	Filter drains	Infiltration basin	Extended detention ponds	Wet ponds	Storm water wetlands	On-/off-line storage
Hydrological	Is pollutant removal a priority?	2	10	10	10	8	4	8	6	6	6	6	8	10	4
	Is water quantity control a priority?	3	15	12	9	6	6	9	9	9	15	12	15	9	15
	Is flow rate control a priority?	3	12	12	6	6	6	12	12	6	12	9	9	9	12
	Is groundwater recharge required?	1	3	2	3	1	3	3	2	1	1	2	2	2	1
Land use	Suitability to type of development	1	5	5	5	3	2	4	3	3	3	3	4	5	3
	Catchment Area	1	5	5	5	5	5	5	5	5	5	1	1	1	5
Physical site features	Site slope	1	5	5	5	5	5	5	5	5	5	5	5	5	5
	Space required	3	15	15	9	15	6	6	6	15	3	3	3	3	15
	Soil infiltration rate	1	5	5	5	5	4	4	2	1	1	4	4	4	5
	Water table depth	1	5	5	5	5	5	5	5	5	5	5	5	4	5
Total Score			80	76	62	59	46	61	56	56	56	50	56	52	70

In the boroughs of Haringey, Waltham Forest, Barnet and Enfield, pervious pavements, green roofs and storage facilities such as wet ponds were cited as being the most applicable SUDS features. However these are not the only SUDS options that are available; the other SUDS techniques are dependent on the local site conditions and the proposed development. These options include various infiltration techniques like swales, bio-retention and other attenuation methods such as on/off line storage. These have gained a lower score as they are not as effective at flow or water quality control however they could be considered should a suitable site or development be available. Filter strips and drains were considered unlikely to be appropriate for use due to the consistent low scores as a result of their overall unsuitability within the development areas.

For the more densely urban areas including Camden, Islington and Hackney, the use of permeable pavements, green roofs and on/off line storage were identified as the most appropriate techniques. Bio-retention and swales are considered to be limited in their use in these areas. Their use is dependent on the local site conditions and the proposed development. The remaining SUDS techniques are unlikely to be used due to the space required, their suitability for the type of development, their limited flow control and limited pollution control.

It should be noted that the all SUDS features should be considered and selection should be undertaken by developers on a site by site basis.

A brief summary of potential SUDS techniques is included in the following sections. For more detailed information including design methods, refer to CIRIA C697, The SUDS Manual.

9.3.3 *Pervious Surfaces*

Pervious pavements allow rainwater to infiltrate through the surface into underlying construction layers where water is stored prior to infiltration to the ground, reused or released to a surface water drainage system or watercourse at an attenuated rate.

While pervious pavements are a good choice of SUDS for use within urban areas, consideration of the proximity of basements and foundations must be made. Where pervious pavements are located within 5m of foundations or basements, an impermeable membrane liner is required to prevent infiltration.

Pervious pavements can either be made from *porous* materials which allow infiltration across their entire surface e.g. gravels, grass and porous concretes, or *permeable* surfaces which are made from impermeable materials with voids to allow infiltration e.g. brick paving.

Figure 4 - Illustration of a Pervious Pavement using Block Paving



(Source: CIRIA website)

Pervious pavements can be used for both infiltration and attenuation collecting water from paved areas and roof catchments. They have been shown to reduce both the peak flow rate and total runoff volume from developments. They can be designed to temporarily store runoff from storm events with a return period of 1 in 100 years and are suitable for incorporation into rainwater utilisation projects.

Pervious surfaces can be incorporated into soft landscaping and oil interceptors can be added to improve pollutant retention and removal. In urban areas where there is a high percentage of hard cover the use of pervious surfaces for car parks and hard areas is a valuable technique that should be used wherever possible.

9.3.4 Green Roofs

“Green roofs comprise a multi layered system that covers the roof of a building with vegetation cover/landscaping/permeable car parking, over a drainage layer. They are designed to intercept and retain precipitation, reducing the volume of runoff and attenuating peak flows.” (CIRIA Sustainable Drainage Systems, Hydraulic, structural and water quality advice 2004”)

Rooftops form a major part of the cityscape, but have been vastly under utilised. The use of green roofs can reduce the size of downstream SUDS and drainage infrastructure that is required.

There are two main types of green roof as described below:

Extensive green roof

This covers the whole roof area with low growing, low maintenance plants. They usually comprise of 25 – 125mm thick soil layer in which a variety of hardy, drought tolerant, low level plants are grown. **Extensive** green roofs are designed to be self sustaining and cost effective and can be used in a wide variety of locations.

Figure 5 - Illustration of an extensive green roof



(Source: The Greater Vancouver Regional District (GVRD) Web site)

Intensive green roof

Intensive green roofs are landscaped areas which include planters or trees and are usually publicly accessible. They may include irrigation and storage for rainwater. They often require more maintenance and impose a greater load on the roof structure than extensive green roofs.

Figure 6 - Illustration of an Intensive Green Roof



(Source: Trelleborg website information green roofs)

Intensive roofs can be adapted to be **simple intensive** green roofs. These are vegetated with lawns and still require maintenance, however, they impose a reduced load on the roof structure and are less expensive.

Figure 7 - Illustration of a Simple Intensive Green Roof

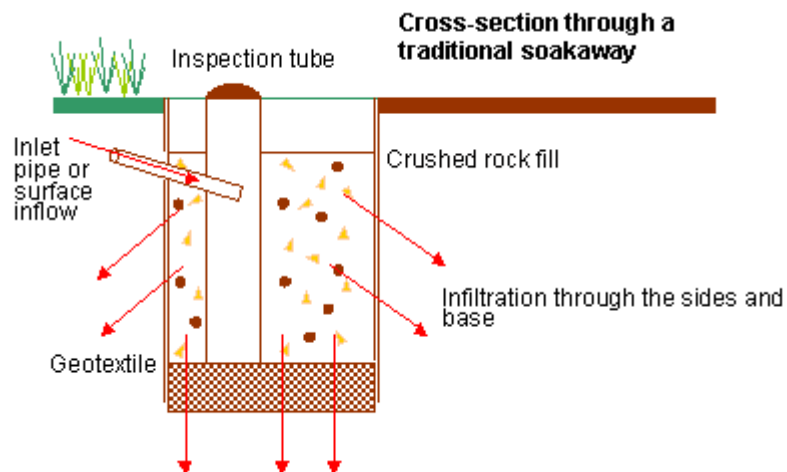


(Source: Rehbein Environmental Solutions website)

While green roofs are designed to absorb most of the rainfall from an ordinary rainfall event (up to a 2 year return period), during larger storms there will still be a need to discharge excess water to the buildings drainage system.

9.3.5 Soakaways

Figure 8 - Illustration of a traditional soakaway design



(Source: SUDS website)

Soakaways are drainage structures with high available storage. Surface water runoff is directed to the soakaway where the storage volume provides attenuation of flows and gradual infiltration to the surrounding soil. Soakaways can be designed to store rapid runoff from a single house, several buildings or highway areas. Long, thin soakaways are called infiltration trenches.

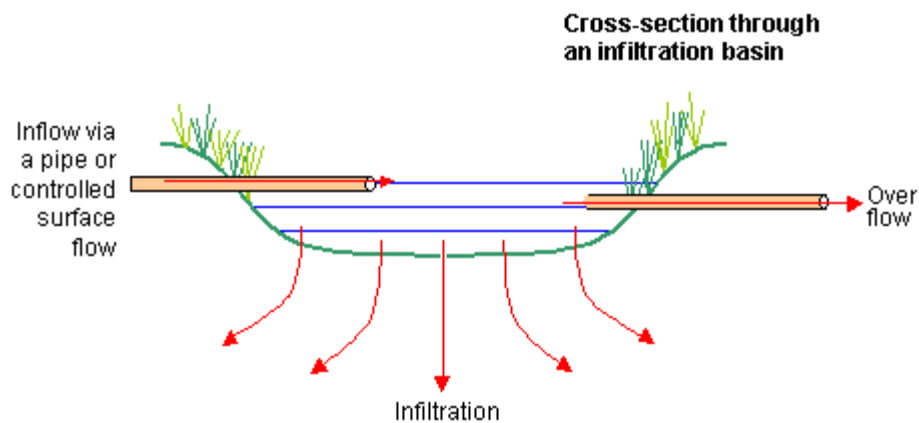
9.3.6 *Infiltration trenches*

Infiltration trenches are shallow trenches filled with rubble or stone that creates temporary storm water storage which is then filtered through the stone material and conveyed downstream or infiltrated into the soil. Infiltration trenches can significantly reduce runoff rates and volumes. They can easily be incorporated into site landscaping and fit well beside roads.

9.3.7 *Infiltration Basins*

Infiltration basins are vegetated depressions designed to store runoff and infiltrate it gradually into the ground.

Figure 9 – Cross section through an infiltration basin



(Source: SUDS website)

9.3.8 *Filter strips*

Filter strips are vegetated strips of gently sloping land designed to accept runoff as overland flow. They are often used as a pre treatment technique before other SUDS techniques such as swales. They have low construction costs and can easily be integrated into landscaping to provide aesthetic benefits. They however offer limited attenuation during extreme rainfall events. They are best suited to treating runoff from relatively small drainage areas such as roads, small car parks and pervious surfaces. They are not suitable for use on contaminated sites or in areas of groundwater vulnerability.

9.3.9 Swales

Figure 10 – Illustration of a swale



(Source: CIRIA website, Site is in Reddich Worcestershire)

Swales are linear vegetated drainage features in which surface water can be stored or conveyed. When used alongside roads, swales can replace conventional gullies and drainage pipes. They are easy to incorporate into landscaping, offer good reductions in both runoff rates and pollutant removal. They are ideal for use as drainage systems on industrial sites because any pollution that occurs will be visible and can be dealt with before it causes damage to a receiving watercourse.

9.3.10 Bio-retention areas

Figure 11 – Illustration of an engineered bio-retention area



(Source: North Carolina division of water quality website)

Bio-retention areas are shallow landscaped areas. They are typically under drained and rely on engineered soils and enhanced vegetation and filtration to remove pollution and reduce runoff downstream. They are designed to treat surface water runoff from frequent rainfall events. During larger rainfall events, excess water is passed forward to other drainage facilities. Bio-retention areas are very effective in

removing urban pollution and are well suited to use in highly impervious areas such as car parks, along side highways and roads or as landscaped islands draining impervious areas.

9.3.11 Detention Basins

Figure 12 – Illustration of a detention basin following a period of heavy rain



(Source: Sustainable Urban Drainage Systems Network website)

These are vegetated surface storage basins that provide flow control through attenuation of storm water runoff and controlled release. Detention basins are normally dry except during and immediately after a storm event. In some instances the land may also function as a recreational facility e.g. playground or sports field.

9.3.12 Ponds

Figure 13 – Illustration of a pond in a high density housing development in Bicester, Oxfordshire



(Source: Environment Agency website)

Ponds can provide both storm water attenuation and treatment. Runoff from each rain event is detained and treated in the pond through sedimentation and biological uptake. Ponds can provide valuable aesthetic and wildlife value to a development site.

9.3.13 *On/Off-line storage*

On-line or off-line storage refers to tanks or other underground storage structures. Tanked storage collects and stores runoff to be released at the required rate into the receiving watercourse or sewer. On/Off-line storage can take the form of oversized pipes, concrete storage and cellular storage systems. They can be applied where space is a constraint and above ground SUDS features such as ponds are not suitable. Tank storage systems do not provide any pollutant removal potential and should, where possible be used in conjunction with other SUDS features. The primary benefit of On/Off-line storage is their ability to attenuate run-off to the greenfield run-off rate.

9.3.14 *Adoption and Maintenance of SUDS*

There is currently no specific provision for the adoption of SUDS techniques by Water Authorities. However, within urban areas much of the development drainage will fall within private development ownership e.g. green roofs, meaning that the adoption scenario should not be a constraint to the use of SUDS.

Owners of developments using SUDS should be provided with an owners' manual to include details of the location of SUDS, a maintenance plan, brief summary of how they work and identification of areas where activities are prohibited e.g. stockpiling materials on pervious surfaces.

Maintenance inspections can generally be carried out monthly to include activities such as grass cutting, plant control and debris removal. If SUDS systems are properly monitored and maintained, any deterioration in performance can be managed out.

9.3.15 *Land Drainage Consent*

The Water Resources Act 1991 and associated byelaws require those wishing to undertake works in, over, under or adjacent to main rivers to obtain a formal consent for the work from the EA. This is to ensure that such activities do not cause or make worse an existing flooding problem, interfere with the existing watercourse, and do not adversely affect the local environment, fisheries, wildlife, and flood defences. These consents are referred to as 'flood defence consents'; in the past they were sometimes called 'land drainage consents', after the old legislation that applied. Under the Land Drainage Act 1991, you also need the EA's consent to construct a culvert or flow control structure (such as a weir) on any ordinary watercourse. It should be noted that the EA generally oppose culverts and in-channel structures because of their environmental impacts.

Once an application of the full details of the proposed work is submitted, it will take at least two months to process. It is recommended to all developers to talk to the EA as early as possible to avoid delays and wasted effort. Works will not be approved if they are believed to harm the environment or increase flood risk, even if the works appear to

be sound from an engineering or structural point of view. The EA promote and encourage the use of 'soft engineering' methods to control erosion. Such as the use of natural materials like woven willow spilling or natural planting to limit erosion where practical, rather than steel sheet piles, unless conditions at the location require that piles are used.

Work must not be conducted without consent. If found without a consent then the consequences could be expensive. The EA can reclaim the cost of whatever action is decided as necessary to remove or alter your work. Or, they can require that the work be removed and the site returned to its original state. Carrying out works without prior consent or failing to rectify problems may be a criminal offence. The EA consent only covers the impact of the structure on flood risk and the environment. It does not:

- confirm that a proposed structure is of sound design.
- check whether your plan complies with other legislation.
- allow you to carry out works on land or rivers that you do not own.

10 Conclusions

The main objective of this level 1 SFRA was to enable the 7 North London Boroughs of Barnet, Camden, Enfield, Hackney, Haringey, Islington and Waltham Forest to apply the sequential flood risk test when allocating development sites, thus ensuring compliance with PPS25, but more importantly, providing sustainable development throughout the Borough.

A review of all flood sources was undertaken culminating in a source pathway receptor model which assessed the risks and consequences posed by the different sources of flooding. However, the review and assessment of risks from sewer and surface water flooding was undertaken due to the limited information provided by Thames Water.

10.1 Summary for Barnet

The LB of Barnet is split between the catchments of the River Brent and the River Lee. In recent years Barnet has seen many flood risk management activities, which include hydraulic modelling, improvements to the flood extent mapping and the construction of flood alleviation schemes.

The Silk Stream, Dollis Brook and tributaries have recently been modelled and the flood extent mapping results have been included in the SFRA. The flood risk zones included in this report are based on the less accurate JFLOW modelling results. Pymmes Brook has been modelled as part of the Lower Lee Tributaries and the most up to date results are shown on map 8.

Barnet also contains the Brent Reservoir that lies on the southern boarder with LB Brent. Flood management plans and supporting inundation mapping is will be a legal requirement from spring 2009.

GARDIT operate an on going abstraction scheme across London to maintain the level of the groundwater table which is assisted by the impermeable geology.

10.2 Conclusions for Barnet

The primary source of flood risk to the LB Barnet was found to be from fluvial flooding from Dollis Brook, Silk Stream, Pymmes Brook and their associated tributaries.

The Brent Reservoir is considered to present a low risk to Barnet. It is anticipated that the Flood Management Plans and associated inundation mapping will provide a more accurate appraisal and assessment of flood risk presented by the reservoir.

Surface water flooding in Barnet presents a low to moderate risk to the borough while sewer flooding is also noted for being low risk. Areas with historical sewer

flooding are low but this assessment is based on limited information from Thames Water.

Groundwater flooding was found to be a relatively low risk.

10.3 Summary for Camden

Camden has no fluvial watercourses within its borough boundaries. The Regents Canal does flow through the borough but the locations of raised canal banks that could pose a flood risk are yet to be identified as attempts to obtain information from British Waterways have been unsuccessful. The Canal could also be considered as a reservoir as in places embankments have been constructed to create the watercourse.

Surface water flooding has a well document and recent history. The 2002 Camden floods highlighted the vulnerability of particular areas (shown in map 22).

The two small reservoirs in Hampstead Heath are part of a series of ponds owned by the City of London Corporation. These reservoirs lie within the River Fleet catchment. The flood management plans and supporting inundation mapping is anticipated to be a legal requirement from spring 2009.

GARDIT operate an on going abstraction scheme across London to maintain the level of the groundwater table which is assisted by the impermeable geology.

10.4 Conclusions for Camden

The LB of Camden has a particularly high risk of flooding from sewer and surface water flooding, while fluvial flood risk remains low due to the lack of watercourses. At present the Canal presents an unknown risk to the borough. A more detailed assessment of the flood risk posed by the Canal to the surrounding properties is required in close partnership with British Waterways.

Surface water flooding zones are in need of further investigation within Camden due to the high level of risk and historic precedent. A more detailed assessment of sewer flooding would also be desirable but this would require the cooperation of Thames Water in releasing the necessary data for a review and analysis to be undertaken. Where sewer and surface water flooding may occur the consequences are unlikely to restrict development providing that mitigation for surface water flooding is applied using the precautionary approach.

Groundwater flooding was found to be a relatively low risk.

The two small reservoirs on Hampstead Heath are considered to present a low risk to Camden. It is anticipated that the Flood Management Plans and associated inundation mapping will provide a more accurate appraisal and assessment of flood risk presented by the reservoir.

10.5 Summary for Enfield

Enfield is completely located in the River Lee catchment and has a number of tributaries that form sub-catchments in the Borough. The flood risk zones for the River Lee and its tributaries are well defined from the extensive studies already undertaken. The flood risk zones are defined on map 8.

In addition, two large water supply reservoirs, King George V and William Girling reservoirs are located within Enfield and owned by Thames Water. It is anticipated that flood management plans and supporting inundation mapping will be a legal requirement from spring 2009. The New River water supply aqueduct passes through Haringey and holds the water in many places above ground level.

GARDIT operate an on going abstraction scheme across London to maintain the level of the groundwater table which is assisted by the impermeable geology. However, a small number of groundwater flooding problems were identified in Enfield which are attributed to drift deposits of gravels and silts overlying the impermeable London Clay.

10.6 Conclusions for Enfield

The primary source of flood risk to Enfield Borough was found to be from fluvial flooding, with the Lower Lee, Pymmes Brook, Salmons Brook and tributaries providing the highest flood risk.

The King George V and William Girling reservoirs do pose a risk to the downstream properties. It is anticipated that the Flood Management Plans and associated inundation mapping will provide a more accurate appraisal and assessment of flood risk presented by the reservoir. In addition, the New River is considered to pose a limited flood risk as its flow is controlled by pumping stations demand.

An assessment of risks from sewer and surface water flooding was undertaken which indicated that the risk of sewers flooding is generally low across the Borough with a small number sewer flood risk zones.

Groundwater flooding was found to be a relatively low risk. However the local geology does increase the risk of groundwater flooding and these risk zones were highlighted.

10.7 Summary for Hackney

Hackney is located in the River Lee catchment and has a number of tributaries that form sub-catchments in the Borough. The flood risk zones for the River Lee are well defined from the extensive studies already undertaken. Some of the Olympic development works are being undertaken in the south of the borough and include watercourse improvements. However there is a tidal influence on the Lower Lee in this borough that could affect the fluvial flooding.

Two large water supply reservoirs, Stoke Newington East and West reservoirs are owned by Thames Water and the LB Hackney are located within the borough to receive water from the New River. The flood management plans and supporting inundation mapping for reservoirs will be a legal requirement from spring 2009. The Regents Canal does flow through the borough but the locations of raised canal banks that could pose a flood risk are yet to be identified as this information was not obtained from British Waterways.

GARDIT operate an on going abstraction scheme across London to maintain the level of the groundwater table which is assisted by the impermeable geology.

10.8 Conclusions for Hackney

The primary source of flood risk to Hackney Borough was found to be from fluvial flooding, with the Lower Lee provides the highest flood risk.

The Stoke Newington East and West reservoirs do pose a limited risk to the downstream properties. It is anticipated that the Flood Management Plans and associated inundation mapping will provide a more accurate appraisal and assessment of flood risk presented by the reservoir. In addition, the New River is consider to pose a limited flood risk as it is flow is controlled by pumping stations demand.

An assessment of risks from sewer and surface water flooding was undertaken that indicated that the risk of flooding from sewers is generally low except in the north of the borough. However, this assessment is based on limited information from Thames Water.

Where sewer and surface water flooding may occur the consequences are unlikely to restrict development if appropriate mitigation is included in the design. However, a more detailed assessment of surface water flooding in partnership with Thames Water would be of significant benefit to the borough.

Groundwater flooding was found to be a relatively low risk.

10.9 Summary for Haringey

Haringey is located in the River Lee catchment and has a number of tributaries that form sub-catchments in the Borough. The flood risk zones for the River Lee are well defined from the extensive studies already undertaken. The New River water supply aqueduct passes through Haringey and has some storage capacity in the Hornsey Reservoir.

GARDIT operate an on going abstraction scheme across London to maintain the level of the groundwater table which is assisted by the impermeable geology. Additionally, a small number of groundwater flooding problems were identified that

are attributed to drift deposits of gravels and silts overlying the impermeable London Clay.

10.10 Conclusions for Haringey

The primary source of flood risk to Haringey is fluvial flooding, with the Lower Lee, Moselle Brook and Stonebridge Brook providing the highest flood risk. While the New River poses a limited flood risk as its flow is controlled by pumping stations demand.

An assessment of risks from sewer and surface water flooding was undertaken which indicated that the risk of sewers flooding is generally low across the Borough with a small number sewer flood risk zones. However, a more detailed assessment of surface water flooding in partnership with Thames Water would be of significant benefit to the borough.

Groundwater flooding was found to be a relatively low risk. However the local geology does increase the risk of groundwater flooding and these risk zones were highlighted.

10.11 Summary for Islington

Islington has no fluvial watercourses within its borough boundaries. The Regents Canal does flow through the borough but the locations of raised canal banks that could pose a flood risk are yet to be identified as attempts to obtain information from British Waterways have been unsuccessful.

Surface water flooding has a recent history in Islington with the 2002 floods and other more localised flood events. Unlike Camden the detailed information of the floods were not recorded.

GARDIT operate an on going abstraction scheme across London to maintain the level of the groundwater table which is assisted by the impermeable geology.

10.12 Conclusions for Islington

The LB of Islington has a particularly high risk of flooding from sewer and surface water flooding, while fluvial flood risk remains low due to the lack of watercourses. At present the Canal presents an unknown risk to the borough. A more detailed assessment of the flood risk posed by the Canal to the surrounding properties is required in close partnership with British Waterways.

The borough has a moderate risk of flooding from sewer and surface water flooding that has been identified from a variety of sources. Further assessment of sewer flooding would also be desirable with the cooperation of Thames Water. Where sewer and surface water flooding may occur the consequences are unlikely to restrict development if appropriate mitigation is included in the design. In addition, recording of flood events would benefit future flood studies.

Groundwater flooding was found to be a relatively low risk.

10.13 Summary for Waltham Forest

Haringey is located in the River Lee catchment and has a number of tributaries that form sub-catchments in the Borough. The flood risk zones for the River Lee are well defined from the extensive studies already undertaken.

Waltham Forest has 11 medium sized reservoirs within the borough that are owned by Thames Water. The flood management plans and supporting inundation mapping for reservoirs will be a legal requirement from spring 2009.

GARDIT operate an on going abstraction scheme across London to maintain the level of the groundwater table which is assisted by the impermeable geology.

10.14 Conclusions for Waltham Forest

The primary source of flood risk to Waltham Forest Borough was found to be from fluvial flooding, with the Lower Lee, Pymmes Brook, Salmons Brook and Silk Stream providing the highest flood risk.

Surface water and sewer flooding poses a moderate flood risk to the borough. A more detailed assessment of sewer flooding would also be desired but this would require the cooperation of Thames Water in releasing the necessary data for a review and analysis. Where sewer and surface water flooding may occur the consequences are unlikely to restrict sustainable development.

The reservoirs do pose a risk to the downstream properties. It is anticipated that the Flood Management Plans and associated inundation mapping will provide a more accurate appraisal and assessment of flood risk presented by the reservoir.

Groundwater flooding was assessed to be a low risk.

11 Recommendations

11.1 Recommendations for Further Work

It should be noted that it is difficult to produce meaningful recommendations if bodies do not provide the relevant needed information on flood risk. The following areas of further work are recommended to be undertaken either by individual Boroughs or through a continued partnership arrangement.

11.2 Recommendations for Boroughs

1. Update the information on flood defence levels to enable accurate assessment of standards of protection and assessment of areas benefiting from flood defences.
2. Assess areas at actual risk of flooding in the Lower Lee Valley and tributaries adjacent to the Lee, Turkey Brook, Pymmes Brook and Salmons Brook. Determine high residual flood risk through breach and overtopping, determining rate of onset of flooding, flood depths and velocities.
3. Boroughs to determine own area action plans and review in conjunction with allocated sites to determine which areas need coverage.
4. Strategic review of flood defences to ensure that future development of the Lower Lee Valley can occur.
5. Undertake further assessment of the surface water risks to better define the surface water flood risk zones. This cannot take place without the co-operation or collaboration of Thames Water who have set out their stance regarding the SFRA process. Engagement of Thames Water is recommended to determine whether any flood relief schemes are in place to alleviate any of the flooding within these zones.
6. Engage with British Waterways to identify raised canal embankments. A detailed study as part of the Level 2 SFRA to consider the level of risk posed by the head of water held at the Camden Lock. The boroughs concerned would benefit from undertaking a joint study on this subject. .
7. Review the document after 12 months and then every 2 – 3 years afterwards. Aspects to be reviewed would include:
 - Flood Zone outlines
 - Planning and Flood Risk Policy at national, regional and Local Authority levels

- Flood risk schemes and drainage initiatives
 - Update and edit information about various watercourses
 - Update of progress on conducting recommendations
8. Review Emergency Flood Plans and update in accordance with the SFRA updates.
 9. Review all reservoirs and ponds that are not on the reservoir register to consider the risk they pose to the surrounding area.
 10. Review the DEFRA “Guide to Emergency Planning for UK Reservoirs” consultation document when issued in summer 2008 and ensure that Emergency Planners review flood plans when they become available.
 11. Flood data collection in the boroughs by the boroughs. By collecting their own flood information in a common format with other boroughs would allow the boroughs to share the information and improve upstream and downstream planning with particular regard to surface water flooding.
 12. The boroughs in partnership with key organisations such as Thames Water and the Environment Agency should seek to develop a Surface Water Management Plan.
 13. This SFRA has been developed through an interactive process involving different bodies. In future revisions, this interaction needs to develop into a partnership that improves the sharing of knowledge and information on a continual basis to ensure the SFRA and any subsequent flood risk management policy is based on the latest and best information available.
 14. Each borough is considering their own requirements for a level 2 SFRA where necessary.
 15. Where opportunities exist, the Environment Agency recommends for developers to consider the opening up of culverts and the setting back of defences to allow hydrological and environmental improvements.

11.3 Recommendations for Developers

1. Review Area Action Plans once available.
2. Review new policies and strategies on a continual basis and when appropriate provide constructive feedback on policy or strategy in question.

3. Review proposed development site with consideration of flood risk posed by reservoirs (either registered or non-registered under the Reservoirs Act 1975) and canals or other artificial water bodies.
4. Provide adequate clearance of development activities from the footings / foundations / toe of canals flood defences, reservoirs and other artificial watercourse structures.
5. Develop closer working relationships with the Local Planning Authority, EA, Thames Water and other organisations to reduce the risk of flood risk to the occupants, neighbours and users of the proposed site through all stages of its development and use.
6. In preparing a site specific FRA or a Drainage Strategy developers must consider consequences of potential flooding from upstream areas. Similarly the developer must consider the effect of overland flows to downstream areas in the event of design exceedence from their site specific drainage system.

References

- 1) Department of Communities and Local Government Planning Policy Guidance 1: *General Policy and Principles*, 1997
- 2) Supplementary Planning Guidance, Sustainable design and construction. Mayor of London, May 2006
- 3) London County Council, Main Drainage of London Descriptive Account, 1930
- 4) CIRIA Special Publication 69 The Engineering Implications of Rising Groundwater levels in the deep aquifer beneath London, 1989
- 5) Thames Water *Central London Rising Groundwater*
- 6) UK Climate Impact Partnership, *Climate Change Scenarios for the United Kingdom: The UKCIP02 Scientific Report*, 2002
- 7) London Climate Change Partnership, *London's Warming: A Climate Change Impacts in London Evaluation Study*, 2002
- 8) <http://te2100.dialoguebydesign.net/dbyd.asp>
- 9) EA / DEFRA, *Flood Risk Assessment Guidance for New Development Phase 2*, 2005
- 10) EA Publication, *Living on the Edge: A Guide to the Rights and Responsibilities of Riverside Occupation*, 2007 available on the EA website.
- 11) Department of Communities and Local Government, *Planning Policy Statement 25: Development and Flood Risk*, 2005
- 12) Sustainable Urban Communities, Building for the Future, ODPM, 2003
- 13) Strategic Planning for Flood Risk in Growth Area – Insurance Considerations, ABI, July 2004
- 14) Preparing for Floods, ODPM October 2003
- 15) Design Guidance on Flood Damage to Buildings, BRE, 1996
- 16) Hother, J., Applying Reliability Risk Analysis to Flood Risk Management, 39th DEFRA Flood and Coastal Management Conference, 2004
- 17) Steven Wade, Mohammed Hassan & Valerie Bain, Flood risks to people in defended areas, (HR Wallingford Ltd) presented at the London CIWEM conference, January 2005.
- 18) Flood Resilient Homes, Association of British Insurers, April 2004
- 19) ABI, 2005; Statement of principles on the provision of Flood Insurance – Updated Version, Association of British Insurers, November 2005
- 20) DEFRA, 2004; Making Space for Water-Developing a New Government Strategy for Flood and Coastal Erosion Risk Management in England.
- 21) Environment Agency 2003; Your Environment – 1953 Floods, Timetable of Events
- 22) Lancaster, J.W., Preene, M. and Marshall, C.T. 2004; Development and Flood Risk – guidance for the construction industry (C624). CIRIA Publications. ISBN 0-86017-624-X
- 23) Development and Flood Risk: A Practical Guide Companion to PPS25 'Living Draft' a consultation paper.
- 24) Environment Agency 2007. Managing Flood Risk, Thames Region Catchment Flood Management Plan, Summary Document, Consultation, January 2007.
- 25) LCCP Report – “Climate Change and London Transport Systems”
- 26) London Catchment Abstraction Management Plan
- 27) Groundwater levels in the Chalk-Basal Sands Aquifer of the London Basin

Appendix A – Maps 1 to 24

Map 1 - Barnet Study Area Map

Map 2 - Camden & Islington Study Area Map

Map 3 - Hackney Study Area Map

Map 4 - Haringey Study Area Map

Map 5 - Enfield Study Area Map

Map 6 - Waltham Forest Study Area Map

Map 7 - Topography Map

Map 8 - Flood Risk Zone Map

Map 9 - Water Features Map

Map 10 - Historic Zone Map

Map 11 - FEH Areas

Map 12 - GW Contours Map

Map 13 - Sewer Flooding Incidents by Postcode Map

Map 14 - Barnet Asset Condition

Map 15 - Camden & Islington Asset Condition

Map 16 - Hackney Asset Condition

Map 17 - Haringey Asset Condition

Map 18 - Enfield Asset Condition

Map 19 - Waltham Forest Asset Condition Map

Map 20 - Flooding Incidents Map

Map 21 - Flood Zone Modelling Approach Map

Map 22 - Camden Floods Map

Map 23 - Surface Water Flood Risk Areas

Map 24 - Infrastructure in the Floodplain

Appendix B - Data Summary

Appendix C - EA Guidance
Safe Access